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MONTHLY.

MAY, 1900.

THE COMING TOTAL ECLIPSE OF THE SUN.

By FRANK H. BIGELOW,

PROFESSOR OF METEOROLOGY, UNITED STATES WEATHER BUREAU.

THE circumstance which renders the coming total eclipse of the sun, on May 28, 1900, of special significance to thousands of people who might otherwise entirely overlook the occasion is the fact that the path of the moon's shadow over the surface of the earth, or the track of the eclipse, is in such a convenient locality—namely, in our Southern States—as to render the places of visibility easily accessible. Instead of being obliged to go to the ends of the earth, at a heavy expenditure of time and money, all the while running the risk of not seeing the eclipsed sun on account of prevailing cloudiness, we are fortunate this time to have the show at home in our own country. While many foreigners will be induced to come to the United States to make observations, it is certain that more people will be in a position to see this eclipse with a minimum amount of trouble than has ever happened before in the history of eclipses, at least since the telescope was invented and careful records of the phenomenon preserved.

The track of May 28th enters the United States in southeastern Louisiana; passes over New Orleans, La., centrally; over Mobile, Ala., which is on its southern edge; over Montgomery, Ala., on the northern edge; over Columbus, Ga.; south of Atlanta, Ga., which lies about twenty-five miles to the north of it; near Macon, Milledgeville, and Augusta, Ga., Columbia, S. C., Charlotte, N. C.; over Raleigh, N. C., which is ten miles north of the central line; and over Norfolk, Va., fifteen miles north of the center. The track is about fifty miles wide in all parts, and the duration of the eclipse varies from one minute and twelve seconds near New Orleans to one minute and forty-four seconds near Norfolk, on the central line. These durations diminish from the maximum at the middle of the track to zero at the northern and southern limits of it, so that an observer must be stationed as near the central line as possible in order to see much of the eclipse. The population of several of the abovementioned cities is at present as follows: New Orleans, 242,000; Mobile, 31,000; Montgomery, 22,000; Columbus, 20,000; Atlanta, 66,000; Raleigh, 13,000; and Norfolk, 35,000. It is evident that with very little exertion more than 500,000 people can see this eclipse. It is most fortunate that the track passes near so many cities, because, with their facilities for the accommodation of visitors, many will be induced to undertake excursions with the purpose of taking in this rare sight, and a little enterprise on the part of railroads and transportation companies might easily increase the numbers. If people will go to a parade, yacht race, or an exposition, and consider themselves paid for their expenses, then surely they will find in this great spectacle of Nature not only an object of wonder and beauty, but also one of peculiar instruction in many important branches of science. All educators who can induce their pupils to make such an expedition will implant a love of astronomy in many impressionable minds which will become a source of pleasure to them for the rest of their lives.

Out of about seventy eclipses of the sun which have occurred somewhere in the world within the nineteenth century, there have been only eight total eclipses of more or less duration visible on the North American continent. The others happened in places often remote from civilization, and sometimes in entirely inaccessible localities, as over the ocean areas. The difficulty of transporting heavy baggage to the remote parts of Asia, Africa, or South America is such as to preclude all but a few scientists from any effort to observe eclipses. The writer was much impressed with the formidable nature of undertaking to establish eclipse stations in places which are distant from centers of population by his own experience on the West African Eclipse Expedition, sent out by the United States Government, for the eclipse of December 22, 1889, to Cape Ledo, on the west coast of Angola, about seventy miles south of St. Paul de Loanda. Nearly eight months were consumed in the course of the preparations at home and in the voyage out and back. The expedition, it should be said, however, went to Cape Town, South Africa, and halted also at St. Helena, Ascension Island, and Barbados for magnetic and gravity observations, so that all this time should not be charged to the eclipse proper. We sailed in the old frigate Pensacola, the companion

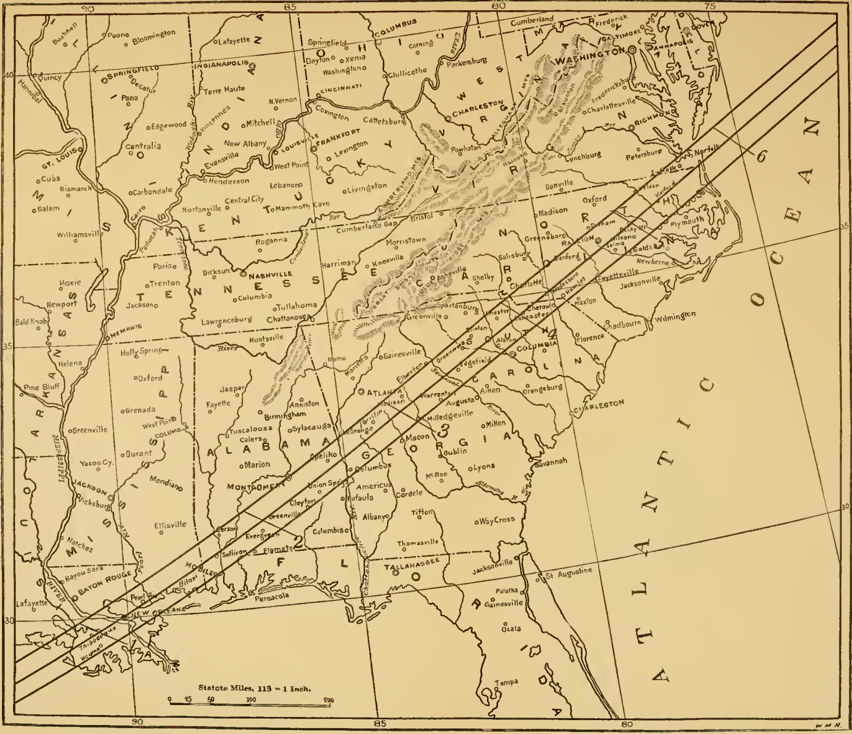


CHART I.—TRACK IN THE UNITED STATES OF THE TOTAL ECLIPSE OF MAY 28, 1900. (By permission of the United States Weather Bureau.)

to Farragut's flagship, the Hartford, with Captain Yates. In earlier days Admiral Dewey commanded this ship, and the expedition was fitted out while he was in charge of the Bureau of Equipment at Washington. The same fine courtesy that has become so well known to his countrymen was at that time extended to all the members of the expedition.

The cloudiness along the track of the eclipse in the Southern States on the 28th of May, 1900, is evidently a matter of much importance not only for all astronomers, but for non-professional spectators. If it could be foretold, with the same precision as the astronomical data give the time and the place of the occurrence of the eclipse, that the day itself will be fair or cloudy, or that certain portions of the track will be clear while others will be obscured, it would be of great benefit. The cost of these scientific expeditions is very great, since it is necessary to transport many heavy and delicate pieces of apparatus into the field, including telescopes, spectroscopes, polariscopes, and photographic cameras, and set them up in exact position for the day of observation. The expedition to Cape Ledo, West Africa, in 1889, carried out a large amount of material, prepared it for work during the totality, and then entirely lost the sun during the critical moments by a temporary obscuring of the sky through local cloud formations. There had been some clouds at the station during the forenoons for several days preceding the eclipse, but the sky was usually clear and very favorable during the middle of the afternoons. The totality came on at three o'clock, and photographs of the sun were taken at first contact about 1.30 P. M.; clouds thickened, however, and totality was entirely lost, while the sun came out again for the last contact at 4.30 P. M. This was a very trying experience, and of course could not have been avoided by any possible precautions. Some astronomers have thought that the advance of the moon's shadow is accompanied by a fall in temperature, and that cloudiness is more likely to be produced from this cause.

Soon after the West African eclipse Professor Todd, of Amherst College, proposed that more systematic observations be made for the probable state of the sky along eclipse tracks, with the view of at least selecting stations having the most favorable local conditions. The method was tried in Chili, April, 15, 1893, and in Japan, August 8, 1896, with some success. Heretofore the available meteorological records, which were originally taken for other general purposes, had been consulted, and some idea formed of the prevailing tendency to cloudy conditions. In accordance with the improved method, the United States Weather Bureau has been conducting special observations on the cloudiness occurring from May 15th to June 15th in each of the three years 1897, 1898, and 1899, for the morning hours of the eclipse—between 8 A. M. and 9 A. M. A tabular form was sent through the local offices to such observers as were willing to act as volunteers in making these records, and their reports have been studied to discover how the cloudiness behaves along the eclipse track at that season of the year. Each of the three years gives substantially the same conclusion—namely, that there is a maximum of cloudiness near the Atlantic coast in Virginia, extending back into North Carolina, and also near the Gulf coast in Louisiana and in southern Mississippi, while there is a minimum of cloudiness in eastern Alabama and central Georgia. The following table will serve to make this plain:

The Prevailing Cloudiness of the Sky along the Eclipse Track.

STATE.	General sky.	Sky near the sun.
Virginia	40.3	38.0
North Carolina	32.4	29.9
South Carolina	26.4	24.9
Georgia	16.4	14.7
Alabama	18.2	17.7
Mississippi	30.8	29.2
Louisiana	32.9	27.7

The significance of these figures is shown by transferring them to a diagram, given on Chart II, which indicates the average cloudiness prevailing over the several States where they are crossed by the track. The marked depression in the middle portions, especially over Alabama and Georgia, indicates that the stations in these districts make a much better showing than those nearer the coast line. The reasons for this difference are probably many in number, but the chief feature is that the interior of this region, especially over the higher lands of the southern reaches of the Appalachian Mountains, which are from six hundred to one thousand feet above the sea level, is somewhat freer from the moisture flowing inland from the ocean at that season of the year. The table shows also two divisions, one for the "general sky," wherein the relative cloudiness was noted in every portion of the visible sky, and for the "sky near the sun," where the observation was confined to the immediate vicinity of the sun. The two records agree almost exactly, except that the sky near the sun averages a little lower than the general sky. This indicates that although the sun will be seen in the morning hour of May 28th, when it is only from thirty to forty degrees above the horizon, yet this is not an unfavorable circumstance. The low altitude, on the other hand, makes it easier for those at the instruments to enjoy a more comfortable observing position than if it were nearer the zenith, where one must look directly upward. Of course, a storm of some kind may occur on that day to modify these general weather conditions and upset all calculations. While the cloud observations suggest that Georgia and Alabama have the best sites for the eclipse, it must be remembered that the duration is about one minute and twenty seconds in Alabama, and one minute and forty seconds in North Carolina. As a gain of twenty seconds in observing time will be considered by many of sufficient importance to take chances on the cloudiness, stations will be selected in North Carolina for that reason, although the probability for minimum cloudiness is

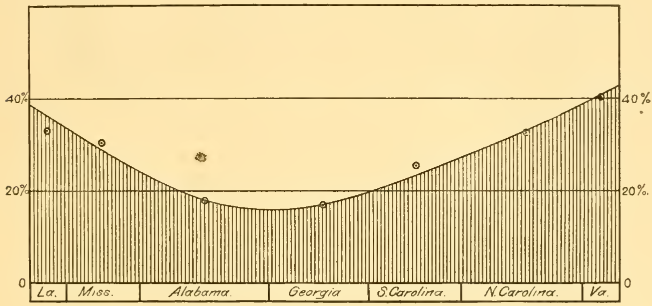


CHART II.—PROBABLE STATE OF THE SKY ALONG THE ECLIPSE TRACK.
Average percentage of cloudiness in May and June.

twice as good in Georgia and Alabama. The table shows that the chances are only one to six against observers located in these States, while near the coast they are about two to six against them. On the whole, the general result is that observing in this region ought to be successful, because the favorable chances for good weather are above the average at that season of the year.

On Chart I there are six lines drawn across the track: No. 1 near New Orleans, and No. 6 on the ocean to the east of Norfolk, Va. These represent the places for which the times of the duration are computed in the American Nautical Almanac, with the following results:

No.		h. m.				h. m.						m. s.
1.	At	1 30	Greenwich	M. T.	=	7 27.	Local	M. T.	the	duration	is	1 12.6
2.	"	1 35	"	"	=	7 47.	"	"	"	"	"	1 19.6
3.	"	1 40	"	"	=	8 05.	"	"	"	"	"	1 26.0
4.	"	1 45	"	"	=	8 22.	"	"	"	"	"	1 31.7
5.	"	1 50	"	"	=	8 40.	"	"	"	"	"	1 37.0
6.	"	1 55	"	"	=	8 54.	"	"	"	"	"	1 41.9

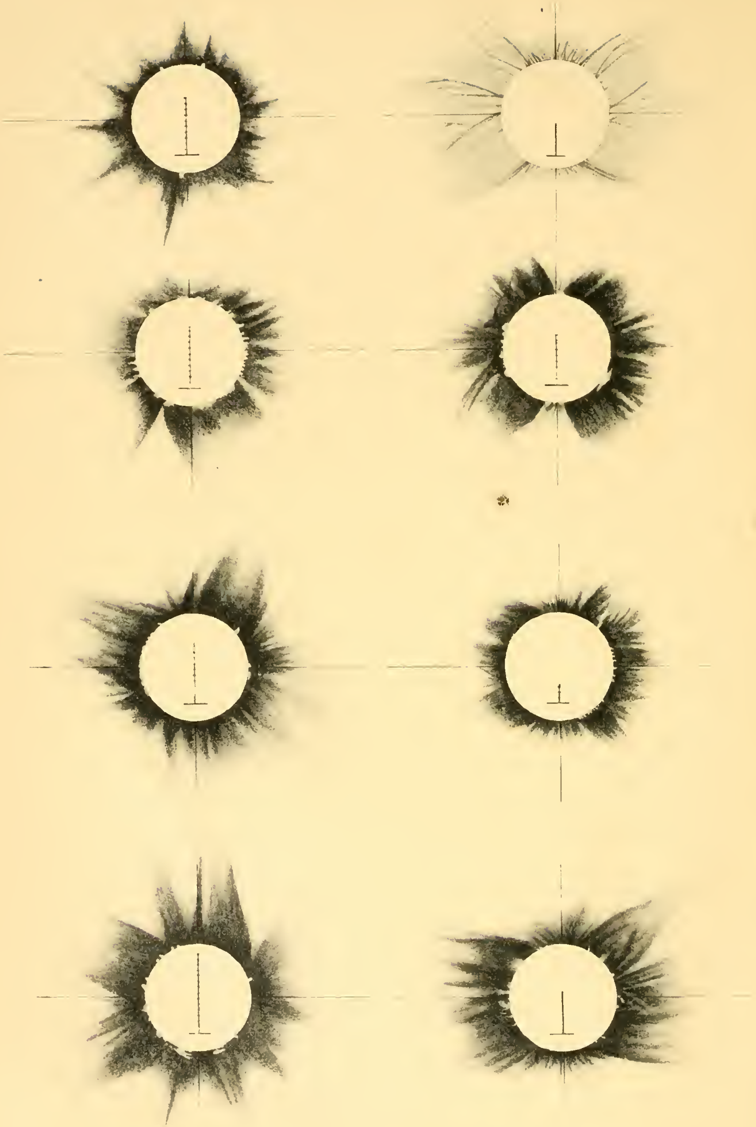
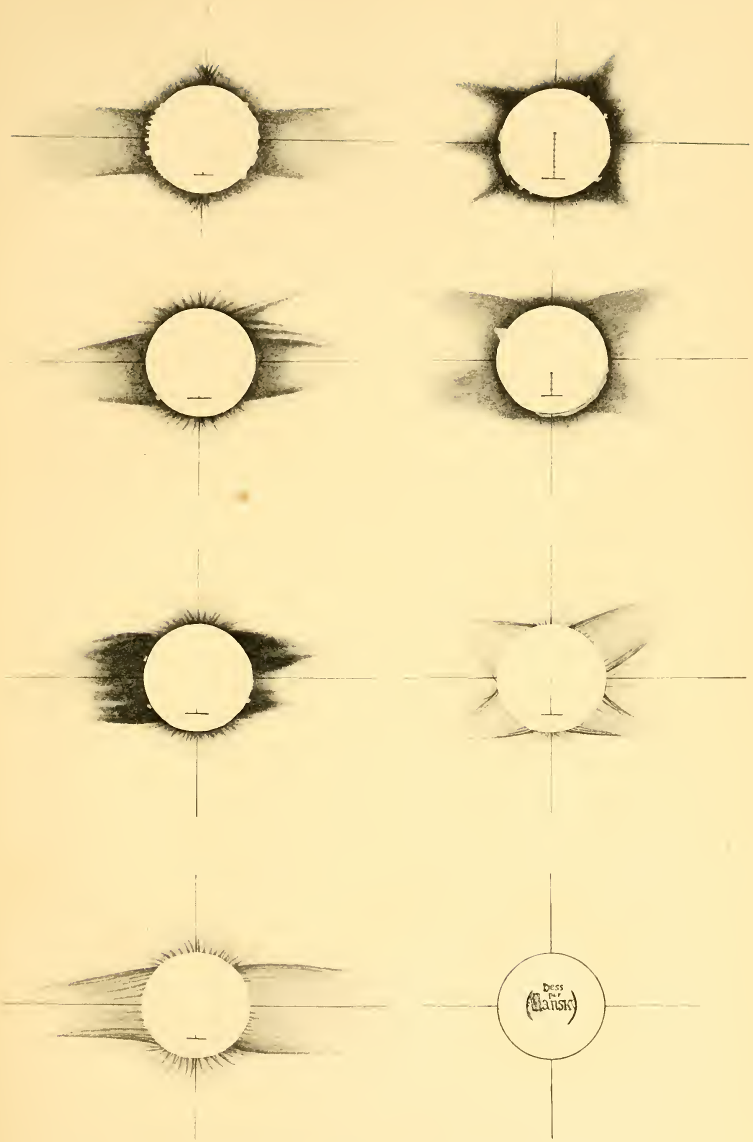


Chart III.—Fifteen Pictures of the Solar Corona, arranged in the Eleven-



YEAR PERIOD, TO SHOW THE RECURRENCE OF SIMILAR TYPES DURING THIS PERIOD.

An observer at the intersection of these cross-lines with the central line will see the totality during the intervals given in the table.

The mode of the formation of the shadow cones of the moon, called the penumbra for the partial shadow and the umbra for the total shadow, are well illustrated in general works on astronomy, and good geometrical pictures of them can there be found, together with much useful information regarding the subject of eclipses. As we are here concerned chiefly with certain practical points about the eclipse of 1900, it will be well for the reader to consult such works for many details regarding the astronomical features attending an eclipse of the sun which must now be omitted.

There are many existing theories to account for the phenomenon of the sun's bright appendage, called the corona, which is visible only during eclipses, on account of the absorbing effects of the earth's atmosphere on its light. Is it electrical, or is it magnetic? Is it composed of fine stuff ejected from the sun, or of meteoric dust falling upon the sun? Is it merely an optical effect, as some suppose, or is it a portion of the newly discovered radiant matter streaming off to enormous distances into space? The answer to these questions is eagerly sought through observation, photography, and every other possible means, on the occasion of each total eclipse.

The efforts of astronomers have thus far secured a series of pictures of the solar corona, which, when compared together, show very distinctly that the corona, as well as the spots, the protuberances, and the faculæ, are going through a series of changes which seem to repeat themselves in the so-called eleven-year period. It has also been proven, with entire distinctness, that the earth's magnetic field, as marked by the changes in the intensity of the magnetic elements, in the auroral displays, and the earth electric currents show variations which synchronize closely with those observed on the sun; also that the weather elements of pressure, temperature, precipitation, and storm intensity all harmonize with the solar and the earth's magnetism in the same synchronism. All attempts of scientists to detect any variations in the sunshine which falls upon the tropics have been entirely futile; on the other hand, it has been shown that the magnetic forces having the characteristics just mentioned impinge upon the earth in a direction perpendicular to the plane of the earth's orbit, just as if the sun, being a magnet, throws out a field of force to the surface of the earth, which, by its variation depending upon the internal workings of the sun, produces the changes just enumerated in the earth's atmosphere and in its magnetic field, also throughout the planetary system, being, of course, strongest near the sun. The belief is gradually growing among scientists that the earth, the sun, and the planets are all magnetic bodies, and have these bonds of connection between them in addition to the Newtonian gravitation. This is a most fascinating field of research, and, though full of difficulties, yet attracts the attention of many who are convinced that one of the most pressing duties of the hour is to clear up the problems connected with the transmission of energy from the sun to the earth in other forms than the ordinary or sunlight radiation. It is entirely probable that the secular variations of the weather changes from year to year, and even from month to month, are bound up with these solar forces, and that the solution of these questions will carry with them much information of practical use to civilized man.

The coronas of the past forty years are shown on Chart III, taken from the report of the eclipse of 1896 (August 9th), by A. Hansky. It arranges the coronas in the eleven-year period so far as the dates at which the eclipses occurred permit this to be done, and by comparing them in vertical lines the similarity is at once seen for the respective quarters of phases of the period. The forecast there given for 1900 is seen to resemble 1867, 1878, and 1889, but it differs in orientation from that on Chart IV, which was prepared by the author. The four coronas on the left in Chart III are taken at the sun-spot maximum, and the appearance is that of total confusion in the structure of the rays; the second and the fourth columns are for the sun's medium intensity at about halfway between the maximum and the minimum, and they show a system of polar rays taking on structural form, the second column being at a stage of diminishing and the fourth at one of increasing solar activity; the third column gives the corona when the spots are at a minimum of frequency and the sun is in a comparatively quiescent state, wherein the polar rifts are very distinct and the equatorial wings or extensions greatly developed.

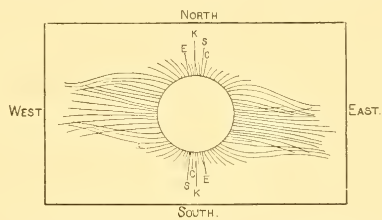


CHART IV.—BIGELOW'S FORECAST OF THE CORONA OF MAY 28, 1900. E, earth's axis; K, axis of ecliptic; S, axis of sun; C, C, poles of the solar corona.

The successful observation of a solar corona depends upon three conditions: the selection of the instrument, its proper mounting, and the photographic process, regarding each of which a few suggestions will be made. The instruments are divided into two classes, for visual and for photographic work. But in either case

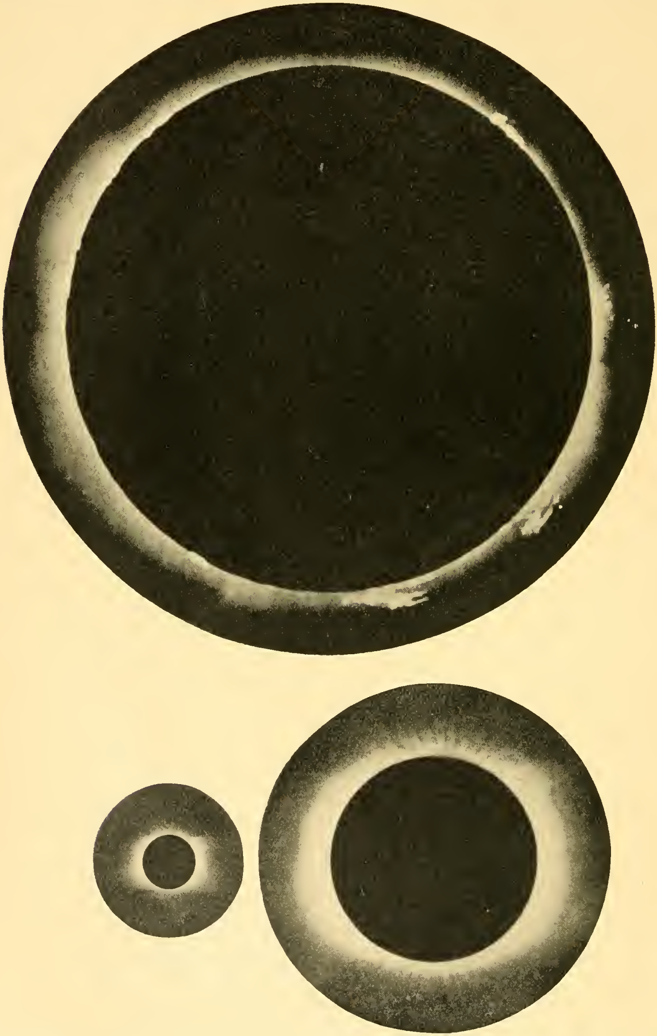


Chart V.—Relative Images of the Corona as taken with Telescopes ranging from Forty Feet to Four Feet in Focal Length.

the most important feature is the focal length or the size of the telescope. Since the photographic image of the corona will not bear magnifying without dispersing the available light, and thus blurring out the details of the picture, which is the most important feature to retain to the utmost, one can not use a short telescope and at the same time a magnifying eyepiece to enlarge the image by projection on a screen or on a photographic plate. The only alternative in order to get an image of large diameter is to use a long-focus lens. The effect of a difference of focus upon the image of the corona is well shown on Chart V, which gives a small corona (1) taken with a four-foot lens (Barnard), (2) with a fifteen-foot lens (Pickering), and (3) with a forty-foot lens (Schaeberle). The diameter is proportional to the focal length, but the difference of effect upon the details is very important. In the small picture the details of the corona near the sun are completely lost in the general light, while the coronal extensions from the middle latitudes are seen at a great distance from the sun—as much as one million miles; at the same time the polar rifts are distinctly marked, so that the pole or central line from which they bend is readily located. On the second picture the details of the polar rays are better brought out, but the extensions are shortened. In the third the region near the sun's edge has many interesting details very clearly defined, while all the extensions are gone. It is evident that each lens has its advantage, according to the details sought, and they ought all to be employed in the eclipse. The reproductions on paper by no means do justice to the original negatives, which make the distinctions even more pronounced than shown on Chart V.

Some amateur observers have telescopes but no mountings suitable for eclipse work, and many astronomical telescopes have good equatorial mountings at home which are yet unavailable in the field for lack of proper foundations and supports. The ordinary telescope balanced near the center, with the eye end subject to all sorts of motions which may happen through jarring and rough handling in the hurry of shifting photographic plates, makes a very poor eclipse apparatus. All telescopes of any length should be held firmly at each end, so as to be perfectly steady, since the least vibration ruins a coronal picture devoted to delicate photographic effects. There are two ways of accomplishing this, and only two. Dispensing with an equatorial mounting, the lens must be set permanently on a base, and light reflected from a mirror must be utilized, which shall be concentrated on a plate also placed on a fixed base. This is the method employed by Schaeberle in Chili, April 16, 1893, to obtain No. III of Chart V. There is no objection to it if an observer possesses a perfectly plane mirror, which it is very difficult and also expensive to obtain; if the reflecting mirror should be imperfect it would distort the image of the corona. The second method, lacking a good mirror, is to mount the long-focus lens in a tube and point it directly at the sun. A forty-foot lens was thus mounted at Cape Ledo for December 22, 1889, and its action was very satisfactory. Of course, it was a cumbersome arrangement, and could not be employed by a small party. The foundation for the mounting of the forty-foot tube consisted of two casks filled with stones and cement, and set firmly in the ground. These made two good piers, since the narrowing tops of the casks held the bed plates of the telescope as in a vise. A triangle, whose base was parallel to the earth's axis and having the telescope tube itself for the long side, was fitted with an extension rod for adjustment in altitude on the third side, and the whole was made to revolve on ball bearings. This triangular support was rotated by a side rod of adjustable length, whose end terminated in a sand piston working with a regulating valve. The sand flowed out steadily like an hour-glass, and dropped the tube, keeping it central on the sun. The image was made to follow accurately for twenty minutes without tremor, all the time holding the solar disk tangent to fixed lines. The principle of a revolving triangle and a short piston, taking the place of an expensive reflecting mirror with a delicate clockwork or one carrying a telescope balanced on its center but subject to jars and side motions, is an important assistance in field work on account of its ready adaptability to all sorts of observations. Since time is limited, it is necessary to provide all operations with automatic arrangements as far as possible, by using such an apparatus as that described. What can be applied successfully to a forty-foot lens can serve for shorter telescopes. In combination with spectroscopes, polariscopes, and special instruments for photographing, an immense amount of work can be compressed into the few seconds allowed by mounting them all on such a movable frame as the triangle. The old-fashioned method of putting one observer to one telescope ought to be abandoned. Of course, for a rising sun during the forenoon a modification in the moving support must be employed. This should be such as to cause the objective of the telescope to rise from the ground toward the meridian, and it must be accomplished by attaching a heavy weight which in sinking draws the tube upward.

Of the two kinds of photographic plates, the wet and the dry, the dry plates are much more convenient in the field, and are good for certain purposes. The objections to them are that the rough granulations of the gelatin film sometimes overpower the fine details of the corona itself; they burn out very near the disk by over-exposure while the faint outer extensions are being taken. Wet plates having the requisite quickness are harder to prepare,

CHART VI.—TRACKS OF THE EIGHT TOTAL ECLIPSES OF THE SUN SEEN ON THE NORTH AMERICAN CONTINENT DURING THE NINETEENTH CENTURY.

but are smoother and hold the coronal rays better from the base to the outer edge, and there is always plenty of time to give the necessary exposure. The No. 26 Seed plate requires from 0.5 to

2.0 seconds only, generally one second being about right; the wet plate will take the corona in eight seconds or less. The best time of exposure should be tested on a bright star of about the second magnitude, by trial before the eclipse. There is no rule about the photographic focus, except to discover it by a series of exposures at different distances near the supposed point. Eclipse work is a practical matter, and many rough-and-ready methods must necessarily be admitted. A good lens in a wooden light-tight tube, supported at each end, having the motion of the sun, the photographic focal plane carefully determined, the time exposures very short, and, finally, exceedingly slow development of the picture after the eclipse—these form the prime requisites. Expensive telescopes, clockwork on heavy iron piers, reflecting mirrors, and such like apparatus are not needed. Ingenuity in practical details, with great anxiety about the essential matter of the light itself, is what is needed for a successful eclipse expedition.

Those persons who have no telescope for viewing the sun, or camera for photographing it, can yet see the corona to great advantage by means of a good opera glass, and indeed this is really the most satisfactory way to thoroughly enjoy the spectacle. The object may be sketched on paper at once or from memory, and this picture may well be of value to astronomy.

The tracks of the eight North American eclipses seen since 1800 are shown on Chart VI. It is noted that three have paths very similarly located, and that five run in directions about parallel to one another, but almost at right angles to the first group. This comprises the eclipse of November 30, 1834, duration two minutes; August 7, 1869, two minutes and three quarters; July 29, 1878, two minutes and a half, which stretch from Alaska southeastward in a fan-shape to the South Atlantic coast. The second group contains the tracks June 16, 1806, four minutes and a half; July 17, 1860, three minutes; January 11, 1880 thirty-two seconds; January 1, 1889, two minutes and a quarter; and May 28, 1900, two minutes. These tracks all trend from southwest to northeast, and cross the North American continent in different latitudes, that of May 28, 1900, being the most southerly and of rather short duration, lasting less than two minutes in the United States.

The path of the total eclipse of May 28, 1900, after leaving the United States, crosses the North Atlantic Ocean to Coimbra, Portugal, and continues over North Africa to its end at the Red Sea. Stations which are not situated on the path of the totality will see the sun partially eclipsed, in proportion to the distance of the locality from the central line to the northern or the southern limits. Thus New England, New York, the Ohio Valley, and the southern Rocky Mountain districts will see the sun about nine

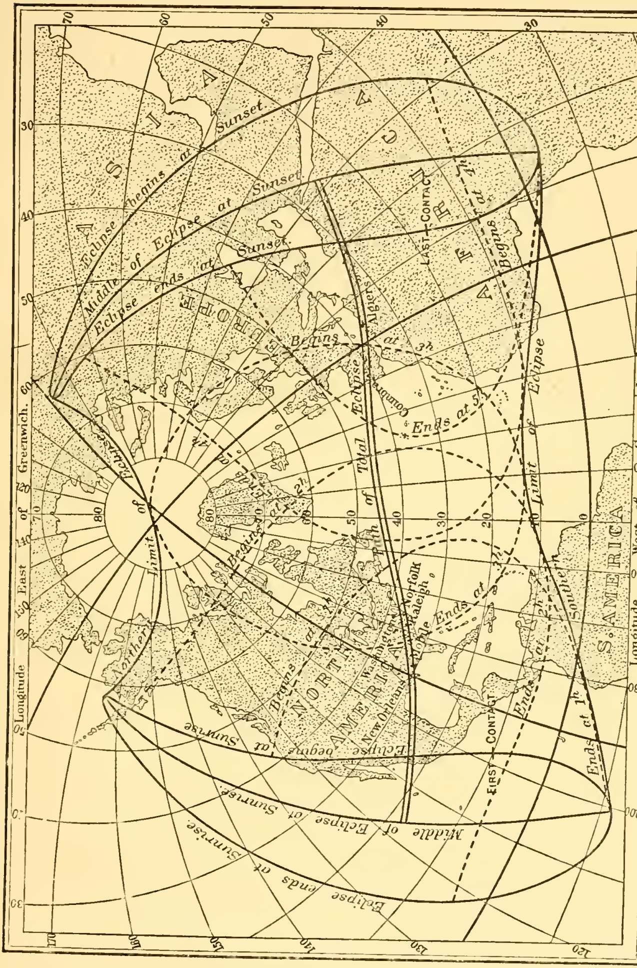


CHART VII.—THE PATH OF THE TOTAL ECLIPSE OF MAY 28, 1900, WITH TIMES OF BEGINNING AND ENDING AT SEVERAL PLACES AND THE NORTHERN AND SOUTHERN LIMITS OF THE PARTIAL ECLIPSE.

tenths covered; the Lake Region, the lower Missouri Valley, and Southern California will see an eight-tenths eclipse; and the northern Rocky Mountain region about six tenths or seven tenths. The best way to view the partially eclipsed sun is to secure three strips of thin colored glass, one and a half inch wide by five inches long —red, blue, and green; bind them over the eye end of a good opera glass, and adjust focus on the sun. This makes the light safe for the eyes and brings out the spherical aspect of the sun's ball. The time of the eclipse can be read by interpolating within the lines marked on Chart VII.

No other eclipse track will occur in this country till June 8, 1918, when one of the first kind will pass from Oregon to Florida, two minutes in duration. Another will occur in New England, January 24, 1925. Eclipses seven minutes in duration will occur in India in 1955, and in Africa in 1973, the longest for a thousand years. The remoteness of the last two, both in time and place, put them out of reckoning for most of us, but those of 1918 and 1925 give additional zest to the approaching eclipse of May 28th, as affording further opportunity for confirming facts and noting differences based upon the observations now made.

THE MOST EXPENSIVE CITY IN THE WORLD.

By Hon. BIRD S. COLER,
COMPTROLLER OF THE CITY OF NEW YORK.

THE annual expenses of the city of New York are larger than those of any other municipality in the world, and the financial transactions of a year represent the receipt and expenditure of more than $200,000,000, counting temporary loans, sinking funds, and bond issues. The gross budget of the city for 1899 was $20,000,000 greater than the expenses of the city of London, $18,000,000 in excess of the budget of Paris, and only $1,000,000 less than the combined expenditures of Boston, Chicago, and Philadelphia.

The expenses of New York last year for local purposes, exclusive of bond issues, amounted to $19.56 per capita of an estimated population of 3,500,000. The combined annual expenditures of the six largest States in the Union are less than those of the city of New York, and the financial transactions of the latter are equal in amount to one seventh of those of the national Government.

The credit of the city, it may be stated at the outset, is second only to that of the Federal Government, and the property owned by the municipality, if sold at market value, would pay the entire funded debt several times over.

The consolidation of ninety municipalities with the former city of New York was the culmination of a sentiment so fixed upon an ideal that there had been little careful reckoning of the cost. The municipality, by taking in the extra territory and population, doubled its debt, added less than one fourth to its tangible assets, and increased the cost of local government $15,000,000 a year. This added cost is the price paid by the taxpayers for a sentiment and for haste and carelessness in the work of completing consolidation. The cost of government for the enlarged city was in 1899 approximately $15,000,000 more than the combined expenditures of the various municipalities for the last year of their separate existence. This increase was excessive and altogether unnecessary to the maintenance of thorough and progressive government.

The present charter of the city is supposed to provide a large measure of home rule, yet the salary of almost every officer and employee, from the mayor to the doormen of the police stations, is fixed by act of the State Legislature. The former cities of New York and Brooklyn had been so long regulated and governed from Albany that the commissioners who drafted the charter evidently overlooked the fact that a municipality might be trusted to regulate the pay of its own employees. To-day the pay of the schoolteachers, policemen, firemen, heads of departments, and chiefs of bureaus is fixed at Albany, where the representatives of the city are in the minority. When the charter was prepared the commissioners agreed that taxation and salaries must be equalized. The members differed in their views on many questions, but they evidently agreed that the way to equalize salaries was to increase the lowest to equal the highest.

In extending the benefits of a great corporate government to the many suburban communities included in the consolidation a uniformed policeman, or five or ten of them, at fourteen hundred dollars a year took the place of a town marshal or constable at three hundred dollars a year, and high-priced trained firemen were substituted for unpaid volunteers. This method of equalizing salaries was extended to every section of the city and to every branch of the government. No attempt, apparently, was made to devise some system that would adjust salaries in various localities to local conditions and cost of living. The sentiment in favor of a great city was not disposed to quibble when the cost of maintaining the visible form of municipal government was increased fivefold in much of the outlying territory.

Aside from the extension of high-priced municipal service throughout the great area of the consolidated city, many useless offices were created and many salaries fixed at excessive figures. Authority was too much divided. The borough system is expensive, and so far useless. The entire charter is a series of compromises, and every compromise on a salary was at the maximum rate.

This method of arranging the expenses of the greater city increased the cost of government beyond the highest estimates of those who had advocated consolidation. The initial cost was further increased by reason of the fact that no precautions were taken to prevent the various municipalities to be united from increasing their bonded and contract indebtedness during the last year of their separate existence. The result of that oversight was that every municipality, the former city of New York included, issued bonds and entered upon contracts with somewhat reckless disregard of the future. In this way a heavy burden of unnecessary expense was added to the legitimate account charged against the consolidated city.

Greater New York began business in a condition of apparent bankruptcy, because the debts exceeded the constitutional limitation of ten per cent of the assessed value of taxable real estate. To overcome this and to meet the extra expense of government by the new system it was necessary to greatly increase the tax rate.

The financial condition of New York on January 1, 1900, was satisfactory except in the matter of current expenses. The gross accepted funded debt on that date was $358,104,307.11, against which there was a sinking fund of $105,435,871.70, leaving a net funded debt of $252,668,435.41. Considered in connection with the wealth of the city, this debt is not excessive. The city of Paris, with smaller available resources, has a debt in excess of $500,000,000. The gross expenditures of the city during 1899, exclusive of permanent improvements, paid for from the proceeds of bonds, were $93,520,082.03, and in 1900 the expenses will be some $3,000,000 less.

The total receipts of the city for the same period, from all sources and for all purposes, were approximately $108,000,000. The income was derived from three general sources, taxation yielding $84,000,000. The budget, which represents the money to be raised by taxation, was reduced $9,000,000 by income known as the general fund. The chief items of this were: Excise taxes, $3,600,000; school money from the State, $1,280,883.45; fees of various county and city offices, $246,576.65; interest on taxes and assessments, $979,185.35; and unexpended appropriations, $1,356,786.57.

Aside from the revenues classed as the general fund, New York has no income from any source that can be applied to current expenses for the reduction of taxation. The immensely valuable franchises heretofore granted to private corporations yield a revenue to the city that is insignificant, the total collected rarely exceeding $300,000 a year.

The gradual reduction of the city debt, except as it is maintained or increased by additional bond issues, is amply provided for by a steadily increasing and protected sinking fund. The total receipts of this fund in 1899 were $15,601,492.50. The Croton water rents, amounting last year to $4,590,502.55, are applied to this fund, as well as the dock and slip rents of $2,362,421.14. Some of the other chief items of this fund are: Revenue from investments, $3,573,519.34; ferry rents, $370,776; market rents, $251,500; interest on deposits, $520,526; installments included in the budget, $2,633,110.

More than $1,000,000 is derived annually from miscellaneous sources, including the sale of various odds and ends of property. The total interest charges on bonds in 1899 amounted to $11,275,822, leaving more than $4,000,000 of the sinking-fund income applicable to reduction of the funded debt.

Two features of the financial system of New York that increase expenditures can and should be changed. Taxes are now collected in the last quarter of the year upon an assessment made twelve months before. This compels the city to borrow large sums of money to meet current expenses. In 1899 the city borrowed, in anticipation of taxes, the sum of $48,027,450, on which the interest amounted to $755,704. If the taxes were collected during the first quarter of the year, the city would not only save this three quarters of a million dollars interest on temporary loans, but for six or seven months would have large cash balances in depository banks earning two per cent. This change would be worth approximately $1,500,000 a year to the treasury, but it must be made by degrees in order that taxes shall not be collected twice in a twelvemonth.

Under the present constitutional restriction upon the borrowing capacity of the city, New York is placed in the contradictory position of getting richer and poorer at the same time and by the same process. The restriction of the debt limit to ten per cent of the taxable real estate is arbitrary, and makes no distinction of obligations. Every time the city acquires additional real estate for parks, docks, schoolhouses, or any other purpose its borrowing capacity and income from taxation are reduced, because the property acquired no longer yields a tax and it is not counted in the valuation upon which the debt limit is fixed. This is the most illogical and unbusinesslike feature of the present financial system.

The piers owned by the city are profitable investments, yielding a revenue in excess of interest and sinking fund for the bonds issued; yet if we should acquire $100,000,000 of additional water front now owned by private parties the borrowing capacity of the municipality would be reduced $10,000,000, and the income would suffer the amount of taxes on the land acquired. There should be adopted a constitutional amendment that would separate debts incurred for revenue-yielding investments, such as docks and waterworks, from those created for general public improvements. The former should not be a charge against the borrowing capacity of the city.

The budget of the city for 1900 is $90,778,972.48, which will be reduced $9,000,000 by the general fund, leaving some $82,000,000 to be raised by taxation. The magnitude of this outlay for current expenses may be better understood by comparison with the expenditures of other large cities. The approximate current expenses of London last year were $73,000,000; of Paris, $75,000,000; of Berlin, $23,347,600; of Boston, $35,454,588; of Chicago, $32,034,008; of Philadelphia, $27,075,014.

In 1899 the State tax paid by the city of New York amounted to $6,275,659, or nearly seventy per cent of the whole; interest on bonds absorbed $11,275,822, leaving $75,813,644 as the actual cost of the current expenses of local government. The gross budget represented a per-capita tax of $24.62 on 3,500,000 inhabitants, of which $19.56 was for local expenses. Of this enormous expenditure more than $35,000,000 is paid out in salaries and wages to 37,000 officers and employees. The Police Department cost $12,000,000 a year, of which $10,700,000 is for salaries. New York has 6,400 policemen. Philadelphia has 2,600, and the annual cost of the department in that city is $3,100,000 a year—much lower in proportion than that of the metropolis.

The salaries and wages paid to all regular department employees, including policemen, firemen, street cleaners, and dock builders, are higher than those paid in any other city in the world, and almost without exception the rate has been fixed by act of the State Legislature, and not by the local authorities. In the matter of fixing the pay of officers and employees the city of New York has never known any degree of home rule.

The magnitude of the city in wealth and population has always operated against economy in local government. There has existed, apparently, an overwhelming popular sentiment in the city, as well as throughout the State, that such a great municipality should pay the maximum price for everything it might require. If this sentiment had been satisfied by the payment of high salaries and wages it might have been excusable from some points of view; but it was not, and the demand for more money from the public treasury has extended to every class of expenditure.

The city of New York is a purchaser in the open market of supplies exceeding in value $5,000,000 a year. This figure applies only to articles purchased without competitive bidding. There is in the charter a provision that all purchases of supplies and labor in excess of $1,000 shall be made by open competitive bidding. This leaves a wide field for fraud and favoritism, and it is an easy matter to evade the spirit and letter of the law relating to competition. If a department requires material and supplies amounting to $10,000, or even $50,000, it is often possible to make the purchases in lots of less than $1,000 from day to day, and thereby obey the letter of the law while permitting the grossest frauds against the city treasury.

Under the system that has grown up, protected by this imperfect legal restriction and opinions and decisions to the effect that the city has no defense against excessive claims unless fraud and conspiracy can be proved, robbery of the public treasury has not only been legalized, it has been made respectable. The comptroller, who is by law the auditor of accounts, may be able to show that the city has been charged double or treble the market rate for supplies purchased, yet under the legal opinions and decisions that have prevailed for two years he is not permitted to interpose any defense to an action to recover unless he can prove that there was a conspiracy or agreement to defraud. In the very nature of things it is next to impossible to secure legal evidence of such agreements; therefore the city has been robbed with impunity. The methods of the Tweed ring have long been out of date in the city of New York, and fraud upon the public treasury has become a respectable calling.

It is not easy—in fact, not possible—to determine accurately how much the expenses of the city have been increased in recent years by the lax interpretation of an imperfect law and the tolerance of a public sentiment that demands proof of crime on a large scale before becoming aroused to a condition of effective action. It is safe to say, however, that a perfect system of buying in the open market at the lowest prices obtainable, if honestly enforced, would save to the taxpayers more than $1,000,000 a year.

Honest and intelligent administration in every department of the city government would reduce expenditures, but the extent of the reduction that might be made would depend largely upon the proper amendment of certain laws, and to an even greater extent upon the development of a thoroughly informed public sentiment that would sustain retrenchment and economy. The expenses of the city are far greater than they should be, but it is going to be a difficult matter to make even an appreciable beginning in economy so long as the State Legislature is permitted to exercise practically unlimited power to regulate the financial affairs of the municipality. Persons and corporations, be they honest or corrupt, when they seek to obtain money from the city treasury for any purpose, are going to proceed along the line of least resistance, and the smooth and open way has long been the Legislature at Albany. Every session of that body adds something to the expenses of the city, and it is a short and dull one that does not add many thousands of dollars to the burden of the New York taxpayers.

The revenues of the municipality are so small in comparison with what they should be that it is a difficult matter to find any excuse for the theory of government that existed in the days when perpetual franchises were given away. It is small consolation that the policy of municipal ownership is at last to prevail after so much of the public property has passed into the possession of private corporations. If all the outstanding franchises that were the property of the people had been sold on short terms for percentages even as large as have been fixed in recent cases, the city to-day would drive from that source an annual revenue of more than $5,000,000, instead of the paltry $300,000 now collected.

The mistakes of the past, however, are beyond undoing, and the taxpayers must look to the future for relief from the burdens they bear. They are paying now $15,000,000 a year for the sentiment that demanded a city great in all save honesty and political wisdom. Consolidation in fact as well as sentiment must result to prove the material advantage of the arrangement. Public opinion and politicians must realize sooner or later that income and expenses are to be adjusted the one to the other upon sound and enduring principles of business, honesty, and intelligence. There must be a union of public and political interests. Every section of the great city must be brought into close touch with every other section by cheap and rapid transit.

The possibilities of the future are greater than the dreams of to-day, but new policies and new methods must and will prevail. The development of Greater New York must not be hampered by a financial system antiquated and imperfect. The city should have power to develop its material resources into revenue-yielding improvements, and then, with honest and intelligent government, the burden of taxation will be reduced to a minimum, and the ideal of the grandest municipality in the world will have been achieved.

A BUBBLE-BLOWING INSECT.

By Prof. E. S. MORSE.

MANY years ago, while preparing an elementary book on zoölogy, I had occasion to make a drawing of the little insect which is found on grass and other plants immersed in flecks of froth. This substance is commonly known as frog spittle or cuckoo spit, and, being found in the spring, is known in France as "spring froth."

Works on entomology gave the general statement that this insect emitted the frothy mass from its body. Curious to ascertain what peculiar gas-secreting apparatus was contained within its anatomy, I dissected a number of specimens, without finding a trace of any structure that could produce from within the body a single bubble of air. On the contrary, I found that the little insect emitted a clear, somewhat viscid fluid, and by means of appendages at the extreme tip of its tail secured a moiety of air by grasping it, so to speak, and then instantly releasing it as a bubble in the fluid it had secreted. At the time of this observation—twenty-five years ago—I supposed that entomologists were familiar with this fact, but, on the appearance of my little book, I received a letter from the late Dr. Hermann Hagen, the distinguished entomologist, stating that he had ransacked his library and failed to find any reference of the nature of my statement. Doubtless the whole history of this insect has since been published, but a somewhat superficial survey of the literature has failed to reveal any reference to the matter. In this connection it is interesting to observe how often the more easily accessible facts of Nature escape the special student. The history of science is replete with such instances. One can hardly take up any subject connected with the life history of animals without finding lacunæ which ought to have been filled long ago. The facts in regard to the ossification of the hyoid bones in man is a case in point. The persistence of these erroneous concepts or half-truths comes about by the acceptance at the outset of some fairly trustworthy account by an authority on the subject, and ever after the statements are copied without a doubt being expressed as to their accuracy.

If we look over the literature of the subject under discussion, we find that in nearly every case the statement in regard to the spit-insect conveys the idea that the creature secretes the froth in which it is immersed. Beginning with De Geer in the last century, we quote as follows: "One may see coming out of the hinder part of its body a little ball of liquid, which it causes to slip along, bending it under its body. Beginning again the same movements, it is not long in producing a second globule of liquid, filled with air like the first, which it places side by side with and close to the preceding one, and continues the same operation as long as there remains any sap in its body." Kirby and Spence, in their Entomology, describe "the white froth often observed on rose bushes and other shrubs and plants, called by the vulgar 'frog spittle,' but which if examined will be found to envelop the larva of a small hemipterous larva (*Aphrophora spumaria*), from whose anus it exudes." In Westwood's Insects we find the following statement: "One of the best-known insects in the family is the *Aphrophora spumaria*, a species of small size which frequents garden plants, the larva and pupa investing themselves with a frothy excrementitious secretion which has given rise to various fancies. A species of *Aphrophora* is also found in great quantities upon trees in Madagascar, the larva of which has the power of emitting a considerable quantity of clear water, especially in the middle of the day, when the heat is greatest." Here the statement is definitely made that the froth is excrementitious, and the Madagascar insect is shown to be different from *Aphrophora* in that it exudes a clear water. In Dr. Harris's Treatise on some of the Insects Injurious to Vegetation, of Massachusetts, we find a most definite statement as to the origin and nature of this froth. He says: "Here may be arranged the singular insects, called frog hoppers (*Cercopididæ*), which pass their whole lives on plants, on the stems of which their eggs are laid in the autumn. The following summer they are hatched, and the young immediately perforate the bark with their beaks and begin to imbibe the sap. They take in such quantities of this that it oozes out of their bodies continually in the form of little bubbles, which soon completely cover up the insects." In Dr. Packard's admirable Guide to the Study of Insects the statement is made that "*Helochara* and *Aphrophora*, while in the larva state, suck the sap of grasses and emit a great quantity of froth, or in some cases a clear liquid, which in the former case envelops the body and thus conceals it from sight. It is then vulgarly called 'toad's spittle.'"

In other accounts it is stated that the larvæ live covered by masses of froth which the insects produce by expelling from their beak the juices drawn out of the tree.

The above extracts are sufficient to indicate the common belief among entomologists that the insect in some way emits this froth from the body. A most cursory examination of the creature, however, shows that its only secretion is a clear fluid.

The so-called frog spittle or cuckoo spit (Fig. 1) appears as little flecks of froth on grass, buttercups, and many other plants during the early summer. These flecks of froth may be found very commonly at the junction of the leaf with the stem. Immersed in this froth is found a little green insect, sometimes two or three of them, concealed by the same moist covering. This little creature represents the early stage of an insect which in its full growth still lives upon grass, and is easily recognized by its triangular shape and its ability of jumping like a grasshopper. There are a number of species; the one living on grass apparently confines itself to the grass alone, though I have seen one species that frequents a number of different plants. A species found on the white pine is dark brown in color, and the froth in which it is found not only hangs pendent from the branch, but the lower portion appears as a large drop of clear water.

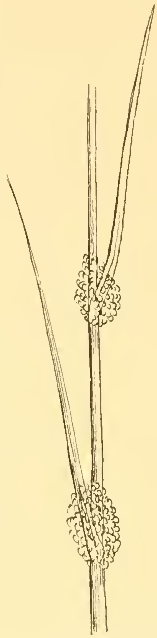


Fig. 1.—Grass stalk and leaves, showing appearance of froth.

Let one provide himself with a good hand lens, a bit of glass (a watch crystal is especially suitable for this purpose), and a common camel's-hair brush, and he is ready to make a preliminary study of *Aphrophora*. The brush is convenient for easily removing the insect from the froth which invests it. If the insect is cleared from the mass of froth, it will crawl quite rapidly along the stem of the plant, stopping at times to pierce the stem for the purpose of sucking the juices within, and finally settling down in earnest, evidently exerting some force in thrusting its piercing apparatus through the outer layers, as shown by the firm way in which it clutches the stem with its legs. After sucking for some time, a clear fluid is seen to slowly exude from the posterior end of the abdomen, flowing over the body first and gradually filling up the spaces between the legs and the lower part of the body and the stem upon which it rests (Fig. 2). During all this time not a trace of an air bubble appears; simply a clear, slightly viscid fluid is exuded, and this is the only matter that escapes from the insect. In other words, its secretion of clear fluid is precisely like that of the Madagascar species referred to by Westwood and others.

This state of partial immersion continues for half an hour or more. During this time, and even when the insect is roaming up and down the grass or twig, the posterior segments of the abdomen are extended at intervals, the abdomen turning upward at the same time. It is a kind of reaching-up movement, but whether this action accompanies a discharge of fluid or is an attempt at reaching for air I have not ascertained. Suddenly the insect begins to make bubbles by turning its tail out of the fluid, opening the posterior segment, which appears like claspers, and grasping a moiety of air, then turning the tail down into the fluid and instantly allowing the inclosed air to escape (Fig. 3). These movements go on at the rate of seventy or eighty times a minute. At the outset the tail is moved alternately to the right and left in perfect rhythm, so that the bubbles are distributed on both sides of the body, and these are crowded toward the head till the entire fluid is filled with bubbles, and the froth thus made runs over the back and around the stem (Fig. 4).

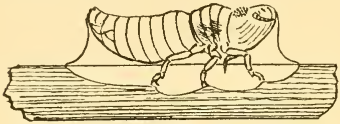


Fig. 2.—The insect first emitting a clear fluid which fills up the interspaces between its body and the stem of grass upon which it rests.

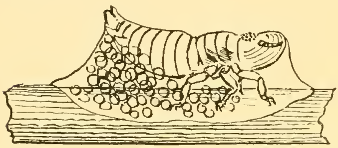


Fig. 3.—After the lapse of some time it begins rapidly to make bubbles.

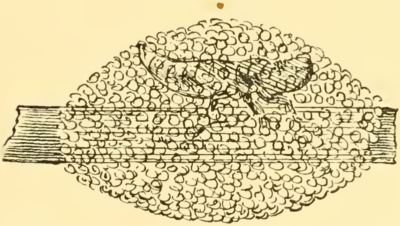


Fig. 4.—Entire fluid filled with bubbles, and the froth thus made enveloping the stem.

Magnified Figures of Aphrophora, showing Successive Stages in the Production of Froth.

Even when partially buried in these bubbles the tail is oscillated to the right and left, though when completely immersed the tail is only occasionally thrust out for air which is allowed to escape in the mass apparently without the right-and-left movement, though of this I am not sure. It is interesting to observe that in half a minute some thirty or forty bubbles are made in this way—a bulk of air two or three times exceeding the bulk of the body—without the slightest diminution in the size of the body.

If the insect is allowed to become dry, by resting it upon a piece of blotting paper, and is then placed upon a piece of glass and a drop of clear saliva be allowed to fall upon it, it proceeds to fill up this fluid with bubbles in precisely the same manner as it did with its own watery secretion. It is quite difficult to divest the creature of the bubbles of air which adhere to the spaces between the legs and the segments on the underside of the body. It may be readily done, however, by immersing it in clear water and manipulating it with a brush. If now it is again dried and placed on the glass it will slowly secrete what spare fluid it has in its body, but not the minutest bubble of air is seen to escape. These experiments should be made on glass, for then one may get transmitted light, and the highly refractive outlines of the air bubbles are more quickly detected. Using a higher power with a live cell, new features may be observed. Confining the insect in this way, inclosed in a drop of water, a very clear proof is offered that it gets all the air for its froth in the way I have described. So long as the insect remains surrounded by water not the minutest bubble of air is seen to escape from the body. During this immersion the creature is incessantly struggling to reach the edge of the drop, and no sooner has this been accomplished than it thrusts out its tail and begins the clutching of air and the making of bubbles. The bubbles, however, disappear as soon as made, as the clear water will not preserve them. As the water becomes slightly viscid from the insect's own secretions, the bubbles remain for a longer time. A bubble will be partially released and then held, or even partially withdrawn, between the claspers.

The claspers seem to be the tergal portions of the ninth segment. On the sides of the seventh and eighth segments may be clearly seen leaflike appendages, which are possibly branchial in their nature (Figs. 5 and 6). They are extremely tenuous, and appear like clusters of filaments, slightly adhering together and forming lamellate appendages similar to the gill-like appendages seen in the early stages of *Potamanthus*, a neuropterous insect, not, however, having the definiteness of these structures. While in

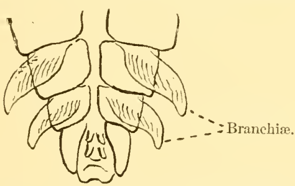


Fig. 5.—Showing underside of posterior extremity of body with appearance of branchiæ.

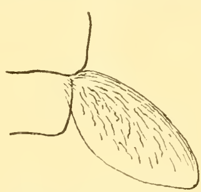


Fig. 6.—A single branchia under slight pressure.

Potamanthus one may easily trace the ramifications of the tracheal system, I have not been able to detect a similar connection with these appendages in *Aphrophora*. Certainly the insect does not depend upon these structures for respiration, as when the creature is perfectly dry it seems to suffer no immediate inconvenience, but will crawl about the table or even on the dusty floor and live for an hour or two in this condition. The usually glabrous surface of the body, however, becomes shriveled after a while. On the other hand, it immediately sinks in water, and will live for some time immersed in this way, and this leads me to believe that the appendages above described may perform a slight respiratory function. The fact that the insect immediately sinks may be cited as an additional evidence that it does not emit air.

It is interesting to observe that regarding this stage of *Aphrophora* as an aquatic stage, since it lives immersed in fluid, we have the same behavior that we observe in the aquatic stages of other *Hemiptera*, as well as in insects of other orders. The great water beetle *Hydrophilus* has an aquatic larva. Myall, quoting Lyonet, says: "They never remain long at the bottom of the water; air is necessary for them, and this they take in by the tail, which they raise from time to time to the surface of the water." In the larva of *Dysticus*, another water beetle, the only functional spiracles are the last pair, opening at the tail. The little oval beetles, known as whirligigs, from their rapid whirling motion, when swimming on the surface of the water carry down a bubble of air on the end of the abdomen, and when this has been exhausted in the process of respiration rise to the surface for a fresh bubble. The larvæ of some forms are furnished on each side with long respiratory filaments.

A number of neuropterous insects whose early stages are passed in the water are furnished with branchial tracheæ or false gills. These consist of filaments springing from the sides of the abdominal segments. In the early stages of certain dragon flies the rectum supports epithelial folds which are filled with fine tubes from the tracheal system. Among certain aquatic insects belonging to the order of *Hemiptera* the creatures reach out the hinder portion of the body to secure air. Dr. Myall, in his very interesting book on the Natural History of Aquatic Insects, says: "A *Nepa* or a *Ranatra* may sometimes be seen to creep backward along a submerged weed until the tip of its breathing tube breaks the surface of the water."

The *Aphrophora* while immersed in the watery fluid, whether secreted by itself or consisting of clear water which has been supplied to it, reaches out for air in a precisely similar manner. Primarily the froth made by this insect not only keeps the body moist, but acts as a protection against its enemies.

A number of individuals may often be found in one fleck of froth, and they are entirely hidden from sight while immersed in this way. The viscid character of the fluid secreted insures the retention of the air the insect collects in the form of little bubbles. This peculiar feature must have been a secondary acquisition. The bubbles not only surround the insect and the stem upon which it rests, but flows in a continuous sheet between the ventral plates of the abdomen, and the insect probably utilizes this air in the manner of other air-breathing aquatic larvæ—namely, through its spiracles. As many aquatic larvæ respire in two ways, either inhaling air through the spiracles or by means of branchial leaflets, so *Aphrophora* may likewise utilize its branchial tufts for the same purpose. For this reason we can understand how each fresh bubble added to the mass may aërate the fluid, so to speak, and thus insure at intervals a fresh supply of oxygen.

THE NEGRO SINCE THE CIVIL WAR.

By N. S. SHALER,
DEAN OF THE SCIENTIFIC SCHOOL OF HARVARD UNIVERSITY.

THE admirable conduct of the negro during the civil war made it seem possible to have the readjustment of his relations on the basis of freedom brought about with a minimum of friction. As a whole, the former slaves had stayed on the land where they belonged. Many of those who had wandered, moved by the homing instinct so strong in their race, found their way back to their accustomed places. The bonds of mutual interest and old affections were enough, had the situation been left without outside disturbance, to have made the transition natural and easy. It is true that the negro, with his scant wage paid in supplies, would not have advanced very far in the ways of freedom. He would have been hardly better than the middle-age serf bound to his field. It would, however, have been better to begin with a minimum of liberty, with provision for schooling and a franchise based on education. But this was not to be. Political ends and the popular misconception of the negroes as beings who differ from ourselves only in the color of their skin and in the kink of their hair led to their immediate enfranchisement and to the disenfranchisement of their masters. This was attended by an invasion into the South of the worst political rabble that has ever cursed the land. There were good and true men among the carpet-baggers, but as a lot they were of a badness such as the world has not known since captured provinces were dealt out to the political gamblers of Rome.

The effect of the carpet-bag period on the negroes was to raise their expectations of fortune to the highest point, and then to cast them down. Those of the poorest imaginations looked for forty acres of land and a mule. In the resulting political corruption the native whites and blacks endured even greater losses than the war had inflicted, the most grievous being a great unsettling of the relations between the races. The way in which the white men of the better sort met this trial is fit to be compared with the best political achievements of their folk. Gradually, on the whole without violence, for they had to abstain from that, working within the limits of the Constitution to which they had been forced to trust for their remedies, they rewon control of their wasted communities, and brought them back to civilized order. There was a share of terrorism and shame from such devices as tissue ballots to lessen the dignity of this remarkable work, yet it remains a great achievement—one that goes far to redeem the folly of the secession movement. The full significance of this action is yet to be comprehended.

The overthrow of the carpet-bag governments, quietly yet effectively accomplished, removed the only danger of war between the blacks and whites. We can not well imagine another crisis so likely to bring about a conflict of that kind. The blacks were driven from power. Their desperate leaders would willingly have led them to fight, but the allegiance to the ancient masters was too strong, their trust in the carpet-bagger, for all his affectation of love, too slight to set them on that way. The negro fell back as near as might be to the place he held at the close of the war. His position was thereafter worse than it was at that station in his history, for the confidence and affection which the behavior of their servants during the rebellion had inspired was replaced in the mind of the dominant race by an abiding sense of the iniquities in which the ex-slaves had shared. Thereafter, and to this day, the black man is looked upon as a political enemy, who has to be watched lest he will again win a chance to control the state. In the greater part of the South this fear is passing away. In several States new laws concerning the franchise have made it practically impossible for the negro vote to be a source of danger for some time to come—until, indeed, the negro is better educated and has property. There is a share of iniquity in these laws, as there is apt to be in all actions relating to a situation that rests on ancient evils, but their effect is better than that of terrorism and tissue ballots which it replaces. They will afford time for the new adjustments to be effected.

In considering the present conditions of the negro, we may first note the important fact that he is hard at work. The production of the South clearly shows that the sometime slaves, or rather their children, are laboring even more effectively than they did in the time of legal servitude. This disposes of the notion that the blacks will not work without other compulsion than those needs which bend the backs of his white brethren. It is evident that the generation born since the war is laborious and productive up to, if not beyond, the average of men. It is also plain that they are fitted for a rather wider range of employment than they were accustomed to follow as slaves. The negro has proved himself well adapted for labor in mines and about furnaces—in all places, indeed, where strength and a moderate share of intelligence are required. The fear that he would desert the land and flock to the cities has not been justified. He appears less disposed to yield to the temptations of the great towns than the whites. The first rage of the freed people for schooling seems to have passed. A good many of them are getting the rudiments of an education, some few a larger culture, but there appears to be danger that the folk may lapse into indifference concerning all training that is not immediately profitable.

As to the moral condition of the negroes, there appears to be good reason for believing that it is now in the way of betterment. Little as they were disturbed in their conduct by the sudden change in their apparent place in the world, they were for a time somewhat shaken as regards the limits of their rights. So far as I have been able to learn, they are much less given to stealing than they were just after they were freed, or even as they were as slaves. Their marital relations, though leaving much still to be desired, are improving, as is all that relates to the care of their children. Most important is the fact that loose relations between white men and negro women have in great measure ceased, so that the unhappy mixture of the races, which has been the curse of tropical states, is apparently not likely to prove serious.

Although the negro is not rapidly gaining property, he is making a steadfast advance in that direction. The money sense in all that relates to capital he, with a few exceptions, is yet to acquire. This part of his task is certain to be difficult to him, as it is to all peoples who are in the earlier stages of civilized thought. The experiment of the Freedman's Bank, by which many suffered at the hands of designing white people, has left a bad impression upon the minds of the negroes. Where they save, they commonly hoard their store. As yet they have not become accustomed to associative action. They rarely enter into any kind of partnership. In this indisposition to attain the advantages of mutual support we have another evidence of the primitive condition of the folk.

Before endeavoring to go further with this account of the present state of the negroes of this country, it is well to note the fact that while much has been done to blend the original diversities of their stock, these differences have by no means passed away. The seekers after slaves in Africa were not choice as to their purchases or captures; they reckoned as black if he were no darker than brown, and they were not at all careful to see that his hair was kinky. Thus it came about that from the wide ethnic range of the Dark Continent there came to us a great variety of people—a much more diverse population than we have received from Europe. It might be supposed that the conditions of slavery would quickly have effaced these differences, but even in that state there was choice in mating, and certain stocks have such prepotency that a small share of their blood stamps those who have it in a definite manner. The result is that, under the mask of a common dark, though really very variedly tinted skin, we have an exceeding diversity of race and quality.

It is discreditable to our students of anthropology that as yet there has been no considerable effort made to determine the varieties which exist in our negro population or the source of their peculiarities in the tribes whence they come. In a small way, for many years, on numerous journeys in the South, I have endeavored to classify the blacks I have met. For a long time I kept these results in a roughly tabulated form. Although such observations, including no measurements and giving only eye impressions of the general form, can have no determinable value, they may, in the absence of better work, deserve consideration. The result of this rough inspection of many thousand of these peoples in nearly every State in the South has been to indicate that there are several, probably more than six, groups of so-called negroes which represent original differences of stock or the mixed product of their union. The more characteristic of these I will now briefly describe.

For convenience I will first note those who are termed mulattoes, in which there is an evident mixture of white blood. Such admixture seems to be distinctly traceable if it amounts to as little as one eighth; it is said that one sixteenth of negro blood, or less, will be revealed on close study of the hair and skin. The proportion of the negroes in our Southern States who have white ancestry in any degree does not, in my opinion, exceed one tenth, and may be as small as one twentieth of the whole number. Judging only by the hue of the skin, the observer will be likely to make the proportion larger, for the reason that he will include many persons who, because they come from stocks that were not blackskinned, appear at first sight to be mulattoes of some degree. These Eu-Africans, as we may term them—imitating in the term the useful word Eurasian, which is applied to the mixture of European and Asiatic people in India—are in appearance exceedingly diverse, the variety being caused by the varying share of the blood of the two races, as well as by the diversities of the stocks to which the parents belong.

Besides the mixture of the European and black, we have another less well known but not uncommon between the negro and the Indian. This is often met with among the remnants of the Indian tribes in all the eastern part of the United States. The two groups of primitive people appear to have found their despised lot a basis for a closer union. The dark skin of the Algonkins, however, makes the remnants of that people appear to have more black blood than they really possess. Not only did stray negroes resort to the Indian settlements, but some of the tribes owned many slaves. The result is that in many parts of this country, but particularly in Virginia, the Carolinas, Florida, and Georgia, the attentive observer often will note the Indian's features stamped on those of the African.

Coming to the diversities of the stock among the pure Africans, we may first note the type which, in the rough judgment of the public, is the real or Guinea negro. That he is so taken is doubtless because he is the most distinctly characterized of all black people. The men of this well-known group are generally burly fellows, attaining at a relatively early age a massive trunk and strong thighs; they have thick necks and small though variedly shaped heads. The bridge of the nose is low, and the jaws protruding. The face, though distinctly of a low type, very often has a very charming expression—one in which the human look is blended with a remnant of the ancient animal who had not yet come to the careful stage of life. The women of this group are well made, but commonly less so than the men. In general form the two sexes of the group are much alike, a feature which also indicates an essentially low station. These people of the Guinea type form perhaps one half of the Southern negroes.

Along with the Guinea type goes another much rarer, which at first sight might by the careless observer be confounded with the lower group. The only common features are the burly form of both, the deep-black hue, and the general form of the features. The men we are now considering have a higher and in every way better head. Their foreheads are fuller, and the expression of the face, to my view, quite other than that of the Guinea men. In place of the sly, evasive child-animal look of the lower creature, this fellow has rather a lordly port, the expression of a vigorous, brave, alert man. This, which I am disposed to term the Zulu type, from the resemblance to that people, is on many accounts the most interesting of all the groups we have to consider. My idea that it may have come from the above-named tribe is based on an acquaintance with a party of southern Africans who some forty years ago were brought to this country by a showman. I came to know them well. They were attractive fellows, of the same quality as certain blacks I had known in Kentucky. When I saw these strangers I perceived their likeness to certain able blacks whose features and quality had made impressions on my mind that remain clear to the present day. It is likely that this element of the negro people I have termed Zulu is not of any one tribe; it may be of several diverse stocks with no other common quality than that which vigor gives. They may, in part, be from Bangora tribes of the Congo Valley, or even Soudanese. The proportion of this group to the whole is small; because it merges into the other it can not well be estimated. I find that I have reckoned it in my notes as one twentieth of the whole black population.

Set over against these robust blacks, but also of high quality, is a group less distinctly limited, which has for its characteristics a rather tall, lean form, a slender neck, a high head, and a thin face, usually with a nose of better form than is commonly found, sometimes approaching the aquiline. The skin of these people is often as black as that of the Guinea folk, yet it is of another hue—a deader black, perhaps due to some difference in the skin glands. Usually, however, there is a trace of brown in the complexion. Now and then the relative straightness of the hair and their facial profiles suggest that the peculiarity of this people is due to an admixture of Semitic (probably Arabian) blood. Negroes of this type are most abundant in the northern part of the South, particularly in Virginia. They are rare in the plantation States. This is mayhap due to the fact that in the selection of people to be sold to the traders such delicate folk were retained where they belonged—as house servants. These rare negroes, which for lack of a better name will be termed Arabs, are few in number. They can not be reckoned at more than one per cent of the whole.

Besides the comparatively recognizable types above reckoned, there is another which puzzles the observer. They are of varied shapes, generally, however, rather smaller than the average. Their peculiarity consists in the reddish-brown hue of their skins, which at first suggests that they are mulattoes. Their faces and hands are often distinctly blotched with darker patches, in the manner of freckles. At times I have been inclined to regard their features as indicating a tendency to albinism, or that change of pigment such as now and then gives silver foxes or white blackbirds. All things considered, it seems more likely that we have in these red negroes the remnant of a people once distinctly separated from the other black Africans. In favor of this view is the fact that the members of the group are very evenly distributed, as they would be if they were a distinct race, and not as we should expect to find them if they were the result of albinism or of a mixture of white blood. The number of this variety of folk is small; it probably does not exceed one per cent of the population.

When the observer has made the divisions above noted he has set apart a little more than one half of the blacks he has tried to classify. Among the remainder he will have remarked other but indistinct types in a way that appears to indicate that several other fairly characterized groups might by close scrutiny be established. The greater part of this remainder, however, evidently consists of mixed people, who have come from a mingling of the original diverse stocks.

Imperfectly founded and inadequate as are the results of my rough inspection of the Southern negroes, they fairly serve to show some facts of importance to those who would helpfully foresee the future of the black people in this country. We may first remark that, notwithstanding the many distinct racial qualities and diversity which, to my eye, far exceed what we may observe among the whites of the United States, they are, with the exception of the mulattoes, in excellent physical condition. They are of curiously even, serviceable size, dwarfs and giants being very rare—much rarer than among the whites. The percentage of deformed persons is, so far as the eye can determine it, very low. I am fairly well acquainted with the peasant class in most of the European states, and I know of no region where the average condition of the folk appears to be so good as it is among the Southern blacks. In fact, this state is doubtless due to the rigid selection which was had when the Africans were chosen for export; in part to the care of their bodies during the time when they were slaves. The result is a distinctly chosen people, well fitted to carry the burdens of this world.

The variety of physical quality which appears to exist among the negroes is important, for the reason that it appears to be associated with mental differences even as great, thus affording a basis for the differentiation of the people as regards occupations and consequent station in life. It is even more difficult to get at the mental peculiarities of the several groups of black folk than it is to ascertain those of their bodies, so what I shall now set forth is stated with much doubt. It represents my own opinion, qualified by that of others whose judgments I have sought. In the Guinea type we have a folk of essentially limited intelligence. The children are rather nimble-witted, but when the body begins to be mature it dominates the mind. It seems likely that thus the largest element of the race is to find its place in the field or in the lower stages of craft work. The Zulu type appears to me fit for anything that the ordinary men of our own race can do. They remain through life alert and with a capacity for a vigorous reaction with their associates. From them may come the leaders of their kindred of less masterful quality. From the Arab type we may expect more highly educable people than is afforded by the other distinct groups. They have more delicate qualities. They lack the wholesome exuberance of the ordinary negro, which is commonly termed "bumptiousness." Their nature is often what we may term clerical. They are inclined to be somber, but are not morose in the manner of a "musty" elephant, as is frequently the case with the Guinea and Zulu types. Of the red or freckled negroes I have no sufficient grounds for an opinion, yet they as a whole impress me less favorably than any other of the distinct groups. As for the unclassified remainder of the blacks, it can only be said that they seem to be as varied in their mental as they are in their physical character.

The mulattoes of this country appear to be of less importance to the future of the people with which they are classed than they are in other parts of the world, where the white element of the mixture is from other than the Teutonic stock. They are in general of feeble vitality, rarely surviving beyond middle age. My father, an able physician, who had been for nearly all of a long life in contact with negroes, was of the opinion that he had never seen a half-breed who was more than sixty years old. There is certainly a notable lack of aged people of a hue that would indicate that they were anywhere near an equal mixture of the white and black races. Those in which the blood of white stock predominates appear to be more enduring than the half-breeds.

While the intellectual qualities of the mixed white and black are often very good and the attractiveness of the person and manner sometimes remarkable, they have in general a rather bad reputation as regards trustworthiness. Such a view of mestizos is common in all countries where they occur. Humboldt is quoted (though I have not found the matter in his works) as saying that all mixed races have rather the evil than the good of the races from which they sprang. In the case of the mulattoes, at least, there seems to be no warrant for this judgment, and all we know of offspring of diverse species in the animal and plant world fails to give it any support. It is most likely that this opinion as to the mixed white and black people is but one of the varieties of race prejudice where the sufferer is often despised by those who are below him as well as those who are above. The lot of all human half-breeds is unhappy in that they are limited to a narrow field of association. They are not perfectly free to make friends with either of the peoples to whom they are kin. Considering the peculiar situation of the mulattoes, the difficulty of which no one who has not sought information on the matter can well conceive, it seems to me that their way of life is creditable to them. On their own and other accounts, however, we may welcome the fact that their mixed stock is likely to disappear, being merged in those whence it sprang.

In considering the future of our American negroes it is important that we should make a judgment as to their moral tendencies. This is not easy to do, for the statistics of crime are not in such form as to make it clear in what regards they depart from the averages of the white population. There can, however, be no doubt that at first they were addicted to small thieving, and that this habit continued until after the civil war. Southern people, well placed for forming an opinion, believe that this evil is passing away, from the development of the property sense. As for drunkenness, the negro appears to be on the whole less tempted to it than are the whites. One rarely finds the sot type among them. Those of the lower class are liable to curious contagious excitements, which often make them behave as if they were intoxicated when they are not so. A scene I witnessed on a train out of New Orleans, a few years ago, illustrates this and other significant features of the negro character. It was a Sunday morning, and the car assigned to blacks was full of sturdy fellows, mostly of the Guinea type. Explaining to the conductor that I wished to see the people, he allowed me to take a seat in the rear of the carriage. At first my neighbors looked askance at me, but with a word they became friendly. While the train was at rest the throng was still, but as soon as it was in motion singing and shouting began. There was a lull at every station, but with each renewal of the motion the excitement rose higher, until it became very great. A white newsboy, a fellow of some eighteen or twenty years, was engaged in selling papers and candy. As he passed along the aisle one of the negroes sprang at him, knife in hand. In a flash the boy had the muzzle of his pistol almost against the assailant's head. At this every negro in the car was afoot and shouting. Fearing the boy might be struck from behind, I moved near to him, intending to caution him not to fire too soon, for I was sure that his opponent would quickly break down. The youngster needed no advice of mine. In a steady, low voice he called, "Put up your knife—*one!*" With that the throng became suddenly still. "Put up your knife—*two!*" whereupon the ugly fellow slowly hid his knife and sank into a seat with bowed head, while the newsboy went on crying his wares, as if nothing unusual had happened.

Thinking that the negro might have had some grudge in mind, I asked the newsboy for the facts. He assured me that he had never seen the fellow before, and had no reason to expect the attack. He agreed with me that none of the people were drunk, and accounted for their conduct much as I was disposed to do—that "coons would get wild when there was a racket going on." It was interesting to note that the brakemen, who, with their pistols ready, came from either end of the car, took the affair as quietly as did the newsboy, making no kind of comment on it. I stayed on for an hour or so in the car. While I was there the negroes were perfectly quiet, it being evident that although the offender was not arrested and no blow had been struck, not even a brutal word used, a profound impression had been made on those half-savage people, as in another way on me. We both felt what means the strong hand of a masterful race—the stronger when it withholds from smiting. I had seen a good example of one of the ways by which the wild men of Africa have been shaped to the habits of their masters. Such a scene as I have sketched is happily possible in only a limited part of the South—that in which there is a great body of negroes who have not yet been to any extent influenced by civilizing contact with the whites.

There is a common assertion that the male negroes are sexually dangerous animals. The lynchings for assaults on white women appear at first sight to give some color to this view. It is, however, evidently a difficult matter on which to form an opinion. It may be fairly said that these instances of violence occur in by far the larger proportion in the States where the blacks are least domesticated, where they have been in the smallest measure removed from their primitive savagery. If we could eliminate this uncivilized material, mostly that which took shape, or rather kept its primitive shape, on the great plantation, the iniquity would be as rare everywhere as it is in Virginia, Kentucky, Missouri, North Carolina, and Tennessee. When we recall the fact that there are now some five million negro men in the South, and that probably not one in ten thousand is guilty of the crime, we see how imperfect is the basis of this judgment. We have also to remember that this offense when committed by a negro is through the action of the mob widely published, while if the offender be a white man it is unlikely to be so well known. I therefore hold to the belief that violence to women is not proved to be a crime peculiarly common among the blacks. I am inclined to believe that, on the whole, there is less danger to be apprehended from them in this regard than from an equal body of whites of the like social grade. This matter is one of exceeding importance, for on it may depend the future of the South. It is fit that in considering it men should keep their heads clear.

In reviewing the condition of the Eu-Africans a third of a century after the war that gave them their new estate, we have, I think, reason to be satisfied with the results of the change. The change has brought us no distinct economic evils, as shown by the statistics of the industries. The labor of the blacks is quite as productive as it was while they were slaves. Their moral situation is not evidently worse than it was before they attained the measure of liberty which they now possess. The first step, that which naturally caused the most fear, has been taken, the people are free and have not turned their liberty to license. In looking forward, however, we see that only a part of the task has been done. The negroes have failed to acquire, save in very small proportion, the capacity for a true political life. It has been found necessary to deprive them of the control they once exercised, to the peril of the States and their own great harm. The question is as to the ways in which they are to be lifted into the safe plane of American citizenship. They must be so lifted, or we shall in time see established in the South a system of serfdom under the control of an oligarchy—a state of affairs in some regards worse than that of slavery, for it will lack the element of personal interest which did much to help the black in the first stages of his life with us.

Faro II is a dog of fine breed and great intelligence, belonging to one of the artists of *La Nature*, and has been engaged as an actor in the play of Robinson Crusoe, at one of the theaters in Paris. On the stage his name is Toby, and he knows it, and knows just what he has to do. He has entered into relations with his fellow-actors, and obeys his cue instantly. He does the stage business with strict accuracy, picks up the bird that is shot and takes it to Robinson, looks up his yams and the vegetable soup and his pipe. He is grieved when Robinson is sad, exults when he is rejoicing, and looks after his fellow-actors—the goat, the monkey, and the parrot—who are not so bright as he. Off the stage he knows nothing of Toby or of Robinson Crusoe, answers to no name but Faro, and recognizes no master but the artist, M. Weisser.

THE BIRDS OF THE ADIRONDACKS.

By Senator GEORGE CHAHOON.

I SHALL make no appeal for the protection of our birds, for that is not necessary to those who know them; but I wish we could all know them better, and when we knew we would surely love and give them our protection. We would then realize their great use as insect and weed destroyers; they would fascinate us with their cunning habits, and charm us with their beauty and grace.

Most of our birds are migrators, passing their breeding season in summer with us and then leaving for warmer climes. In addition to the climatic reasons for this migration, the question of food supply is doubtless an important factor, for while they might stand the severity of our winters the insectivorous birds could not get any food when our ground was covered with snow and ice, and, in proof of this, as a rule the omnivorous migratory birds are the first to come in the spring and the last to leave in the fall.

In 1877 I began making notes of the arrival of the robin, bluebird, and swallow; these notes have been made every spring, mostly by myself, but during my absence by some member of my family, and were all taken at Au Sable Forks. The earliest date for the robin is March 10th; for the bluebird, March 7th; and for the swallow, April 4th. The latest date for the robin is April 7th; for the bluebird, April 7th; and for the swallow, April 25th. The average date is for the robin, March 28th; bluebird, March 26th; and the swallow, April 15th.

In every year the first robins that came were males, and this was true with the bluebird excepting two years when I saw both male and female birds on the same day. The sex of the swallow is not as easily determined, and I am not sure about them, but my general observation has been that the males come first, and are followed in a few days by the females, and that the courtship and mating are all arranged after their arrival. My observations have been quite careful, and I think they are full enough to go far toward establishing this fact. Of course, there will be exceptions and our observations are necessarily imperfect, for it is not probable that we happen to see the very first bird that comes.

No bird is more generally known or more universally liked than our common robin. Every year he sings for us our praises to the coming spring from the tallest limb of the elm, and he hops across our lawn with a cuteness that forces a hearty welcome, and, differing from most birds, he seems to be more numerous each year. In a few days his mate joins him, and a search for a site for their first nest begins. The robin lays four eggs, and frequently raises three broods of young in a season, never, so far as I know, using the same site or the same nest twice in one season, or more certainly never using the same nest or site for two consecutive broods. Year after year the same corner in the porch or the same crotch in the apple tree will be used as a nesting place by the robin, and we have all wondered if the same robins came back every year, or if the young birds returned and used the nest in which they were hatched. The birds look and act wonderfully familiar when the old site is occupied, and many people are sure they remember the birds from the year preceding. I have never seen a statement from any ornithologist throwing light on this interesting question, and I twice made an attempt, without success, to obtain the information for myself.

All thrushes except the robin are mottled on the breast, and the breast of the young robin is mottled for the first season, so the young can be readily told from the old birds. The robin is a great lover of angleworms. The young follow the mother while she gathers worms to feed them, and about the time for weaning the young birds I have frequently seen the mother bird pick up straws and sticks and offer them to her young instead of food. This may be done to discourage them from following her any longer, but I think it is more probably caused by a return of the nest-building instinct to the mother.

Some years ago I put a small bird box on a post in our yard, which was soon occupied by a pair of summer wrens, and all went nicely with them until a pair of English sparrows concluded to drive the wrens away and take the house for themselves, and for three or four days the wrens and sparrows were constantly fighting, but the wrens finally won and held possession of the house, although at a great sacrifice, for after the fight was over I raised the lid of the box and found the young birds dead, the fight evidently taking so much of the time and attention of the old birds that they allowed their young to starve. I removed the dead birds, and in a short time the wrens rebuilt the nest, and this time they closed the hole for entrance until it was scarcely large enough to admit my thumb.

The box was occupied by wrens for several years, but the entrance was never closed afterward, and I kept the sparrows from any further interference. In this connection I would say that, at least so far as the English sparrow is concerned, the male selects the site for the nest. When I shot the female the male soon returned with another mate, but when I shot the male the female did not return. The wren builds a very coarse nest, and fills the box nearly half full of sticks three or four inches long. As these sticks are carried in the birds' bills by the middle, they would naturally strike the hole crosswise and could not enter, so when the birds get near the box they turn sideways and poke the sticks in end first, following in and arranging them afterward.

The merganser is a fish duck nearly as large as our common domestic duck, and is known under the names of sheldrake and sawbill duck. The male is considerably larger than the female; he has a jet-black head, and the black extends down the neck for about two inches, where the color changes to a pure white, the line being as regular and distinct as the painting on the smoke-stack of a steamship. The body is generally white, with black markings on the wings and some black on the body; the breast is a beautiful salmon color when the bird is killed, but if mounted soon fades to a pure white. The male merganser in full plumage is one of our most beautiful birds.

The female, besides being smaller, is of a grayish color, and the plumage and general appearance are entirely unlike the male, so that the sex can be easily determined even at a long distance.

This bird is common on the Champlain and waters of the Adirondacks. Like all fish ducks, it has a long, sharp bill, which is serrated with sawtooth-shaped notches strongly suggesting teeth, a fact which has given this bird much interest to our evolutionary scientists.

I have noticed a habit of this bird that I believe is entirely unique, and one I am surprised that our authorities on birds have not mentioned—that is, that the males are entirely migratory and the females are not. After the lakes and still waters freeze the mergansers go to the rivers which are open in some places on the rapids all winter. For more than twenty years I have seen female mergansers on the Au Sable River all winter, and I have frequently seen them on the other Adirondack rivers; but I have never seen a male merganser in the winter, and in the late fall the males and females gather in separate flocks, and when the male mergansers appear in the spring they are always in flocks by themselves.

I think the merganser lives entirely on fish, and it is surprising to one who has made no observations on the subject to know what an enormous number of young fish a flock of these ducks will destroy in a season. I quote the following from my notebook: "October 13, 1882, killed fish duck (female merganser) in Slush Pond, and found in her throat and stomach one pickerel, four black bass, and eleven sun perch. Bob (my brother) present. October 18, 1882, killed same kind of duck on Lake Champlain, and took out of her sixty small perch. James R. Graves present."

Our most valuable game bird is the ruffed grouse or partridge. He stays with us all the time. He is a strong, swift flier, and taxes the nerve and skill of the sportsman to a high degree, and to bring down a partridge under full wing in the evergreens in November sends a thrill of delight through one's veins.

The partridge is a gallinaceous bird, and the young leave the nest as soon as hatched, running around with the mother like chickens. Upon the approach of danger the young hide themselves under the leaves in an incredibly short time, and the mother flutters off with an apparently broken wing, keeping just out of reach to lure you away from the hiding place of her young. This ruse is employed by many birds, but in none, so far as I know, to as large an extent as the partridge. Naturally a very timid bird, the partridge will put up quite a bluff for a fight in defense of her young, and on two occasions I knew a partridge to show fight without any young. Experience has satisfied me that a partridge knows enough to try and get a tree between himself and the huntsman, and to keep it there until he is out of range.

Partridges are less numerous around my home than they were twenty years ago, and their habits have undergone a very decided change. Then they usually took to a tree when flushed; now they seldom light on a tree, and take much longer flights. When hunting in Canada last fall I found that the partridges were very tame, and simply ran away from me, or if pressed flew into trees near by and waited for their heads to be taken off with rifle balls.

I notice considerable difference in the shade coloring of the partridge, some being much darker than others, but all have the same markings. The partridge is omnivorous, and, like man and the pig, he eats almost everything. In the winter he lives upon the buds of trees, and many a bird has lost his life while filling his crop from this source, as he is then an easy mark for the hunter, and I have seen the marks of his bill on the carcasses of animals. He is fond of blackberries, and sportsmen often visit blackberry patches when looking for him in the early fall, but I have been surprised to find that when feeding in a blackberry patch he apparently shows no preference for the ripe berries, filling his crop with all kinds. A fact about the partridge which I find is not generally known is, while in summer its toes are plain, like the toes of a chicken, in the winter they are bordered with a stiff hairy fringe that gives it support on the snow, having the same effect as the meshes of our snowshoes. This is a fact of considerable interest, for it seems to have a bearing upon the theory that there is a tendency in animals to develop conditions favorable to their environment. Under this theory one might hope to find a development of a substitute for a snowshoe on a non-migratory bird whose habits keep it largely upon the ground, while no such development would be expected on a bird that leaves us in the winter for warmer climes.

In this connection I would say that while few of our native birds change the color of their plumage as an adaptation to the seasons, our pretty thistle bird, or American goldfinch, undergoes a radical change. In summer he has a bright yellow body with black markings and a black head, while in winter his plumage is all pale brown or sparrow-color, and we often fail to recognize in our somber winter resident the brilliant goldfinch of our summer. These little birds are gregarious in the winter, and as they fly in small flocks into the trees by the roadside they are frequently mistaken for sparrows, and in fact are usually called tree sparrows.

There are few things connected with the study of natural history more interesting than the tendency in animals to develop conditions suitable to their environment, and it is surprising to see for how long a time an acquired habit will sometimes survive after its usefulness has ceased.

The common chimney swallows always build their nests in chimneys that are unused during their breeding season. They make a semicircular nest of sticks, which they glue to the inside wall of the chimney with a secretion from their mouths. It is interesting to see the swallows gather the sticks for their nests, for they do not alight on the ground, but, while flying, break off dead twigs from trees without stopping in their flight.

This habit of building in chimneys must have been acquired in a comparatively short time, for there were no chimneys in this country before the arrival of the white man, and for a long time afterward the settler had but one chimney in his house, which must have been used, at least for cooking purposes, in the summer. So perfect is this habit that the swallow looks and acts as though he were made for the chimney; his color is a sooty black, so that he does not tarnish his coat by rubbing against the chimney walls; the feathers of his tail end in hard spikes, that he can use them to prop himself against the wall. I have been interested on a summer evening watching these swallows in hundreds circling around a church chimney in Plattsburg, until finally the birds in the center began to enter the chimney, the circle growing smaller and smaller as they apparently poured down in the vortex of a whirlpool of swallows. Many birds have acquired a habit of associating with man, and we rarely find them, except during the season of their flight, far away from houses.

The barn swallows always place their nests under the eaves or cornices of some building, usually a barn. These nests are built of mud gathered by the birds from wet places on the ground, and carried in their mouths to the sites chosen by them. Many of our farmers have an unkind feeling for the barn swallows, as they think the mud-daubed nests on the new red paint are not an artistic addition; but if our cattle could give an intelligent opinion they would welcome the birds, for all swallows are entirely insectivorous, and they must eat many flies and mosquitoes that otherwise would be left to torment our animals.

Birds that build in inaccessible places seem to rely upon that for security, and apparently make little effort to conceal their nests, while those building on or near the ground are generally careful to hide them, and they display considerable cunning in preventing discovery. Robins, for instance, after the young are hatched, never drop the eggshells over the side of the nests to the ground, where they would attract attention and cause one to look directly overhead and thus find the nest, but take the broken shells in their bills and carry them off, dropping them while flying. Frequently birds are very shy and easily frightened away from their nests, but after they are well established they sometimes show a good deal of tenacity in staying by them until the young are ready to leave.

Some years ago we opened an old ore mine, where a pair of phœbe birds had placed their nest on a shelf a few feet overhead, a projecting rock protecting it from the flying stones of the blasts that were fired several times a day, and the men were working so near that they could almost touch it with their hands. These birds did not desert their nests until the young were old enough to leave. The site was not used the following year, as is usually the case with the phœbe bird.

No bird has insinuated himself into our affections more deeply than the bluebird. He charms us as he flits through the air like a painted arrow, reflecting the sunlight from the metallic luster of his wings, while he pours out his inspired song "in notes as sweet as angels' greetings when they meet." He comes to us before the unfolding of the first bud of spring, sings to us until our hills and mountains are covered with the richness of their summer verdure, and stays with us until this verdure is changed to all the beauty of its autumnal glory. I am very sorry, but I believe our bluebirds are gradually though steadily decreasing in numbers. Some years ago two pairs nested in our yard, one pair in a hole in an old apple tree and one pair in a box, but for several years these nesting places have been unoccupied, and I know of a number of other former nesting places that have been vacant for years.

Twenty years ago the wild pigeons were quite plentiful in the fall of the year in this part of our State, but each fall they came in decreasing numbers, and for the last four or five years I have not seen a single bird.

There is no sweeter songster than the shy hermit thrush, and I am much pleased in believing that his numbers are increasing. In former years they were not often heard; now, as our spring afternoons decline into twilight, his charming notes come to us from almost every suitable point.

For the first eight or ten years of my residence in Au Sable Forks I did not see a turtle dove, and now I see them nearly every summer.

Our American eagle is occasionally seen in the Adirondacks, and some years ago a large female golden eagle was caught in a steel trap near my home and came into my possession, where she occupied a slatted hencoop, and whenever curiosity led a hen to poke her bill through the slats her head was taken off very quickly. I was afraid that if I kept the eagle I would turn vivisectionist or become too cruel for a hunter, so I presented her to the Zoölogical Gardens in Central Park.

In birds of prey the female is the larger and finer bird, while the reverse is true with other birds; but there is a striking exception in the noble woodcock. No bird is held in higher appreciation by the sportsman, and a female woodcock in full plumage is as rich in coloring and as beautiful in marking as any bird I know. He lies well for the dog, is rare sport for the gunner, and has no equal for the palate. He nests in our alder thickets or on wet marshy ground, and around my home it is the work of a man to get him. He is nocturnal in his habits, feeding at night and pushing his long, slender bill into the soft ground, leaving holes that to the casual eye look like worm holes, but which are easily recognized by one familiar with his habits.

Cow blackbirds are common to this locality during the summers, and they are found in our pastures with the cattle. I have never found their eggs in the nests of other birds, but they are Mormonistic in their habits, one often having as many as a dozen wives, and I have known the crow blackbird to have more than one mate.

Some years ago an article went the rounds of the newspapers telling of a man catching a flock of crows by soaking corn in alcohol and leaving it for the crows to eat, and when they became drunk he caught them. I tried bread crumbs soaked in whisky on English sparrows, but they would not eat them, and I finally got a crow, and though I kept him until he was very hungry I could not get him to eat corn soaked in whisky, and he found no difficulty in picking up every unsoaked kernel and leaving the others. You may draw your own moral, but I am satisfied that the crow will not eat food saturated with alcohol. He is either too uncivilized or too intelligent.

Orioles and other birds sometimes give us much annoyance by eating the green peas from our gardens, and, except in the case of English sparrows, we do not like to shoot them. I once killed a hawk and roughly stuffed it with straw, putting it on a pole near my pea vine, where the birds collected in numbers to scold and peck at it, but they were afraid to touch the peas, and finally left mine for those of my neighbors across the street.

The Acadian owl is a pretty, cunning-looking little bird, not much larger than a robin. He is the smallest of our owls and quite tame, and is not often seen around my home. Some two years ago, while hunting with my brother we saw one of these little birds on the limb of a tree not far from the ground, and we concluded to try and snare him. We cut a long pole and made a slip noose with a shoe string, and while my brother kept the owl's attention by standing in front of him I slipped the noose over his head from behind. When we had the owl we wanted to tie him, and since we could not spare the shoe string for that purpose, my brother decided to tie him with his watch chain. He snapped the catch around one leg, and while trying to fasten the other leg the owl made a flutter and got loose, and the last we saw of him he was sailing over the tops of the trees with the watch chain hanging to his leg.

I have always taken an interest in birds because I have loved them, but it does not follow that I know much about them. Some one said that the more we know men the less we love them, but that man was an old cynic and doubtless told an untruth. Certain it is that the more we know our native birds the more we love them, and it is one of the encouraging signs of the day that it has become fashionable for young people to take an increasing interest in the birds and wild flowers of their own country, and a young person would hardly be considered accomplished to-day who is entirely ignorant of at least the common names of the flowers that bloom in our fields and woods and the birds that pour out their ecstatic music from our trees and hedges.

Herbert Spencer's work on Education has been translated into Sanskrit by Mr. H. Soobba Row, who gives as his reason for publishing a version in an "unspoken" language that the pundits, for whom the version is primarily intended, "can more easily appreciate the ideas conveyed in Sanskrit than perhaps in any other vernacular."

THE STRUCTURE OF BLIND FISHES.

By CARL H. EIGENMANN,
PROFESSOR OF ZOÖLOGY, INDIANA UNIVERSITY.

THE COLOR OF THE AMBLYOPSIDÆ.—The three species of Chologaster are colored, with varying intensity, from C. cornutus, which is darkest, to C. Agassizii, in which the color is faintest. The color cells are in all cases arranged in a definite pattern. These are determined by the underlying muscles. The pattern consists of three longitudinal bands on the sides, following the line where the muscle segments are angularly bent, and cross-stripes along the line separating successive segments.

The general color of Typhlichthys is cream and pink. It is abundantly pigmented. In younger specimens the pigment is arranged in more definite areas about the head. In the old it is more uniformly distributed, being, however, specially abundant about the brain. The pigment pattern of the body is precisely as in Chologaster, except that the individual pigment cells are minute and their aggregate not evident except under the lens.

The retention of the color pattern of Chologaster in Typhlichthys is not less interesting than the retention of similar habits. It is perhaps due to different causes. The color pattern in Chologaster is determined by the underlying muscular structure, and the retention of a similar pattern in Typhlichthys is due to the same underlying structure, rather than to the direct hereditary transmission of the color pattern.

Amblyopsis is flesh-colored, ranging to purple in the gill region, where the blood of the gills shows through the overlying structures, and over the liver, which can be seen through the translucent sides and ventral wall. About the head and bases of the fins the color is yellowish, resembling diluted blood. The surface of the body is slightly iridescent, and the surface of the head has a velvety, peach-bloom appearance.

The general pink color of Amblyopsis is due to the blood. It is not due to any abnormal development of blood-vessels in the dermis. In the fins, where the blood-vessels are near the surface, the general effect is a yellowish color. The surface vessels of the dermis also appear yellowish. It is only on account of the translucent condition of all the tissues, permitting the deeper vessels to show through a certain thickness, that the pink effect is produced. Amblyopsis has always been spoken of as white. The term "white aquatic ghosts" of Cope is very apt, for they do appear white in the caves, and their gliding motion has an uncanny effect. All alcoholic specimens are white.

The pigment cells can not be made to show themselves, even by a prolonged stay in the light. The old, if kept in the light, will not become darker, and a young one reared in the light until ten months old not only showed no increase in the pigmentation but lost the pigment it had at birth, taking on the exact pigmentless coloration of the adult. Pigment cells are late in appearing in Amblyopsis. When the young are two months old pigment is abundant. This pigmented condition is evidently a hereditarily

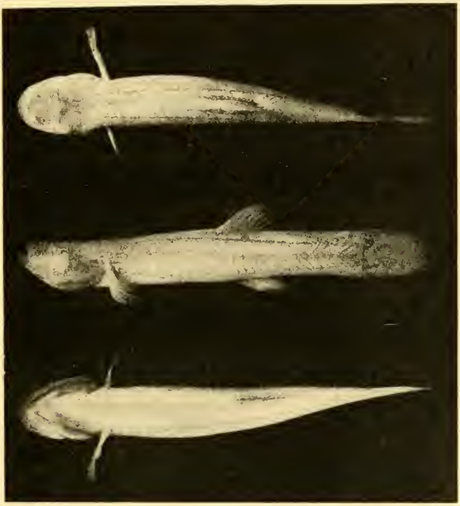


Fig. 1.—*Chologaster Agassizii* from Cedar Sinks Cave, Kentucky.

transmitted condition. It disappears with age. Primarily this disappearance was probably individual. But, as in the flounder, the depigmentation has also become hereditarily transmitted, for even those individuals reared in the light lose the color. Numerous facts and experiments show that while pigment may be, and is, developed in total darkness, the amount of color in an individual animal depends, other things equal, directly on the amount of light to which it is habitually exposed.

The lower and upper surfaces of the flounder, the one protected and the other exposed to the light, give the most striking example, and the argument is clinched here by the fact, noted by Cunningham, that a flounder whose lower side is for long periods exposed to the light takes on color. Loeb has shown that in the yolk sacs of Fundulus embryos more pigment cells are developed if the embryos are kept in the light than when they are kept in the dark. However, in the body, and especially in the eye, the pigmentation was not affected by the absence of light.

The general absence of color in cave animals is conceded. Packard states, "As regards change of color, we do not recall an exception to the general rule that all cave animals are either col-

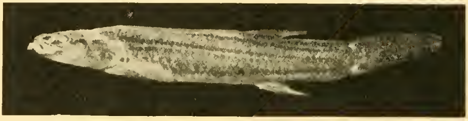


Fig. 2.—*Chologaster papilliferus* from Illinois.

orless or nearly white, or, as in the case of Arachnida and insects, much paler than their out-of-door relatives." Chilton has made the same observation on the underground animals of New Zealand. Similar observations have been recorded by Lönnberg, Carpenter, Schmeil, and Viré. Hamann enumerates a number of species living both in caves and above ground. In such cases the underground individuals are paler than the others. This confirms similar observations by Packard.

Poulton has mentioned that Proteus becomes darker when exposed to the light. This has been verified by others. Typhlotriton larvæ living at the entrance of a cave are dark, while the adult living farther in the cave are much lighter, but with many chromatophores containing a small amount of color. Epigæan

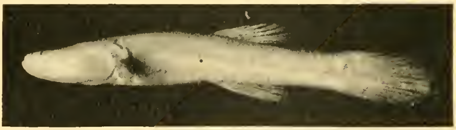


Fig. 3.—*Typhlichthys subterraneus.*

fishes found in caves are always lighter in color than their *confrères* outside.

We have thus numerous examples of colored epigæan animals bleaching in caves, and also bleached cave animals turning dark when exposed to the light. We have also animals in which the side habitually turned to the dark is colorless, while the side habitually turned to the light is colored. Finally, we have cave animals that are permanently bleached.

Natural selection can not have affected the coloration of the cave forms, for it can be absolutely of no consequence whether a cave species is white or black. It could affect the coloration only indirectly in one of two ways: First, as a matter of economy, but since the *individual* is in part bleached by the direct effect of the

Fig. 4 *a*.

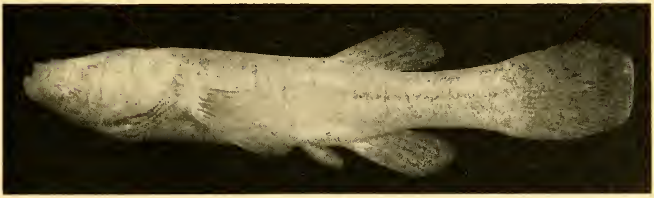


Fig. 4 *b*.

Fig. 4 *c*.

Fig. 4 *a*, *b*, *c*.—Three views of *Amblyopsis*.

darkness there is no reason why natural selection should come into play at all in reducing the pigment as a matter of economy; second, Romanes has supposed that the color decreases through the selection of correlated structures—a supposition he found scarcely conceivable when the variety of animals showing the bleached condition is considered.

Panmixia can not account for the reduction of the color, since it returns in some species when they are exposed to the light, and disappears to a certain extent in others when kept in the dark. Panmixia, Romanes thinks, may have *helped* to discharge the color. In many instances the coloration is a protective adaptation, and therefore maintained by selection. Panmixia might in such instances lower the general average to what has been termed the "birth mean." Proteus is perhaps such an instance. But in this species the bleached condition has not yet been hereditarily established, and since each individual is independently affected "the main cause of change must have been of that direct order which we understand by the term climatic."

Since, however, the bleached condition, which in the first instance is an individual reaction to the absence of light, has become hereditarily established in Amblyopsis so that the bleaching goes on even when the young are reared in the light, it is evident that in Amblyopsis we have the direct effect of the environment on the individual hereditarily established.

THE EYES OF THE AMBLYOPSIDÆ.—The structure of the eyes has formed the basis of a separate, fully illustrated paper.* The prominent features in the eyes of the various species must, however, be known before the question of the origin of these forms and the causes of degeneration can be seriously considered. The eyes of the species of Chologaster are normally formed, possessing a lens, pupil, vitreous body, retina, and optic nerve, and all the eye muscles normal to the fishes. The eyes are functional. The retina is, however, very much simplified. The eye of papilliferus is, in this respect, more perfect than the eye of cornutus. In papilliferus the outer nuclear layer consists of two series of nuclei, the inner layer of about five series of nuclei, and the ganglionic layer of a complete single layer of nuclei except where the optic fibers pass between them, for an optic-fiber layer is not present. In Chologaster cornutus the outer nuclear layer has been reduced to one or two series, and the ganglionic layer to cells widely separated from each other or in rows and little groups, but no longer forming a complete layer. In Amblyopsis and Typhlichthys the largest eyes are not more than one twentieth the diameter of those of Chologaster, or one thousandth of their bulk; the lens is nearly, if not quite, obliterated; the same is true of the vitreous body and the optic nerve in the adult. Beyond this the eyes differ much. In Amblyopsis scleral cartilages are present and prominent, the pigmented layer is prominent, the outer and inner nuclear layers form one layer only, two or three cells deep. In T. subterraneus

* Archiv f. Entwickelungsmechanik, viii, pp. 545–617, Plates XI–XV.

the pigmented layer is insignificant, and no pigment is ever found in it, while the outer and inner nuclear layers are still separate. In both these species the ganglionic layer forms a central core of cells. In Amblyopsis several or all the eye muscles are present; in Typhlichthys nothing is left of them.

Scleral cartilages are not present in Chologaster or Typhlichthys; in Troglichthys they are very prominent, sometimes *several times as long as the eye.* While there is no pigment left in Typhlichthys, there is in Troglichthys. The eye in the former is about 0.168 millimetre in diameter, while the entire eye of the latter is but about 0.050 millimetre, or less than one third the diameter, and less than one ninth the bulk.

The entire eye of Troglichthys is smaller than many single cells, and I shall be pardoned for not going into the details of its structure here.

THE TACTILE ORGANS.—The tactile organs are among the most important in the consideration of the blind forms. Their minute structure will form the basis of a separate paper. The prominent tactile organs about the head of Amblyopsis have been mentioned

FIG. 5.—Three views of the head of an *Amblyopsis*, prepared to show the tactile ridges.

by nearly every writer, and they have been figured by Putnam-Wyman * and Leidig,† but the figures of the distribution of the ridges are worthless. The description of Professor Forbes ‡ of Chologaster papilliferus is the only systematic enumeration of the ridges that has appeared. The accompanying figures, drawn by me with the *camera lucida*, and verified and copied by Mr. U. O. Cox, give the exact extent and position of the ridges in Amblyopsis and Chologaster papilliferus. It will be seen that in the number and distribution of the tactile area the two forms agree very closely, the eyed form having the same number and distribution of ridges or rows that the blind forms have. In Chologaster

* American Naturalist, 1872, Plate II, Figs. 1 and 2.

† Untersuchungen z. Anatomie und Histologie d. Tiere, Plate III, Fig. 28.

‡ American Naturalist, 16, 1882, p. 2.

papilliferus most of the ridges are much less prominent than in the blind species, being sunk into the skin. About the nose and chin, however, the ridges are as prominent as in the other species. In the small Chologaster cornutus there are no distinct ridges at all, the tactile organs being arranged as in other species of fishes. In specimens of the same size the papillæ are not more prominent in papilliferus than in cornutus. It is only in the oldest of papilliferus that the papillæ become prominent. The number of individual papillæ in each tactile ridge differs considerably with age (size), so that an exact comparison between the large Amblyopsis and the much smaller species of Chologaster and Typhlichthys can not be made. From a number of counts made by Professor Cox I take the liberty of giving the following: Ridge No. 6 contains, in Chologaster papilliferus, six organs; in Typhlichthys, eleven; in two specimens of Amblyopsis, respectively eighty-three and one hundred and six inches long, twelve and twenty.

Fig. 6.—Snout of *Chologaster papilliferus*, to show the tactile ridges.

Aside from the tactile organs in ridges, there are many solitary ones not evident from the surface in Amblyopsis. When the epidermis is removed by maceration, the dermal papillæ on which these rest give the whole head a velvety appearance.

In the young, at least of Amblyopsis, each of the tactile organ of the ridges is provided with a club-shaped filament abruptly pointed near the end. They wave about with the slightest motion in water, and are so numerous as to give the whole head a woolly appearance.

To recapitulate the facts ascertained concerning the eye and tactile organs:

1. The eyes were degenerating and the tactile organs developing beyond the normal before the permanent underground existence began.

2. The eyes continued to degenerate and the tactile organs to increase after permanent entrance to underground waters.

3. In the degeneration of the eye the retina leads; the vitreous body and lens follow; the more passive pigmented layer and sclera remain longest; the bony orbit is not affected.

Bearing of the Facts gained on the Origin of the Cave Fauna.—The origin of the cave fauna and of the blind fauna are two distinct questions. This was first recognized by H. Garman. Before, the two questions were considered as one, and two explanations are prominent among those suggesting its solution:

1. The explanation of Lankester seems either a pleasantry or the most unwarranted speculation. He says: "Supposing a number of some species of Arthropod or fish to be swept into a cavern or to be carried from less to greater depths in the sea, those individuals with perfect eyes would follow the glimmer of light, and eventually escape to the outer air or the shallower depths, leaving behind those with imperfect eyes to breed in the dark place. A natural selection would thus be effected. In every succeeding generation this would be the case, and even those with weak but still seeing eyes would in the course of time escape, until only a pure race of eyeless or blind animals would be left in the cavern or deep sea."

This process does not, of course, account for the degeneration of the eye beyond blindness. But, aside from this objection, the humor of his "glimmer of light" impresses itself very forcibly on one after spending a day in following the devious windings of a living cave, not to mention his tendency in cave animals, which are negatively heliotropic, to follow it. There are other objec-

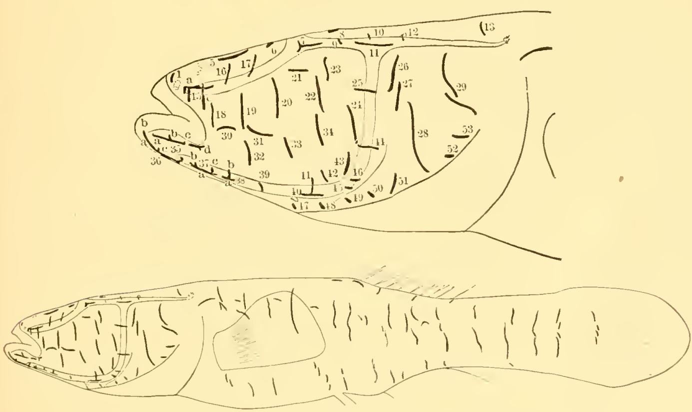


FIG. 7.—Lateral view of *Amblyopsis*, showing the location of the tactile ridges.

tions. Fishes are annually swept into the caves, but they are not able to establish themselves in them. To do this they must have peculiar habits, special methods of feeding and mating before a successful colonization of caverns can become successful. Further, if the origin of the cave fauna is due to accident, the accident must have happened to four species out of six of the Amblyopsidæ, while none of the numerous other species of fishes about the caves met with the same accident.

2. The second explanation is that of Herbert Spencer: * "The existence of these blind cave animals can be accounted for only by supposing their remote ancestors began making excursions into the caves, and, finding it profitable, extended them, generation after generation, farther in, undergoing the required adaptations little by little."

This second view has been modified by H. Garman in so far as he supposes the adaptations to do without eyes and consequent degeneration of eyes to occur anywhere where a species has no use

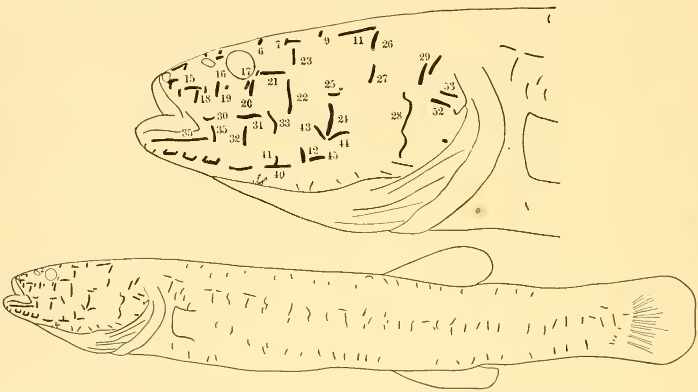


Fig. 8.—Lateral view of *Chologaster papilliferus*, showing the location of the tactile ridges.

for eyes, enumerating burrowing animals and parasitic animals, concluding that "the origin of the cave species (nonaquatic especially) of Kentucky were probably already adjusted to a life in the earth before the caves were formed." In this modified sense, Spencer's view is directly applicable to the Amblyopsidæ. Hamann goes so far as to suppose that darkness itself is not the primary cause of degeneration, but unknown factors in the animal itself.

The three things to be considered in this connection are (*a*) the habit of the cave form, (*b*) the modifications to enable the form to do without the use of light, and (*c*) the structure of the eye as a result of *a* and *b*.

a. The prime requisite for a candidate to underground existence is a negative reaction to light. We found that even the epigæan Chologaster is negatively heliotropic.

b. It must also be evident that a fish depending on its sight

* Popular Science Monthly, vol. xliii, pp. 487, 488.

to procure its food can never become a cave form. Sunfishes, which are annually carried into caves, belong to this class of fishes. They are always poor when found in the caves, and will never be able to establish themselves in them. On the other hand, there are no reasons why fishes detecting their prey either by smell or touch should not be capable of colonizing caves. The catfishes and Amblyopsidæ belong to the latter class. It is surprising that more catfishes have not established themselves in caves. Among the Amblyopsidæ even those with functional eyes depend on touch and vibrations for their food. Chologaster has well-developed tactile organs and poor eyes. It is found chiefly at the mouths of underground streams, but also in the underground streams themselves. The tactile organs are not different in kind from those of other fishes, and their high development is not more marked than their development in the barbels of the catfishes. The characters which distinguish Chologaster as a fish capable of securing its food in the dark are emphasized in Typhlichthys, and the tactile organs are still more highly developed in Amblyopsis. The eyes of the last two genera are so degenerate that it is needless in this connection to speak of degrees of degeneration. On account of the structure of their eyes and their loss of protective pigment they are incapable of existence in open waters. With the partial and total adaptation to an underground existence in the Amblyopsidæ and their negative reaction to light, it is scarcely possible that for this family the idea of accidental colonization can be entertained for a moment. Their structure is not as much due to their habitat as their habitat is to their structure and habit.

Typhlogobius lives in the holes of shrimps under rocks on the coast of southern California. It is a living example of the origin of blind forms in dark places remote from caves. Here again the "accidental" idea is preposterous, since no fish could by accident be carried into the devious windings of the burrows they inhabit. Moreover, a number of related species of gobies occur in the neighborhood. They live ordinarily in the open, but always retreat into the burrows of crustaceans when disturbed. The origin of the blind species by the gradual change from an occasional burrow seeker to a permanent dweller in the dark and the consequent degeneration of the eye is evident here at once. Among insects the same process and the same results are noted. We have everywhere the connection of diurnal species with dark-loving and blind forms, a transition the result of habit entered into with intent, but no evidence of such a connection as the result of accident. Also numerous instances of daylight species being swept into caves, but no instance of one establishing itself there.

This view accounts also for the wide distribution of the blind fishes. The ancestry of the Amblyopsidæ we may assume to have had a tendency to seek dark places wherever found, and incipient blind forms would thus arise over their entire distribution. The structural differences between Troglichthys and Typhlichthys argue in favor of this, and certainly the fearless, conspicuous blind fish as at present developed would have no chance of surviving in the open water. Their wide distribution after their present characters had been assumed, except through subterranean waters, would be out of the question entirely. The same would not be true of the incipient cave forms when they had reached the stage at present found in Chologaster. It will be recalled that Chologaster, and even the blind forms, have the habit of hiding underneath boards and in the darker sides of an aquarium. These dark-seeking creatures would, on the other hand, be especially well fitted to become distributed in caves throughout their habitat. S. Garman's able argument for the single origin and dispersal of the blind fishes through epigæan waters was based on the supposition that the cis-Mississippi and trans-Mississippi forms were identical. The differences between these species are such as to warrant not only that they have been independently segregated, but that they are descended from different genera. The external differences between these species are trifling, but this was to be expected in an environment where all the elements that make for external color marking are lacking. The similarity between Typhlichthys and Amblyopsis is so great that the former has been considered to be the young of the latter.

Judging from the structure of the eye and the color of the skin, Troglichthys has been longest established in caves. Amblyopsis came next, and Typhlichthys is a later addition to the blind cave fauna.

"Those," said Dr. J. N. Langley, in his sectional address on Physiology at the British Association, "who have occasion to enter into the depths of what is oddly, if generously, called the literature of a scientific subject, alone know the difficulty of emerging with an unsoured disposition. The multitudinous facts presented by each corner of Nature form in large part the scientific man's burden to-day, and restrict him more and more, willy nilly, to a narrower and narrower specialism. But that is not the whole of his burden. Much that he is forced to read consists of records of defective experiments, confused statement of results, wearisome description of detail, and unnecessarily protracted discussion of unnecessary hypotheses. The publication of such matter is a serious injury to the man of science; it absorbs the scanty funds of his libraries, and steals away his poor hours of leisure."

A HUNDRED YEARS OF CHEMISTRY.

By F. W. CLARKE,
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[*Concluded.*]

IT is evident, from what has been already said, that chemistry and physics are near akin—indeed, they can hardly be separated. Avogadro's law and spectrum analysis are but two illustrations of the relationship, but many other examples are equal to them in importance. Take, for instance, the action of light upon chemical substances; it may provoke union of elements, or effect the decomposition of compounds; upon the latter phenomenon the art of photography depends. That salts of silver are chemically changed by light was the fundamental observation, and upon this fact most photographic processes, though not all, are founded. Thus light, working as a chemist in the laboratory of the photographic plate, has become the useful servant of all arts, all sciences, and all industries—an indispensable aid to invention and research. On this theme a volume might be written; a bare reference to it must be sufficient here.

Still another branch of chemistry, recently developed but essentially an extension of the theory of valence, is also due to the study of optical relations. That different crystalline bodies differ in their behavior toward polarized light has long been known, and the polariscope is recognized as an instrument of great value in chemical research. To the analysis and valuation of sugars and sirups it is most effectively applied, and commercial transactions of great magnitude depend in part upon its testimony. Here is practical utility, but the development of theory is what concerns us now.

The discovery of isomerism, of the fact that very different compounds might contain the same elements united in the same proportions, was easily interpreted by the theory of valence in a fairly complete and satisfactory way. In the structural formulæ the different atomic groupings were clearly shown, but with one essential limitation—the arrangement was in a single plane. That is, the linking of the atoms was considered, but not their relations to tridimensional space. For the study of reactions, for the classification of compounds, the structural symbols sufficed; but human thought is not so easily satisfied, and more was soon required. One class of isomers was unexplained, and an explanation was demanded.

A typical example of the difficulty was offered by tartaric acid, which exists in two forms differing crystallographically and optic-ally. One form, dissolved in water, twisted a ray of polarized light to the left, the other produced a rotation to the right, while the crystals of the two acids, similar in all other respects, also showed a right- and left-handedness in the arrangement of their planes. The crystal of one variety resembled the other as would its reflection in a mirror—the same, but reversed. These differences, discovered by Pasteur as long ago as 1848, the theory of valence could not explain; to interpret them, and other similar cases, the arrangement of the atoms in space had to be considered.

In 1874 two chemists, Van t'Hoff and Lebel, working independently, offered a solution of the problem, and stereochemistry, the chemistry of molecular structure in three dimensions, was founded. They proposed, in effect, to treat the carbon atom essentially as a tetrahedron, the four angles corresponding to the four units of valence or bonds of affinity. They then studied the linking or union of such tetrahedra, and found that with their aid the formulæ for tartaric acid could be developed in different ways, showing right- and left-handed atomic groupings. Other similar compounds were equally explicable. Thus the definite conception of a tridimensional, geometric atom led to a new development of structural formulæ, from which many discoveries have already proceeded. The fruitfulness of the speculation vindicates its use, but it is only the first step in a method of research which must in time be applied to all of the chemical elements. Probably the study of crystalline form will be connected with these chemico-structural expressions, and from the union some greater generalizations will be born. From the geometry of the crystal to the geometry of the molecule there must be some legitimate transition. With all their utility, our present conceptions of chemical structure are incomplete; they represent only portions or special phases of some great general law, but so far as they go, properly used, they are valid.

But light is not the only physical force involved in chemical changes; heat and electricity are far more important. Heat, in particular, is essential to every chemical operation; it provokes combination and effects decomposition; it appears in one reaction and vanishes in another; apart from thermal phenomena the science of chemistry could not exist. From the very beginnings of chemistry this interdependence has been recognized, and its study has led to notable discoveries and to great enlargements of resource. In the theory of phlogiston the connection between heat and chemical change was crudely stated, and when Lavoisier saw that combustion was oxidation, thermochemistry began to exist.

In every chemical change a definite amount of heat is either liberated or absorbed—a distinct, measurable quantity. This fact was established by Hess in 1840, and since then the thermal values of many reactions have been determined, notably by Thomsen in Denmark and Berthelot in France. The data are already numerous, but as yet they have not been co-ordinated into any general law. They are in great measure the raw material with which some future scholar is to build. One fact, however, is already clear—namely, that the heat of formation or of combustion of any compound is conditioned by its structure. Two isomeric substances may differ widely in their calorific constants, an observation which has repeatedly been verified. Thus the conception of structure, of atomic grouping, appears again a chief factor in a set of unsolved problems.

In the relations of chemistry to heat perhaps the greatest advances have been made in the extension of our resources, particularly in regard to the development and control of temperatures. At the beginning of the century the range of temperatures available to the chemist was narrowly limited—from the freezing point of mercury at one end to the heat of a blast furnace at the other. His command of heat and cold are now vastly greater than then, and the steps which have been taken are worth tracing.

At the lower end of the scale the greatest progress has been made through the liquefaction of gases. When a liquid evaporates, heat is absorbed, or, reversely stated, cold is produced, and the more rapid the evaporation the greater is the cooling effect. A command of more volatile liquids is therefore a command of cold, and the liquefied gases represent the extreme limit of our power in that direction.

Near the beginning of the century, by combining cold and pressure, sulphurous acid and chlorine were reduced to the liquid state. In 1823 Faraday succeeded in liquefying still other gases, and in 1835 Thilorier went even further and reduced carbonic acid to a snowlike solid. Liquid chlorine, sulphurous acid, and carbonic acid, stored in strong cylinders of steel, are now commercial products, manufactured and sold in large quantities like any other merchandise. They can be transported to long distances and kept indefinitely, to the great convenience of chemists and the furtherance of research.

In 1845 Faraday published the results of further investigations, when it appeared that all but six of the known gases had been reduced to the liquid state. Through cold and pressure lower and lower temperatures were gained, each step forward having given a foothold from which a new advance was possible. In 1877 Pictet and Cailletet simultaneously succeeded in liquefying four of the supposedly permanent gases; nitrogen yielded to the attacks of Wroblevsky and Olzewski in 1883, and hydrogen alone remained unconquered. In 1898 Dewar overcame this last obstacle, and in the year following he actually reduced hydrogen to an icelike solid which melts at only eighteen degrees centigrade above the theoretical absolute zero. Every gas has been liquefied, and probably the lowest degree of cold attainable by man has been reached. Within the century the work began and ended; the future can only improve the working methods and utilize the new resources. Liquid ammonia has long been used in the manufacture of artificial ice and for direct refrigeration; liquid air, with its temperature of two hundred centigrade degrees below zero, is now almost a commercial product, obtainable in quantity, but with its possibilities of usefulness as yet practically undeveloped. The infant Hercules will doubtless find no lack of tasks to do, each one more arduous and more helpful to man than any labor of his mythical prototype.

To the chemist the possibilities thus opened are innumerable. Pictet has shown that at the low temperatures which are now easily attainable all chemical action stops, even the most energetic substances lying in contact with each other quiet and inert. A greater control of the more violent chemical reactions is therefore within reach, doubtless to be utilized in many ways yet unforeseen. At the highest temperatures, also, chemical union ceases, and compounds are decomposed; each reaction is possible only within a limited thermal range, of which the beginning and the end are measurable. From future measurements of this sort new laws will surely be discovered.

The first step in the upward scale of temperatures was taken in 1802, when Robert Hare, an American, invented the oxyhydrogen blowpipe. With this instrument platinum, hitherto infusible, was melted, a result of great importance to chemists. Apart from recent electrical applications, platinum finds its chief use in the construction of chemical apparatus, and Hare's invention was therefore of great assistance to chemical research. Later in the century electrical currents were utilized as producers of great heat, until in the very modern device of the electric furnace the range of available temperatures has been at least doubled. Temperatures of three to four thousand degrees of the centigrade scale are now at the disposal of the chemist, and these are manageable in compact apparatus at very moderate cost. Cheap aluminum is one of the products of this new instrument, and the extraordinary abrasive substance, carborundum, is another. New industries have been created by the electric furnace, and in the hands of Moissan it has yielded scientific results of great interest and remarkable variety.

The rarest metals can now be separated from their oxides with perfect ease, and new compounds, obtainable in no other way, the furnace has placed at our disposal. This field of research is now barely opened; from it the twentieth century should gather a rich harvest.

With electricity also chemistry is nearly allied, and along some lines the two branches of science have been curiously intertwined. Like the other physical forces, electricity may either provoke or undo combination, and, like heat, it may itself be generated as a product of chemical action. The voltaic pile and the galvanic battery owe their currents to chemical change, and it is only since the middle of the century that any other source of electric energy has become available for practical purposes. It is not surprising, therefore, that many thinkers should have sought to identify chemical and electric force, the two have so much in common. It was with the galvanic current that Davy decomposed the alkalies, and since his day other electro-chemical decompositions have been studied in great number, to the development of important industries. To the action of the current upon metallic solutions we owe the electrotype and all our processes for electroplating, and these represent only the beginnings of usefulness. Even now, almost daily, advances are being made in the practical applications of electrolysis, and the forward movement is likely to continue throughout the coming century. From the curiously reversible chemical reactions of the secondary battery the automobile derives its power, and here again we find a field for invention so large that its limits are beyond our sight. From every peak that science can scale new ranges come into view. The solution of one problem always creates another, and this fact gives to scientific investigation its chief interest. We gain, only to see that more gain is possible; the opportunity for advance is infinite. Forever and ever thought can reach out into the unknown, and never need to weep because there are no more worlds to conquer.

It was the study of electro-chemical changes which led Berzelius to his electro-chemical theory of combination, and then to the dualistic theory, which has already been mentioned. In or about the year 1832, when the Berzelian doctrines were at the summit of their fame, Faraday showed that the chemical power of a current was directly proportioned to the quantity of electricity which passed, and this led him to believe that chemical affinity and electric energy were identical. Electrolysis, the electrical decomposition of compounds in solution, was a special object of his attention, and by quantitative methods he found that the changes produced could be stated in terms of chemical equivalents or combining numbers. One equivalent weight of zinc consumed in the galvanic battery yields a current which will deposit one equivalent of silver from its solution, or which, decomposing water, will liberate one equivalent each of oxygen and hydrogen. All electro-chemical changes followed this simple law, which gave new emphasis to the atomic theory, and furnished a new means for measuring the combining numbers.

In the early days of electro-chemistry the products of electrolysis were studied in the light of the dualistic theory. But as chemical investigation along other lines overthrew this hypothesis, a closer examination of electrolytic reactions became necessary. Electrical decompositions were dualistic in character, but the dualism was not that taught by Berzelius. When a salt, dissolved in water, is decomposed by the current it is separated into two parts, which Faraday called its *ions;* in Berzelian terms these were in most cases oxides, but this conclusion fitted only a part of the facts, and finally was abandoned. Whatever the *ions* might be, they were not ordinary oxides.

Many and long were the investigations bearing upon this subject before a satisfactory settlement was reached. The phenomena observed in solutions, raised still another question, that of the nature of solution itself, and this is not yet fully answered. Two lines of study, however, have converged, within recent years, to some remarkable conclusions, the latest large development of chemical theory.

It has long been known that solutions of salts do not freeze so easily as pure water, and also that their boiling points are higher. In 1883 Raoult discovered a remarkable relation between the freezing point of a solution and the molecular weight of the substance dissolved, a relation which has since been elaborately studied by many investigators. From either the freezing-point depression or the elevation of the boiling point the molecular weight of a soluble compound can now be calculated, and many uncertain molecular weights have thus been determined.

Another phenomenon connected with solutions, which has received much attention, is that of osmotic pressure. A salt in solution exercises a definite pressure, quantitatively measurable, which is curiously analogous to the pressure exerted by gases. In a gas the molecules are widely separated, and move about with much freedom. In a very dilute solution the molecules of a salt are similarly separated, and are also comparatively free to move. The kinetic theory of gases, therefore, is now paralleled by a kinetic theory of solutions, founded by Van t'Hoff in 1887, which is now generally accepted. All the well-established laws connecting pressure, temperature, and volume among gases find their equivalents in the phenomena exhibited by solutions. In Avogadro's law we learn that equal volumes of gases, under like conditions of temperature and pressure, contain equal numbers of molecules. According to the new generalizations, equal volumes of different solutions, *if they exert the same osmotic pressure*, also contain equal numbers of molecules. The parallelism is perfect. With these relations the freezing- and boiling-point phenomena are directly connected.

But, both for gases and for solutions some apparent anomalies existed. Certain compounds, when vaporized, seemed not to conform to Avogadro's law, and called for explanation. This proved to be simple, and was supplied by the fact that the anomalous compound, as such, did not exist as vapor, but was split up, *dissociated*, into other things. For instance, ammonium chloride, above a certain temperature, is decomposed into a mixture of two gases—hydrochloric acid and ammonia—which, on cooling, reunite and reproduce the original compound. Twice as much vapor as is required by theory, and specifically half as heavy, is produced by this transformation, which is only one of a large class, all well understood.

In the case of solutions it was found that certain compounds, notably the acids, alkalies, and metallic salts, caused a depression of freezing point which was twice as great as ought to be expected. This fact was illuminated by the phenomena observed in gases, and soon it was seen that here too a splitting up of molecules, a true dissociation, occurred. These anomalous solutions, moreover, were electrolytes—that is, they conducted electricity and underwent electrolytic decompositions—while normal substances, especially solutions of carbon compounds, such as sugar, were not.

Van t'Hoff's discoveries went far, but one more step was needed, and this was taken by Arrhenius in 1888. Electrolytic compounds, when dissolved, are actually dissociated into their *ions*, partially so in a strong solution, entirely so in one which is infinitely dilute, a statement which leads to some extraordinary conclusions. For instance, the *ions* of common salt are sodium and chlorine. In a dilute solution the salt itself ceases to exist, while atoms of sodium and atoms of chlorine wander about, chemically separated from each other but still in equilibrium. Sodium sulphate may be regarded as made up of two parts—sodium and an acid radicle which contains one atom of sulphur to four of oxygen—and these parts, its *ions*, are severed apart during solution to move about independent of each other.

This theory of Arrhenius, the theory of electrolytic dissociation, is supported by many facts, and fits in well with the kinetic theory of Van t'Hoff. Electrolysis is no longer to be considered as a separating process, but rather as a sorting of the *ions*, which receive different electrical charges and concentrate at the two electrical poles. The phenomena of freezing and boiling points in solutions, and of the absorption of heat when solid salts are dissolved, all harmonize with the conclusions which have been reached. A complete theory of solutions is yet to be proposed; but these new doctrines, which are true so far as they go, represent a long step in the right direction. A final theory will include them, but they are not likely to be set aside.

As we near the end of the century we find one more discovery to note, from a most unexpected quarter—the discovery of new gases in the atmosphere. In 1893 Lord Rayleigh was at work upon new determinations of density, with regard to the more important gases. In the case of nitrogen an anomaly appeared: nitrogen obtained from the atmosphere was found to be very slightly heavier than that prepared from chemical sources, but the difference was so slight that it might almost have been ignored. To Rayleigh, however, such a procedure was inadmissible, and he sought for an explanation of his results. Joining forces with Ramsay, the observed discrepancies were hunted down, and in 1894 the discovery of argon was announced. Ramsay soon found in certain rare minerals another new gas—helium—whose spectral lines had previously been noted in the spectrum of the sun; and still later, working with liquid air, he discovered four more of these strange elements—krypton, xenon, neon, and metargon. By extreme accuracy of measurement this chain of discovery was started, and, as some one has aptly said, it represents the triumph of the third decimal. A noble dissatisfaction with merely approximate data was the motive which initiated the work.

To the chemist these new gases are sorely puzzling. They come from a field which was thought to be exhausted, and cause us to wonder why they were not found before. The reason for the oversight is plain: the gases are devoid of chemical properties, at least none have yet been certainly observed. They are colorless, tasteless, odorless, inert; so far they have been found to be incapable of union with other elements; apart from some doubtful experiments of Berthelot, they form no chemical compounds. Under the periodic law they are difficult to classify; they seem to belong nowhere; they simply exist, unsocial, alone. Only by their density, their spectra, and some physical properties can these intractable new forms of matter be identified.

In a sketch like this a host of discoveries must remain unnoticed, and others can be barely mentioned. The isolation of fluorine and the manufacture of diamonds by Moissan, the synthesis of sugars by Fischer, the discovery of soluble forms of silver by Carey Lea—all these achievements and many more must be passed over. Something, however, needs to be said upon the utilitarian aspects of chemistry, and concerning its influence upon other sciences. Portions of this field have been touched in the preceding pages; the interdependence of chemistry and physics is already evident; other subjects now demand our attention.

Medicine and physiology are both debtors to chemistry for much of their advancement, and in more than one way. From the chemist medicine has received a host of new remedies, some new processes, and advanced methods for the diagnosis of disease. The staining of tissues for identification under the microscope is effected by chemical agents, the analysis of urine helps to identify disorders of the kidneys; nitrous oxide, chloroform, ether, and cocaine almost abolish pain. The disinfection of the sick-room and the antiseptic methods which go far toward the creation of modern surgery all depend upon chemical products whose long list increases year by year. Crude drugs are now replaced by active principles discovered in the laboratory—morphine, quinine, and the like—and instead of the bulky, nauseous draughts of olden time, the invalid is given tasteless capsules of gelatin or compressed tablets of uniform strength and more accurately graded power. A great part of physiology consists of the study of chemical processes, the transformation of compounds within the living organism, and practically all this advance is the creation of the nineteenth century. Modern bacteriology, at least in its practical applications, began with a chemical discussion between Liebig and Pasteur as to the nature of fermentation: step by step the field of exploration has enlarged; as the result of the investigations we have preventive medicine, more perfect sanitation, and antiseptic surgery. The ptomaines which cause disease and the antitoxins which prevent it are alike chemical in their nature, and were discovered by chemical methods. Physiology without chemistry could not exist; even the phenomena of respiration were meaningless before the discovery of oxygen. The human body is a chemical laboratory, and without the aid of the chemist its mysteries can not be unraveled.

To agriculture also chemistry is a potent ally, whose value can hardly be overrated. It has created fertilizers and insecticides for the use of the farmer and taught their intelligent use, and in the many experiment stations of the world it is daily discovering facts or principles which are practically applicable to agriculture. The beet-sugar industry was developed by chemical researches and chemical methods; the arts of the dairy have been chemically improved;

the food of all civilized nations is better and more abundant than it was before the chemist gave his aid to its production. Adulteration, always practiced, is now easily detected by chemical analysis, and, though the evil still exists, the remedy for it is in sight. To Liebig, who gave to agricultural chemistry its first great impulse forward, mankind is indebted to an amount which is beyond all computation.

In manufactures the influence of chemistry is seen at every turn. When the century began, probably no industrial establishment in the world dreamed of maintaining a chemical laboratory; to-day, hundreds are well equipped and often heavily manned for the sole benefit of the intelligent manufacturer. Coal gas is a chemical product; its by-products are ammonia and coal tar; from the latter, as we have seen, hundreds of useful substances, the discoveries of the last half century, are prepared. Better and cheaper soap and glass owe their existence to chemical improvement in the making of alkalies; chemical bleaching has replaced the tedious action of sunlight and dew; chemical dyestuffs give our modern fabrics nearly all their hues. Metallurgy is almost wholly a group of chemical processes; every metal is extracted from its ores by methods which rest on chemical foundations; analyses of fuel, flux, and product go on side by side with the smelting. The cyanide and chlorination processes for gold, the Bessemer process for steel, are apt illustrations of the advances in chemical metallurgy; but before these come into play the dynamite of the miner, another chemical invention, must have done its work underground. For rare minerals, the mere curiosities of twenty years ago, uses have been found; from monazite we obtain the oxides which form the mantle of the Welsbach burner; from beauxite, aluminum is made. The former waste products of many an industry have also revealed unsuspected values, and chemistry has the sole honor of their discovery.

In education, chemistry has steadily grown in importance, until a single university may have need of as many as twenty chemists in its teaching staff, teaching not only what is already known, but also the art of research. As a disciplinary study, chemistry ranks high in the college curriculum, and it opens the way to a new learned profession, equal in rank with those of more ancient standing.

For the material advancement of mankind the nineteenth century has done more than all the preceding ages combined, and science has been the chief instrument of progress. Scientific methods, experimental investigation, have replaced the old empiricism, and no man can imagine where the forward movement is to end.

Hitherto research has been sporadic, individual, unorganized; but fruitful beyond all anticipation. In the future it should become more systematic, better organized, richer in facilities. Through laboratories equipped for research alone the twentieth century must work, and chemistry is entitled to its fair share of the coming opportunities. The achievements of the chemist, great as they have been during this century, are but a beginning; the larger possibilities are ahead. The greatest laws are yet undiscovered; the invitation of the unknown was never more distinct than now.

MOUNT TAMALPAIS.

By MARSDEN MANSON, C. E., Ph. D.

MOUNT TAMALPAIS is the southern and terminating peak of the westerly ridge of the Coast Range, which confronts the Pacific Ocean from the Golden Gate to the Oregon line.

Its outliers form the bold headlands which skirt the Golden Gate and adjacent waters to the north, and which bound the peninsula constituting Marin County. The spurs extending to the east reach the shores of the Bay of San Francisco, and inclose small alluvial valleys of great fertility and beauty. In some instances these valley lands are fringed by tidal marshes, in part reclaimed and under cultivation.

The top of the mountain breaks into three distinct peaks, each reaching an altitude of nearly half a mile above sea level, although bounded on three sides by tidal waters.

No land points visible from the summit, except those bounding the apparent horizon, reach equal or greater altitude. The mountain is therefore a marked feature from all parts of the area visible from its summit, which area has an extent of about eight thousand square miles.

The adjoined photographic reproduction of a portion of a relief map of the State gives a general idea of the adjacent land, bay, and ocean areas.

The westerly group of islands, opposite the Golden Gate, are the Farallones. The bold headland northwest of the Gate is Point Reyes; it protects from the north and northwest winds the anchorage known as Drake's Bay. The strip of water between the adjoining peninsula and the mainland is Tomales Bay.

The most westerly headland south of the Golden Gate is San Pedro Point, and the prominent headland farther south is Pescadero Point. The whole of San Francisco Bay is visible from Mount

Tamalpais, except a few sheltered nooks and portions behind islands.

The tidal area inside the Golden Gate is about seven hundred and forty square miles at high tide; this includes that portion which extends east of the Coast Range into the valley of California, and

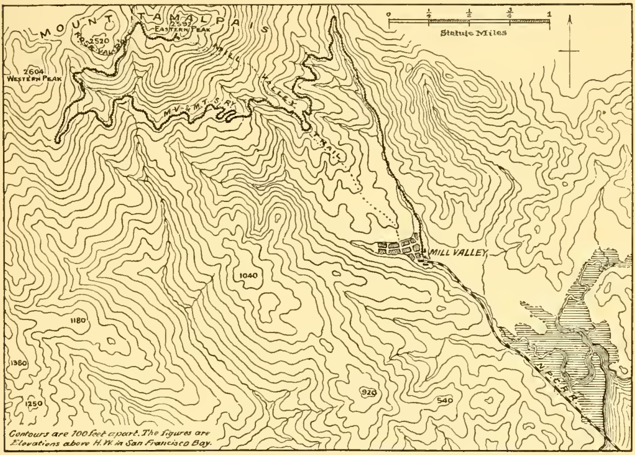
VICINITY OF THE GOLDEN GATE.

known as Suisun Bay; this bay is connected with San Francisco Bay through the Straits of Carquinez and San Pablo Bay. Emptying into Suisun Bay at its easterly end are the Sacramento and San Joaquin Rivers. Thus the tidal waters washing the base of Mount Tamalpais are connected with the interior valley of California, and tributary to them are about twelve hundred miles of navigable channels, tapping the central part of the State.

From the summit of this peak the eye sweeps the horizon of the Pacific Ocean for nearly one hundred and fifty degrees. To the northwest, north, and northeast lie Petaluma, Santa Rosa, Sonoma, and Napa Valleys, the view over these being bounded by the ridges inclosing them. To the east are the Straits of Carquinez, the outlet of the fifty-eight thousand square miles of drainage of the Sacramento and San Joaquin Rivers, and the only water gap in the entire perimeter.

From the east to the south lie the slopes of the Contra Costa Hills and the ranges bounding the drainage into the Bay of San Francisco, and including the Santa Clara Valley, thus embracing a magnificent view of the garden spots of California, and the cities and towns around the bay—the homes of about one third the population of the State. Three prominent peaks mark the limits of the land view: Mount Hamilton, the site of the Lick Observatory of the University of California; Mount Diablo, the base and meridian of the United States land surveys of central California; and Mount St. Helena, a volcanic peak the summit of which is common to Napa, Sonoma, and Lake Counties, and whose spurs are noted for their quicksilver mines, mineral and hot springs.

The plant life of the immediate Tamalpais region is abundant and interesting; the flowering plants are represented by about eighty orders, three hundred and fifty genera, and from seven to eight hundred species, of which about one hundred are trees and shrubs.* Some of the Sierra forms occur on Mount Tamalpais, and it is also the locus of the most southerly extension of certain boreal species. Owing to the wide range of temperature, moisture conditions, and exposures, many of these plants can be found in bloom during every week in the year. During the warm, moist



MAP SHOWING LOCATION OF RAILROAD FROM MILL VALLEY TO SUMMIT OF MOUNT TAMALPAIS.

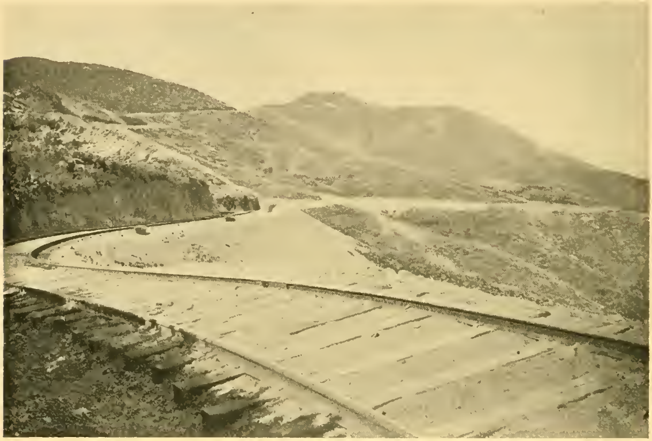
autumn and winter the hardiest species bloom from October to April in protected areas, and in the cold, exposed areas these same species require the heat of the season from April to September to bring them into bloom. Thus, within a radius of four or five miles from the summit there is not a week in the year when the flowers of certain species can not be gathered—this in face of the fact that

* Estimated by Miss Eastwood, curator of the Department of Botany of the California Academy of Sciences.

during the months of December, January, and February the summit may be covered with sleet or snow for a day or two at a time.

Mount Tamalpais is therefore a point of great interest to the sight-seer, the tourist, and the student of Nature.

Modes of reaching the Summit.—For many years a trail has existed from Mill Valley to the summit, and another from Ross



View of Summit from a Point Sixteen Hundred Feet above Tide.

Valley, both practicable for pack mules. Later the Ross Valley trail was improved so as to be practicable for light vehicles, but these did not answer the needs of the increasing travel, and in 1895 the Mill Valley and Mount Tamalpais Scenic Railway Company was organized. The purpose of this company was bold—to construct a traction railroad from tide level to the summit of a peak not two miles off and nearly half a mile high appeared visionary, if not impossible, to many. But with persevering skill a road was located upon a line 8.19 miles long, having an average grade of five and a half per cent and maximum grades of seven per cent, and overcoming 2,353 feet elevation in this distance. Four and nine tenths miles are curved, the minimum radius being seventy feet. Owing to the rough and ravine-cut topography, twenty-five trestles were necessary, the curvature and grade being maintained over these.

In order to reduce the cost of grading and to develop sufficient length to overcome the elevation, the grade contour was followed as closely as possible. The very short radius employed permitted this to be done without tunnels and with but two through cuts.

The accompanying map, prepared from the United States Coast and Geodetic charts and the maps and profiles of the company, gives a general idea of the location and main features. To the student of railroad location it forms an interesting exhibit of the extreme flexibility of railway location.

The rails are steel, fifty-seven pounds to the yard, laid to standard gauge upon the ordinary redwood ties in use on the Pacific coast. Grading, trestle work, and laying cost about $55,000. The entire road cost $136,746.44, or practically $16,700 per mile.

The equipment consists of one thirty-ton geared locomotive (Heisler), one twenty-ton geared locomotive (Shay), six open canopy-top observation cars, one half-closed passenger car, and two flat cars. Cost of equipment, $22,450.*

The locomotives and cars are very thoroughly provided with brakes: first, the Westinghouse automatic air brake; second, a water brake; and, third, a powerful hand brake to each locomotive and car. The efficiency of this equipment is attested in the opera-

View from Summit of Mount Tamalpais Hotel at Terminus.

tion of the road without accident or injury of any kind. The locomotives are always operated on the lower end of trains, and the maximum speed allowed is eight miles per hour.

The ride up the winding cañons and through the superb scenery traversed by this road is a treat of which one never tires. The

* The writer is indebted to the officers of the Mill Valley and Mount Tamalpais Scenic Railway for the above accurate statistics.

point of view, the direction, and the character of the landscape are continually changing. With no deep cuts, no tunnels, facing first one and then the other and finally all the points of the compass, sweeping around spurs, with distant views of land and sea, and near views of great beauty; then facing the steep sides of the mountain, its geology and flora affording interesting pictures; then over trestles with the branches of the bay, redwood, madroño, oak, and manzanita just out of reach—all these form beauties and attractions possessed by no other road known to the writer. A faint idea of the appearance of the road and of the scenery may be had from the appended photographs.

The Meteorological Station.—The advantages of Mount Tamalpais as a meteorological station have long been recognized, and

The Double Bow.

many efforts have been made to utilize them. It frequently projects many hundreds of feet above fogs which cover the adjacent shores, and during these periods one can look out upon an ocean of rolling, fleecy clouds which break upon the mountains around its base and visible from its summit. This freedom from obscuring conditions gives an opportunity to more freely observe and study meteorological phenomena, and caused the Weather Bureau to make a series of preliminary observations in 1897, and, these resulting favorably, a fully equipped permanent station was subsequently built. The results have fully equaled expectations. The advantages of the location may be briefly summarized as follows:

1. It is close to the coast line, and is so elevated that it is

not seriously affected by the local indraught of air through the Golden Gate and adjacent gaps in the Coast Range. This local indraught is a disturbing and often a misleading factor in all observations taken near and south of the Golden Gate for at least a score of miles. The elevated station on top of the peak eliminates the source of errors based upon observations at lower stations, and enables the forecast official to determine the effects of the local disturbances, and thus to give observations taken at or near sea level their true weight at the proper time.

2. No station in the United States has so full and free a projection into the lower third of the vapor-bearing stratum as has the station on this peak. No other station furnishes, as it does, an opportunity to study the distribution of vapor in the lower third of that stratum of the atmosphere, the physics of which is most important to human life and industries.

3. In studying the phenomena connected with the occurrence of fog, this station furnishes highly valuable data that could be obtained from no other; and, again, enables the student of weather lore to correct misleading impressions and deductions based upon observations taken below the one-thousand-foot contour above sea level.

On the 16th of June, 1899, the observations taken on Mount Tamalpais marked a difference of about thirty degrees in temperature over those around its base. In San Francisco, at Point Lobos and at Point Reyes, the temperature was down to 48°, while on Mount Tamalpais it was 79°, thus marking an approaching change in weather conditions, and giving the Weather Bureau the first opportunity of using the vertical temperature gradient in forecasting.

As a station for furnishing the data for a study of the problems of the physics of the atmosphere Mount Tamalpais is of further importance, as it stands near the easterly limits of the great area of high pressure which, during summer, lies over the North Pacific and which dominates the climatic phenomena of California for the greater portion of the year.

Stations on the Hawaiian Islands to the south and others on the Aleutian Islands to the north of this area of high pressure will still further aid in the solution of the great and vital problems now before meteorologists. These stations are the most reliable ones which can surround on three sides the two great "weather breeders"—the "summer high" and the "winter low" of the North Pacific.

INTERNATIONAL LAW AND THE PEACE CONFERENCE.

By JAMES HARRIS VICKERY, LL. B.

"In truth these 'cut-and-dried' schemes are of no value at all, unless as monuments of the mingled simplicity and ingenuity of their authors."—Lawrence.

THE view has been very generally entertained that all efforts to promote the cause of peace and order in the world by cut-and-dried schemes are bound to fail, and it must be admitted that few truer words have been written than those which stand at the head of this article. But this truth, like some others, may be abused. Evidences are not wanting to show that the incredulity which preceded the convening of the Peace Conference, the skepticism which marked its first sessions, and a certain want of faith which has since been manifested in various quarters in the practical value of the measures adopted, are all mainly due to a misapplication of this truth.

The measures formulated at The Hague do not constitute a "cut-and-dried scheme," but, on the contrary, they form an additional step in a natural, healthy, and orderly evolution of the forces of peace which have so effectively asserted themselves in the improvement of international relations during the latter half of this century.*

The Geneva Red Cross Rules.—The first matter to which attention will be invited is the extension of the Red Cross rules to naval warfare.

The Geneva Convention of 1864, which marks the beginning of the organization known as the Red Cross Society, inaugurated a vast and beneficent improvement in the then existing usage of nations as regarded the care of the sick and wounded in war. Its two salient features are the neutralization of the officers and forces of the society and the disabled soldiers under their care, and the establishment of a *system* to govern the conduct of its humane work.

At the dawn of modern international law during the first quarter of the seventeenth century not only the sick and wounded of a vanquished foe, but every prisoner, and even women and children, suffered to the fullest the indignities and cruelties incident to the rough warfare of the age; but the growth of mercy has softened

* For an excellent statement of the work of the Conference from the German point of view, see Die völkerrechtlichen Ergebnisse der Haager Conferenz, by Professor Zorn, of Königsberg, one of the German delegates, published in the Deutsche Rundschau, January *et seq.*

the asperities of war, and among the milestones that mark this advance toward a more humane usage the Red Cross Society holds an honored place. Under its rules the sick and wounded were no longer left to the irregular and capricious care of private benevolence, but were made the subject of organized and systematic treatment by a staff of skilled physicians and experienced nurses provided with hospital and ambulance facilities, and, thus equipped and assured the protection of both combatants, they were able to work effectively in their ministrations to the sick and dying.

Vast as was this progress from the days when at the siege of Acre the first real attention since the dark ages was given to the wounded by the Order of Teutonic Knights, there was still one serious imperfection that limited its sphere of usefulness—it did not apply to warfare on the seas. An effort had indeed been made in 1868 to extend the Red Cross rules to naval warfare, but it failed, and the wounded in conflicts on the sea continued to be left to the old provisions, which were necessarily inadequate and could not be exercised under the joint protection of the combatants. The virtue of the good Samaritan is a potent force, but to be fully effective on the field of battle it must be exercised under a common system established and maintained by the mutual consent of nations. It would, however, be a mistake to suppose that because the effort made in 1868 to extend these rules to sea warfare failed on account of their non-ratification, they were not sustained by public opinion. Many difficulties, especially those of a technical character, stood in the way; but public opinion was ever growing in their favor, and it eventually came to be regarded as an anomaly that while the care of the sick and wounded in land warfare had been regulated upon a common basis of international agreement, no similar provision existed for the care of the victims of naval combat. Without some such extension of the rules no adequate expression could be given to the growing humanity of the age.

For these reasons it will be obvious that the next step necessary in the further development of the Red Cross work consisted of its extension to naval warfare. The Peace Conference subjected the Convention of 1864 and the additional rules of 1868 to a careful examination, considered at length the difficulties in the way, and finally adopted a new series of rules providing for an organized staff of physicians and nurses, with hospital ships and life-saving appliances, which shall, without interfering with operations, be henceforth employed in naval engagements and enjoy the protection of both combatants.

The newly formulated rules, in conjunction with the previous ones relating to land warfare, are the practical embodiment of the growing feelings of humanity and mercy in the conduct of warfare which, commencing with the Peace of Westphalia, has been ever more and more effective in securing the evolution of a better usage.

The Brussels Rules.—So, too, with reference to the rules governing the conduct of armies in the field the work of the conference represents a sound and healthy evolution.

It may be remarked, by way of preface, that the old idea of war regarded hostilities as working the absolute interruption of all relations between belligerents, save those arising from force; it also regarded the enemy as a proper object of violence and depredation. Even in the time of Grotius the universal usage permitted the putting to death of all persons found in the enemy's territory, and in the terrible struggles of the Thirty Years' War in Germany and the Eighty Years' War in the Netherlands the story of the fate of men, women, and children at the hands of a conquering soldiery forms one of the darkest chapters in human history.

But while Grotius declared this to be the usage, he also took care to point out that considerations of justice and mercy dictate a better course, and he made a distinction between certain classes, declaring that justice requires the belligerent to spare those who have done no wrong to him, especially old men, priests, husbandmen, merchants, prisoners, women, and children. This merciful distinction was eagerly seized upon by his successors, who gradually developed out of it different rules for the treatment of the "combatant" and "non-combatant" portion of the enemy inhabitants. After the Peace of Westphalia in 1648, which marked the close of the great struggles that had so long convulsed Europe, the older and more brutal customs fell into disuse, and the theory that only so much stress should be put upon an enemy, and primarily upon the combatant portion, as was sufficient to destroy his power of resistance was substituted for it. Along with this new usage grew the ever-increasing rights of neutrals, among them being that of trade and commerce with the non-combatant portion of belligerent states, which has done so much to lighten the hardships of war suffered by those devoted to peaceful pursuits in the enemy's territory.

The next important step in this evolution belongs to the present century, and is due to the enlightened initiative of the United States. This step consisted in the preparation of a manual containing a code of rules for the conduct of land warfare. Keenly alive to the inevitable sufferings incident to the great civil conflict then being waged, Abraham Lincoln commissioned Francis Lieber to prepare a series of rules for the conduct of the armies of the republic in the field which should set bounds to the passions of the soldiery.* In pursuance of this commission, a code of rules was prepared and adopted which has since been known as Lieber's Manual; it was published in 1863, and proved a blessing to soldier and civilian alike. So obvious, indeed, were its good results that other nations rapidly followed the lead of the United States, and similar manuals were issued by Great Britain, France, Germany, Russia, and other powers.

But while Lieber's Manual was thus taken as the model by various nations, there were inevitably developed serious divergencies in the rules and details. Recognizing the desirability of a common code, which should be binding upon all nations, Alexander II of Russia attempted to secure the united action of the leading states, and, pursuant to his initiative, the Conference of Brussels was called in 1874. In the sessions of this conference the rules already developed were carefully examined, and ultimately a series of articles, well calculated to form the basis for an excellent international code, was adopted. As the delegates, however, had not been given plenary powers by their respective governments, their action was necessarily ineffective without subsequent ratification. Upon this rock the conference was wrecked, and the rules which it had formulated acquired no binding authority.

But indirectly they had a most happy effect, for they worked as a unifying influence in the preparation of subsequent manuals and the amendment of existing ones. The increasing interest in the subject thus stimulated led the Institute of International Law to give the matter still further thought, with the result that that eminent body of jurists in 1880 adopted a very full and excellent code, which gave evidence of much advance in the knowledge of the subject.

But neither the Brussels rules nor the code of the Institute of International Law possessed any binding authority, save in so far as they embodied generally accepted usage; their influence, however, increased the tendency in the direction of a common manual such as that which Alexander II had hoped to secure—a hope which has now been realized, and in a manner worthy of the subject. This logical step, too long delayed, is due to the Peace Conference. It devoted most careful consideration to the various codes, and has enriched, extended, and unified the rules and improved the whole by many valuable provisions suggested by the intervening experience. Altogether, the result is a splendid example of a natural evolution which, commencing with the distinction between "combatant" and "non-combatant" founded on the considerations of mercy and justice pleaded by Grotius, subsequently recognized

* See Pierantoni, Die Fortschritte des Völkerrechts im neunzehnten Jahrhundert.

in the Peace of Westphalia, increasingly practiced since then, and at the instance of Lincoln embodied in a manual, has now led to the adoption of a common international code for the conduct of future armies in the field—a result which marks the triumph in our day of the conception of civilized warfare tempered with mercy over the old idea of indiscriminate and inhuman slaughter.

The Sphere of Arbitration.—A matter that has given rise to much speculation is the *jurisdiction* of arbitral tribunals. It has come to be recognized that a distinction must be made between different classes of international disputes. What may be called "business disputes" between states, such as boundary lines, tariffs, damages, fishery claims, questions of citizenhip, and various treaty arrangements—like the most-favored nation clause—are all fit subjects for arbitration.* But the graver questions involving the consideration of national policy and aspirations, vital interests and honor, race and religious prejudices and passions, and last of all self-preservation, are, at least for the present, far beyond the competence of an arbitration tribunal.†

If the list of arbitral decisions hitherto given be examined it will show that questions of the first sort above are those which have thus far been submitted to judicial settlement.‡ It is therefore in harmony with past experience that the conference, in generally defining the scope of arbitration, declared it to be intended for the settlement of "questions of a juridical nature," especially the interpretation and application of international agreements upon the basis of respect for law.# The frequency of these "business questions" is on the increase; they seriously embarrass diplomatic representatives, whose proper duty is the conduct of graver matters of policy, and there is a growing disposition to submit them to legal settlement. Under these circumstances, there is little doubt that

* See Essai sur l'Organisation de l'Arbitrage International, by M. Descamps, p. 24.

† The Transvaal War pertinently illustrates the prevailing want of knowledge regarding the true sphere of arbitration. Ever since the outbreak of war the Continental press and some American papers have been asking why the provisions of the Peace Conference are not put in operation. Much of this is due to anglophobia; much to a genuine ignorance of the matter. The treatment of the subject usually takes the form of an antithesis in which Great Britain as a peace power at the conference is contrasted with Greater Britain making war on a little republic, and this is invariably followed with a statement or inference that the Peace Conference was a huge farce, and the Permanent Court a dire failure. It is now quite plain that the root of the difficulty between England and the Transvaal was not the franchise nor the dynamite monopoly, but English *versus* Dutch predominancy in the whole of South Africa, and therefore a grave clash of two opposing policies, involving the deepest questions of interest and even self-preservation. Regarding these questions the conference was unanimous in the opinion that they are entirely outside the sphere of arbitrable question.

‡ See especially the list given in the back of Darby's International Tribunals, p. 286.

See Article XV of the Convention.

the time has come when the system of special temporary courts of arbitration, splendid as their work has been, must give way to a more adequate system—they were indeed but stepping stones to a more permanent organization. Under the old system each power was likely to wait for the other to take the initiative; then came a squabble as to just how much and what part of the difficulty should be submitted to arbitration, then a squabble about judges, then a squabble about procedure, place of trial, and so on—all was unpreparedness, uncertainty, and meantime angry passions had full play.

In the preparation for war the modern state lays no end of force on the necessity for a rapid and systematic mobilization. The weak point, however, in preparing for a judicial contest hitherto has been the absence of any system by which to "mobilize judges and counsel" and get the legal forces out into the field. To attain this end the scheme presented by Lord Pauncefote and unanimously adopted by the conference will be found to be a most striking example of the happy adaptation of a means to an end where the way seemed blocked by infinite difficulties. It consists of a few simple provisions for the establishment of an International Bureau of Arbitration with an Administrative Council, and this, with the addition of various other features drawn from the United States, Russia, France, and Italy, with some others, constitutes the composite plan embodied in the Final Act. In brief outline it is as follows:

PERMANENT COURT OF ARBITRATION.—The diplomatic representatives of the signatory powers accredited to The Hague, including the Netherlands Minister of Foreign Affairs as president,* are to constitute an administrative council. This council shall organize and establish an International Bureau of Arbitration, of which it shall retain the direction and control, pursuant to the provisions of the conference. This bureau shall serve as the office of the court, and contain the archives, and the routine business shall be conducted therein. The signatory powers will each appoint four persons, who shall be men of recognized ability in international law and of high character, and the whole number of persons so appointed shall form a list or panel of members of the court, or the international bench. In case of a difficulty arising between two or more powers which they desire to submit to arbitration, they agree to notify the bureau, and the bureau will ask them to choose a certain number of judges from the panel, and these shall constitute the special bench.† An agreement is then to be drawn

* The amendment to Lord Pauncefote's plan, by which the Dutch Foreign Minister was made the president, is due to Mr. White, President of the American Commission.

† In case states, between whom a dispute may arise, do not of their own accord have recourse to the tribunal, Section 27 permits the powers to remind such states that the Per-

up stating the object of the litigation and the powers of the arbitrators. This agreement implies the engagement of the parties to submit in good faith to the sentence.

Arbitral Procedure.—For the purpose of promoting the development of arbitration certain simple rules are formulated. The powers will appoint special agents, who shall be intermediaries between them and the tribunal; they will also appoint counsel. The proceedings consist first of *instruction*—communications by the agents and counsel to the tribunal and the opposing party, of the pleadings, etc.; and, secondly, of *argument*—the oral development of the pleadings. The argument being closed, the bench shall deliberate in secret, and a decision is to be reached by a majority vote. The decision shall be written, and is to contain the reasons of law and fact upon which it is based. In case of disagreement, the dissenting opinion shall also be written and contain the reasons therefor; the signature of each member is to be added to his opinion. Subsequently the decision is to be read in open session, in the presence of the agents and counsel of the parties.

To sum up: it contains all the essentials; it is immediately available, provided with a permanent office, with officials, with a code of procedure, with directions for the commencement of proceedings, the presentation of cases, the taking of evidence by an International Commission of Inquiry, the oral explanation and argument of the printed case, the pronouncement of sentence in open court, the recording of such decision, the subsequent rectification of an error therein on the discovery of new and important facts of a decisive character, and the preservation of the records.*

Basis for Future Evolution.—With these essentials there is a basis for a future evolution until the court shall have become as perfect in its organization and details as the High Courts of Justice in England or the Supreme Court of the United States.

It may not be amiss here to suggest the influence which the permanent tribunal is calculated to exercise in the future development of international law. The provision for a permanent bureau or record office, in which the archives shall be kept, is sure to prove a valuable condition for future growth, for the deposit in such bureau of all arbitral decisions will mark the true beginning of what we may call "International Law Reports." To this bureau the powers undertake to send certified copies of all special

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manent Court is open to them, and the giving of this reminder is declared to be a duty in the superior interests of peace, and is to be regarded only as an exercise of "good offices." To this section the United States agreed on condition that its consent should not be regarded as a departure from the well-known principles underlying the foreign policy of the Republic.

* See Articles XV to LVII of the Convention.

arbitration agreements, whether embodied in treaties or otherwise; to it also will be sent the result of all special arbitrations hereafter resorted to, and in it will be deposited the papers, pleadings, and other documents, and especially the decisions of the permanent court, as well as those of any special courts which may hereafter be created from time to time. These archives will thus furnish a wealth of material not locked up or available only by jurists of the particular state where they may happen to be situated, as has too often been the case heretofore, but accessible alike to the great text writers and commentators of all nations. The criticisms and opinions of eminent text writers have heretofore been of great value in the improvement of international law, and under these new and more favorable conditions their influence should be even more beneficial in the future.

To the works of text writers will in future be added the able discussions of counsel and the learned opinions of judges handed down in writing, with the reasons upon which they are founded.* Where rules and usages are becoming obsolete or obviously hostile to the growth of opinion, international judges may feel themselves bound for a time by them and give their decisions accordingly, but they may embody in their written decisions an *obiter dictum* which shall prove the death knell of the old rule and the establishment of a healthier one. Many are the wholesome changes that have thus been wrought in English " judge-made law " as the direct result of learned and convincing *obiter dicta.*

The interest which will thus be stimulated in the whole subject of international law will promote its study in all nations. Hitherto this branch of legal education has been rather slighted; not being regarded as essential to the ordinary practitioner, it has been neglected for the petty provisions of some state code or involved corporation law, but the influences already at work in favor of a more thorough and scholarly study of this branch will be effectively aided under the new conditions.

Though the law of nations should be uniform in all countries, a comparison of the leading works in different countries, English and German for instance, will reveal many differences partly traceable to the particular system of law in which the author was grounded, and in part to his peculiar "judicial instinct." It is not often that one finds an English or American lawyer thoroughly grounded in the Roman system and the modern Continental systems founded upon it; quite as rare is it to find a Continental lawyer learned in the system of English jurisprudence. There have

* For an admirable example, see the published proceedings of the Paris Tribunal in the Venezuelan case.

been such men, as, for example, Rudolf Gneist, whose great work on English Constitutional Law and History has become a classic. But, as a rule, there is among text writers on this branch of law and among the eminent jurists who have hitherto been connected with international tribunals much "provincialism in thought and conception," if the phrase may be allowed, and to overcome it the future jurists who shall take part in international contests before the high tribunal of the nations will require to be more thoroughly grounded in the history and evolution of law in general and in the study of comparative law, both private and public, in particular, than their predecessors have been.* In this connection it is not too much to hope that the unifying influence of an international tribunal will eventually exercise a good effect in promoting the solution of various perplexing problems on the private side of international law, or what is known as "conflict of laws."

Having indicated some directions in which the growth of international law will be likely to be promoted by the tribunal, the question suggests itself whether the jurisdiction of the international court will eventually be enlarged beyond the scope at present contemplated by the Convention of The Hague. Will the time ever come when such a court shall take cognizance of various matters which now lie without the sphere of "business disputes and questions of a juridical nature" and within that of essential interests, honor, race, and religious policies and ideals? The statement, which is sometimes heard, that such will never be the case, does not seem warranted when we regard the growth of law in general, and indeed the development of this particular branch of it, in the past, but it is safe to say that the time is a long way off; it will depend on many things: the efficiency of the court itself, the continued growth of neutral rights, the increasing necessity for preserving international peace, and the infinite forces which have tended to widen the jurisdiction of municipal law.†

In the growth of systems of "National Law" ‡ there has been evolved from small beginnings an ever-widening jurisdiction. Impartial courts have inspired confidence which stimulated individuals to seek their aid, and this has reacted to extend their jurisdiction, until now the most intimate and complex relations between individuals, at one time wholly without their sphere, are in these days submitted as a matter of course to judicial settlement. Even questions of individual honor are settled according to the well-developed

* As evidence of increased attention to this matter in Germany, see Wertheim, Wörterbuch des Englischen Rechts.

† See Le Droit de la Paix, by M. Descamps.

‡ In contradistinction to "International Law."

principles of libel and slander which were once considered as requiring a duel for their satisfaction.

A similar growth may be expected in the jurisdiction of the international tribunal. Upon the reputation which it shall succeed in establishing for impartiality, freedom from race and national prejudices, regard for broad principles of law and equity, and the thoroughness and ability with which it shall discharge its high duties within its present sphere, will largely depend the extent to which an advancing public opinion will enlarge its jurisdiction until it shall embrace various classes of questions now declared non-arbitrable. No detailed classification, however, can be thought of; each difficulty as it arises must be determined in view of the surrounding circumstances with due regard to the growing public feeling in favor of judicial settlement. Under the system of voluntary arbitration there is abundant room for growth, for the *onus* will be thrown on each contending state to square its conduct with that growing feeling in favor of arbitration which it will become more and more difficult to ignore. In every country the growth of law and the extension of the jurisdiction of the courts which administered it have been concurrent; the same rule must govern in the field of international law.

There are vast fields at present untouched by the law of nations. The discovery of the New World threw the jurists of that day into bewilderment as to how rights in the American continents might be acquired and established. A period of doubt and dispute ensued, until finally Grotius, by applying certain rules of Roman law regarding the acquirement of rights by individuals through purchase, possession, etc., and by inventing certain other rules, helped to supply a legal foundation upon which the acquisition of these territories could be regulated. Looking toward the future, one can see that, since there are no more continents to be discovered and the habitable parts of the earth have been already taken possession of by the colonial pioneer, the great principle of the survival of the fittest must henceforth mainly work itself out in competitions confined to the existing territories of the various powers. This will necessitate the consideration of some deep questions concerning the life and death of nations and the heirship to their dominions.*

It is widely believed, for instance, that China is dying a natural death. Assuming it to be the fact, what will be the rules to govern the inheritance of these Oriental domains? Great Britain, Russia, Germany, the United States, and other nations have acquired footholds and established interests within Chinese territory.

* *Vide* Contuzzi, Leggi di Composizioni e di Decomposizioni degli Stati.

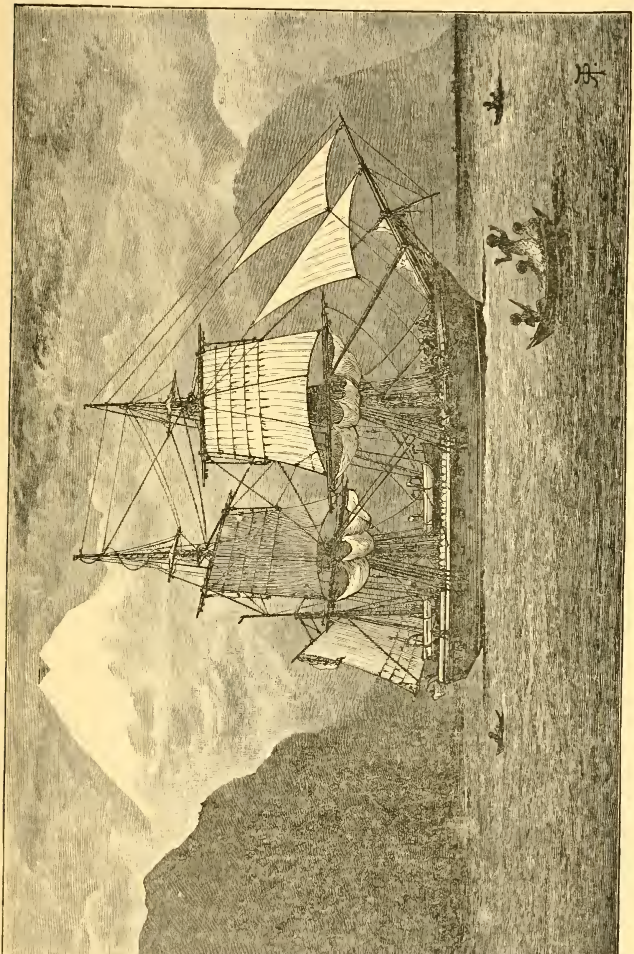
Disputes will inevitably arise between them; many will be settled by mutual compromise in which, perhaps, the chief consideration will be the amount of warlike force behind the arguments advanced; many others will be sure to find their way to an arbitral tribunal, and before that body arguments will be made and by that body decisions will be handed down embracing principles not now to be found in the books, but which the circumstances of the case and the demands of justice require. And so will doubtless ensue a growth of "international judge-made law and equity" which will gradually work an extension of the arbitral jurisdiction into fields at present unknown to the law of nations. One thing is certain: the law so developed must not, on the one hand, be in conflict with the Grotian doctrine of the equality of states as rightly understood, nor, on the other, with that great all-pervading law of the survival of the fittest—a law which determines the destinies of men and nations alike.

THE FATE OF THE BEAGLE.

By the Rev. V. MARSHALL LAW.

ON the 27th of December, 1831, his Majesty's ship Beagle, a ten-gun brig, under the command of Captain Fitz Roy, R. N., sailed from Devonport, England, on an expedition the purpose of which was to complete a survey of Patagonia and Tierra del Fuego that had been begun under Captain King (1826–'30); to survey the shores of Chile and Peru, and of some islands in the Pacific; and to carry a chain of chronometrical measurements round the world. The voyage was one of the most memorable ones in the annals of scientific exploration, for, besides the direct results, which, in the condition of geography and natural history at the time, constituted very important additions to knowledge, it carried Charles Darwin, then young and full of the enthusiasm for study that never left him. Mr. Darwin accompanied the expedition on the invitation of its commander, Captain Fitz Roy, and with the special sanction of the Lords of the Admiralty, and, as it turned out, next to the captain of the vessel was perhaps the most important member of it. He made it his special business to inquire into the character and method and the reason of all the natural objects and phenomena he saw, examining what was in the sea while they were upon it, and, when they landed, going ashore and studying the geography and geology and life of the region as thoroughly as the time of stay would permit, and collecting no end of notes and specimens as material for future study.

Besides his elaborate work giving the full story of the expedition and the details of its scientific results—a book which has ever



H. M. S. Beagle in the Straits of Magellan. Mount Sarmiento in the Distance.

since been a standard authority, and still keeps students in active discussion and investigation—the voyage of the Beagle has to be credited with having supplied the occasion for the composition of the briefer and more popular account which has become one of the classics of English literature.

More than this, and vastly transcending it in the importance of its bearing on the future of science, it was while going round the world and observing on the Beagle that those fundamental facts were gathered and stored in Mr. Darwin's mind which, worked over and developed in after years and compared and combined with subsequently accumulated facts, bore fruit in the Origin of Species and the transformation of science that resulted upon the enunciation of Mr. Darwin's theory of descent.

We all regard the association of any object with great events or with those in which we have great interest as making it precious. We endow ships with a kind of personality, regard them affectionately, and often speak of them fondly, as if they were real living beings in whom we had an interest. Such feelings we might legitimately entertain with regard to the Beagle, so closely associated with the history we have referred to. Few associations deserve, in fact, to be more highly valued than that of this brig, the Beagle, with Mr. Darwin's books and his theory. It is therefore a matter of legitimate concern to inquire into what was the fate of the famous vessel.

The inquiry has been made, and is answered by the Rev. V. Marshall Law, of Oakland, Cal., whose account follows:

"I was lying in my room, in Tsukiji, as I had been day after day, in 1890, watching the lazy roll of the school-ship in the Imperial Naval Academy, just a little to the south, when a caller and an old resident, Mr. Arthur Morris, said to me, 'I see you have Darwin's old ship, the Beagle, in plain sight out there.'

"'Is that the Beagle?' I asked in great surprise.

"He assured me that it was, and somehow after he had gone it impressed itself more strongly on my mind the more I thought of it. I lay ill, and part of the time in delirium, for ten days. When I at last got up, the Beagle was gone. I sent inquiries to the Naval Academy, but no one seemed to know anything about her. As soon as I was able to go out, I lost no time in setting on foot inquiries of the whereabouts of the missing ship. I finally learned that she had probably gone to the Imperial Navy Yard in Yokosuka, about thirty miles from Tokio. As soon as I was able to travel we started to go to Yokosuka in search of the missing vessel. Before this, however, I had taken the precaution to put on the track the Englishman, Mr. F. W. Hammond, who taught the young Japanese gunnery in the Imperial Naval Academy at Tokio, and he promised to do all in his power—which in this instance was very great—to help me in my search for the

Beagle. To aid him, I gave him the following list of questions, to which he sent me the answers given below months afterward. My questions had gone through the regular naval channels. The answers show how methodical the Japanese are, even if they are slow. In these answers I use their language:

" 'Question. How did the Japanese Government happen to get the Beagle?'

" 'Answer. The details of getting are not plainly known, but the Prince of Kagoshima procured it on seventy-five thousand dollars, at the 23d of July, first year of Genzi (1860), afterward he offered it to the Government at the June of the third year of Genzi.'

" 'Q. Are there any good photographs of her as she was when a war ship?'

" 'A. No, we have no one.'

" 'Q. Where is the Beagle now?'

" 'A. After out of use, she was applied as a Chastising Place for seamen at the Yokosuka station, and then was auctioned at the March, twenty-second year of Genzi.'

" 'Q. What was the date of her arrival in Japan?'

" 'A. She was received by the Prince of Kagoshima, at Nagasaki, July, the first year of Genzi.'

" 'Q. What is her present name? When was her name changed?'

" 'A. At the present this ship has no name in the consequence of out of use, but after procured by the Kagoshima Prince the name of Beagle was changed into Kenko Kan.'

" 'Q. Do you know how old this ship is, and what she was used for by the British Government before the Japanese got her?'

" 'A. She was actually used during twenty-three years, after which she was put out of use, having been constructed at Liverpool, and we can not know what she was applied for before got by Japan, but she remained more or less than one year in England.' (Darwin made his famous voyage in her from 1831 to 1836.)

" 'Q. What is the name of the captain who had charge of her after she became the property of the Japanese Government?'

" 'A. Commander Sadakumi Shiba was appointed the acting captain February, 2d year of Genzi; Commander S. Hamataki, from December, 5th year of Genzi; Commander M. Omura, from November, 10th year of Genzi; Commander Sadakumi Shiba, from December, 11th year of Genzi; then the last was dismissed on the September, in the 14th year of Genzi.'

" 'Q. In what capacity did the Japanese Government use her from the time she arrived up to the time she was dismantled?'

"'A. She was rated as the fifth class at the November, 4th year of Genzi, then the fourth class May the 8th year.'

"We found Yokosuka, and our party were shown every courtesy by the Japanese naval officials; so at last we ran down the Beagle, lying on the shore and showing not a vestige of her proud, historic self. She was being torn to pieces, and the parts were sold for 'old junk.'

"I reflected, as I stood among her spars and chains, her anchors and her capstan, of the significance of the career of the famous vessel, and of her associations with the man whose investigations revolutionized scientific thought and spread consternation for a time in the pulpits of the world. The attitude of these pulpits has been modified by reason of those researches, and the blessings of the world and of the Church now follow the author of them for having shown the way to a juster and more rational conception of the power and purposes of the Creator."

SCIENCE STUDY AND NATIONAL CHARACTER.

By ALBERT B. CROWE.

UNTIL very recently it had come to be a commonly accepted view in America that the civilization of a nation is directly proportional to the amount it expends for education, and inversely proportional to the amount it expends for war. The budgets of European countries have given Americans good reason to accept this standard, since its application gave the most gratifying evidence of our great intellectual and moral advancement. Less than three years ago the President of the National Educational Association proudly exclaimed: "England, six to one for war; Russia, thirty-eight to one for war; America, four to one for education!"

Since that time our country has become involved in war projects, from which we can hardly hope it will withdraw, that have increased our expenditure for war four times, and a policy has been inaugurated which, if persisted in, will certainly almost at once reverse our boasted ratio, making it "four to one for war"! This course has been supported by a great body of our people. Even our Christian ministers have committed "The White Man's Burden" to memory, and breathe never a whisper of the sixth commandment. If, as has been held by all wise and good men, the victories of peace are more worthy to be sung than those of war; if the ability to avoid quarrels or to settle them without force of arms is nobler than that which achieves military success; if true enlightenment and education make for peace and not for war, then our law of direct and inverse proportion has lately been scandalously dishonored.

If we have expended so much for education and at the same time have lowered our ideal of national greatness, something must be wrong with that education. If the sharpening and quickening of the intellect are accompanied by a blunting and atrophy of the moral sense, the best and the worst thing that can be said of our school system is that it gives daily rations to hundreds of thousands of teachers. Evidence of disease of the national conscience must raise in the minds of thoughtful men grave doubts as to the sufficiency of our education to "insure national progress, prosperity, and honor," whether because of inherent weakness of the system or because of the strength of the forces opposed to it.

Has our system of education, then, failed to elevate our national character? He who would answer this question in the affirmative would be a pessimist indeed. Incalculable "general good" has come to us, we think, by the agency of our schools. Without them our civilization could not be so far advanced as it is; our national life might have ended long since. In every crisis, however black has been the storm, however fierce and ominous the lightning flash, there has followed in good time the gentle rain, soothing and allaying our fear, and giving renewed promise of prosperity and peace. It is the sober second thought, we are in the habit of saying, which saves us, which takes the helm and sheers us away from the half-hidden reefs in our first mad course. It is not. It is the sober first thought which has redeemed us from destruction time after time—the sober first thought of the few who are truly educated, who have looked below the surface of things and considered the hidden and obscure results, who have weighed the right and wrong and stood immovable for the right. It is the counsel of such men which has fallen like the rain that follows the first bursting of the storm, and has given us courage and power to restrain ourselves and to face our hardest duty. For such men in our national affairs we may reverently offer thanks, and for an educational system which is partly, at least, responsible for them we may have sincere praise. But our safety must always depend upon the presence of such men, strong enough in numbers and in influence to control each difficult and dangerous situation which may threaten us. Our work as teachers is not faithful if we do not increase this number and strengthen this influence. And if such men have been overpowered in the important events of the past two years, if they have been entirely ignored, or if they have been taunted and ridiculed, we have reached a dangerous crisis, and our sacred duty is to stop and take our bearings. If we have manifested certain national traits hitherto scarcely suspected, and now unwillingly confessed, every motive of patriotism and of prudence should impel us to study our case, that we may effectively prescribe for it.

Are there not, then, certain signs which we may all agree are discernible? Have not the waves of powerful feeling which have swept over us, the storms of acrimonious debate which have raged in our papers and forums, the pæans of praise which we have chanted at our "peace jubilees" and hero parties, revealed the prevalence and rapid growth of certain sentiments which we may all, without regard to political belief, clearly recognize? I do not in this place raise the question of the political wisdom or simple justice of the course which the country has taken in its international relations. I do not now challenge any belief as to these matters which has been formed thoughtfully, honestly, manfully; but I do maintain that the past few months have left lessons for thoughtful, honest men to unite in studying.

Probably the most striking phenomenon which we have witnessed has been the tremendous display of excited feeling. However careful our national leaders may have been, however honest in basing their actions on what they considered sufficient information, or however careless and dishonest, no man who has read any considerable number of our papers, who has listened to the clamor of the crowds, can doubt that the force of blind passion has been in hundreds of thousands of men the dominant force. If during the war with Spain you stood in the cheering, surging crowds before the bulletin boards, if you heard storms of hisses greet the name of the innocent boy-King of Spain, or noted the cheer of triumph which applauded the capture of a lumber scow by an armored cruiser, you will have no difficulty in agreeing with me. You will smile at the idea of imputing to such men the credit of serious thought. On the birthday of the greatest American, whose life was a message of liberty—"who," said a great Spanish orator, "laid down his life at the foot of his finished work"—our papers printed jokes about the mistake of the Filipinos in trying to fight Uncle Sam, and in our cities, at least, the report of their slaughter was received with exultation. Whether they were civilized or not, whether they were misled or not, whether they were ignorant of America's carefully concealed intention or not, the killing of thousands of men who thought they were fighting for their freedom, who faced machine guns, and who crawled away into the bushes to die for the cause for which they had fought, is hardly a subject for jokes or for exultation, when people are governed by reason and not by feeling alone. When the Maine was sunk in Havana Harbor her captain, in a notable dispatch telling of the disaster, urged a suspension of judgment until the facts should be known. Facts! In an hour our battle-cry was, "Remember the Maine!" Under that motto, within a few days, one of the great Chicago dailies (the Inter-Ocean) hung out the pennant of the wrecked battle ship and enlistment signs. Who was right—the Maine's captain or the paper? Which appeal meant safety, and which danger? Our own commission investigated the wreck. After an examination, which was kept entirely within our own hands, the commission reported that the ship had been destroyed from the outside, but that there was no evidence to fix the responsibility. Did we fix the responsibility? Though the investigation board could find no evidence, though reason said that the destroyer of the Maine, were he Spain's own king, was Spain's worst enemy, we forgot the cause of deliverance, and went into battle with the cry of vengeance on our lips. This is not a statement of sentiment but of fact. Your motives, or the President's, or mine may have been pure—your opinion may have been unprejudiced—but these things around us we all saw and all heard. We know that many men were carried away by their feelings, and did not think. We know that their feelings grew into a prejudice which was absolutely certain to distort the facts and to drive them far from the truth if they ever came to the point of thinking. The ears of the multitude have been closed to all counsels, however wise; their eyes to all consequences, however fatal; their minds to all logic, however clear and simple.

We may consider more briefly, but not less carefully, other tendencies which have been shown, seeing many of them in the facts which have already been referred to.

From the fact that passion has so largely supplanted reason in moving many of our people we have developed some wonderful instances of credulity. The sequence is most natural. When men become unwilling, or uncaring, to ascertain the truth for themselves they inevitably display a great willingness to swallow any statement which may obligingly be offered them by some one else. So, with half of the Spanish navy sunk and the other half accounted for, we spent hours of glorious, wild conjecture, in the dear dead days beyond recall, listening to the awful sound of cannonading in the Windward Passage, which reached us by the way of Mole St. Nicholas. We believe what is sufficiently exciting to be true.

Related to the phenomena we have noticed is another—the evident loss of individuality—of moral and mental independence.

How striking is it to compare some of our newspaper editorials of to-day with those of two years ago in the same papers, and to see how their writers have been dragged, step by step, into line with those whom they formerly opposed! They have not changed their faith; they have deserted it. For them there is the defense of business necessity; but if you will to-day talk to many men who gave you their opinions a few months ago, you will find that they have broken down and given up—surrendered to superior numbers. In our bulletin crowds we have all seen the spirit of the mob, which meets the newcomer indifferent or doubtful, thrills him with the mysterious influence of the men packed around and against him, and sends him away an irresponsible monomaniac.

With such forces at work, it is inevitable that we should act, or be ready to act, quickly. Why not? Reflection takes time. To learn the facts fully and certainly takes time. To feel—how long? To take another man's word—how long? To give way to a thousand other men—how long? We have all seen men cheering our war with Spain only yesterday. To-day Austria seems friendly to the queen regent. We'll whip Austria, too. To-morrow Germany is impudent to Dewey. We shall be ready by night to whip Germany. If Europe combines against us, how long shall we consider the cost of such a war as that? Write it on the bulletin board—the crowd will be ready before the writing is done.

Near to this is the spirit of fickleness, of inconstancy, which has been frequently manifested. We have not only made up our minds on insufficient evidence, but we have unmade them in a hurry on no evidence at all, showing a startling lack of confidence in our own judgments and of respect for them. Attention might well have been called, in a former paragraph, to the small amount of our real knowledge of the character of Aguinaldo. On what petty and inconsequential evidence have we first called him a great liberator, and now a scheming politician! Men who could hardly read his most remarkable appeal to this country do not hesitate to call him an unprincipled, conceited, ignorant barbarian: what reliable information have they received with reference to his motives? They have found no trouble in changing their opinions. In the past few months we have been mercurial almost beyond mercurial Frenchmen. Think of the revulsion of feeling that followed Hobson across the continent; and, more recently, of our sad lack of self-restraint shown by the vicious and ungrounded attack upon Admiral Dewey, only a few days after he had been the object of the greatest display of hero worship America has ever seen. And how many important changes may we count, if we carry back our comparison to the time before the war?

But by so doing we uncover another significant fact. We find that many of the ideas so quickly thrown aside are those which have been the foundation principles, and bear the prestige of great names. We have held it our special mission to show to warlike nations that a power which stands for peace may be greater than theirs; and, alas! many of our leaders, and our people, too, are crying that the time has come—has *now* come—for us to take our place among the great nations of the earth. We have pitied the war-taxed peoples of Europe, and offered them a home where they would not have to buy powder and guns. And now we are eagerly rushing to take up the burden from which they have been fleeing to us. We have held that great standing armies are unnecessary and dangerous, and already we have quadrupled ours. We have declared our determination to avoid foreign entanglements, and now we are in the very heart of the sputtering coil in the far East. With those who have thoughtfully decided that these changes have been necessary or wise I have no wish to debate now, but we must all unite in recognizing the spirit which has been shown, and is now shown, in speaking of our past positions. The principles which for years have been our rules of national conduct have been thrown aside in a day, scoffed at, mocked. And we smile at the names of the great men who have announced those principles and defended them, or we flatly declare they are out of date. We once listened with reverent and full hearts when our wise men spoke to us of freedom, and recalled our national traditions and taught national righteousness. Now we laugh at swaddling clothes outgrown, out-used, and smile at the innocent simplicity of our fathers. We lift our brows at the name of Washington: we say he was a fine old gentleman, and his Farewell Address, considering everything, was a very creditable paper, and well adapted to the exigencies of the time in which it was written. And this carnival of irreverence is holding not only in our streets, but in our newspaper offices, in our pulpits, and in some of our higher institutions of learning.

These are the phenomena of our recent national experience which I desire you to consider. There may be other unfavorable indications. There may be others, and many more, which are hopeful and encouraging. But these clearly warn us of danger. Furthermore, I insist that whatever may have been your sympathy with the Administration, or your opposition to it; however numerous the men of your acquaintance who have been free from such influences, you must have seen them at work in a dangerously large part of our population. Even if that part has, in your judgment, reached the right position, you must recognize the ominous character of their method of reaching it.

Now, what has this to do with us? What connection has it with our work? If science teaching has any educational value, the most definite and direct connection. I shall not do you the injustice of supposing that any tendency I have named did not at once bear to you its proper suggestion. If it has failed, the fault has been in the presentation of a very simple matter. For every perilous tendency I have mentioned has its life in direct violation of the essential principles of science study, and may be restrained by extending the knowledge and habitual use of those principles.

I do not wish to claim for science work an unwarranted value in this respect, nor to deny the influence of other subjects in bringing about a moral evolution. It is true that history warns us by examples, that it points us to the failure of free governments in whose steps to destruction many of us seem only too willing to follow. It is true that we can learn from Rome the results of imperialism; from France, of irreverence; from Spain, of tyranny. In other fields of learning we may find other lessons of present value. But to meet the dangers that just now assail us, the national weaknesses that I have enumerated, the scientific studies seem especially fitted.

"The great peculiarity of scientific training," says Huxley, "that in virtue of which it can not be replaced by any other discipline whatsoever, is the bringing of the mind directly into contact with fact, and practicing the intellect in the completest form of induction—that is to say, in drawing conclusions from particular facts made known by immediate observation of Nature." "The bringing of the mind into contact with fact." This means the recognition of the existence of incontrovertible truth. The dawning knowledge of such truth must bring with it the consciousness that much that we have always accepted as truth is open to question. Thus every belief, no matter what its nature, is in time subjected to examination. If it stand, it stands because it is able to bear this searching scrutiny and to answer fairly the questions of honest doubt. Honest doubt may be the result of honest reasoning; it must absolutely demand honest reasoning to satisfy it. This exercise of the rational faculty, then, depends upon and results from an awakened love of truth. How directly do these most obvious principles of scientific investigation bear upon the facts we have been considering! How flatly do they forbid us to be carried away into excesses! Let us apply them briefly, point by point.

If love of truth and appeal to reason mean anything at all, they mean, first of all, eternal opposition to the power of unthinking passion—of blind feeling. They mean that every sentiment should have a rational cause and a reasonable object. They do not forbid feeling, but they require thinking.

Secondly, they defy prejudice. They call for the open court, the fair trial, the impartial judge. They say "No" to worthless witnesses and to packed juries.

Thirdly, they demand a sufficient amount of evidence. True science is the enemy of wildcat theories and reckless generalizations. "The United States has always come out on top in every war!" cries one. "There's no danger that we'll ever be whipped." "I don't like foreigners," says another. "I had a Frenchman for a neighbor once, and he was dishonest. I'm in favor of shutting out foreigners." Such reasoning as this—and how astoundingly common it is!—must be cut down at the root by the habit of trained induction.

Fourthly, the love of truth and appeal to reason, which are in the very grain of the scientific mind and heart, laugh at credulity. They do not scoff at authority, or reject it. But they say: "We must know. If we learn from you, we must know that you know. Who are you? How do you know? If you know, you will not offer us absurd contradictions of reason and accepted truth."

Again, they make their abode with the man who can receive them at his own intellectual fireside. They require that his mind be his own, that his opinions be his own, that his acts be his own, and that he defend his property in them, have pride in them, and stand by them.

Again, they demand sufficient time for care, for securing the evidence and for weighing it, and for considering its effect. They demand the completed work, and they reject all results which do not come from time employed, but are hasty guesses.

And they are not tossed about like a wave of the sea. They do command to prove all things, but they also exhort to hold fast that which is good. First, to what is good of our own and in ourselves. It is well enough to throw away our guesses, quickly made and often wrong. But the fruit of honest investigation, the conclusions of careful reasoning on sufficient information, these are the science student's riches. He may add to them or replace some of them by better, but he will not throw them away at a suggestion, or trade them to the first speculator who offers something else. He will not have a supply of new beliefs for every day, or for every month, or for every year. Second, we should hold fast the proved good which we have received from others. And we should honor and revere those who have opened the way for us to the truth—those who have above other men possessed the power of reason and beneficently used it for the world. The spirit of science, which sets infinite value on knowledge, can not fail to teach reverence for those who have made it possible for us to know.

At every point, then, the scientist opposes the tendencies I have deplored. Against them all he must stand, by training and by instinct. Against them all he would teach others to stand, by giving to them his own training. Against them all we science teachers may arm our countrymen if we are faithful to our duty. But this end of our work is defeated if our students are allowed to indulge in careless statements of what they see and do; if they are permitted to use exaggerated description or inaccurate terms. Right here is the crucial test of the teacher's honesty of purpose. The careful examination of written descriptions and reports, the enforced correction of every inaccurate detail, the personal consultation—all require untiring labor, and time never allotted in the schedule. But such work carried out has its own reward. The student first respects the truth, then learns to love it. He conscientiously avoids the vague, the doubtful, the unsubstantiated. If in our schools we might insure to every boy and girl this attitude of mind, this desire for strict veracity, we should have started him well on the way to correct judgments and wise conduct; we should have implanted in his nature the first elements of good citizenship. As Tennyson says:

> "Self-reverence, self-knowledge, self-control,
> These three alone lead life to sovereign power.
> Yet not for power (power of herself
> Would come uncalled for) but to live by law,
> Acting the law we live by without fear,
> And because right is right, to follow right
> Were wisdom in the scorn of consequence."

THE fish called Lepidosiren (*Lepidosiren paradoxica*) is one of the only three still existing survivors of the once prominent group of *Dipnoi*, or lung fishes, which are characterized by the possession of well-developed lungs in addition to their gills. Mr. Graham Kerr, who spent several months in the swamps of the Gran Chaco, South America, a habitat of these fishes, describes them as living among the dense vegetation of the swamp, swimming in eel fashion, or clambering through the mass of vegetation by means of their leglike limbs. In the dry season they retire into the mud, and breathe entirely by means of their lungs. When the wet season begins they are set free, and at once prepare to spawn. They lay their eggs in burrows at the bottom of the swamp, where the eggs develop into larvæ. The phenomena of their development are of special interest, because it takes place in seclusion, away from the disturbing features due to adaptation to varied surroundings. It has been discovered that the young lepidosirens become white and transparent during the hours of darkness.

Editor's Table.

THOUGHTS FOR THE TIMES.

GOOD use was made of a Washington celebration at Oberlin College, Ohio, by the chief speaker of the occasion, the Rev. A. A. Berle, to utter words that are peculiarly needed at the present time. His subject was Popular American Fallacies, and among these he noted the following: That Anglo-Saxondom is identical with the kingdom of God; that national glory and power can supply the place of national character; that new occasions always teach *new* duties; and that political alliances may do away with the necessity for "a dual alliance," as he expressed it, "between the people and God."

These particular fallacies, in our opinion, were happily chosen. There is a great deal of silly talk current about the incomparable glories and unimaginable destinies of the Anglo-Saxon race; and it never seems to occur to those who indulge in such talk that a profound sense of one's greatness is very far from being a sure sign of greatness. The greatest characters are the simplest and least boastful. Their greatness is so native to them that they are scarcely conscious of it; and they leave it to others to sing their praises. It is presuming altogether too intimate an acquaintance with the designs of Providence to claim that any race in particular is charged, above all others, with carrying those designs into effect. Who knows what reservoirs of moral and intellectual force may reside in nations and tribes whose world-action has been very obscure as yet? Dr. Arnold, of Rugby, thought that much of high value for civilization lay dormant in the negro race, and it is too soon to say he was mistaken. Then, who knows what the Slavonic race may bring forth? Who can calculate the future of the vast human hive known as China? And, after all, what has any nation got to do except to behave itself, be it great or small, famous or of no great repute? How is it in the community? Do we admire great men who swagger, who boast of their wealth, their strength, their courage, or their virtue? A little quiet consideration will persuade any man that there is one law for all nations alike—the law of justice and humanity—and that the greatest nation, according to any true conception of greatness, is the one which exemplifies that law most perfectly in its domestic and foreign policy. The surest sign of greatness in a nation, we venture to say, is that it should hate war—not dread it, but hate it.

It is a singular thing that any but the most light-headed portion of the community should fall into the second fallacy which the speaker mentioned—that national glory and power can take the place of national character. A nation requires a true heart, an honest self-consciousness, just as much as an individual, and time will avenge national misdoings just as surely as it will those of individuals. No numbers, nor any amount of huzzaing or factitious enthusiasm, can make a vicious policy safe. You may win victories with chariots and horsemen, but to enjoy the fruits of peace there must be a dominant love of justice, and that is what war does not tend to promote. It is also very true, as the speaker said, that there are not many *new* duties to be learned in this age of the world. There is enough of moral truth taught in old

Hesiod's Works and Days to make any society now existing a good deal better than it is. When people talk of new duties they generally mean some new harum-scarum enterprise. The old duty would be good enough if they would only consider it closely and follow it faithfully. The Rev. Mr. Berle has spoken words in season; and it would be well if all who are like minded would unceasingly proclaim the same doctrines, if perchance they may sink into the heart of the masses, and give to this great people a public policy founded on righteousness and the love of peace.

A HUMILIATING SITUATION.

"How far, O Catiline, when all is said and done, are you going to abuse our patience?" So said the great Roman orator on a certain famous occasion. Our Catiline is no individual man; it is the party system which has inflicted on us the Puerto Rican disgrace. It was obvious to the common sense of every one that, having laid our hands on the island of Puerto Rico, there was no decent course to take save to make it, for all practical purposes, an integral portion of the Union. We had cut it off from the market it enjoyed in Spain, and left it to contend with the hostile tariffs of other countries—were we going, in addition to that, to make it a stranger to the land that had seized it, and subject its products to our own high scale of duties? The President, in his message to Congress, conceiving the proposition to be almost self-evident, had declared that it was "our plain duty to abolish all customs tariffs between the United States and Puerto Rico, and give her products free access to our markets." So thought nearly every disinterested citizen, and yet what have we since seen? The President, terrorized by the cry of party unity in danger, repudiates his former emphatic declaration, and gives his approval to a measure which virtually makes our unfortunate possession a foreign country. With the "free access to our markets" which the President had promised, the island would have entered on a new career of prosperity; but with its leading industries weighed down under an impost of fifteen per cent, there is nothing in view but commercial stagnation and general poverty. That the island has already languished under American rule—our revolutionary forefathers did not expect that their descendants would so soon go into the "ruling" business—the most disinterested witnesses attest. A leading journal of this city, The Herald, prints in heavy-faced type the following statement of a correspondent:

"American military officials told me at the outset that the year and a half of American sovereignty had been a blight on the island. This was not the echo of Spanish or of Puerto Rican feelings. They spoke their own views with soldierly frankness and sometimes with a word of regret for their own position. Their talk was more pointed than when filtered through official channels."

It is in these circumstances that our Legislature, at the instance of a benevolent President, decides to refund to the people of the island two million dollars of duties collected in our ports on their products. Our tariff system breeds poverty in the population it oppresses, and then we rush to their assistance with a largess. They ask for justice and we offer them alms—alms for which the correspondent already quoted says he can not find a single individual who is grateful. We rob the Puerto Rican Peter to pay our own tobacco-growing Paul; and then we rob the whole community in order to pay back Peter. And, strange to say, some of us feel very virtuous over the business. The countenance of the President glows with satisfaction over the thought of all the good he is doing. For our part, we view the matter in a different light. The money will, of course, meet certain expenses of government in Puerto Rico; but there is reason to fear that it will do as much to pauperize the island in one direction as the restriction of its trade will do in another. What the Puerto Ricans want is not alms, but commercial liberty. The repayment of this money will not stimulate their trade; it will not stimulate anything except their helplessness. It is an open question whether they will suffer more by our protectionist greed or by our wishy-washy sentimentality. Meantime what are we to think of the party system whose exigencies place us in so ridiculous a position before the world? How long shall it abuse our patience?

Fragments of Science

Ventilation of Tunnels.—The question of the ventilation of tunnels forms the subject of a series of articles, by M. Raymond Godfernaux, published recently in *Le Génie Civil.* The principal sources of definite information, upon which the discussion of M. Godfernaux is based, are the reports of the committee on ventilation of tunnels of the Metropolitan Railway of London, and of the commission appointed by the Italian Minister of Public Works to investigate the tunnels of the railways of the department of the Adriatic. Although the vitiation of the air in a tunnel may proceed from three sources—i. e., the lighting, the respiration of the passengers, and the combustion of the fuel in the engines—yet the two former sources are insignificant compared with the latter, which alone need be considered. The principal products of combustion which are injurious are carbonic acid, carbonic oxide, and sulphurous acid. Of these it is found that the proportion of carbonic oxide should not exceed 0.01 per cent, which corresponds to 0.13 per cent of carbonic acid in excess of the normal proportion of 0.03 per cent and to 0.00027 per cent of sulphurous acid. In practice it is found that if the total proportion of carbonic acid be limited to 0.15 per cent the proportions of the other gases will be well within the comfort and danger limits. This is much lower than is often attained in crowded auditoriums, where the proportion of carbonic acid sometimes reaches 0.4 to 0.5 per cent, but in such cases there is no carbonic oxide produced, while in the case of tunnels traversed by steam locomotives we may assume that the carbonic oxide will be about 1 to 13 of the carbonic acid, and the sulphurous acid about 1 to 440. Assuming a given limit of deterioration of the air, it would be easy to devise a system of ventilation if it were possible to treat the tunnel as if it were a closed room or controllable space. In practice, however, the conditions are peculiar. The space to be ventilated is a long, narrow passage, usually open only at the ends, and traversed periodically often almost continuously, by trains in one or both directions, these trains emitting the objectionable gases and also disturbing the air currents best adapted to proper ventilation. How best to reconcile these conflicting conditions forms the problem under consideration. Where there are but few trains it has been proposed to close the ends of the tunnel by doors, and provide a fan exhaust or pressure system, but this method is obviously limited in its applications. The practical conditions which must be considered are those in which frequent trains in opposite directions pass through the tunnel, and these conditions M. Godfernaux has analyzed graphically in a very interesting manner. Assuming a double-track tunnel eight hundred metres (a metre contains

39.37 inches) in length, with an exhausting ventilator placed in the middle and with trains of a given gas-producing capacity passing on each track every three minutes, he constructs a diagram showing how the composition of the atmosphere of the tunnel varies at successive points, and how, by an examination of the diagram thus made, it is possible to discover the maximum vitiation of the air, and consequently the extent to which the conditions are satisfied. By one or two such constructions any such problem may be solved to a degree quite within the limits of practical work, and the effect of various systems of ventilation compared. M. Godfernaux discusses various systems of ventilation, including those involving the use of shafts, fan blowers and exhausters, and air jets, and concludes with a description of the Saccardo system, in use in the Apennine tunnel of the Bologna-Pistoia line, and to the St. Gothard Tunnel. While all this investigation and discussion is of much value, it certainly seems as if the true remedy lies not so much in the removal of deleterious gases as in the absence of their production. The substitution of electric traction avoids altogether the fouling of the air of tunnels and subways, and electric locomotives are already used in the Baltimore Tunnel in the United States and elsewhere, and it seems as if this remedy is the true one to be applied in all cases.

Liquid Air.—The following warning appears in The Engineering and Mining Journal of March 3d: "The advertisements which are now appearing in the papers all over the country of companies which are to furnish liquid air on a large scale must be accepted with a great deal of caution. The public mind has been very adroitly worked up for the reception of these by lectures, paragraphs in the press, and other well-understood methods. Undoubtedly liquid air possesses some valuable properties, and many striking experiments can be performed with it. It is not by any means certain yet that it can be prepared, transported, and used economically on a commercial scale, or that the difficulties in the way have been overcome. We do not say that they may not be overcome in the future; but to talk, as the advertisements do, of the certainty that liquid air will soon largely replace steam in furnishing motive power is going entirely too far. Such assertions have no present basis of fact to warrant any one in making them. The liquid-air people have a great deal to do yet before they can establish their claims or carry on business on a scale that will warrant the organization of ten-million-dollar companies. The question of validity of patents is also quite an open one. It is doubtful if there is any valid patent on this subject."

Taka-Diastase.—The following is taken from an interesting article, by W. E. Stone and H. E. Wright, in The Journal of the American Chemical Society: "Taka-diastase is, so far as known, somewhat similar to malt-diastase in its chemical character, viz.: a highly nitrogenous substance, readily soluble in water, and dependent upon certain conditions of temperature for its maximum activity. Its action is also affected by alkalies and acids. It is produced as the result of the growth of a species of mold (*Eurotium oryzæ*, Ahlberg) upon rice, maize, wheat bran, etc. For its production, as at present practiced in this country, wheat bran is steamed and, after cooling, is sown with the spores of the fungus. After twenty-four hours in culture rooms, at a temperature of about 25° C., the fungous growth becomes visible. In forty or fifty hours the content in diastatic material has reached the maximum, and further growth of the fungus is checked by cooling. The material, now consisting of the bran felted together with fungus mycelium, is called 'taka-koji.' It may be mixed with grain or starchy materials in the same manner as malt is used, and, like malt, will speedily convert the starch into fermentable sugars. An aqueous extract of the mass may be used for a similar purpose. For the preparation of a pure product, which, however, is not necessary for ordinary industrial purposes, the aqueous extract is concentrated by evaporation, and on the addition of alcohol the diastatic substance may be precipitated as a yellowish powder, easily soluble in water, of stable keeping qualities, and possessed of an unusual power of converting starch into sugar. The medicinal preparation above mentioned is obtained in this way, and represents a fairly pure form of the diastatic principle. This bears the name of 'takadiastase.'"

Professor Agassiz's Investigations on Coral Islands. — Having steamed and observed for twenty-five hundred miles among the Paumotu Islands, Prof. Alexander Agassiz says, in a second letter from the Albatross Expedition, published in the American Journal of Science, that he has seen nothing tending to show that there has anywhere been a subsidence, but that the condition of the islands does not seem to him capable of explanation on any theory except that they have been formed in an area of elevation. All the islands examined are composed of a tertiary coralliferous limestone, which has been elevated to a greater or less extent above the level of the sea, and then planed down by atmospheric agencies and submarine erosion, and the appearance of this old rock is very different from that of the modern reef rock. In these islands the rims of the great atolls, after having been denuded to the level of the sea, are built up again from the material of their two faces, so that a kind of conglomerate, or breccia, or pudding stone, or beach rock is found on all the reef flats. On the lagoon side sand bars grow into small islands and gradually become covered with vegetation. Whenever the material supplied from both sides is very abundant the land ring becomes more or less solid; the islets become islands, separated by narrow or wider cuts, until they at length form the large islands, which seem at first to be a continuous land around the rim of the lagoon, while they are often really much dissected. In time water ceases to pass through the channels, and only the marks of them are left. Few if any of the lagoons appear to be shut off from the sea, as Dana and other writers have supposed. They simply have not boat passages. Unlike other coral regions, the Paumotu reefs seem to bear only a scanty life.

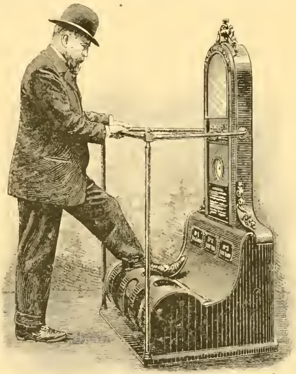
"Winking."—No satisfactory determination has been made of the reason we wink. Some suppose that the descent and return of the lid over the eye serves to sweep or wash it off; others that covering of the eye gives it a rest from the labor of vision, if only for an inappreciable instant. This view borrows some force from the fact that the record of winking is considerably used by experimental physiologists to help measure the fatigue which the eye suffers. In another line of investigation Herr S. Garten has attempted to measure the length of time occupied by the different phases of a wink. He used a specially arranged photographic apparatus, and affixed a piece of white paper to the edge of the eyelid for a mark. He found that the lid descends quickly, and rests a little at the bottom of its movement, after which it rises, but more slowly than it fell. The mean duration of the downward movement was from seventy-five to ninety-one thousandths of a second; the rest with the eye shut lasted variously, the shortest durations being fifteen hundredths of a second with one subject and seventeen hundredths with another; and the third phase of the wink, the rising of the lid, took seventeen hundredths of a second more, making the entire duration of the wink about forty hundredths, or four tenths of a second. The interruption is not long enough to interfere with distinct vision. M. V. Henri says, in *L'Année Psychologique*, that different persons wink differently—some often, others rarely; some in groups of ten or so at a time, when they rest a while; and others regularly, once only at a time. The movement is modified by the degree of attention. Periods of close interest, when we wink hardly at all, may be followed by a speedy making up for lost time by rapid winking when the tension is relieved.

An Ingenious Method of Locating an Obstruction.—The Engineering Record gives the following interesting account of the scientific solving of a practical commercial problem: "The pneumatic dispatch tube for the delivery of mail between the main Philadelphia post office and a branch office at Chestnut and Third Streets is a cast-iron pipe buried below the surface of the street, and in it small cylindrical carriers, six inches in diameter, are propelled from end to end by air pressure. At one time a carrier became lodged at some unknown point in the tube, and to remove the obstruction it was desirable to locate its position as closely as possible before digging down to the pipe. This was satisfactorily accomplished by firing a pistol at one end of the tube; its report was echoed from the obstruction, and indicated its position by the time required for the transmission of the sound. The pistol was fired in a hole in the side of the pneumatic tube near the end, which was capped and had a rubber-hose connection to the recording apparatus. The end of the rubber hose terminated in a chamber closed by a diaphragm about five inches in diameter, which had a stylus attached to it. A cock in the middle of the rubber hose was partly closed to reduce the force of the explosion on the diaphragm, and the pistol was fired. The sound-wave immediately produced a movement of the diaphragm, causing the stylus to make a mark on the record diagram. The hose cock was then fully opened, and when the sound-wave had traveled to the obstruction and been reflected back it again moved the diaphragm, and caused the stylus to make a second mark on the diagram. The lapse of time had been automatically recorded on the same diagram, so to determine the distance it was only necessary to note the exact interval of time between the direct and reflected reports, divide it by two, and multiply the quotient by the velocity of sound under the existing conditions." The obstruction was indicated at 1,537 feet from the diaphragm. Excavations were made at this place, and the carrier was found nearly at the calculated point. The limits of distance at which this method is applicable have not yet been determined, but Mr. Batcheller, the engineer of the Pneumatic Tube Company and the deviser of the above ingenious expedient, has found that in a tube 43.3 inches in diameter a pistol shot will vibrate a sensitive diaphragm at a distance of 65,129 feet; decreasing the diameter of the tube decreases the distance over which the pistol shot will act.

Diseased Meat in Paris.—The police of Paris, says the Lancet, have just laid hands on a vast fraudulent organization for evading the precautionary measures drawn up by the authorities for inspecting the meat distributed for consumption in the suburbs of Paris. Both for Paris and the suburbs all animals destined for food have to be killed in public slaughterhouses, where the strictest watch is kept by the municipal veterinary surgeons, who forbid the delivery to the butchers of any meat which exhibits the slightest suspicious signs. Elaborate regulations have been laid down as to the various diseases which render meat unfit for the food of man, and naturally enough tuberculosis is the complaint most rigorously watched for. The swindlers who have been arrested made up a vast organization which used to buy up from the farms of the eastern provinces and even in Germany such animals as, owing to disease, would have been refused for slaughter at the abattoirs, and, moreover, they bought them dirt cheap. These animals were then conveyed in regular herds to a small place near Paris and killed in sheds built at the bottom of an old quarry. Under cover of night the meat was taken away by the accomplice butchers and resold in the various suburban shops. In connection with this clandestine slaughterhouse the firm had a kind of cemetery, where those animals were buried the meat of which was too bad for even the swindlers to risk its sale in the market. Ivry was the place where the fraud was discovered, and the official inquiry shows that the organization was singularly complete. It is extraordinary that the slaughterhouse, which was in full work, should never have attracted the attention of the villagers, but it must be remembered that all killing was done by night and that the slaughtermen were all Germans who did not understand a word of French, and were therefore unable to engage in imprudent conversation with the neighbors.

How Aluminum is made.—In a paper read before the Manchester Junior Electrical Engineers, J. H. Henderson describes the two commercial methods of making aluminum: The agent which has made aluminum a commercial product is electricity. This is how electrolysis produces it (by one successful method): In a metal, carbon-lined crucible having two carbon electrodes, one of which acts as anode and the other as cathode, are put the following ingredients: Fluoride of calcium, 234 parts by weight; double fluoride of cryolite, 421 parts by weight; fluoride of aluminum, 845 parts by weight. To these add three to four per cent of a suitable chloride—for example, calcium chloride. To this add alumina sufficient to form a very stiff mixture. Before electrolysis can begin the above are fused by means of heat, which should not exceed 1,210° F. The heat is obtained from a furnace heated by gas, coke, or charcoal, care being taken that no gases from the furnace enter the crucible. The bath fused, the electrodes are dipped into it, the current switched on, and the metal is deposited (in the best and largest of these crucibles) at the rate of one pound per five electrical horse-power hours. The current pressure required is six to eight volts, at a density of one and a half ampères per square inch. The metal from time to time is removed from the crucible by means of a siphon or a ladle, care being taken to remove as little of the haloid salts as possible. There is another method of extraction equally successful with this, but also more economical. In this other method a set of similar ingredients are placed in a crucible having one or more vertically movable carbon electrodes, which are used as one, or a collective anode, respectively. The crucible, though lined principally with carbon, has some metal exposed to act as a cathode at the beginning of the process, this to generate heat enough to fuse the bath, after which the anode is placed so that the extracted aluminum acts as a cathode. The molten metal is from time to time run out of a tap-hole into a mold, and thence cast into ingots, or granulated by being poured into cold water. The same particulars as to results apply to this crucible furnace process also, only that not nearly so much of the bath is wasted in it, and the metal needs less purifying when molten. There are, also, no loss of time and money from the use of gas, coke, or charcoal, and of an extra furnace in this method.

"A Mechanical Bootblack."—A bootblacking apparatus is one of the latest developments of the nickel-in-the-slot machine, a specimen of which is undergoing trial in a French public garden. The customer drops his coin—in the present case a ten centime, or a two-and-a-half-cent piece—into the receptacle, which opens the way to a compartment where a brush cleans his boots; he next puts his feet into a second compartment and has them blackened; and then into a third, where they are polished. The operation takes about a minute and a half, and during the time the customer may watch the indications



of its progress as they are shown upon the dial. The machinery working in the inside is very simple. An electric motor of small power—about eighteen kilogrammetres per second—controls the shaft on which the three rotary brushes are fixed, and the customer has only to unlock the machine, the same as all others of its kind, with his coin, and move the handle which opens the circuit and starts the motion. A representation of the machine at work is given in the accompanying illustration, for which we are indebted to *La Nature*.

The "Barisal Guns."—A curious phenomenon of unexplained sounds like those of explosions, occasionally heard in different places over the earth, has attracted much attention, has been made the subject of a book recording several hundred accounts of it, by M. Ernest Van den Broeck, of Brussels, and has already been mentioned in the Popular Science Monthly. The phenomenon has been most carefully observed in India, where it seems to have assumed a peculiarly marked form, and is known there as the "Barisal guns." M. Van den Broeck calls it "mistpoeffers," or air-puffs. The most definite description of it is given in Nature by Mr. Henry S. Schurr, as he has heard it in India, where it has been observed over a wide range, but most clearly and frequently in the Baekergunge district, of which Barisal is the headquarters. The Barisal guns are heard most frequently from February to October, not during fine weather but just before, during, or immediately after heavy rain. They always sound in triplets—that is, three reports occur, one after another, at regular intervals—and though several guns may be heard, the number is always three or a multiple of three. Sometimes only one series of triplets of sounds is remarked in a day; at other times the author has counted as many as forty-five of them, one after another, without a pause. The report is exactly like the firing of big guns heard at a distance, except that it is always double, or has an echo. A number of conjectural solutions of the phenomenon have been put forth, but none of them accounts for it as a whole in any approaching a satisfactory manner.

Photographing Live Fishes.—A number of methods are mentioned by Dr. R. W. Schufeldt, in a paper on the subject, by which fishes may be photographed in their natural element, with natural surroundings. This can be done, even under the surface of the water, by the use of certain subaquatic apparatus. By the employment of instantaneous photography some fishes have been taken in the air, as of salmon in the act of leaping, or of flying fish in flight. Such pictures, however, illustrate special habits rather than the ordinary life of the subjects. Well-arranged aquariums afford opportunities for photographing fishes in almost every condition and position, and a command of light and situation can be had in them which is of great advantage to the operator. The specimens of fish photographs published by the author with his paper are in every way satisfactory. The spots on the sunfish, for example, are almost as clear and distinct as if we had the fish lying before us in the broad light. The photograph of the pike has afforded opportunity to correct some inaccuracies in the drawing of it as given in previous works of high authority.

Marine Life at Cold Spring Harbor, Long Island.—Mr. Francis N. Beach, in presenting to the Boston Society of Natural History a list of the Marine Mollusca of Cold Spring Harbor, Long Island, speaks of the locality as representing "a fairly distinct facies of molluscan life—the fauna of the oyster beds, broadly speaking. From this point of view, its homogeneity and the absence of stragglers lend it value. Probably almost every species enumerated lives on the spot where found or in the immediate vicinity. This characteristic makes the spot a good sample of actual conditions of life in that interesting transitional region where the 'Virginian' and 'Acadian' (or 'Boreal') faunas overlap. From this point of view it is, so far from being homogeneous, strikingly heterogeneous." Of the two faunas, the southern one contributes a quota rather more than twice that of the more northern one, and the increase in the preponderance of southern forms can be detected in a range of forty miles. The author concludes from his examination that, notwithstanding the well-marked character of Cold Spring Harbor as "muddy," its molluscan fauna is determined not at all by that character, but predominantly by the depth of water and by the factors included in the "inclosedness" of the place—that is, he supposes, by the temperature, the specific gravity, the percentage of organic matter, etc. "It looks as though the various species would manage somehow to be represented on almost any stretch of shore or bottom, provided only the *water conditions* be right."

Farm Homes for Neglected City Children.—The system of providing homes upon farms is represented in the last annual report of the New York Juvenile Asylum as being on the wane. While from 1880 to 1890 twenty-four per cent of the children committed to the asylum were placed in Western homes, the percentage from 1890 to 1897 was only fifteen. Among the reasons assigned for this diminution are the increase of undesirable material, chiefly of races against which prejudice is strong, and the growing habit of parents expecting their children to be restored to them when their services become profitable. Placing out street waifs and neglected and dependent children in the homes of private families, the report says, has been sadly abused. The degradation and moral corruption of the condition of such children are apt to make them so refractory and unsusceptible to the wholesome influences of family life that an abrupt transfer is liable to be attended with failure and disaster. The children should therefore be previously brought under the restraining and reformatory influences of a training school. At the best, a placing-out work can not be exempt from serious contingencies. "The second decade, the adolescent age, under most favorable conditions, is the period when the will is apt to be wholly dominated by the emotions, and unless the environment is peculiarly favorable, guardianship becomes a difficult function. With an indenturing system that prolongs the term of apprenticeship for boys throughout their minority, both apprentice and guardian must possess an extraordinary measure of amiable qualities to insure a continuance of their relation through an extended period." When the boy is old enough to earn wages from strangers the temptation to leave and go out for hire is very strong, and must be met by a corresponding degree of tact and liberality; and even when interests are happily adjusted "a placing-out system ought to take account of the tastes and aptitudes of young people, and leave the way open for the deserving at a suitable age to start upon a new career."

Animals Helping One Another.—While the ruminant animals as a rule do not seem to have made any further advance toward forming communal groups than to post sentinels while pasturing together, a few marked cases are found in which a division of labor and some system of assistance seem to have been given effect. One such instance is cited in the London Spectator as having been observed by Lord Lovat in the Highland deer, where large stags have smaller stags to attend them and serve them very much as the English school bully is attended and served by his fag. Lord Lovat tells another story of compassion manifested and help afforded by a stag to a younger animal. Of three stags on the move, two jumped the wire fence, and the third, a two-year-old, halted and would not venture the leap. The two waited for some time while the little fellow ran along the fence, till the larger of them came back to coax him, and "actually kissed him several times." Finally, the animal gave up and went on, after which the little stag took courage and made the jump. The social organization is very far advanced with the beavers, and is quite elaborate with the rabbits, which excavate common and interlacing burrows, and with insects like ants and bees.

Geological Formations and Forests in New Jersey.—From a study of the relation between forestry and geology in New Jersey, Arthur Hollick finds that two distinctly defined forest zones have long been recognized in the State —a deciduous and a coniferous—the contrast between the two being so obvious as to attract the attention even of superficial observers. While the deciduous zone is roughly confined to the northern part of the State and the coniferous to the southern part, yet when the line of demarcation is carefully followed up across the State and beyond its confines it is found not to coincide with any parallel of latitude or isothermal line, and not to be entirely dependent either on topography or the physiographic conditions. "If, however, a geological map of the region be examined, the line of demarcation between the two zones will be found to follow the trend of the geologic formations whose outcrops extend in a northeast direction across the State and southward beyond. A coincidence was suggested, and it became more apparent, as the investigations proceeded, that the two classes of angiosperms and gymnosperms were severally identified with certain geological formations, and also that the distribution of many species within each of the zones was capable of being similarly associated, and their limits of being more or less accurately defined. The deciduous zone is roughly located as lying north of a line between Woodbridge and Trenton, and the coniferous zone as being south of a line between Eatontown and Salem. Between these two lines is an area about sixteen miles wide where these zones overlap, which the author calls the "tension zone," because a constant state of strain or tension in the struggle for existence prevails in it. In the deciduous zone the geological formations are numerous, with various soils and every gradation of topography, and the diversity of trees is great. Its southern line is coterminous with the southern edge of the Triassic formation. The coniferous zone presents but little diversity in geology or topography, and little variety of trees. Its northern border is coterminous with the northern border of Tertiary gravels, sands, and sandy clays. The "tension zone" includes practically the whole of the Cretaceous plastic clays, and the clay-marls and marls.

MINOR PARAGRAPHS.

A conference was appointed, to be held at Wiesbaden, Germany, October 9th and 10th, to promote the formation of an International Federation of Science—a scheme which was referred to in Sir Michael Foster's presidential address before the British Association. This idea for the establishment of an international association of great learned societies appears, the London Athenæum says, to be the outcome of discussions carried on at Göttingen in 1898. For some time past the Academies of Vienna, Munich, Göttingen, and Leipsic have been federated into an association or "Castell," each meeting in turn at their respective headquarters to talk over scientific matters of joint interest. At two or three recent meetings questions were brought up, such as antarctic research and the cataloguing of scientific literature, which, besides being of sufficient interacademic value to come before the "Castell," were of prime importance to English men of science. English delegates were therefore invited to attend, and did so; and out of this invitation has grown a desire for a wider international basis for the association. The adherence of the principal learned societies of the world, including our National Academy, is said to have been secured to the movement.

The thirteenth season of the Department of Botany at the Marine Biological Laboratory, Woods Holl, Mass., will open July 5th and continue till August 16th. Three laboratory courses are provided, accompanied by lectures, including the subjects of cryptogamic botany, plant physiology, and plant cytology and micro-technique. The principal instructors are Dr. Bradley R. Davis, Mr. George T. Moore, and Dr. Rodney H. True. The department extends a special welcome to investigators, and desires their co-operation in the development of the laboratory. Woods Holl offers great attractions in variety of material and facilities for biological research, and is proposed as an excellent center of resort where the botanists of the country may meet for a few weeks. A six weeks' course in Nature study, including both animals and plants, and consisting largely of field work, is a new feature offered this year for the first time.

On Friday, March 9th, occurred the death of two of the six surviving founders of the American Association for the Advancement of Science—Dr. Charles E. West, of Brooklyn, and Professor Oliver Payson Hubbard, of Manhattan. Both were distinguished teachers. Dr. West was born in Washington, Mass., in 1809, and after being graduated from Union College, began his career as a teacher in the Albany Female Academy. He was afterward principal of the Rutgers Female Institute, the Buffalo Female Seminary, and the Brooklyn Heights Seminary, where he remained twenty-nine years. He also assisted in preparing the original courses of instruction of Vassar Female College. He was one of the founders of the Long Island Historical Society; was a fellow of the Royal Antiquarian Society of Denmark; and was a member of the American Ethnological, the American Philosophical, and the New York and the Long Island Historical Societies. Professor Hubbard was born at Pomfret, Conn., in 1809, was graduated from Yale College in 1828, and was appointed Professor of Chemistry, Pharmacy, and Mineralogy at Dartmouth College in

1836. He remained there, with an interval, from 1866 till 1871, in which he devoted himself to lecturing, till 1883, when he became professor emeritus. He was made in 1871 overseer of the Thayer School of Engineering at Dartmouth, and he was a member of the New Hampshire Legislature in 1863 and 1864. Only four of the founders of the American Association are now living—namely, Dr. Martin H. Boye, of Cooperstown, Pa.; Prof. Walcott Gibbs, of Harvard; Dr. Samuel L. Abbot; and Epes Dixwell.

The firm of Burroughs, Wellcome & Co., says the Lancet, are to be congratulated on the generous care which they have taken to promote the material and intellectual welfare of their employees. Their principal works are at Dartford, where they employ more than eight hundred persons of both sexes, including some two hundred scientific workers. For the purpose of establishing a sort of club for these employees, Mr. Wellcome succeeded in purchasing the Manor House known as Acacia Hall, and the extensive and beautiful grounds in which it is situated. The Manor House he has fitted up as a club for the members of his staff. An old mill which stands close by has been converted into what is called the library building. The upper floor is fitted out as a lecture-room, and there is a library which already contains some thousands of volumes. A third building, called the Tower House, contains club accommodations for men. Then there are elaborate bathrooms, and finally a large gymnasium. The grounds are most extensive, being half a mile in length and very tastefully laid out. There is a lake, a river, and many pleasure boats for rowing, a large field for sports of all sorts, a grand stand to witness the same, a rich orchard and a beautiful pleasure garden, several luxurious lawns, and many superb trees.

A peculiar kind of glassy bodies, known as moldavite or bouteillenstein, is attracting the attention of Austrian and Bohemian geologists. These glasses are ovals from an inch to an inch and a half long, and are characterized by various markings, some of which suggest finger impressions, while others form a network of furrows, which may have in part a rough radial arrangement. They have been regarded by some authors as relics of prehistoric glass manufacture, but this view does not appear to have been sustained. Dr. F. E. Suess, the famous Austrian geologist, finds resemblances between them and meteorites, and the most general disposition of students of the subject is now to consider them of extra-terrestrial origin. Resemblances have further been pointed out between them and some peculiar obsidian bombs found in Australia. The moldavites in Bohemia occur in sandy deposits which are assigned to the late Tertiary or early Diluvial period.

At the Massachusetts Institute of Technology, besides studies bearing directly on science and the arts, courses are given in modern languages, as an important means of access to foreign works in the student's professional department: English, for the purpose of training pupils to express themselves readily, accurately, and adequately, and of aiding them in the understanding and appreciation of good literature; history and political and social science, the instruction in which is arranged to connect with that in biology, so that the two departments shall present "an unbroken sequence of related studies extending through three successive years, and resting upon the fundamental knowledge of living forms and of prehistoric man that is presented in general biology, zoölogy, and anthropology," followed by comparative politics and international law; and economics.

A witness recently admitted to the British Government's Committee now making inquiry into the use of coloring matters and preservatives in food, that yellow coloring substances were largely purchased without any discrimination for the purpose of giving a rich appearance to milk and milk products. As a rule, no question was asked as to the injurious or non-injurious character of the dye so used. One of the best coloring matters was known as Martius's yellow, naphthol yellow, naphthalene yellow, Manchester yellow, saffron yellow, or golden yellow, and is chemically the same as the dinitro-alpha-naphthol prepared from the naphthalene that crystallizes in gas mains, which is an important constituent in the making of lyddite. It is slightly explosive when heated, is injurious when it comes in contact with an abrasion of the skin, and has been shown by physiological experiments to be a highly improper substance to mix with food.

A goose market is held regularly in October at Warsaw, Poland, to which about three million geese are brought, most of them to be exported to Germany. Often coming from remote provinces, many of these geese have to travel over long distances, upon roads which would wear out their feet if they were not "shod." For this purpose they are driven first through tar poured upon the ground, and then through sand. After the operation has been repeated several times the feet of the geese become covered with a hard crust that effectively protects them.

NOTES.

The first summer session of Columbia University, 1900, will open July 2d, instruction beginning July 5th, and will continue till August 10th. The work will be under the general direction of Prof. Nicholas Murray Butler, and will be conducted by a large corps of instructors, in eleven courses, of thirty lectures or other exercises or their equivalent in laboratory or field work, each. The concluding examinations will be held August 9th and 10th. Credits will be given for courses pursued at the school in the requirements for a degree at the university, and for a Teachers' College diploma, and in the examinations for teachers' licenses in New York city.

An International Congress of Medical Electrology and Radiology has been connected with the International Congress system of the Paris Exposition, 1900, and will be held July 27th to August 1st. The commission is composed of representative men from various universities, institutions, and hospitals of France, with Prof. E. Doumer, 57 Rue Nicolas Leblanc, Lille, as secretary.

A curious fall of "black snow," which was observed at Molding, Austria, at the beginning of the year, was found to consist largely of the insects known as "glacier fleas," which were supposed to have come along with a violent snowstorm from some of the Alpine glaciers.

How to write 1900 in Roman numerals is a question of the day that will have to be settled. Three ways are suggested by Mr. J. Fletcher Little in the London Times, either of which is correct according to the Roman system. They are MDCCCC, MDCD, and MCM. But when we reach the year 1988, if we use the first of these methods we shall have to write the formidable-looking formula MDCCCCLXXXVIII, whereas if we use the third and shortest method, it will only be MCMLXXXVIII—and that is long enough. The third method, therefore, which may be interpreted as meaning one thousand plus another thousand lacking a hundred, seems to be the simplest.

Dr. St. George Mivart, Professor of Biology in University College, Kensington, died suddenly in London, April 1st, aged seventy-two years. He was author of numerous scientific works, of treatises critical of Darwinism and the theory of evolution, and of demonstrations of the harmony of Roman Catholic dogma with proved scientific facts. His name has been made prominent of late by his recantation of his previously expressed views of the consistency of dogma with science, and the correspondence with Cardinal Vaughan which grew out of it.

An International Congress of Ethnographical societies has been arranged for by the Ethnographic Society of Paris, to be held in Paris, August 26th to September 1st.

The Wollaston medal of the Royal Geological Society, London, for the most important geological discoveries, has this year been awarded to Mr. Grove K. Gilbert, of the United States Geological Survey. This is the third time the medal has been awarded to a citizen of this country.

Among the recently announced publications of John Wiley and Sons we notice a third edition, revised and enlarged, of Allen Hazen's Filtration of Public Water Supplies; a new and revised edition of Olof's Text-book of Physiological Chemistry; The Cost of Living as Modified by Sanitary Science, by Ellen H. Richards; Examination of Water (Chemical and Biological), by William P. Mason; and the fifth edition of H. Van F. Furman's Manual of Practical Assaying.

In a method of sterilization of water by means of ozone, described by Dr. Weyl, of Berlin, at the German Scientific Conference, 1899, water is pumped to the top of a tower and allowed to flow freely over stones, meeting as it falls a current of air charged with ozone. The process appears to be likewise effectual in purifying peat and bog water, the solution of the iron salts of humic acid being decomposed and oxidized, and the brown color disappearing in consequence. The method, it is said, can be advantageously used in connection with filter beds.

Our death list this month of men known in science is large. It includes the names of M. Philippe Salmon, archæologist, subdirector of l'École d'Anthropologie of Paris, President of the Ministry of Public Instruction's Commission on Megalithic Monuments and author of numerous monographs on subjects of his studies, in Paris, aged seventy-six years; Dr. C. T. R. Luther, director of the Observatory at Bilk, near Dusseldorf, aged seventy-eight years. He discovered twenty-one of the minor planets and calculated the orbits of them all, as well as those of several other bodies; Dr. C. Piazzi Smith, formerly Astronomer Royal of Scotland, author of studies of the amount of heat given by the moon to the earth, and of some famous speculations upon the construction and purposes of the Great Pyramid as an exponent of the standard of measurement, February 21st, aged eighty-one years; M. Émile Blanchard, dean of the section of Anatomy and Physiology of the French Academy of Sciences; Captain Bernadières, member of the French Bureau des Longitudes and Director of the Observatory School of Montsouri for Officers of the Marine, who had fulfilled several astronomical and geodesic commissions; Dr. Hermann Schaeffer, honorary professor of Mathematics and Physics at Jena, aged seventy-six years; Leander J. McCormick, founder of the McCormick Observatory at the University of Virginia; President James H. Smart, of Purdue University, Lafayette, Ind.; General A. A. Tillo, Vice-President of the Russian Geographical Society, founder of an exact physical geography of Russia, based on scientific data, and of many contributions on the science, at St. Petersburg, January 11th, aged sixty years; Prof. E. Beltrami, of the University of Rome (Mathematical Physics), President of the Accademia dei Lincei, and correspondent of the Paris Academy of Sciences; M. Emmanuel Liais, Mayor of Cherbourg, France, also distinguished for useful and very meritorious work in Astronomy and Physics, aged seventy-four years; Dr. Hans Bruno, Professor of Mineralogy and Geology in the University of Dresden, Saxony, distinguished for his investigations of the Paleozoic, Cretaceous, and Permian rocks of Saxony, at Dresden, January 28th, aged eighty-five years; and William Thorpe, one of the Vice-Presidents of the Society of Chemical Industry.

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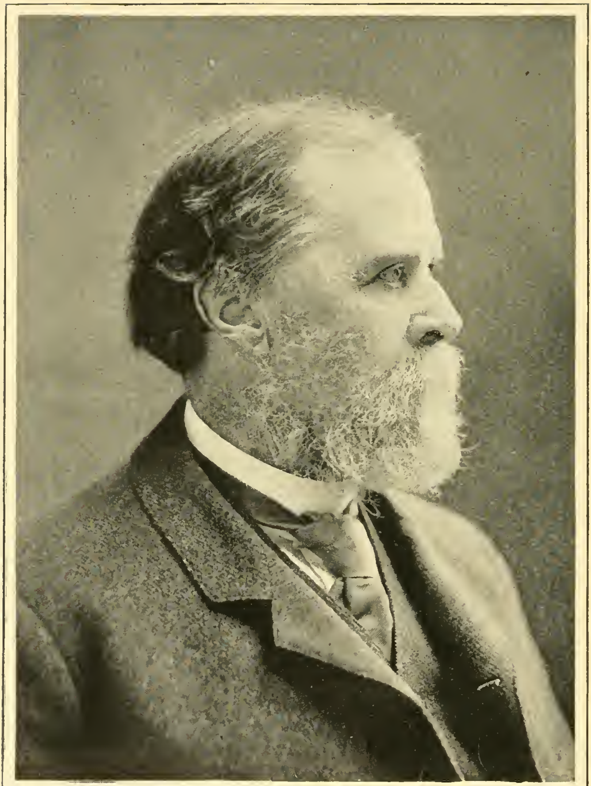

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PREVENTIVE INOCULATION. (I.)

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IT was due to certain particularly favorable circumstances that the first ideas on preventive inoculation were gathered from observations on smallpox patients. Such circumstances were presumably the following:

a. It is a disease which attacks epidemically, in a short time and within a small area, large numbers of people, thus permitting of easy comparisons and suggesting conclusions from the facts observed.

b. Its fatality is comparatively small, so that after each outbreak a large number of convalescent persons remain alive to serve as objects for future observation and comparison.

c. These convalescents are marked and are thus easily distinguishable from the rest of the population who have not been attacked, and even the severity of the disease they have gone through is, so to say, written down on their faces and bodies.

d. The disease is easily communicable, owing to the infectious matter appearing on the surface of the patient's body in the pustules.

It was easy, therefore, to notice in this case, as was indeed very early done in the East, that a person who has gone through one attack, as shown by his pitted face, very rarely suffers even during severe subsequent epidemics. Smallpox, like other epidemic diseases, breaks out in some years in very fatal, in others in milder forms. It is admissible that by a mixed process of thought and faith an impression insensibly gained ground that it was *lucky* to have been touched by the smallpox deity—of course, not in years when that deity appeared in terrifying mortality. Accordingly, in times of *mild* outbreaks people would not be very careful in avoiding infected persons, and would even seek their company so as to get infected from them. The practice of intentionally rubbing one's skin with a pustule, or with bits of it, from an attacked person, must have been a subsequent stage.

Such or a similarly gradual development of ideas may explain why it is impossible to fix a date or place for this discovery, which indeed goes back to the darkness of antiquity. Research points to its practice among the Chinese and Hindus in very ancient times. The Chinamen induced a mild attack by inserting a crust from a smallpox pustule into the nostrils. The Hindus, on the contrary, used the fluid pus, which they inoculated under the skin of the arm. In either case, in the course of a week, the inoculated was attacked by some slight preliminary symptoms followed by an eruption, sometimes profuse, sometimes scanty, and then the disease would run its ordinary course. The only difference between an attack caused by inoculation and that caused by natural infection was, as a rule, the milder nature of the former, especially when the matter for inoculation was taken from a notoriously mild case. The result, however, was by no means certain. A mild form of an infectious disease may be due either to the virus being of a weak nature; and then such a virus would be the desired one for inoculating persons seeking artificial protection; or else the mildness of the case may be due to the patient himself being of a resistant organization, in which case, though exhibiting mild symptoms himself, he may be harboring an intense form of contagion, apt to cause a severe outbreak when transferred to other less resistant persons. Many plans were consequently adopted to secure with more certainty a mild artificial infection. Some of these were directed to the treatment of the patient preparatory to inoculation, others to the preparation of the infectious matter in order to attenuate its virulence. The Brahmans, who were the operators in India, in addition to selecting material from patients with a mild form of the disease, were accustomed not to employ the pus at once, but to keep it wrapped up in cotton wool for a period of about twelve months, and thus to weaken its power. They inoculated in the early part of the year, at the time when smallpox prevailed, and the practice they used was to moisten with water a bit of cotton wool prepared in the previous outbreak, to place it on the arm of the person to be inoculated, and to prick the arm, through the wool, over an area of about the size of a twenty-five cent piece. In a few days a vesicle would appear at the seat of the inoculation, which later on developed into a pustule and eruption. Notwithstanding these precautions, great variation in the results was observed, and many succumbed to the operation; but those that passed through it safely were proof against further attacks.

Besides the personal risk to the inoculated, the illness produced in them was infectious to others, and unprotected persons coming in contact with the inoculated were likely to get infected from them. The latter result was largely avoided by the practice adopted by the Brahmans of inoculating all the inhabitants of a family or village at the same time. The benefits secured under the above precautions were considered far to outweigh the risks of inoculation.

With the extension of smallpox westward the system of artificial protection spread toward Europe through the intermediary of travelers and merchants. The Arabs and Turks appreciated its benefits at an early date. The slave dealers supplying the bazaars and harems of Constantinople adopted the system to protect against disfigurement their Circassian and other live stock. In the early part of the eighteenth century the method was made known to the English practitioners by Lady Mary Wortley Montagu, the wife of the English ambassador at Constantinople, who had her two children inoculated according to the Turkish system. Curiously enough, it was soon afterward discovered that a similar method was in practice among the peasants of some of the districts in Wales and the Highlands of Scotland, and had long been known there as 'buying the smallpox.' When inoculation was given a more extensive trial it was found, in England as in the East, that the effect of it was decidedly beneficial, but fraught with danger. At first one in every fifty of those operated upon succumbed to the consequences of inoculation. By improved methods the mortality was gradually reduced to one in a thousand; but the most serious danger lay in the spread of infection to healthy persons. The precaution of inoculating whole groups of inhabitants at one time, or of keeping the inoculated apart from the healthy, as had been practiced by the Brahmans ages ago, was overlooked, and the result was often disastrous to the community.

It was at this time that Jenner achieved great progress and threw a vast amount of new light on the question. As is well known, he started from a belief that existed in the west of England, that cowpox was a bovine form of smallpox, and that the milkers who attended on cows suffering from that disease and who became infected with the eruptions on the teats and udders, passed through a mild illness, which rendered them immune against smallpox. Jenner determined to put this tradition to the test, and succeeded in establishing, by a few accurate and well-planned experiments, a series of most important facts.

He showed, first, that cowpox could be artificially given to the cow by infecting it with virus from a smallpox patient, and that the disease thus produced was transferable by inoculation from cow to cow.

He showed further, that by having been bred in the tissues of the cow, the virus lost its intense infective properties for man. When the matter from an artificially infected animal was transferred by inoculation to a human being, it produced at the seat of its insertion a discrete vesicle, which was not followed by a general eruption, as would often be the case with the original smallpox virus.

Though the illness thus induced was not infectious in the sense that it would not be communicated spontaneously from person to person, it could be so transferred artificially by inoculating patients with the lymph from a ripe human vesicle.

When transferred from cow to cow or from man to man the matter preserved unchanged the same property of producing the mild inoculation vesicle, harmless to the patient and to his surroundings; and thus a matter for inoculation was obtained of *invariable strength*, what was called later on, by Pasteur, 'virus fixe.'

The last and the most essential property which Jenner demonstrated to belong to the substance in question was the following: A man who had been inoculated with that substance could afterward be with impunity infected with a virus taken direct from a smallpox patient; the inoculation would be either abortive altogether or the effect much milder than in a man not so prepared. Jenner concluded from this most striking result that the inoculation with the matter cultivated by him in the cow would protect a man forever against contamination with smallpox, and he called that matter 'vaccine,' or cow lymph.

Jenner's experiments produced an immense impression throughout the world, and inoculation according to his system, which was called 'vaccination,' was rapidly applied to large numbers of people. When outbreaks of smallpox occurred in the midst of vaccinated communities, observations began to come in as to the actual effectiveness of the method in protecting against the disease.

These observations proved that the system possessed an undoubted and exceedingly high beneficial effect, though the following two restrictions had to be imposed upon the originally conceived expectations:

1. The protection was not absolute. In every outbreak of smallpox a number of patients were and are met with who are attacked, generally mildly, but also in some cases fatally, though they had undergone a successful vaccination, some even at a comparatively recent date before the attack. Only the proportion of such patients to the whole of the vaccinated community is very markedly smaller than the proportion of attacks in the non-vaccinated; and also the severity of the attack, as well as the proportion of deaths to attacks, is in the vaccinated much smaller.

2. This favorable difference between the outbreaks among vaccinated and non-vaccinated is maintained not for life, but for a limited number of years, and disappears gradually, and at length altogether, unless the individuals be revaccinated. Observation has shown that the

period during which the protective effect of vaccination lasts extends over from three to seven years.

Vaccination very rapidly displaced inoculation, and spread to every part of the civilized world. The results have been dwelt upon in innumerable books and pamphlets. At present great outbreaks of smallpox have become very rare, at least in the civilized part of the world, and there is a tendency to forget or ignore the devastations they used to cause.

The first successful attempt in extending the system of inoculation to other diseases was made only after the discovery of the fact that 'infection' is caused by living animal or vegetable parasites, capable in the majority of cases of being cultivated and bred in artificial media outside the animal body. Pasteur found that he was able to effect protection against disease similar to vaccination against smallpox by the use of such artificially bred micro-organisms.

It may be interesting to relate that this important discovery was made unintentionally, and represents one of those happy 'accidents' which occur to those who diligently search. Pasteur had been working with cultures of chicken-cholera microbes, an extremely fatal form of virus when it is introduced into fowls and small birds. It so happened that one of his cultures was left forgotten in the incubator when work was stopped for the vacation. On the return of Pasteur and his assistants the experiments were continued. When the bottle was discovered, thinking that the microbes might have been exhausted or dead from long starvation, Pasteur tried to make what is called a fresh culture of them, by inseminating a sample from the old bottle into a freshly prepared nutritious broth. The microbes were not dead, and multiplied and grew luxuriantly; but when they were injected into a fowl they caused only a transient and non-fatal disease. To make a fresh start, Pasteur took some old blood, which he had drawn a long time previously from a chicken-cholera fowl and preserved in a cupboard in the laboratory in a sealed-up tube, and made a culture with the material that was in that tube. The culture thus obtained killed fresh fowls as usual, but when it was injected into the bird that had resisted the first culture it resisted this injection also. Pasteur, who excelled all men I ever knew in his ability of quickly analyzing and discerning true connections between facts, required no further hints. Others might perhaps have dwelt on the peculiarity of the fowl that happened to resist the injections, or on some other circumstances. Pasteur relinquished this and other suggestions at once, and thought of the microbe. The fact that old specimens of microbes may become impotent when injected into animals was known to him, and was readily explained by the vitality of such microbes being lowered or exhausted by starvation. But, then, such a microbe when transferred into a fresh medium, if not dead, generally regains its vigor, and after that, when inoculated into an animal, it produces its usual effect. The remarkable circumstance about the culture left in the incubator was that even when it was transferred into a fresh medium and its vitality renewed, it remained still impotent. Pasteur concluded from this that an infectious microbe possesses two distinct properties: one, which it shares with any other living being—viz., *vitality*—which may be weakened or strengthened according to the conditions of life and food; and another, which he considered as its 'virulence,' its power of causing diseases, which may be also weakened or strengthened by special means, but which is quite independent of 'vitality.'

The lucidity of thought of which Pasteur made proof on this occasion was magnificent. Later researches confirmed and explained these facts with a singular completeness, and now the idea, as is always the case, looks simple and self-evident. One must remember that at that time Pasteur had every reason to believe that disease is caused by the mere fact of a foreign micro-organism of a given species penetrating and settling down to live in the system of a man or animal. Its capability of *living* there, *i. e.*, its vital properties, seemed all that was necessary for causing disease. It was only later that it was found that pathogenic microbes cause diseases by producing so-called toxines or poisonous substances distinct from their own bodies and separable from them. The process may be illustrated by a comparison, for instance, with a cobra or any other animal producing a special venom. By starvation or some other treatment the vitality of the cobra may be temporarily weakened. When it obtains fresh food again and gets generally in good condition, it recovers, without its ability of producing venom having been in any way impaired. On the other hand, a snake may be by an operation deprived of its fangs and power of secreting poison without its health and strength being in the least affected. Pasteur at once asserted that in a similar way it was possible by starvation to weaken a breed of microbes without their virulence being diminished, and, on the other hand, to deprive them of their power of producing disease without impairing their vitality, though what the above power consisted in he did not know. He called the latter result *attenuation* of a virus. An attenuated virus in his meaning is therefore a special breed of pathogenic microbes which can be maintained, by suitable breeding, in best conditions of health, but which has lost either partially or entirely its power of producing poison and disease.

Pasteur extracted from the few experiments related above a further most-important conclusion—viz., that such an attenuation was due to and could be produced artificially by the effect of oxidation. This he deduced from the fact that the microbes in the sealed-up tube had not lost their virulence, while those forgotten in the open bottle in the incubator and exposed to the access of air had done so. Oxidation proved indeed to be one of the most general methods of artificially producing attenuated virus, to which method later on were added others—the effect of light, of chemicals, of passage through certain animals, etc.

And, of course, the last and crowning conclusion was that an ordinary, susceptible fowl that has undergone the injection with an attenuated culture becomes immune against a culture which kills other fowls; and that conclusion, in the particular circumstances under which Pasteur was working, proved to be true.

Pursuing the new line of research, Pasteur demonstrated that a protection similar to that obtained against smallpox and chicken cholera could be secured also against *anthrax*, a disease which, by the destruction it caused among sheep and cattle, was entailing heavy loss on the farmers of France. After a long series of experiments he prepared two specimens of virus, different in strength, but both weaker than the natural contagion, and worked out the proportions in which sheep, horses and cows could be safely injected first with the weakest virus and then with the virus of the somewhat greater strength, after which they became capable of withstanding the strongest anthrax infection.

In honor of Jenner, who was the first to discover the way of preparing a virus of a fixed strength safe to be used for the preventive treatment of men, Pasteur proposed that all such artificially bred, so to say, domesticated forms of microbes be called *vaccines*, while the word *virus* be reserved for a contagion growing in nature in a natural condition, or taken direct from an infected individual. The French distinguish between 'vaccin,' which is used as a generic term in Pasteur's sense, and 'vaccine,' which name they reserve for smallpox vaccinia lymph. The word 'vaccination' has been also extended to designate inoculation with artificially vaccinized virus, while the word 'inoculation' is used for the injection of a natural, not vaccinated virus, taken direct from a patient. The latter distinction is, however, not yet strictly maintained in English literature, nor in the subsequent pages of this paper.

Pasteur gave a memorable demonstration of the efficiency of his method of anthrax vaccination. At Pouilly-le-Fort, in the midst of an assemblage of scientists, delegates of agricultural societies, government officials, landlords, farmers and representatives of the press, he performed the following experiment: Sixty sheep were taken; ten of these were put aside, twenty-five were vaccinated with the two attenuated anthrax vaccines at an interval of twelve days, and twenty-five were left untouched. Twelve days afterward the two groups of twenty-five sheep were inoculated with virulent anthrax; and the result was that at the next visit the twenty-five unvaccinated and one vaccinated pregnant female were found dead, while twenty-four out of the twenty-five that had been vaccinated were perfectly well, and exhibited during the whole time they were kept under observation the same degree of health as the ten sheep that had been put aside for comparison.

An impetus was given by these discoveries to researches having for their object the protection of *men* against infectious diseases. The most important of these researches was Pasteur's own into the nature of hydrophobia and rabies, and the way of inoculating against that disease. This was followed a few years later by the preparation of a prophylactic against cholera.

Inoculation against hydrophobia was rendered possible by the discovery of the fact that the rabies or hydrophobia virus is found in a pure condition, free from other microbes, in the nervous centers of animals. The material for inoculation is prepared from such nervous matter, the virulence of which is rendered *fixe*, as will be mentioned below.

The cholera microbe, which was subsequently named *comma bacillus*, was discovered by Koch in 1883, in the intestinal contents of cholera patients. Two years later cholera broke out in Spain, and Dr. James Ferran, a Spanish physician, began inoculating men with living cultures of comma bacillus taken from patients attacked with the disease. The procedure in its essential features corresponded to the pre-Jenner method of inoculation. The failure to fix the strength of the virus used for treatment rendered the method subject to the same uncertainty as that which was connected with inoculation with small-pox virus taken direct from patients. It was impossible to predict the effect of the injections. Comma bacilli taken from cholera patients may, under cultivation, show themselves extremely virulent, or, on the contrary, extremely mild. There are specimens which, when injected into a Guinea pig, even in an insignificant dose, will prove fatal to it, and there are others which will appear harmless when given in a dose seventy times greater. The immediate effect, and the protection caused by the inoculation, must, of course, vary accordingly. The attempt made by Ferran caused great interest, and a number of scientific commissions were sent to Spain from different countries of Europe to study the results of his work. They could, however, come to no conclusion, and the treatment speedily lost its position. Only some seven years later a method was found of fixing the strength of the cholera virus. I was connected with this stage of the work, and it may perhaps present some interest to the reader to relate the way in which the problem was solved, and to show how gradual is the development of ideas by which results in laboratory investigation are arrived at.

It has been mentioned already that the virulence of microbes changes under the influence of different agents in Nature—heat, light, chemicals. When a virus is first obtained from a patient or outside a patient its preceding history, its antecedents, the conditions under which it lived before, are extremely variable. Jenner's method of cultivating the smallpox virus by transferring it from calf to calf secured for that virus uniform conditions of life, and its strength could thus be maintained unchanged for an indefinite length of time. Pasteur, in the preparation of hydrophobia vaccine, followed the same plan, and found in the successive inoculation from rabbit to rabbit a method of propagating the hydrophobia virus in a uniform condition. But attempts made to cultivate in a similar way the comma bacillus by transferring it from animal to animal failed.

The most susceptible animals for the cholera microbe are Guinea pigs. There are two principal methods of ingrafting upon them the virus: Koch's method of administering it through the mouth and leaving it to develop in the intestines of the animal, and Pfeiffer's of injecting it, not into the intestines, but into the abdominal or peritoneal cavity, where the intestines are lodged, by introducing there the virus with a hypodermic needle not allowed to penetrate into the intestines themselves. But by neither of these methods could the microbe be cultivated in an unbroken series of animals, as it became gradually weakened and soon lost its power of affecting such animals. For the purpose in question, cultivation in the peritoneal cavity had the advantage that in a healthy individual the peritoneum is free from other microbes, whereas in the intestines there are always present a large number of micro-organisms which interfere in variable ways with the growth of the particular microbes.

But when one inoculates the peritoneal cavity of a Guinea pig with a dose of cholera microbes sufficient to cause a fatal disease, it is found, when the animal dies, that the microbes have died also. Thus, the attempt to ingraft the virus from a first animal to a subsequent one is checked at the very beginning. This initial difficulty was overcome by merely giving to the first animal a dose larger than was necessary to cause a fatal effect. The animal then succumbs more rapidly, and the microbes have no time to disappear. At the post-mortem examination there is found, in the peritoneal cavity, a small amount of exudate liquid which contains large numbers of those microbes alive. When, however, that exudate is injected into the peritoneal cavity of a second animal that animal does not succumb to the infection, or even if it succumbs one finds that the microbes have again disappeared in this second animal. By starting with a still larger initial dose one may have three, perhaps four, successive animals affected by the virus, but it invariably ends by being weakened, and finally dies out.

In trying to obviate this result I found, perhaps contrary to expectations, that the exudation liquid should be exposed to the air for a few hours before it is injected into a subsequent animal. This result was contradictory to the effect which Pasteur had found to be exercised by atmospheric oxygen on the virulence of microbes, and it requires at least some provisional explanation. The microbes of cholera differ from a certain number of other microbes in that they stand in need of a free and abundant access of air for growing and multiplying quite satisfactorily. They are deprived of this condition in the peritoneal cavity of an animal. It is possible, therefore, that a certain opposition between the maintenance or development of virulence on the one hand, and a lowering in vitality on the other, takes place while they are cultivated there, and a respite must be given them between each successive 'passage' through the Guinea pig by leaving them for a time in the free atmosphere. Be that explanation true or not, the result is that under such conditions the successive animals inoculated with the virus do succumb, and even in a shorter and shorter time, after the inoculation, the microbe apparently undergoing under such a treatment a progressive increase in virulence. A similar development up to a certain stage was observed by Pasteur when transferring the rabies virus from rabbit to rabbit. The last difficulty that presented itself was the following: The exudation liquid which is found in the peritoneal cavity post mortem varies in quantity; sometimes it is inconveniently large and diluted; sometimes, on the contrary, so scanty that it becomes difficult to collect and transfer it to another animal. I found that this variation stands in connection with the size of the animal, so that a diluted exudation fluid can be concentrated by injecting it into a small animal, while a too much concentrated exudate is rendered more dilute by transferring it to an animal of a larger size.

Thus, by the initial use of more than a fatal dose, by alternating cultivation in an animal with exposure to air, and by attention to the size of the animal employed, a material was obtained which, as mentioned, increased in intensity from the first and proved fatal to animals in a shorter and shorter time after inoculation. Later the virus reached a stage when it killed a Guinea pig of three hundred and fifty grammes weight in eight hours. After that, in each further inoculation the time of eight hours remained stationary, showing that the virus has reached the condition of a 'virus fixe.' These experiments were conducted by me in the Pasteur Institute, in 1889 to 1893, simultaneously on the cholera microbe and on the bacillus of typhoid. The two exhibited a number of common features in their nature, and the results as above detailed for the cholera microbe were found valid for the typhoid bacillus also.

Starting from the 'virus fixe' obtained as above, a method of double inoculation was worked out, one with an attenuated virus prepared from the 'virus fixe,' and another with the latter itself. The two 'vaccines,' when inoculated successively into Guinea pigs, protected them against all possible forms of cholera infection. The vaccines were cultivated on a solid medium, and when the crop of microbes was ready at the end of some twenty-four hours, they were washed off the surface of the medium and used as a kind of medicinal plant. It was found that the substances contained in the microbes preserved to a great extent their immunizing properties even when the microbes were killed by some delicate processes not affecting considerably their chemical constitution. The washings could, therefore, be prepared in dilute solutions of carbolic acid, and employed in the form of preserved vaccines. In 1892 and in the beginning of 1893 I made a series of experiments in Paris, in Netley, in London, in Cambridge, and in Calcutta, with these carbolized cholera vaccines, which had been preserved in sealed tubes for a period of six to seven months, and it was possible to show the protective effect of the method on animals as conclusively as Pasteur had done in the demonstration at Pouilly-le-Fort with anthrax. For the inoculation in man, however, I decided to use at first only unaltered living vaccines, as much more promising than the dead ones, especially from the point of view of the durability of the effect.

[*To be concluded.*]

PROFESSOR EWART'S PENYCUIK EXPERIMENTS.*

THE views and works of Darwin have influenced in an unexpected way the nature of the work carried on by biological investigators during the latter end of this fast-dying century. To a great extent, while generally holding the doctrines he held, they have forsaken his methods of inquiry.

If animals and plants have arrived at their present state by descent with modification from simpler forms, it ought to be possible by careful searching to trace the line of ancestry; and it is this fascinating but frequently futile pursuit which has dominated the minds of many of our ablest zoölogists for the last thirty years. To such an extent has this pedigree hunting been carried that there is scarcely a group of invertebrates from which the vertebrates have not been theoretically derived; and to-day one of the ablest of our physiologists is using his great powers in the attempt to trace the origin of the backboned animals from a spiderlike creature, and is exercising his ingenuity in a plausible but unconvincing effort to equate the organs of a king-crab with those of a lamprey. This appeal to comparative anatomy and the consequent neglect of living animals and their habits are no doubt partly due to the influence of Huxley, Darwin's most brilliant follower and exponent. He had the engineer's way of looking at the world, and his influence was paramount in many schools. The trend which biology has taken since Darwin's time is also partly due to a fervent belief in the recapitulation theory, according to which an animal in developing from the egg passes through phases which resemble certain stages in the past history of the ancestors of the animal. For example, there is no doubt that both birds and mammals are descended from some fishlike animal that lived in the water and breathed by gills borne on slits in the gullet, and every bird and mammal passes through a stage in which these gill-slits are present, though their function is lost and they soon close up and disappear. In the hope, which has been but partially realized, that a knowledge of the stages through which an animal passes on its path from the ovum to the adult would throw light on the origin of the race, the attention of zoölogists has been largely concentrated on details of embryology, and a mass of facts has already been accumulated which threatens to overwhelm the worker.

The two chief factors which play a part in the origin of species are

* Abstract from an article in the Quarterly Review discussing Professor Ewart's 'Experimental Investigations on Telegony,' read before the Royal Society last year, and his book, 'The Penycuik Experiments,' published by Messrs. A. & D. Black.

heredity and variation, and until we know more about the laws which govern these factors we can not hope to arrive at any satisfactory criteria by which we can estimate the importance of the data accumulated for us by comparative anatomists and embryologists. Signs are not wanting that this view is beginning to be appreciated. The publication of 'Materials for the Study of Variation,' by Mr. Bateson, a few years ago, shows that there exists a small but active school of workers in this field; and the recent congress on hybridization, held in London under the auspices of the Royal Horticultural Society, is evidence that in America, on the Continent and in Great Britain one of the most important sides of heredity is being minutely and extensively explored. Prof. Cossar Ewart's experiments, which we shall attempt to summarize, deal with heredity and cognate matters, and, although they are so far from complete that the results hitherto obtained can not be regarded as final, they mark an important stage in the history of the subject.

Five years ago Professor Ewart began to collect material for the study of the embryology of the horse, about which, owing to the costliness of the necessary investigations, very little is at present known. At the same time he determined to inquire into certain theories of heredity which have for centuries influenced the breeders of horses and cattle, and the belief in which has played a large part in the production of our more highly bred domestic animals. Foremost among these is the view widely held among breeders that a sire influences all the later progeny of a dam which has once produced a foal to him. This belief in the 'infection of the germ,' or 'throwing-back' to a previous sire, is probably an old one—possibly as old as the similar faith in maternal impressions which led Jacob to place peeled wands before the cattle and sheep of his father-in-law Laban. The phenomenon has recently been endowed with a new name—Telegony. Since the publication of Lord Morton's letter to Dr. W. H. Wollaston, President of the Royal Society, in 1820, it has attracted the attention not only of practical breeders, but of theoretical men of science. The supporters of telegony, when pressed by opponents, having almost always fallen back on Lord Morton's mare, it will be well to recall the chief incidents in the history of this classic animal.

It appears that early in this century Lord Morton was desirous of domesticating the quagga. He succeeded in obtaining a male, but, failing to procure a female, he put him to a young chestnut mare, of seven eighths Arab blood, which had never been bred from before. The result was the production of a female hybrid apparently intermediate in character between the sire and the dam. A short time afterward Lord Morton sold his mare to Sir Gore Ouseley, who bred from her by a fine black Arabian horse. The offspring of this union, which were examined by Lord Morton, were a two-year-old filly and a year-old colt.

He describes them as having "the character of the Arabian breed as decidedly as can be expected where fifteen sixteenths of the blood are Arabian, and they are fine specimens of that breed; but both in their color and in the hair of their manes they have a striking resemblance to the quagga." The description of the stripes visible on their coats is careful and circumstantial, but the evidence of the nature of the mane is less convincing: "Both their manes are black; that of the filly is short, stiff, and stands upright, and Sir Gore Ouseley's stud groom alleged that it never was otherwise. That of the colt is long, but so stiff as to arch upward and to hang clear of the sides of the neck, in which circumstance it resembles that of the hybrid."

This is the classical, we might almost say the test, case of telegony: the offspring resembled not so much the sire as an earlier mate of the dam. The facts related tended to confirm the popular view, and that view is widely spread. Arab breeders act on the belief, and it is so strongly implanted in the minds of certain English breeders that they make a point of mating their mares first with stallions having a good pedigree, so that their subsequent progeny may benefit by its influence, even though poorly bred sires are subsequently resorted to.

The evidence of Lord Morton's mare convinced Darwin of the existence of telegony; after a careful review of the case he says "there can be no doubt that the quagga affected the character of the offspring subsequently got by the black Arabian horse." Darwin, however, latterly came to the conclusion that telegony only occurred rarely, and some years before his death expressed the opinion that it was "a very occasional phenomenon." Agassiz believed in telegony. He was strongly of the opinion "that the act of fecundation is not an act which is limited in its effects, but that it is an act which affects the whole system, the sexual system especially; and in the sexual system the ovary to be impregnated hereafter is so modified by the first act that later impregnations do not efface that first impression."

Romanes also believed that telegony occasionally occurred. He paid a good deal of attention to the matter, commenced experiments in the hope of settling the question, and corresponded at length on this subject with professional and amateur breeders and fanciers. The result of his investigations led him to the conclusion "that the phenomenon is of much less frequent occurrence than is generally supposed. Indeed, it is so rare that I doubt whether it takes place in more than one or two per cent of cases." A recent controversy in the Contemporary Review shows us that Mr. Herbert Spencer is a firm upholder of telegony, and that he has a theory of his own as to the mode in which it is brought about. He suggests that some 'germ-plasm' passes from the embryo into the mother and becomes a permanent part of her body, and that this is diffused throughout her whole structure until it affects, among other organs, the reproductive glands. This view, which in some respects recalls the pangenesis of Darwin, is intermediate between the saturation and the infection hypothesis. Professor Ewart refers to it as indirect infection.

Weismann, to whom we owe the term telegony, came to consider the facts for and against its existence in connection with his well-known inquiry into the inheritance of acquired characters. If telegony be true, there is no need to look further for a clear case of the inheritance of a character which has been acquired during the lifetime of the parent. The quagga-ness—if one may be permitted to use such an expression—of Lord Morton's mare was acquired when she was put to the quagga or shortly afterward, and was transmitted to her foals. A clearer case of a character acquired during lifetime and transmitted to offspring could not be imagined. Weismann does not absolutely deny the possibility of the existence of telegony, but he would like more evidence. In the Contemporary Review he writes, "I must say that to this day, and in spite of the additional cases brought forward by Spencer and Romanes, I do not consider that telegony has been proved." And further: "I should accept a case like that of Lord Morton's mare as satisfactory evidence if it were quite certainly beyond doubt. But that is by no means the case, as Settegast has abundantly proved." He would, in fact, refer the case to reversion, and quotes Settegast to the effect that every horse breeder is well aware that the cases are not rare when colts are born with stripes which recall the markings of a quagga or zebra. We shall return to this point later.

A considerable number of German breeders support the contention of Weismann that telegony is as yet unproved, and it may be pointed out that in Germany, on the whole, breeders have had a more scientific education than in England, and that in that country science is regarded with less aversion or contempt than is usually the case among so-called practical men in England. We may mention one more case of an experienced breeder who was equally skeptical—the late Sir Everett Millais, who was, as is well known, an authority of great weight in the matter of dog-breeding. He writes as follows, in a lecture entitled Two Problems of Reproduction: "I may further adduce the fact that in a breeding experience of nearly thirty years' standing, during which I have made all sorts of experiments with pure-blood dams and wild sires, and returned them afterward to pure sires of their own breeds, I have never seen a case of telegony, nor has my breeding stock suffered. I may further adduce the fact that I have made over fifty experiments for Professor Romanes to induce a case of telegony in a variety of animals—dogs, ducks, hens, pigeons, etc.—but I have hopelessly failed, as has every single experimenter who has tried to produce the phenomenon."

It is thus evident that there is a considerable body of opinion, both practical and theoretical, for and against telegony; and that a re-investigation of the subject is urgently needed. Such a reinvestigation has been begun by Professor Ewart at Penycuik. Since the clearest and most definite evidence of this throwing back to a previous sire is derived from the crossing of different species of the *Equidae,* it was desirable to repeat the experiment of Lord Morton. This is now unfortunately impossible, because the quagga is extinct. The zebra is, however, still with us, and the mating of a zebra stallion with every variety of horse, pony, and ass, and subsequently putting the dam to pure-bred sires, has been the more important part of the numerous experiments carried on in the Midlothian village some ten miles south-west of Edinburgh.

MATOPO.

Before considering in detail the result of the experiments it will be necessary to say a few words on the question of the various species of zebra; and since, like Weismann, Professor Ewart explains certain of the phenomena attributed to telegony by reversion, it will be as well to inquire how far reversion is known among the *Equidae,* and what evidence we have that the ancestor of the horse was striped.

Matopo, the zebra stallion from which Professor Ewart had up to last midsummer bred eleven zebra-hybrids from mares of various breeds and sizes, belongs to the widely distributed group of Burchell's zebras. Many subspecies or varieties are included in this group, which, as regards the pattern of the stripes, passes—in certain varieties found in Nyassaland—into the second species, the mountain zebra, once common in South Africa. The third species is the Grévy's zebra of Shoa and Somaliland; it is probably this species which attracted so much attention in the Roman amphitheaters during the third century of our era. A pair of Somali zebras has recently been presented to the queen by the Emperor Menelik, and is now lodged in the Zoological Gardens, Regent's Park. The species measures about fifteen hands high, is profusely striped, and stands well apart from the other two groups. It is important to note that, in Professor Ewart's opinion, it is the most primitive of all the existing striped horses.

There is no direct evidence that the ancestors of horses were striped. Certain observers think that some of the scratches on the lifelike etchings on bone, left us by our palæolithic cave-dwelling ancestors, indicate such stripes, but little reliance can be placed on this. On the other hand, there is much indirect evidence. Every one who has an eye for a horse, and who has traveled in Norway, is sure to have noticed the stripings, often quite conspicuous, on the dun-colored Norwegian ponies. Colonel Poole assured Darwin that the Kattiawar horses had frequently "stripes on the cheeks and sides of the nose." Breeders are well aware that foals are often born with stripes, usually on the shoulders or legs, less frequently on the face. Such stripes, as a rule, disappear as the colt grows up, but can often be detected in later life for a short time after the coat has been shed; they are sometimes only visible in certain lights, and then produce somewhat the same impression as a watered silk. From the facts that more or less striped horses are found all over the Old World; that in Mexico and other parts of America the descendants of horses which were introduced by the Spaniards and which afterward ran wild are frequently dun-colored and show stripes; that foals are frequently striped; and that mules not uncommonly have leg and shoulder stripes, the inference is largely justified that the ancestors of all our horses were striped.

We now pass to the experiments made at Penycuik in crossing the zebra Matopo with various mares of different breeds: 1. Matopo was first mated with Mulatto, one of Lord Arthur Cecil's black West Highland ponies. The result was the hybrid Romulus (see p. 132), which on the whole, both in mental disposition and bodily form, takes more after his father than his mother. His striping is even more marked than that of his sire. He has a semi-erect mane which has been shed annually. The pattern of the markings, on both body and face, resembles the stripes on a Somali zebra—which, as we have seen, is regarded by Professor Ewart as the most primitive type—more than they resemble that of any of Burchell's zebras. The profuse striping is a point of difference between this hybrid and Lord Morton's. The quagga-hybrid was less striped than many dun-colored horses.

The mother Mulatto was next mated with a highly bred gray Arab horse, Benazrek. The offspring agrees in all respects with ordinary foals; it had, however, a certain number of indistinct stripes, which could only be detected in certain lights. The stripes were not nearly so clear as in a foal bred by Mr. Darwin from a cross-bred bay mare and a thoroughbred, and they disappeared entirely in about five months.

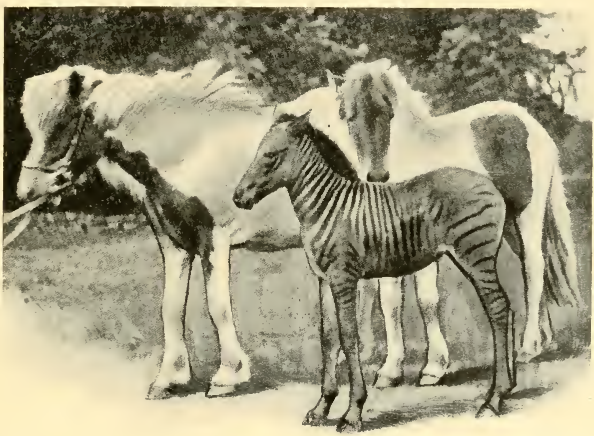
Recently Mulatto has produced a third foal to Loch Corrie, a sire belonging to the Isle of Rum group of West Highland ponies, and closely resembling his mate. This foal was about as much striped as its immediate predecessor. In both cases the pattern of the stripe differed not only from that of Matopo, the previous sire, but from that of the hybrid Romulus. These two foals seem to lend some support to teleg-

Romulus, Twenty-seven Days Old.

ony; but the evidence which might be drawn from the second of them is destroyed by the fact that the sire Loch Corrie has produced foals from two West Highland mares, one brown and one black, and each of these foals has as many and as well marked stripes as the foal of Mulatto.

2. Four attempts were made to cross the zebra with Shetland ponies; only one succeeded. The hybrid was a smaller edition of Romulus. The dam Nora had been bred from before, and had produced, by a black Shetland pony, a foal of a dun color which was markedly striped. After the birth of the hybrid she was put to a bay Welsh pony; the resulting foal had only the faintest indication of stripes, which soon disappeared. It is a remarkable fact that Nora's foals were more striped before she had been mated with the zebra than afterward.

3. Five Icelandic ponies were mated with Matopo, of whom one produced, in 1897, a dark-colored hybrid. The dam, Tundra, was a yellow and white skewbald which had previously produced a light bay foal to a stallion of its own breed. Her third foal (1898) was fathered by a bay Shetland pony, and in coloration closely resembled its dam. There was no hint of infection in this case. This year Professor Ewart has bred from this mare, by Matopo, a zebra-hybrid of a creamy-fawn color, and so primitive in its markings that he believes it to stand in much the same relation to horses, zebras, and asses as the blue-rock does to the various breeds of pigeons (see illustration).



TUNDRA (AN ICELAND PONY), HER FOAL, CIRCUS GIRL (BORN 1898), AND HER HYBRID FOAL, SIR JOHN (BY MATOPO), WHEN A MONTH OLD (BORN 1899).

4. Two Irish mares, both bays, produced hybrids by Matopo, and subsequently bore pure-bred foals. One of the latter was by a thoroughbred horse, the other by a hackney pony. The foals were without stripes, and showed no kind of indication that their mother had ever been mated with a zebra.

5. Although Professor Ewart experimented with seven English thoroughbred mares and an Arab, he only succeeded in one case. The mare produced twin hybrids, one of which unfortunately died immediately after birth. This summer the same mare has produced a foal to a thoroughbred chestnut; "neither in make, color, nor action" does it in any way resemble a zebra or a zebra-hybrid.

6. A bay mare which had been in foal to Matopo for some months

miscarried. Here—if there is anything in the direct infection theory —the unused germ-cells of the zebra had a better chance than usual of reaching the ova from which future offspring are to arise, yet neither of the two foals which this mare subsequently produced to a thorough-bred horse "in any way suggests a zebra."

The above is the record of the successful experiments which have been tried at Penycuik, with a view of throwing light on the existence of telegony in the *Equidae*. Experiments have also been made with other animals, such as rabbits, dogs, pigeons, fowls, and ducks. Space allows us to quote but one. Six white doe rabbits, all of which had borne pure white offspring to white bucks, were crossed with wild brown rabbits. The result was forty-two young rabbits, all of a bluish-black color, which in a very short time turned to a brown. These, at the time of writing, were about half grown, and Professor Ewart tells us that it is almost impossible to distinguish them from a full-blooded wild rabbit kept in the same inclosure. The half-breeds, however, were tamer and slightly lighter in color. The mother does next bred with white bucks again, and in every case bred true. The pure white young showed no trace of throwing back to a previous sire.

A phenomenon somewhat similar to telegony, and one which seems at present quite unexplained, is that a hen which has been crossed with a cock of another breed often lays eggs whose shell is no longer like that of its own breed, but in color, and frequently in texture, resembles that of the breed with which it has been crossed. When one calls to mind that the shell is deposited by a special shell-gland which is in no way connected with the ovary, but is a part of the quite distinct oviduct, and that the change in the color of the eggshell must be caused by some change brought about in this gland by cross-fertilization, we begin to recognize how mysterious and inexplicable are many of the problems which affect breeding.

Throughout his account of his experiments Professor Ewart is extremely cautious in claiming to prove anything, but we think he has justified his claim to have shown that telegony by no means always occurs, as many breeders believe. His experiments so far support the view of Continental mule breeders, that telegony, if it takes place, occurs very seldom. But the experiments are not complete, and it is much to be hoped that they may be continued. If it should subsequently appear that out of fifty pure-bred foals from dams which have been previously mated with the zebra no single instance of telegony be found, the doctrine may surely be neglected by breeders; and if in the experiments which are now being carried out with various other mammals and birds telegony does not occur, the doctrine may be relegated to the 'dumping-ground' of old superstitions. The present state of the matter may be summed up in the professor's own words: "The experiments, as far as they have gone, afford no evidence in support of the telegony hypothesis." Nothing has occurred which is not explicable on the theory of reversion.

There is no factor in breeding of more importance than prepotency, and none which is more difficult to estimate. The term is necessarily a relative one, and, further, it may affect some characters and not others. Often it must go undetected, as in the case of the leader of a herd of wild cattle, who may be highly prepotent, but whose prepotency, unless he is mated with members of another herd displaying different characters, may pass unnoticed. Breeders claim to be able to produce cattle so prepotent that they will produce their like, however mated. A well-known dealer in highly-bred ponies used to boast that he had a filly so prepotent that, though she were sent to the best Clydesdale stallion in Scotland, she would throw a colt showing no cart-horse blood. Prepotency is usually obtained by inbreeding, which up to a certain point fixes the character of a race, and in all cases tends to check variation and reversion—the Jews, for instance, as a race are strongly prepotent —but there is no doubt that it may also arise as a sport, and this is probably its more usual origin in a state of Nature. Professor Ewart, however, believes that inbreeding is much commoner among wild animals than has usually been conceded, and he holds the opinion that the prepotency so induced has played a considerable part in the origin of species. This, if true, would to some extent take the place of Romanes' 'physiological selection'; for Romanes also thought that, though of great importance, variation and natural selection were insufficient to account for the origin of species without some factor which would help to mitigate the swamping effect of intercrossing—some such agency as the fences of modern farms and cattle ranches—without which the famous cattle breeds of the world would soon disappear in a general 'regression toward mediocrity.'

In inbreeding the great difficulty of the breeder is to know when to stop. Carried too far it undoubtedly leads to degeneracy. In the 'Domesticated Animals of Great Britain,' Low records the case of a gentleman who inbred foxhounds to such an extent that "the race actually became monstrous and perished." Hogs, if too closely inbred, grow hair instead of bristles; their legs become short and unable to support the body; and not only is their fertility diminished, but the mothers can not nourish the young.

So far as is known, no direct investigations have been made to test how far inbreeding may be carried in the *Equidae*; but, on the other hand, the breeding of race-horses may perhaps be looked upon as a gigantic experiment in this direction. Our English thoroughbreds can be traced back to a few imported sires—the Byerly Turk, imported in 1689; the Darley Arabian, in 1710; and the Godolphin

Arabian, in 1730. Since then, by careful breeding and nutrition, they have increased on an average some eight or nine inches in height. There is, however, a widely spread impression that at present there is a marked deterioration in the staying power and in the general 'fitness' of the racer. The falling off is further shown by a fact commented on by Sir Walter Gilbey—viz., "the smallness of the percentage of even tolerably successful horses out of a prodigious number bred at an enormous outlay." In support of this he quotes a sentence from the *Times* (December 27, 1897), referring to a sale in which thirty-two yearlings had been sold for 51,250 guineas: "These thirty-two yearlings" (said the *Times*) "are represented by two winners of five races, Florio Rubattino and La Reine, who have contributed about 2,000*l.* to the cotal cost; and there is not, so far as can be known, a single one of the thirty others with any prospect of making a race-horse."

If, then, it is true that the English race-horse is on the down grade, what steps should be taken to arrest this descent? Sir Everett Millais restored a pack of basset hounds by crossing them with a bloodhound, the original forefather of bassets. The resulting pups were bassets in form, but not quite bassets in color; when, however, these cross-breeds were mated with bassets the majority of the pups turned out to be perfect bassets both in shape and coloration. This indicates that one way to rejuvenate the race-horse would be to have recourse to a new importation of the best Arab mares that the plains of Arabia can produce. Breeders hesitate to adopt this course, because their present breed is not only larger but, over very short distances, fleeter than its forefathers. The shortening of the course in recent years is probably a further sign of the degeneracy of our present racers. Were new blood introduced and more three- or four-mile races instituted, we should doubtless soon have a return to the champion form of bygone days. Another method would be to import some of the racers of Australia or New Zealand and cross them with the home product. Different surroundings, food, etc., soon influence the constitution, and this being so, it would be advisable to select those horses of pure descent which have been longest subjected to these altered conditions. Thus the chance of reversion occurring would be increased.

It has been noticed more than once in the preceding pages that a young animal showing reversion is strong and vigorous. It is the belief of dog breeders that those members of an inbred litter which show reversion are the strongest and best. Similarly, experience shows that if an inbred sire and dam produce a dun-colored striped foal it almost always turns out well. Reversion is accompanied by a rejuvenescence; it is as though the young animal had appeared at an earlier period in the life history of the race, before the race had undergone those changes in the way of deterioration which so often accompany inbreeding.

Wild animals are frequently thought to be prepotent over tame ones, but of the eleven zebra-hybrids bred at Penycuik only two took markedly after their sire, the zebra Matopo.* There are other experiments recounted which tell the other way, and at present this matter remains in a state of considerable uncertainty.

This article must not close without a word or two more about the zebra-hybrids. It is mentioned above that only two out of the eleven which have already been born took strongly after their father.

ROMULUS.

MATOPO.

Those who have seen the young hybrids playing about in the fields at Penycuik must agree that they are the most charming and compactly built little animals possible. Of Romulus, the eldest of the herd, Professor Ewart says: "When a few days old [he] was the most attractive little creature I have ever seen. He seemed to combine all the grace and beauty of an antelope and a well-bred Arab foal. . . . What has struck me from the first has been his alertness and the expedition with which he escapes from suspicious or unfamiliar objects. When

* The illustration shows the difference between the facial marks of the zebra and those of the hybrid. The latter, in this respect, bears much the same relation to the former as a blue-rock pigeon does to a fancy type.

quite young, if caught napping in the paddock, the facility with which he, as it were, rolled on to his feet and darted off was wonderful."

The writer can fully confirm all the praise Professor Ewart lavishes on his pets; in truth, Romulus has been well described as a "bonnie colt with rare quality of bone . . . and with the dainty step and the dignity of the zebra." Remus, the offspring of the Irish mare, has been from the first more friendly than his half-brother; he objected less to the process of weaning, and, if he survives, promises to be the handsomest and fleetest of the existing hybrids.

On the whole, the hybrids are unusually hardy; only two have been lost—one, a twin, which died almost as soon as it was born, and another which lived some three months and then succumbed. It is only fair to say that the dam of the latter, who was only three years old when the hybrid was born, had been much weakened by attacks of the strongylus worm, and that she was the victim of close inbreeding. Both the zebras and the hybrids which have been under observation at Penycuik show a remarkable capacity for recovering from wounds. Accidental injuries heal with great rapidity. On one occasion the surviving twin was discovered with a flap of skin some five inches long hanging down over the front of the left fetlock. The skin was stitched into its place again, during which operation the little hybrid fought desperately and cried piteously; but it soon recovered, the wound healed, and now scarcely a scar remains. There was no lameness and no swelling either at the fetlock or above the knee. About a year ago four hybrid colts and three ordinary foals were attacked by that scourge of the stable, the strongylus worm. One of the latter died and another was reduced almost to a skeleton; the hybrids, though obviously affected, suffered much less than the others and soon recovered. It is further noticeable that the hybrids suffer less from colds and other slight ailments than the mares and horses among which they live.

There is no doubt that it is a comparatively easy matter to breed these hybrids, and that they are not only extremely attractive animals to the eye, but hardy and vigorous, possessed of great staying powers, and promising to be capable of severe work.

From what we have said, it is evident that the Penycuik experiments are of the highest interest, both practical and theoretical, and the public spirit and self-devotion shown by the Edinburgh professor in carrying them out can not be too widely recognized.

COLONIES AND THE MOTHER COUNTRY. (I.)

BY JAMES COLLIER.

WE may conceive a country, with its colonies and dependencies grouped round it at unequal distances and in different directions, as a giant organism, which has its laws of growth and development, its phases of expansion, activity and decay, like all other organisms. We see it enlarging in mass, but to the last remaining amorphous, or assimilable to no known forms. We observe the heart and brain fostering, helping and sometimes hindering, directing, controlling and guarding the evolution of the nearer or remoter portions. We perceive on scrutiny threads of relationship being woven, new nervous, muscular and circulatory systems being developed, which connect the extremities with the center and unite both into an organic whole. We are struck at times with the rupture of the mass and the permanent separation of parts of it; at times we are impressed by an unexpected augmentation in previously unknown areas, as if to repair the loss of the old. We witness the extremities reacting on the original nucleus, to some extent remodeling the heart and brain and thus creating a type of organism unprecedented in Nature. And we find that of a limited number of such colossal types, ever battling for predominance, one or another gains an ascendency and the rest are reduced to a secondary rank, or, being lopped of their colonial extensions, cease to be world-wide organisms and shrink into the merely national organisms from which they sprang.

Snails put out their feelers as they go. The bolder insects and the more adventurous birds fly small or great distances in search of a feeding ground; some are carried out to sea, and become involuntary 'discoverers' of new lands.* The social organism puts out its feelers and extends in mass. The community pushes out its scouts, and a portion of it, at longer or shorter intervals, follows their lead. Thus the mother country discovers many of the territories it colonizes. Cadiz was unknown to the Eastern world till a Phœnician merchant ship was blown thither. The West African coast and the mouth of the Rhone were discovered by the Carthaginians. Libya (west of Egypt) was a *terra incognita* to the Greeks till a Greek sailor who had been driven on its inhospitable coast informed the emigrant Theræans of its existence. The Portuguese discovered the Azores. The Span-

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*Examples of insects are given in Darwin's 'Journal,' and of birds in Wallace's 'Malay Archipelago.'

iards discovered the West India Islands, Mexico, Peru and Florida. France discovered the country lying along the basin of the St. Lawrence and the valley of the Mississippi. Holland, through an English navigator, discovered the Hudson River and the future site of New York. England, through another alien, discovered the New England coast and that of Virginia; it discovered, or rediscovered, vast Australia, New Zealand, Tasmania and other South Sea islands; in quite recent years it discovered the sources of the Nile. All these countries have been or are about to be colonized by the peoples that discovered them.

Discovery is chiefly the work of private enterprise. It was Phœnician and Greek traders who explored the northern and western coasts of Africa, of Spain, of Gaul, and of Britain. Scandinavian mariners, Norman and English fishermen, discovered North America. Spanish adventurers found the Canaries. The host of travelers have explored on their private account. Yet there are animals, like Mr. Thompson's Lobo, the wolf, and Spot, the crow, able generals and leaders of large bands, who seem to direct exploratory movements. So after a while governments lend their aid when they have ends of their own or their aid is needed. The two most memorable exploring expeditions of modern times, and the most momentous in their results, were either in great part or wholly equipped by their respective governments. Two of the vessels of Columbus were impressed ships, and the equipment proceeded from the Castilian treasury, the third being fitted out by merchant mariners of Palos. The expedition of Captain Cook, which practically added a new continent to the globe, was altogether a state enterprise, and its celebrated commander was not, like Columbus, its designer and organizer, but only its director. The Portuguese discoveries of the Azores and the Cape were also state-aided. From this time forward Spanish and Portuguese adventurers received a royal license to discover, and the South American continent, with Mexico and Peru as its brightest jewels, was discovered by just such adventurers. Where a government refuses itself to discover, it may, like the States-General of Holland, assure to the enterprising a terminable monopoly of trade with newly discovered lands, and to this assurance the exploration of New York and its neighborhood and the discovery of Connecticut were due. Merchant companies have naturally a keen eye to the main chance, but those English and Dutch merchants can not be accused of timidity who chartered Cabot, Gilbert, Hudson and other daring mariners to seek a northwest passage to the East. Kings, in their private capacity, newspaper proprietors and rich individuals, from generous motives, sometimes equip and support explorers like Stanley and Winwood Reade.

Geographical, like scientific, discovery is often accidental. Phœnician and Greek traders, Spanish adventurers, Norman and English fishermen were blown by a succession of gales to Cadiz and Cyrene, the Canaries, Mexico and Newfoundland. Diaz was storm-carried southward to the Cape, where two shipwrecked mariners long afterward induced the Dutch to settle. Columbus, Cabot and Hudson sought a passage to India or China. The day comes, however, when chance gives way to a systematic art of discovery. The voyage of Columbus was the first where the end was deliberately aimed at and patiently worked up to. Under Ferdinand the Catholic maritime discovery was raised to an art. A board of eminent Spanish navigators, with Vespucci at its head, sat to construct charts and trace out routes for projected voyages. The primary object of Cook's first voyage was astronomical, and he was scientifically equipped for discovery on that, as of course also on the two later voyages, whose sole end was the one so gloriously gained.

Prior discovery confers an indefeasible title to occupy as against any other colonizing power. Misled by a false statement, a British man-of-war entered the Mississippi presumably to take possession of Louisiana, but turned aside on being informed of the earlier French occupation. In the thirties two naval expeditions were exploring at the same time in Spencer Gulf, South Australia. Though the French gracefully yielded the *pas* to the prior English ship, they left a mark on a number of points that still bear French names. There seems to be now no doubt that Brazil had been discovered and rediscovered by Spanish navigators before the Portuguese *carbajal* set foot on it, but, owing to an international agreement, the discoverers ceded their claim.

Discovery does not necessarily issue in colonization. The more or less mythical discoveries of the coasts of North America and Australia in the ninth and sixteenth centuries interest the antiquarian rather than the historian. They resemble the so-called anticipations of scientific discoveries—Cesalpino's, of Harvey; Vico's, of Wolf and Niebuhr; Swedenborg's, of Kant; and a host of guessers, of Darwin. As proof alone is discovery in science, so only exploration is discovery in geography. For lack of this essential element even well-certified discoveries are apt to be fruitless. Tasman's frightened glimpse of New Zealand and his more careful coasting of Tasmania left durable marks on both countries, but only in nomenclature. They led to nothing. No Dutch settlement seems ever to have been made south of New Guinea; no northern nationality is more conspicuously absent among the colonizers of the South Seas. The earlier Portuguese discovery of the Cape of Good Hope was regarded as that of a halfway house to a more distant goal; they stopped to recruit, then hurried off to rich Cathay. The French left their names to a dozen headlands and rivers on the coast of Western Australia, but, though they often excited the suspicions of New South Wales, they made no attempt to settle.

Discovery, to assure sovereignty over the discovered country, must be followed, among animals as among men, by effective occupation. The Portuguese were roused into warlike excitement a few years ago by the advance of the Chartered Company into Mashonaland, where their settlements had long ceased to exist. Their claims to the basin of the Congo were on the same ground equally disregarded—this time by all the powers. A bit of seacoast can more easily be kept, and Delagoa Bay was assured to them by the French arbitrator. Mere occupation has at various times given a valid right to a territory. The Puritans found several islands off the New England coast to be destitute of inhabitants, and the shores so thinned of Indians by an epidemic as to be practically uninhabited. Yet they were careful to assure their title by purchase. The Manowolko Islands of the Malay Archipelago were without indigenes when the first settlers arrived. Pitcairn and Norfolk Islands were found by the mutineers of the Bounty and the convicts from New South Wales to answer to Defoe's notion of a desert island. The first English settlers in Australia and the first French settlers in New Caledonia met with no resistance from the blacks at the initial stages of occupation. When the Boers trekked across the Vaal they entered on a country that had been left, through exterminating native wars, to the beasts of the field and the forest. The situation is very different when a rival civilized power lays claims to the territory. When Great Britain forcibly took possession of West Griqualand in 1871 she had to salve, without satisfying, the claims of the Orange Free State to one of the richest diamond fields in the world by a payment differently stated at £90,000 and over £100,000. Having to deal with a European power, she was constrained to submit to arbitration her pretensions to the so very useful and convenient Delagoa Bay. In attempting to extend British Guiana, so as to gain command of the Orinoco, she came into collision with the mightiest of American peoples, which now guards the interests of all the others. The United States refused to acknowledge the doctrine of 'squatter sovereignty,' and one of the preliminaries of the Venezuela arbitration was the addition to international law of the rule that a period of fifty years' uninterrupted occupancy was required to constitute valid sovereignty. England has gone through the world, like Sir Tantalus's man with his iron flail, beating down the weak and robbing the helpless. Yet few countries can show an equal record of honorable renunciations. It long refused to annex New Zealand, now one of the finest of its colonies. It long refused Fiji and Natal. It refused Samoa. It refused Bechuanaland for a time. It refused Angra Pequena. It would not listen to the discoverer who called on it to occupy equatorial Africa. It disavowed the action of Queensland in annexing New Guinea. It surrendered the Ionian Islands. Its constant injunction to its high commissioner in South Africa was not to advance the line of conquest. It surrendered, in 1854, its sovereignty over the Boers of the Orange River. That surrender was condemned by British governors, is still condemned by historians, and was disliked by the wealthier and more intelligent Boers; how wise and just it was is shown by the jealousy with which the republic has since watched over its independence. To its eternal honor—or rather to that of Gladstone—it nobly gave back the Transvaal to its stalwart farmers. France long relinquished Algeria and Madagascar, which her missions and commercial stations in the seventeenth century gave her a prescriptive right to occupy two centuries later. It refused to support De La Tours, and abandoned Labourdonnais and Dupleix. Through mere inertia Portugal has let slip from her hands a grand inheritance. The Dutch repressed the extension of their colony at the Cape. Java flourishes, but Dutch New Guinea lies rotting.

A species, extending beyond its original habitat, has often to battle with lower species already in possession of that portion of the earth or water. So, except in rare cases, occupation means the necessity of conquest. The Puritans, as they advanced into the interior, had to fight for the possession of New England. The nomadic Australian blacks offered no resistance to the earliest settlers, but as they were driven inward they disputed, and are still fiercely disputing, every foot of territory. As the indigenes rise in the scale, have clearings and cultivate the soil, the resistance increases. No savage peoples have cost the invaders so much in disturbance, blood and treasure as the Indians, Maoris, Kaffirs and Algerian Arabs. Mashonaland was occupied by the Chartered Company without firing a shot or losing a life, but it had soon to fight for possession. The incessant turmoil, though the waves of it spread to the remote mother country, affects the settlers mainly. The blood shed is both colonial and metropolitan. The North American settlers fought their own hard battles; though British troops engaged, to their cost, with the Indians, it was against these as allies of the French; in recent years the British garrison in Canada has been employed against the half-castes. In New Zealand colonial volunteers joined with the regular troops to defeat the Maoris, and the former were sometimes found the more efficient.

The most picturesque conquests in history were effected by private enterprise. Mexico was conquered by local recruits. Pizarro was authorized to conquer Peru in the name of the Spanish crown, and, besides various other encouragements, he received a modest sum from the Spanish treasury. But it was again by local recruits, not one of them furnished by the Spanish Government, that the conquest was made and maintained. Algeria has a very different story to tell. The troops employed in effecting a difficult conquest spread over thirty years were French from first to last. In general, it may be said that where there have been regular campaigns and pitched battles the metropolitan troops bear the brunt of the fighting. Where there is a guerrilla warfare, as with the Australian blacks, it is carried on by the colonial police or by the settlers, sometimes with the aid of the natives themselves. The Carthaginians built up their empire by native auxiliaries. The French and English conquered Canada with the Hurons and Iroquois as auxiliaries. The English mastered New Zealand with Maoris for allies, and defeated the Kaffirs with the help of the Fingoes (a related variety of the Bantu race). Rhodesia was won by a force half Kaffir. Peruvians aided Pizarro. India has been made British by armies of which four fifths were Indian. A people, like a man, contributes to its own subjugation. The expense is likewise distributed. Fifty years of intermittent war with the Kaffirs cost Great Britain twelve million pounds, and it may safely be assumed that a no smaller sum was expended in New Zealand. The colonists honorably bear their share. The premier of the latter colony told a London audience in jubilee year that it was now cheerfully paying the interest on a debt of eleven millions incurred in "holding the colony for the empire." After a Kaffir war Cape Colony was saddled with a debt of three or four millions. Other losses fall more directly on the settlers. Probably none have borne such disasters and so much suffering as the early colonists of North America. The destruction of property in a single New Zealand campaign amounted to £150,000, and the farmers on the frontiers of Cape Colony have suffered far more severely, as those on the frontier of Queensland are suffering now. If blood and money, poured forth like water, can furnish conquest with a valid title to territory, not a few British and French colonies have been justly annexed.

The expansion of an organism or a species is determined also by its struggle with other equal organisms or species which conflict with it. The hardest fight is with individuals of the same or similar species. So are rival colonizing powers usually more formidable opponents to the acquisition of a country than its indigenes. The Carthaginians were robbed of some of their colonies by the more numerous Greeks, and the Greeks of many of theirs by the all-conquering Romans. The Swedes lost a colony to the Dutch. The short but decisive struggle between the Dutch and the English was followed by the loss of the Dutch colonies in North America and the West Indies. In the eighteenth century, after every great war a group of colonies fell into the hands of the victorious power. The West India Islands and those of the Indian Ocean were for many years tossed as in a game of battledore and shuttlecock between France and England. The possession of Canada was a bone of contention between the two countries for several decades. Seeley even maintains that the hundred years' war ending in 1815 was a long rivalry between France and England for the New

World and India. If so, it was marked by striking acts of generosity. Conquests made in Canada by England, with the efficient aid of the American colonies, were more than once given back to France. When all but two of the West India colonies were surrendered in 1814 the Foreign Minister explained that it was desired to open to France the means of peaceful expansion, and it was not the interest of England to make her a military and conquering power. The rivalry did not end with the Napoleonic wars. According to one historian, Australia was saved to the English in 1788 by six days, and for long afterward there was a constant jealousy of French occupation. Ships were sent by Australian governors to take possession of Van Diemen's Land, of southern, western and northern Australia when it was believed that the French had designs on them. An English war ship, sent by the governor of the North Island of New Zealand to annex the rich and fertile South Island, anticipated by only a few hours a French ship dispatched for the same purpose. The rising of the French Canadians in 1838 has been described as "the last convulsion of despair of a sinking nationality." The English, French, and now the Germans are still rivals in present and future colonizing grounds in Africa, China, and the South Seas. But no British colonist doubts that further pacific defeats (if only by being bought out of their possessions) await the French in different quarters of the globe, for it is the colonies that press forward. The North American colonies were at all times more aggressive than the mother state, as the Australasian are now. They are unconsciously on the way to become the suns of new systems.

Conquests may be made on various pretexts. The Cape was twice seized by the English to prevent it from falling into the hands of the French, and a few years later the Dutch were constrained to cede the colony to its temporary possessors. Gambetta schemed to annex and colonize the whole North African coast from Egypt to Morocco, and thus to create a *France nouvelle* along the northern shores of the Mediterranean in place of the New France lost in Canada more than a century before, or of that still older New France on the shores of the Bosporus. In pursuance of this policy, the powers at the Berlin Conference in 1878 permitted France to occupy (not to annex) Tunis, prohibiting her, however, from fortifying its chief port. But no one doubts that the 'regency' there, as in Madagascar, will speedily give way to undisputed sovereignty, and Bizerta is already fortified. Writers are said to be dreamers, and Locke's constitution for Carolina, Rousseau's for Corsica, Bentham's for Russia, with many another quixotic proposal, furnish proof of their simplicity or their wrong-headedness. It is nevertheless a fact that most of the new ideas that are being carried into effect are the suggestions of publicists—journalists who stand midway between men of thought and men of action. Sometimes the former contribute immediately practicable proposals. Russia, Germany, France, and Great Britain—the four grasping powers—along with Italy and Belgium, are now, after a digestive interval of thirty years, carrying out a suggestion made by Renan in 1871. The Chinese, who threw off the yoke of the conquering Mongols, belong (it appears) by ordination of Nature to the subject races. The people that produced Confucius and Lao-tze consist of laboring men who need direction and organization. China, therefore, calls for conquest. The powers have obeyed the call, and that vast and peaceful land is now undergoing dismemberment, with a view to final wholesale partition. It is a parallel to the conquest of Peru by the Spaniards. In both countries a more perfect civilization of a lower type was or will be superseded by a less perfect civilization of a higher type. In this alone lies its assumed justification. Evidently the argument may be carried far. It would justify Russia in occupying Turkey, the United States in conquering not only Spanish colonies but Spain itself. It was the moral justification of the Gothic invasions of the early Christian centuries. It is a sentence of death or (it may be) of new life to all moribund nationalities.

Other modes of acquiring colonies are by cession and by purchase. The former is often disguised conquest, like that of the Cape to England. The latter may be so as well, like that of the African diamond fields by England. Colbert bought, for less than a million francs, certain of the West India Islands and the Antilles. The United States has bought her last colonies from dying Spain for four million pounds. At no distant time the Australian colonies will probably buy France and Germany out of the Pacific, and Holland and Germany out of New Guinea. It will be none the less a moral conquest. The right of the stronger, or the more fit to colonize, will still be, as it ever has been, the sole title to possess.

By these various means habitats have been found for future colonies, spheres for future colonial expansion.

[*To be continued.*]

THE FUTURE OF THE NEGRO IN THE SOUTHERN STATES.

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WHATEVER danger there may be of serious conflict between the negroes and whites in the Southern States—at most but slight —is likely to arise from the fact that the old class of slaveholders, men accustomed to hold a caretaking relation to the lower race, is passing away. Already the greater number of the white people know the blacks only as they are known by the Northern folk. Race prejudice, which in the days of slavery was hardly more than formal, finding expression mainly in certain rules as to the behavior of the inferior class, is likely to increase in proportion as the two peoples become parted from one another in interests. If the present movement to disfranchise the negroes should lead to their general and permanent separation from political life, or if in elections they should again array themselves as they did immediately after the war—under the lead of white adventurers against the property interests of the commonwealth—then there may be disaster. The aim of the statesman—of every citizen in his quality of a statesman—should be to make the present political separation of the races, as far as possible, temporary. Their effort should be to develop in the blacks the qualities which may make them safe holders of the franchise, and to give that trust to all who become worthy of it. We may at once put aside all the futile expedients for other dispositions of the negroes than the simple plan of adopting them into our national life. The ancient project of returning them to Africa, the suggestions that they should be deported to some part of the American tropics, or be segregated in some one of the Southern States, are all too impracticable to deserve a moment's attention. They must be dismissed, if for no other reason, because the labor of the negroes is needed where they now dwell. Their exodus would mean the commercial ruin of half a dozen great States. It is hardly necessary to suggest that any such action would involve a trespass upon the rights of both the whites and blacks too great to be thought of in our day.

Assuming that the only thing to do with the negroes is to shape them so that they may be fit for the place of citizens, the question is as to the steps which may be taken to attain this end. It is evident that it cannot quickly be done. Acting on the basis of our experience with immigrants from Europe, a majority of Congress concluded that all the negro needed to convert him from the slave to the truly free man was the ballot. We failed to see that between the primitive station of our race, two thousand years ago, and its present state there lay twenty centuries of toil and pain, spent in winning the state of mind of the citizen. We mocked the African with the gift of the franchise. We have now to begin where we should have begun thirty-five years ago, with measures that are proportionate to the need—with a system of education that may serve to develop the saving qualities of the race. What should this education be?

To most of us education begins with an alphabet and goes on to an indetermined limit of things that are to be had from books. The method is naturally esteemed, for we behold that the useful citizen comes forth from such teaching. Yet, logically, we might as well attribute the shape and quality of the body to the clothes it bears. The real education of our race, that which gives the most of its value to the trifle of instruction we give our children, is clearly a matter of race experience; of training in the generations of deeds since it began to pass from primitive savagery. First came the lessons in the art of continually laboring. Fortunately this lesson of labor the negro either brought with him, or learned so well in the generations of slavery that it is safely acquired. Next came the training in the occupations above the plane of simple agriculture—the industries of the forge, the loom, the ship and of military service and with it the habits of associated action. Along with these came the development of the commercial sense with the enlargements of view it gives, and from this the common sense of public affairs that makes a democracy possible. We assumed all this race training in the African when we cast him the ballot. Now that he has failed to profit by our folly, we begin to doubt whether there is, after all, the making of a citizen in him. A reasonable view of the facts leads us to conclude that he can be made a valuable citizen, provided he has a fair share of real help in the task of becoming such.

The first need of the negro is the conviction that his salvation depends upon himself. So long as he is deluded by the hope that some great external power is to lift him to the social and economic level of the whites, there is no chance that he will come to depend on himself for advancement. From this point of view, at least, it is advantageous that the attention of this country is for the time turned away from them in a search for other, and less practicable endeavors, to lift lowly peoples to the Saxon's estate. The next is that the negroes be as rapidly as possible employed in varied craft work—work in which they may receive a larger training than the toil the fields afford. The simple yet valuable lessons of the soil-tiller they have had. For the greater number of their race, particularly those of the Guinea type, this grade of employment is as high as they may be expected to attain. Yet somewhere near one-third of the people of their color are fit for employments demanding more skill and, because of that skill, giving a better intellectual station. The mechanical employments of the day are ever gaining in their culture-giving powers. The complication of the machines which are used, and the mysterious nature of the powers which they apply, seem to make them more effective means of enlargement than the old simple tools. Those who have observed the process by which the horse-car driver of a decade ago has been converted into the motor-man of to-day have had a chance to see what the control of energies may do for them. I feel safe in saying, from the basis of personal experience with the negroes, that somewhere near one third of them are fit to be trained for mechanical employment of a fairly high grade. They will need more instruction than the average whites, but they will have a keen interest in their work, and are more likely than the whites to lead up their children in their own trades. For such employment the types which, for lack of a better name, I have termed the Zulu and the Semetic are clearly well fitted. Here and there in the South we find these people of the abler stocks already so employed.

There seems no reason to believe that there is at present enough race prejudice in the South to oppose any effective resistance to negroes entering on any such employment as that of the engineer. It is true that among the women operatives in spinning and weaving mills there has been such objection already found as to make it impossible to employ the negro and white in the same rooms. It is, however, improbable that there would be any opposition to having the black women engaged in the industry, provided the personal association with the whites was not required. Whatever resistance it would be necessary to overcome in order to make the negro free to engineering employments would proceed from the poor white class or from Northern loom operators who brought to the South the obdurate hatred of the negro which is so strong in the regions where he is rarely seen. The old slave-holding class, and those who inherit their motives, will, I am convinced, welcome the effort to open such places to well-trained blacks. As an evidence of the state of mind of this ruling class, I may relate an experience of a year or two ago in one of the most remote corners of the extreme South:

I was lodged for some days in a small rustic inn whereto came, in the evening, a dozen men of the planter class to spin yarns, smoke and drink. They had all been Confederate soldiers—some of them were the very remnants of war. Willingly they allowed the talk to be led to the question as to the future of the black people. They showed their interest in all the forms of trade schooling that could be given them, and their contempt for the results of the literary education which they have received. Repeated reference was made to the great work that Booker Washington was doing at Tuskegee, and for it there was nothing but praise. One of the men dwelt with pleasure on the fact that in the nearest large town two negroes, trained at Tuskegee, were doing all the contract building, having 'run out' some cheap, ill-trained whites who had long been in the business. This talk was clearly not shaped for Northern ears, for the double reason that the Southern folk are not in the least moved to such deception, and also because I was with them as one of their own people. Very many such occasions for learning the temper of the ex-slaveholder class have convinced me that at present, and until the Southern conditions are assimilated to those of the North, there will be no difficulty in developing the technical skill of the blacks arising from the disinclination of the people when they are thus employed. It is true that the old slaveholder, with his care-taking humor towards the blacks, is passing away; but his motives are likely to be continued in his descendants at least for some generations.

There are at present in the South many thousand places for which it would be easy to train negroes—places which would give them a liberal education of the kind most needed by their race. It is not too much to reckon that each year, in the development of the industries of that region, adds some thousand chances which can not well be filled from the native white people, but are likely to go to men brought from elsewhere. Every opportunity to establish a family supported by a skilled mechanic is of value. With even five per cent of the male negroes thus employed, the prospects of their future would be greatly benefited. The means for attaining this end are not difficult to find. What is needed is an extension of the system followed at Tuskegee, where youths are trained with the intent that they shall be made ready for high-grade manual labor, the general schooling being limited to what is necessary to ensure success in such practical work. A system of trade schools for negroes, sufficient to supply the present demand for skilled mechanics, is now the gravest need of the South.

It has been suggested that the troops which are required for the Federal service in tropical lands might well be recruited from the negroes. It has indeed been proposed that these soldiers should be permitted to take their families with them so that they might become permanently and contentedly established in Luzon and elsewhere in the colonies. There is no doubt but that the abler negroes, when properly officered, make excellent soldiers—at least as infantry men. The experience had with them during the Spanish War makes this point perfectly clear. It may also be reckoned that they would endure tropical climates better than the whites. It may further be said that the existence of a large and well respected force of blacks in the Federal army would unquestionably add to the social position of the negroes in the estimation of both races. Again, the return of these men to their homes, after their period of service, would be advantageous. Their training and experience would make them of much value to their people.

There are, however, certain signal disadvantages which would arise from the employment of negroes as soldiers. In the first place, it would tend to remove from the body of the folk the abler men—those to whom we should mainly look for the uplifting of their race. This evil, great in the case of all levies, would be most serious in this case; for the reason that, while with white troops the rank and file are not commonly by nature leaders of their society, they would be so with black recruits. If the choice could be made of the Guinea type, this loss would not be serious; but it certainly would fall to the more militant stocks—those to which we have to look for advancement. In the next place, we must see that the negro does not need the training in passive obedience and mere order of life that the common soldier receives. He has had that already in quite sufficient measure. He now should have the lessons of individual responsibility—of control of his life from within—lessons that civil life alone can give. Therefore, the well-wisher of the race will be inclined to oppose this project of recruiting our armies from the negroes of the Southern States. If it is determined to enlist them it would be best to limit the age of the recruits to about twenty years, and the period of active service to five years, so that the men may be returned to civil life young enough to enter on ordinary employments.

At present it is most desirable that the negroes of the South should be induced to save money, for until that habit is formed, there is little chance of lifting them in the economic scale or of developing in them the business sense, which is one of the corner-stones of civilization. It is probable that more could be done in the way of correcting the faults and stimulating the latent capacities of the race by developing this motive than by any other means. It is difficult to suggest any effective system by which this end can be attained. The general conditions of the South make rural savings-banks impossible. The receipts, at least for many years, would be too small to render the business remunerative. The only practicable method appears to be that of a Federal system operated through the post-offices. The institution of such a system appears to be justified by the two conditions: the exceeding need of such a provision and the impossibility of doing the work except through the postal machinery of which the Federal Government holds a monopoly. It may be said that this method has proved successful under other governments, and that it has been for some time established in Canada. In our own country it is clearly demanded, in all rural communities, though nowhere else so gravely as in the Southern States.

In looking over the latent possibilities of the negro people, the observer can not fail to remark their keen delight in music. Statistics on this, as on other facts, are lacking; but from what I have been able to learn, it appears probable that a far greater proportion of the blacks are sensitive to musical effects than is the case with the white people. I have indeed never been able to find a black man who was so far lacking in this sensibility that he did not enjoy the songs of his people. It is not unlikely that close inquiry would show this to be a remarkable feature in this unexplored race. As yet little effort has been made to determine the true measure of this capacity of the negro for music. It may be that they can not attain to the higher levels of the art; yet it is perfectly evident that their voices are exceptionally good, and that they have a keen native sense of time and tune. The most effective dance music I have ever heard has been made by negroes who could not read a note. When we consider how large a place music has in our life, it is a fair suggestion that this quality of the black nature might well be made the subject of experiment.

Those who look closely at the conditions of the negroes of the South are led to the belief that the existing separation in sympathy of the races is not likely long to continue. The greater number of the negroes instinctively crave a protective relation with the whites. It is the ancient disposition of the weak man to lean upon the strong which has in all ages and lands determined the relations of folk. At present the two peoples are held apart by the memories of slavery, rather than by any real personal dislike—the race prejudice which so commonly separates the Northern white from the negro. As this temporary barrier wears down, we may hope to find a new form of association arising—one in which the negroes will seek and find their friends among the trusted men of the superior race. I have seen marks of this new relation here and there, not many nor very clear, but fairly indicative of what may come about, provided the political excitement is allowed to subside and the people of the South, black and white, make their adjustments according to their motives and capacities, with no reference to the Federal power.

At first sight it will appear to most of the Northern people overmuch to ask that the powers at Washington give up all efforts to deal with the needs of the negro folk—the so-called wards of the nation. Yet experience has shown the impracticability of the project of helping these negroes with the long arm of the Federal law. All that has been undertaken in this way has been fruitless or worse. The only chance for lifting the black man to the full status of the citizen is by leaving his future essentially in the hands of the masterful folk who alone can help him. We see that the ruling class in the South have a measure of interest in the status of the negro and an opportunity to benefit his state that can never belong to the people of the North.

Although the country, as a whole, will, of course, suffer from the failure to elevate the blacks, the burden will lie most heavily on those with whom they dwell.

The Southern whites have given evidence of political capacity of a high order. Even their blunder in the rebellion is in good part compensated for by the sagacity with which they accepted the results of the war and turned them to the best account they could. They are not likely to cower before the vast undertakings which the uplifting of the blacks will entail; as yet, they have not accepted the task as their own. They have indeed been brought to believe that their business was to defend their own class interests, as well as they might be able to, against the attacks of the negroes, aided by the Federal power. If they are forced to see that within the limits the Federal Constitution sets to action, the responsibility for the future of their several States is in the hands of those who control their politics, we may hope to find the political and economic skill which went to the development of the system of slavery given to the advancement of the Africans. While the work must needs be done by the men who are near to it, it should receive every possible aid and sympathy from those who, because they are far away, can not effectively control the matter. The cause is so large that it needs the help of all who wish it well.

It appears to me that the time has come for an effective union of endeavor on the part of those of North and South, ex-slaveholder and ex-abolitionist alike, who wish to see the negro have, not his rights in the common sense of the word (for mere rights are a pitiful share for a man), but rather a good human chance to climb the ladder of civilization, upon which our ancestors set him. The aims of these two ancient parties surely have for a common end the best that can be done for the negro people. It is just as much a mistake to suppose that the majority of the slaveholders in a malign spirit sought to oppress and torture the blacks, as to fancy that the abolitionists desired to set the negroes over their sometime masters; for history will probably write it down that the better men of these two parties were both dealing with the same very difficult problem: that their contentions grew from a failure on both sides to see the whole of the matter.

It is possible that something might be done to help towards effective work, looking to the end we have in view, through a society for the study of the African problem. Such an association, provided it included men who were guided by a true spirit of inquiry and had no political ends to win, especially if it was in part made up of Southerners who had a large-minded view of the matter, could do much to guide action in profitable ways. In general, I am opposed to the increase in the number of societies; so that, if there be any in existence that could fairly undertake this task, I should prefer to see it set about the work.

I am not aware, however, that there is any existing association which includes such questions in its field of inquiry.

It will be observed that the suggestions I have made concerning the immediate needs of the negro do not include any mention of the higher scholastic education. This is not because I disbelieve in such training for those blacks who, by their evident capacity, show that it fits them; but because it seems futile at the present time to waste efforts in giving these people an education for which they are in general by no means ready—which, if attained, does not afford them a way to a suitable station. The few youths of the race who really desire what is commonly called a college education, are reasonably certain to receive it in some one of the many schools where they are sure of a welcome and of all due help. Even in the case of those blacks who, by some rare chance, have inherited the proper foundations of the higher mental training, and are made ready for the so-called professions, I see but a very poor chance of advancement to any fit positions in this country. Even in the part of the North where one would expect these well-trained negroes would have a fair chance in life, it does not avail them. As physicians, lawyers, clergymen or engineers they can look forward to no future having a definite relation to their capacities. They can not expect to have any range of social opportunities, and their employment will have to be essentially with their own people.

The youth of negro blood might naturally expect to find in a community devoted to the maintenance of his rights at least a welcome to the external business society. He will, however, find that the people who would willingly sacrifice much to ensure him an equal place in matters political, allow their race prejudices or those of their associates to deny him fair play. It is a lamentable fact that this dislike to these men of the other aspect is far stronger in the North than in the South. In the parts of the North where negroes are rare, there is, it is true, a sense of duty by them that ensures their place before the law; but not enough personal contact with them to wear away the first offence of their diverse aspect. In most parts of the Southern States the black man is so constantly in view that the instinctive prejudice is worn away —he is perhaps, in a somewhat contemptuous way, personally liked. The race prejudice takes the form of certain rules of intercourse, expressing about the feeling that separates the commissioned officers and the enlisted men of an army. There is an element of truth in the statement, attributed to Thomas Carlyle, that the Northern man said, "God d—d you, Sambo, be free;" and the Southerner, "God bless you, Sambo, be slave." The result to Sambo is the same—a deprivation of opportunities in all the higher walks of life.

The only safe way up for the negro appears to lie in the industrial field, in mechanical employments, where his race may not weigh against him, and where head and hands may help one another to profit of mind and pocket—in business of varied kinds where he may get money, and with it the station that, in the common view, nothing else will afford him; in good work done for his race such as will give him the dignity in the eyes of all men that the master of Tuskegee has won. It is very much better for a negro youth, and for his race, that he should be a successful blacksmith, farmer or engineer, than a lawyer or physician, hindered and shunned, sorely burthened as he is sure to be by the cross that his fellowmen force him to bear. Therefore, unless they are willing to betake themselves to countries where the government is in the control of mixed peoples, thereby escaping the worst evils of race prejudice, it seems best for negroes not to seek the so-called learned professions, but to win their way on the lines where they will find less resistance—on ways quite fit for a man, even if not the highest.

It has been suggested that our colonies may afford a field for professionally educated negroes; but there, if they are to be ruled by the home government, it is likely that they will find a white caste in control. We may thus expect that the same essential disfranchisement will be found there as at home. Moreover, as before remarked, this project of sending to far lands the individual of ability who is needed at home, can not commend itself to those who feel the need which is with us, a need that calls for all the capacity we can hope to develop among the black people. It is clearly not a time to consider a proposition to export these abler youths of the black population.

Back of all our projects to bring the negroes of the South to the full station of citizens, to get rid of the contempt and the consequences of the contempt in which they are, as a race, so generally held, is the grave question as to the practicability of framing a social and political system in which men of such diverse origin may have a substantially equal chance. It must be granted that in no modern state of high grade has this problem been fairly solved. The instances from the tropical colonies of Great Britain are not really apposite; but there seems no fundamental difficulty to contend with in order to attain this end. With cultivated people of their own race about them the better negro youth would not be deprived of that element of education. We have taken into our political family races scarcely less different in motives from our own than are the negroes, making no kind of objection to their sharing the commonwealth with us. In certain ways it is true that a nation loses strength where it fails to have its elements closely knit together. But it may be doubted whether these losses are not more than compensated for by the gains that arise from diversities such as would come from the introduction into our system of a body of folk with the capacities which our Africans are likely with thorough training to develop.

In this matter there are but two courses open to us—one of folly, the other of wisdom. We may leave the black people to work out their own salvation as best they may, to lie as a mass at the bottom of our society, except so far as the abler men who may arise among them help their struggling fellows. The result of this will be the perpetuation of all the existing evils. Or we may set to work, after the true manner of our folk, with the full knowledge that the task is very great, but that we have the strength to see it done. With this spirit we may accomplish the noblest work that men have ever undertaken in any nation.

To the people of the South we may fairly say: "These negroes were brought here by your forefathers, and thus tied to the land. In their training as slaves, they were given an opportunity to rise far above their primitive savagery. You have seen in serious trials how, as a race, they are trustworthy. They are now your fellow-citizens in name, but are in a condition to be a permanent menace to your commonwealth. Properly aided on their way upward, they may be of great value to your descendants." To the people of the North we may plead for all the help they can give; for hardly less than the Southerners, their ancestors shared in the actions which brought the negroes to this country. They gave the blacks the semblance of citizenship by the process of emancipation. If the work stops there, it may be questioned whether it was a boon to the masses of the folk it made nominally free. To be what it was meant to be, then, it needs more than enactments. There must be long continued and devoted labor, wisely directed.

A necessary part of the work of a true emancipation of the negro is a careful inquiry into the history and former status of the people. Such an inquiry, placed and kept in good hands, is a necessary preliminary to sagacious action. It may serve to unite the men of all parts of the country in a work that so nearly concerns us all. There is not, nor is there likely to arise, a situation that so calls for intelligent patriotism as this we are sorely neglecting. We may go far away and rear an empire with our armies; but if we leave these, our neighbors, without a fair chance to develop the good that is in them, we shall have lost our real opportunity for great deeds—mayhap we shall fix among us evils that in the end will drag us down.

THE PHYSICAL GEOGRAPHY OF THE LANDS.

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THE most important principles established in physical geography during the nineteth century are that the description of the earth's surface features must be accompanied by explanation, and that the surface features must be correlated with their inhabitants. During the establishment of these evolutionary principles, exploration at home and abroad has greatly increased the store of recorded facts; the more civilized countries have been in large part measured and mapped; the coasts of the world have been charted; the less civilized continents have been penetrated to their centers. This harvest of fact has been an indispensable stimulus to the study of physical geography; yet it can not be doubted that the spirit which has given life to the letter of the subject is the principle of evolution—inorganic and organic. This is especially true of the geography of the lands.

The century has seen the measurement of higher peaks in the Himalayas than had been previously measured in the Andes. The Nile has been traced to its source in the lakes of equatorial Africa, verifying the traditions of the ancients; and the Kongo has been found to cross the equator twice on its way to the sea. Facts without number have been added to the previous sum of knowledge. But at the same time, it has been discovered that the valleys of mountain ranges are the work of erosion; that the product of valley erosion is often seen in extensive piedmont fluviatile plains; that waterfalls are retrogressively worn away until they are reduced to the smooth grade of a maturely established river; and that interior basins are slowly filling with the waste that is washed in from their rims upon their floors. Here are explanatory generalizations, involving, yet going far beyond matter of direct observation. Such generalizations in geography correspond to the recognition in astronomy that planetary movements exemplify the law of gravitation; they are the Newton as against the Kepler of the subject.

The sufficient justification of the demand that has now arisen for explanation and correlation in the study of land forms is found in the repeated experience that until an explanatory description of a region can be given, one may be sure that some of its significant elements pass unnoticed; and until the controls that it exerts on living forms are studied, one may be confident that its geographical value is but half measured. A sentence from Guyot's Earth and Man may here be taken as a guide: "To describe, without rising to the causes, or descending to the consequences, is no more science than merely and simply to relate a fact of which one has been a witness." There could hardly be devised a more concise and searching test of good work than this quotation suggests. The causes, in so far as the physical geography of the lands is concerned, have been learned chiefly through the study of geology; yet it does not by any means follow that all geologists are possessed of such knowledge of these causes as will constitute them geographers. The consequences have been learned through the study of evolutionary biology; yet a distinct addition to the usual discipline of biology is required in order to apprehend its geographical correlations. The limited space allowed to this article will require that further consideration of the consequences be excluded, in order to give due consideration to the causes.

One of the preparatory steps in the century's advance was taken by the German geographer, Ritter, who, near the beginning of the century, advocated a new principle that may be illustrated by the change in the definition of geography from "the description of the earth and its inhabitants" to "the study of the earth in relation to its inhabitants;" but advance beyond this beginning was for a long time obstructed by certain ancient beliefs. Theological preconceptions as to the age of the earth and the associated geological doctrine of catastrophism, although attacked by the rising school of uniformitarianism, were then dominant. They gave to the geographer a ready-made earth, on which the existing processes of change were unimportant. Furthermore, the belief in the separate creation of every organic species led to the doctrine of teleology, which maintained the predetermined fitness of the earth for its inhabitants, and of its inhabitants for their lifework. All this had to be outgrown before geographers could understand the slow development of land forms and the progressive adaptation of all living beings to their environments. Yet the beginning that Ritter made was of great importance, and it would have led further had it not happened that for many decades professors of geography in Europe brought chiefly a historical training to their chairs, to the almost entire neglect of physical geography. In the last thirty years there has been a reaction from this condition in Germany and France, but Italy, with many professors of geography in her universities, still for the most part follows historical methods.

In the victory of the uniformitarians over the catastrophists began the fortunate alliance of geography with geology, which was long afterwards happily phrased by Mackinder: "Geology considers the past in the light of the present; geography considers the present in the light of the past." Instead of believing in cataclysmic upheavals and in overwhelming floods, Playfair and other exponents of the Huttonian school taught that mountains were slowly upheaved and slowly worn down. The simplicity of Playfair's argument finds excellent illustration in the often quoted passage regarding the origin of valleys: "Every river appears to consist of a main trunk, fed from a variety of branches, each running in a valley proportioned to its size, and all of them together forming a system of vallies, communicating with one another, and having such a nice adjustment of their declivities that none of them join the principal valley either on too high or too low a level; a circumstance which would be infinitely improbable if each of these vallies were not the work of the stream that flows in it." Descriptions of valleys should always recognize the share that rivers have had in eroding them, or else the "nice adjustment of their declivities" may pass unnoticed.

It should be noted, however, that to this day explanation is not always allowed an undisputed place in the treatment of the lands, however fully it is accepted as appropriate to the presentation of other divisions of physical geography. But the manner in which explanation is extending over a larger and larger part of the subject gives assurance that the geographers of the coming century will insist upon a uniformly rational treatment of all divisions of their science. The active phenomena of the earth's surface first secured explanation; it has long been considered essential to explain as well as to describe such phenomena as the winds of the air and the currents of the ocean; indeed, this is now so habitual that many geographers who may object to the explanation of a peculiar kind of a valley as a trespass upon geology, will nevertheless demand an explanation of rainfall and tides, although these truly geographical subjects are manifestly shared with physics and astronomy. Land forms of very elementary character, like deltas, or of rapid production, like volcanoes, have had to give some account of themselves all through the century; but it was not for many years after the announcement of Playfair's law, that the erosion of valleys by the rivers that drain them came to be regarded as a subject appropriate to a geographical treatise. Only in the later years of the century has the fuller treatment of this beautiful subject been attempted; even now much of it remains to be developed in the century to come.

The treatment of physical geography will be much more even, to the great advantage of its students, when explanatory description is applied to all its parts. The alluvial fans at the base of arid mountains should be accounted for as well as the dunes of deserts. The fault cliffs of broken plateau blocks and the weathered cliffs of retreating escarpments deserve to be considered as carefully as the wave-cut cliffs of coasts; the essential differences of these forms are reached most easily through their explanation. The varied sculpturing of a mountain slope may, in time, come to be as well understood as is now the erosion of a simple valley in a low plain.

One of the most notable elements of the century's progress is the increasing breadth of view gained as explanatory descriptions are extended further and further over the geographical field. At first explanation was given to various individual features, item by item; now it is recognized that an appropriate place must be provided for all kinds of land forms in a comprehensive scheme of physiographic classification. Many instances of the earlier stage might be given, beginning with examples from the works of Humboldt, the acknowledged leader of scientific explorers in the opening decades of the century. His attempts, more or less completely successful, to explain the facts that he observed, as well as to correlate life with environment, may be traced all through his writings; but his 'Cosmos' (1845) did not reach a careful discussion of land forms, although it entered so far into an explanatory treatment as to consider the formation of mountain ranges.

Innumerable examples of isolated facts and special explanations, unrelated to a comprehensive scheme of physiographic classification, might be taken from the reports of exploring expeditions and of geological surveys; from books of travel and from geographical and geological journals with which the nineteenth century has filled so many library shelves; but lack of space will prevent mention of all sources, save a few treatises in which the accumulated knowledge of their time is summarized. Such a work as Mrs. Somerville's 'Physical Geography' (1848) gives in the early pages a brief general consideration of land forms, and then enters at once upon the areal description of the continents; later pages present a short outline of the features of rivers, and then the rivers of the world are taken up. This is as if a text-book of botany should pass rapidly over the structure and classification of plants, and devote most of its pages to the flora of different regions. Again, Klöden's compendious geography includes a volume on 'Physical Geography,' in which much material is gathered (3d ed., 1873); but the treatment is very uneven, as is natural in the absence of a good scheme of classification. Glaciers receive much attention, but valleys are rather curtly dismissed; deltas are elaborately described, but little space is given to other forms assumed by the waste of the land on the way to the sea. Ansted's 'Physical Geography' (5th ed., 1871) contains abundant fact, but much of it is a kind that is better presented on a map than in verbal form. Many pages are devoted to statistical statements, from which no student can gain inspiration for further study, for example: "The Danube receives a large number of tributaries, of which the most important are, on the right, the Isar, Inn, Raab, Drave, Save, Morave, and Isker. On the left are the Altmühl, Regen, Waag, Gran, Theiss, Temes, Aluta, Sereth, and Pruth. Many of these are large streams with other important tributaries. The Danube drains upwards of 300,000 square miles of country."

A decided advance over earlier books in the way of rational or explanatory treatment is found in the works of Peschel and Reclus; it is to the former that a reaction against the historical treatment of geography in Germany is largely due; while the latter is to be credited with an enlarged attention to the detail of land forms; but the books of neither of these authors recognize the systematic evolution of land forms. The same may be said of various other treatises which approach, but do not yet reach, the ideal that seems to be in sight. One of the chief responsibilities of the geographer—the description of landscape—can not be fully met by students who accept the principles set forth in these books as their guides; for in spite of the increasing attention given to the lands in modern books, and in spite of the greater number of forms recognized, the combination of all forms in a well-organized whole is not yet accomplished.

It seems to have been against the empirical method of such books as Ansted's that Huxley protested in his 'Physiography,' urging its replacement by a more educative method. He wrote:

"I do not think that a description of the earth, which commences by telling a child that it is an oblate spheriod, moving around the sun in an elliptical orbit, and ends without giving him the slightest hint towards an understanding of the ordnance map of his own country, or any suggestion as to the meaning of the phenomena offered by the brook which runs through his village, or of the gravel pit whence the roads are mended, is calculated either to interest or to instruct. . . . Physiography has very little to do with this sort of Physical Geography. My hearers were not troubled with much about latitudes and longitudes, the heights of mountains, depths of seas, or the geographical distribution of kangaroos or *Compositae* . . . . I endeavored to give them . . . . a view of the 'place in nature' of a particular district of England—the basin of the Thames—and to leave upon their minds the impression that the muddy waters of our metropolitan river, the hills between which it flows, the breezes which blow over it, are not isolated phenomena, to be taken as understood because they are familiar. On the contrary, I endeavored to show that the application of the plainest and simplest processes of reasoning to any one of these phenomena suffices to show, lying behind it, a cause, which again suggests another; until, step by step, the conviction dawns upon the learner that, to attain to even an elementary conception of what goes on in his own parish, he must know something about the universe; that the pebble he kicks aside would not be what it is and where it is, unless a particular chapter of the earth's history, finished untold ages ago, had been exactly what it was. . . . Many highly valuable compendia of Physical Geography, for the use of scientific students of that subject, are extant; but in my judgment most of the elementary works I have seen begin at the wrong end, and too often terminate in an *ominum gatherum* of scraps of all sorts of undigested and unconnected information; thereby entirely destroying the educational value of that study which Kant justly termed the 'propædeutic of natural knowledge.'" (Preface to 'Physiography,' 1878).

Here we find clear recognition of the need of introducing a consideration of causes, just as was urged by Guyot; and furthermore a recognition of the need of linking together in their natural relations all the items which together constitute the content of the subject. It may, however, be contended that the attempt to combine in a single course of study the elementary principles of chemistry and physics, of geology and astronomy, along with those of physical geography, is not practicable from an educational point of view; such a combination will not secure either the clear knowledge or the strong discipline that can be derived from systematic courses in two or three of these subjects, presented separately. Text-books like Hinman's 'Eclectic Physical Geography' and Mill's 'Realm of Nature,' in both of which a broad range of other than geographical subjects is covered, do not seem to-day to be in so much favor as those books which attend more closely to the true content of our subject. Indeed, with respect to physical geography, considered from the scientific and educational point of view, a report on College Entrance Requirements, recently published by our National Educational Association,* presents the best definition and outline of the subject that has yet appeared. It advises the omission of irrelevant matter, however interesting such matter may be in itself. The principles of physics and the succession of geological formations with their fossils, the classification and distribution of plants and animals must be taught elsewhere; but much profit may be had from terrestrial phenomena by which the principles of physics are illustrated, and from the consequences of past geological changes in determining present geographical conditions, and especially from the physiographic controls by which the distribution of organic forms is determined.

The general scheme under which all land forms may receive explanatory description must consider chiefly the movement and erosion of the earth's crust. Deformation offers a part of the earth's crust to be worked upon. Various destructive processes of erosion work upon the offered mass, and the streams, with their transported waste, follow the depressions in the carved surface. So important is the element of erosion, and so leading is the part played by rivers in erosive

* Proceedings, 1899, 780-792; also in the *Journal of School Geography*, September, 1898.

work, that McGee would gather all land forms under a classification determined by their drainage systems.* Others have preferred a classification based, first on peculiarities of structure as determined by accumulation and deformation; and, secondly, on the progress of erosion; but in either scheme, the erosive work of rivers is so important that a sketch of the progress of the physical geography of the lands towards a systematic classification of its items may well follow the order in which valleys have been explained, branching off, as occasion may require, from the leading theme of rivers that flow under a normal humid climate to special conditions of erosion under an arid or a frigid climate. The progress which has made the physical geography of the lands what it is to-day is more the work of geologists than of geographers; and the chief reason for this is the indifference of many geographers to the physical side of their subject; an indifference that was undoubtedly favored by the cultivation of historical geography in continental Europe, and by the acceptance of the traveler or explorer as a full-fledged geographer in Great Britain. In the United States, it is only in the latter part of the century that the physical geography of the lands has gained a scientific standing, and the advantages that it now enjoys are geographical grafts upon a geological stock.

The emancipation of geology from the doctrine of catastrophism was a necessary step before progress could be made towards an understanding of the lands. The slow movements of elevation and depression of certain coasts in historic time were of great importance in this connection. Studies of geological structures at last overcame the belief in the sudden and violent upheaval of mountain chains, which, under the able and authoritative advocacy of Elie de Beaumont, held a place even into the second half of the century. But even when it came to be understood that mountains and plateaus have been slowly upheaved, it still remained to be proved that the valleys and canyons by which they are drained were produced by erosion, and not by fractures and unequal movements of elevation. Advance was here made on two lines. Along one, a better understanding was gained of the forms producible by deformation alone; along the other, sea currents, floods and earthquake waves, to which the earlier observers trusted as a means of modifying the forms of uplift, were gradually replaced by the slow action of weather and water. Processes of deformation were found to act in a large way, producing massive forms without detail—broad plains and plateaus, extensive domes, straight cliffs and rolling corrugations; and thus it was learned that the varied and detailed forms of lofty mountain ranges and dissected plateaus must be ascribed almost entirely to the processes of erosion. But it should be noted that in

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* *Nat. Geogr. Magazine*, i, 1889. 27-36.

exceptional instances land forms initiated by deformation, so recently as to have suffered as yet only insignificant sculpture, may exhibit much irregularity. The most striking example of this kind, an example of the very highest value in the systematic study of land forms, is that afforded by the diversely tilted lava blocks of Southern Oregon, as described by Russell.*

Turning now to the second line of advance, it is noteworthy that so keen an observer as Lesley insisted, as late as 1856, that the peculiar topographical features of Pennsylvania, which he knew and described so well, could have been produced only by a great flood. But the principles of the uniformitarians were constantly gaining ground against these older ideas; and after the appearance in England of Scrope's studies in Central France and of Greenwood's polemic little work on 'Rain and Rivers' (1857), victory may be said to have been declared for the principles long before announced by Hutton and Playfair, which, since then, have obtained general acceptance and application.

Yet even the most ardent uniformitarians would, in the middle of the century, go no further than to admit that rain and rivers could roughen a region by carving valleys in it; no consideration was then given to the possibility that, with longer and longer time, the hills must be more and more consumed, the valleys must grow wider and wider open, until, however high and uneven the initial surface may have been, it must at last be reduced to a lowland of small relief. The surface of such a lowland would truncate the underground structures indifferently; but when such truncating surfaces were noticed (usually now at considerable altitudes above sea level, as if elevated after having been planed, and therefore more or less consumed by the erosion of a new system of valleys), they were called plains of marine denudation by Ramsay (1847), or plains of marine abrasion by Richthofen (1882). To-day it is recognized that both subaërial erosion and marine abrasion are theoretically competent to produce lowlands of denudation; the real question here at issue concerns the criteria by which the work of either agency can be recognized in particular instances. In the middle of the century, not only every plain of denudation, but every line of escarpments was held by the marinists to be the work of sea waves; and it was not till after a sharp debate that the bluffs of the chalk downs which enclose the Weald of southeastern England were acepted as the product of ordinary atmospheric weathering, instead of as the work of the sea. Whitaker's admirable essay on 'Subaërial Denudation,' which may be regarded as having given the victory in this discussion to the subaërialists, was considered so heterodox that it was not acceptable

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*4th *Ann. Rep. U. S. Geol. Survey*, 1883.

for publication in the *Quarterly Journal* of the Geological Society, of London, but had to find a place in the more modest *Geological Magazine* (1867), whose pages it now honors. So signal indeed was this victory that, in later years, the destructive work of the sea has been not infrequently underrated in the almost exclusive attention given to land sculpture by subaërial agencies. Truly, the sea does not erode valleys; it does not wear out narrow lowlands of irregular form between enclosing uplands, as was maintained by some of the most pronounced marinists in the middle of the century; but it certainly does attack continental borders in a most vigorous fashion, and many are the littoral forms that must be ascribed to its work, as may be learned from Richthofen's admirable 'Führer für Forschungsreisende' (1886). As this problem can not be further considered here, the reader may be at once referred to the most general discussion of the subject that has yet appeared, in an essay on 'Shoreline Topography' recently published by F. P. Gulliver.*

At about the time when the subaërial origin of valleys and escarpments was being established in England, the explorations and surveys of our western territories were undertaken, and a flood of physiographic light came from them. One of the earliest and most important of the many lessons of the West was that Playfair's law obtained even in the case of the Grand canyon of the Colorado, which was visited by the Ives expedition in 1858. Newberry, the geologist of the expedition, concluded that both the deep and fissure-like canyon and the broader valleys enclosed by cliff-like walls "belong to a vast system of erosion, and are wholly due to the action of water." Although he bore the possibility of fractures constantly in mind and examined the structure of the canyons with all possible care, he "everywhere found evidence of the exclusive action of water in their formation." This conclusion has, since then, been amply confirmed by Powell and Dutton, although these later observers might attribute a significant share of the recession of cliffs in arid regions to wind action. In a later decade, Heim demonstrated that the valleys of the Alps were not explicable as the result of mountain deformation, and that they found explanation only in river erosion. By such studies as these, of which many examples could be given, the competence of rivers to carve even the deepest valleys has been fully established; yet so difficult is it to dislodge old-fashioned belief that Sir A. Geikie felt it necessary to devote two chapters in his admirable 'Scenery of Scotland' (1887) to prove that the bens of the Highlands were not so many individual upheavals, but that the glens were so many separate valleys of erosion; and as able an observer as Prestwich, a warm advocate of the erosion

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* *Proc. Amer. Acad.*, Boston. 1899, 152-258.

of ordinary valleys by their rivers, maintained (1886), with the results of our western surveys before him, that fissures were probably responsible for the origin of the deep and narrow canyons of the Colorado plateau.

The tumultuous forms of lofty mountains 'tossed up' as they seem to be when viewed from some commanding height, are, in by far the greater number of examples yet studied, undoubtedly the result of the slow erosion of the valleys between them; but it should not be forgotten that regions of very recent disturbances—as the earth counts time—may possess strong inequalities directly due to deformation. The tilted lava blocks of Oregon have already been mentioned. The bold forms of the St. Elias Alps, also described by Russell, are regarded by him as chiefly produced by the tilting of huge crustal blocks on which erosion has as yet done relatively little work. An altogether exceptional case is described by Dutton, who says that on the margin of one of the "high plateaus of Utah a huge block seems to have cracked off and rolled over, the beds opening with a V and forming a valley of grand dimensions." 'Rift valleys,' or trough-like depressions produced by the down-faulting of long, narrow, crustal blocks with respect to the bordering masses, are occasionally found, as in eastern Africa, where the 'Great Rift valley' has been described by Gregory. Trough-like depressions of similar origin, but much more affected by the degradation of their borders and the aggradation of their floors, are known to European geographers in the valleys of the Saône and of the middle Rhine. But no rift valley, no depression between the tilted lava blocks, resembles the branching valleys that are produced by the erosive action of running water.

Thus far, while much attention had been given to the work of rivers, little or no attention had been given to the arrangement of their courses. It seems to have been tacitly assumed that the courses of all streams were consequent upon the slope of the initial land surface. The explicit recognition of this origin, indicated by the provision of a special name, 'consequent streams,' was an important step in advance due to our western geologists. The discovery soon followed that rivers have held their courses through mountain ridges that slowly rose across their path; the rivers, concentrating the drainage of a large headwater region upon a narrow line, cut down their channels as the land was raised. This idea first came into prominence through Powell's report on the Colorado River of the West (1875), in which he gave the name, 'antecedent,' to rivers of this class. He believed that the Green river, in its passage through the Uinta mountains, was to be explained as an antecedent stream. Much doubt has, however, been thrown upon this interpretation. Other accounts of antecedent rivers have been published, and to-day the Green is not so safe a type of antecedence as the Rhine below Bingen, the Meuse in the Ardennes, or several of the Himalayan rivers in the gorges that they have cut through the youngest marginal ridges of the range.

Rapidly following the establishment of these two important classes of valleys came the recognition of the very antithesis of antecedent rivers in those streams which have grown by headward erosion along belts of weak structure, without relation to the initial trough lines. To these the term 'subsequent' has been applied. It is frequently in association with streams of this class that drainage areas are rearranged by the migration of divides, and that the upper waters of one river are captured by the headward growth of another. This is accomplished by a most beautiful process of inorganic natural selection, which leads to a survival of the fittest and thus brings about a most intimate adjustment of form to structure, whereby the more resistent rock masses come to constitute the divides, and the less resistent are chosen for the excavation of valleys. Many workers have contributed to the solution of problems of this class; notably Heim, in his studies of the northern Alps (1876), and Löwl, who showed that, in folded mountain structures of great age, the original courses of streams might be greatly altered through the development of new lines of drainage (1882). A valuable summary of this subject is given by Philippson in his 'Studien über Wasserscheiden' (1886). The extraordinary depredations committed by the waxing Severn on the waning Thames have recently been set forth by Buckman. The turning of side branches from the slender trunk of the Meuse has been recognized in France. Many remarkable instances of stream captures have been found in the Appalachians, where the opportunity for the adjustment of streams to structures has been exceptionally good. Hayes and Campbell have, on the other hand, emphasized the importance of drainage modifications independent of the growth of subsequent streams on weak structures, but governed by a slight tilting of the region, whereby some streams are accelerated and their opponents are retarded. It should be noted that the proof of the adjustment or rearrangement of drainage marks a victory for the uniformitarian school that is even more significant than that gained in the case of the antecedent rivers; for in one case a growing mountain range is subdued by the concentrated discharge of a large drainage area; but in the other case, the mountain slowly melts away under the attacks of the weather alone on the headwater slopes of the growing valleys.

The reason why all these studies of land carving are of importance to the geographer is that they greatly enlarge the number of type forms that he may use in descriptions, and that they recognize the natural correlations among various forms which must otherwise be set forth in successive itemized statements. The brief terminology learned in early school days, somewhat enlarged by a more mature variety of adjectives, is usually the stock of words with which the explorer tries to reproduce the features of the landscapes that he crosses, and as a result his descriptions are often unintelligible; the region has to be explored again before it can become known to those who do not see it. The longitudinal relief of certain well-dissected coastal plains, or the half-buried ranges of certain interior aggraded basins, may be taken as examples of forms which are easily brought home and familiarized by explanation, but which commonly remain remote and unknown under empirical description.

It may be urged that in many geological discussions from which geography has taken profit, consideration is given to form-producing processes rather than to the forms produced. This was natural enough while the subject was in the hands of geologists; but geographers should take heed that they do not preserve the geological habit. The past history of land forms and the action upon them of various processes by which existing forms have been developed, are pertinent to geography only in so far as they aid the observation and description of the forms of to-day.

Further illustration of the growing recognition of form as the chief object of the physiographic study of the lands is seen in the use of the term, 'geomorphology,' by some American writers; but more important than the term is the principle which underlies it. This is the acceptance of theorizing as an essential part of investigation in geography, just as in other sciences. All explanation involves theorizing. When theory is taken piecemeal and applied only to elementary problems, such as the origin of deltas, it does not excite unfavorable comment among geographers. But when the explanation of more complicated features is attempted, and when a comprehensive scheme of classification and treatment, in which theorizing is fully and frankly recognized, is evolved for all land forms, then the conservatives recoil, as if so bold a proposition would set them adrift on the dangerous sea of unrestrained imagination. They forget that the harbor of explanation can only be reached by crossing the seas of theory. They are willing to cruise, like the early navigators, the empirical explorers, only close along shore; not venturing to trust themselves out of sight of the land of existing fact; but they have not learned to embark upon the open ocean of investigation, trusting to the compass of logical deduction and the rudder of critical judgment to lead them to the desired haven of understanding of facts of the past.

One of the bolder explorers of the high seas of theory is Powell, who defined in the term 'baselevel' an idea that had long been more or less consciously present in the minds of geologists, and which has been since then of the greatest service to physiographers. Powell and his followers, especially Gilbert, Dutton and McGee, have consistently carried the consequences of subaërial erosion to their legitimate end in a featureless lowland, and have recognized the controlling influence of the baselevel during all the sequence of changes from the initial to the ultimate form. It is not here essential whether such a featureless lowland exists or ever has existed, but it is absolutely essential to follow the lead of deduction until all the consequences of the theory of erosion are found; and then to accept as true those theoretical deductions which successfully confront the appropriate facts of observation. Only in this way can the error of regarding geography as a purely observational natural science be corrected. Following the acceptance of the doctrine of baselevels came the method of reconstituting the original form initiated by deformation, as a means of more fully understanding the existing form; for only by beginning at the initial form can the systematic sequence of the changes wrought by destructive processes be fully traced and the existing form appreciated. This had often been done before in individual cases, but it now became a habit, an essential step in geomorphological study. Naturally enough, the terms of organic growth, such as young, mature, old, revived, and so on, came to be applied to stages in the development of inorganic forms; and thus gradually the idea of the systematic physiographic development of land forms has taken shape. This idea is to-day the most serviceable and compact summation of all the work of the century on the physical geography of the lands. It recognizes the results of deformation in providing the broader initial forms on which details are to be carved. It gives special attention to the work of destructive processes on these forms, and especially to the orderly sequence of various stages of development, recognizing that certain features are associated with youth, and others with maturity and old age. It gives due consideration to the renewed movements of deformation that may occur at any stage in the cycle of change, whereby a new sequence of change is introduced. It gives appropriate place, not only to the forms produced by the ordinary erosive action of rain and rivers, but to the forms produced by ice and by wind action as well; and it co-ordinates the changes that are produced by the sea on the margin of the land with the changes that are produced by other agencies upon its surface. It considers not only the various forms assumed by the water of the land, such as torrents, rapids, falls and lakes, appropriately arranged in a river system as to time and place, but also the forms assumed by the waste of the land, which, like the water, is on its way to the sea. In a word, it lengthens our own life, so that we may, in imagination, picture the life of a geographical area as clearly as we now witness the life of a quick-growing plant, and thus as readily conceive and as little confuse the orderly development of the many parts of a land form, its divides, cliffs, slopes and water courses, as we now distinguish the cotyledons, stem, buds, leaves, flowers and fruit of a rapidly-maturing annual that produces all these forms in appropriate order and position in the brief course of a single summer.

The time is ripe for the introduction of these ideas. The spirit of evolution has been breathed by the students of the generation now mature all through their growing years and its application to all lines of study is demanded. It is true that the acceptance of inorganic as well as of organic evolution is often implied rather than outspoken; yet evolution is favorably regarded, as is proved by the eagerness with which even school boards and school teachers, conservatives among conservatives, hail the appearance of books in which the new spirit of geography is revealed. In the last years of the century, the school books most widely used in this country have made great advance in the explanatory treatment of land forms. Tarr's Physical Geographies and Russell's monographic volumes on the 'Lakes,' 'Glaciers,' 'Volcanoes' and 'Rivers' of North America, all presenting land forms in an explanatory rather than an empirical manner, have been warmly welcomed in this country. Penck's 'Morphologie der Erdoberfläche' (1894), although largely concerned with the historical development of the subject, presents all forms as the result of process. De Lapparent's 'Leçons de géographie physique' (1886) treats land forms generically; and a second edition of the book is called for soon after the first. 'Earth Sculpture,' by James Geikie (1899), and Marr's 'Scientific Study of Scenery' (1900), carry modern ideas to British readers. There can be little doubt that the books of the coming century will extend the habit of explanation even further than it has yet reached.

This review of the advance of the century in the study of land forms, the habitations of all the higher forms of life, might have been concerned wholly with the concrete results of exploration, as was implied in an earlier paragraph. Travels in the Far East of the Old World, or in the Far West of the New, have yielded fact enough to fill volumes. But such a view of the century has been here replaced by another; not because the first is unimportant, for it is absolutely essential, but because the second includes the first and goes beyond it. Not the facts alone, but the principles that the facts exemplify, demand our attention. These principles, founded upon a multitude of observations, are the greater contribution of the closing to the opening century in the study of the Forms of the Land.

THE NEW YORK BOTANICAL GARDEN.

By DANIEL TREMBLY MACDOUGAL,
DIRECTOR OF THE LABORATORIES.

A BOTANICAL garden is a museum of plants in the broadest sense of the term, and its chief purpose is to represent, by means of living specimens so far as possible, the principal types of the vegetation of the globe. It is obviously impossible to cultivate on any small area more than a few thousand of the quarter of a million of species in existence, and hence the plantations are supplemented by preserved specimens to illustrate the forms, which, by reasons of limitation of space, climate and soil, cannot be grown in the locality. In addition the species which formed the vegetation of the previous geological periods are represented by fossil specimens completing the history of the plant world so far as it is known, and yielding suggestions as to the descent of the present types.

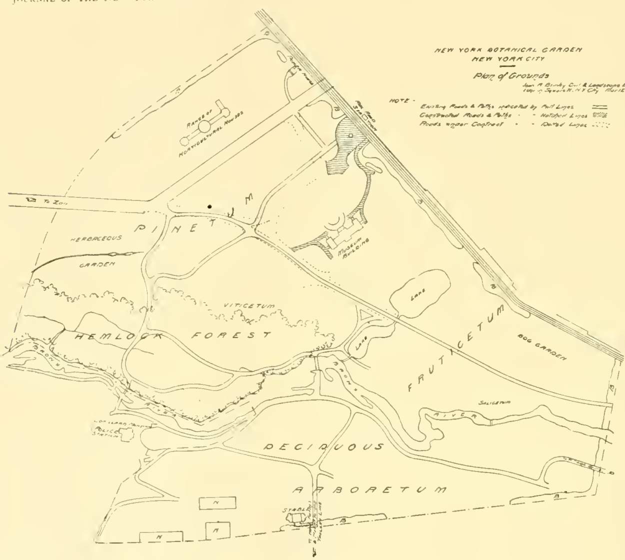
Two general educational purposes are served by an institution of this character. Its collections are arranged to present information on the form, relationship, mode of life, habit and general biological character of the principal types of vegetation, in such manner as to be capable of comprehension by persons unacquainted with the technical aspects of the subject. Further interpretation of such facts may be made by means of books, journals, and lectures devoted entirely to this phase of the subject.

The material accumulated for the exploitation of popular knowledge of plants also affords an excellent basis for the induction of students into the more strictly scientific aspects of botany, and when supplemented by laboratories furnished with apparatus, miscroscopes, and other instruments of precision, the activities of these students may be carried beyond the frontiers of the subject in the investigation and discovery of new facts and phenomena. This extension of the boundaries of knowledge concerning the plant world may be carried on to advantage, only when a library is at hand, which contains all of the more important literature bearing upon the subject. The descriptions of the results of such researches should be made in publications devoted exclusively to this purpose, in accordance with the practice of all the more important botanical institutions in the world.

The general scope of the New York Botanical Garden has already been described by the writer in a previous number of this magazine (January, 1897). The greater part of its actual construction and organization has taken place in the last three years, and it has now entered upon the discharge of its chief functions.

The Garden comprises two hundred and fifty acres of land in Bronx Park, in the City of New York, which was set aside for that purpose by the Department of Public Parks in 1895. A fireproof museum building of stone, brick and terra cotta, 308 by 110 feet, has been erected for the Garden by the city in the western part of the grounds, near the Bedford Park Station of the New York Central Railroad. The building has a basement floor and three stories, with a total

JOURNAL OF THE NEW YORK BOTANICAL GARDEN. PLATE III.



MAP OF THE GARDEN.

floor space of nearly two acres, and a window area equal to half that of the floor area. The basement contains a lecture theater capable of seating seven hundred people, two large exhibition halls, preparation rooms, constant temperature laboratory, offices and storerooms. The first floor is devoted to a collection of economic plants, and the temporary installation of useful products in the way of foods, drugs, timbers, woods, fibers, gums, waxes, resins, oils, sugars, starches, poisons, utensils, etc., gives hints as to the great diversity of uses that may be made of vegetable products, together with an illustration of their method of preparation and their derivation.

The second floor is given over to an exhibit of types of all of the more important families and tribes of plants, from the simplest and most minute, to the highest and most complex. Specimens, models, fruits, seeds, drawings and photographs are used to bring the principal facts clearly before the observer. A set of swinging frames running parallel to the cases containing the types of the flora of the world, are used to display specimens of the plants found within a hundred miles of New York City. A number of special microscopes have been constructed for the purpose of forming a perfect exhibit, which will enable the visitor to see some of the more salient features in the minute structure of some of the plants in the cases.

The third floor contains the library, herbarium and laboratories. The library occupies a stack room extending to the rear of the middle of the building, two small storerooms and a large circular reading-room, under the illuminated dome. Here are assembled the botanical

THE MUSEUM.

books of Columbia University, as well as those accumulated by the Garden, now numbering more than eight thousand volumes, with no reckoning of unbound separates and pamphlets. The collection of botanical periodicals is nearly complete, and the library is especially rich in literature concerning the mosses, ferns, and the flora of North and South America.

The main herbarium occupies a room in the east wing, eighty-five by forty-seven feet, and connected with it are storerooms and offices adequate to its administration. Windows on all sides of the main room and skylights give ample illumination. The number of mounted specimens on the shelves is not less than three quarters of a million, including the herbarium of Columbia University, which is deposited here in accordance with the agreement between the two institutions. The collection is especially rich in fungi, embracing the collections of Ellis and other eminent mycologists. A large amount of material of great historic value in connection with the work of Dr. John Torrey and the earlier botanical development of America is included. Accessions are being made to the herbarium at the rate of fifty to a hundred thousand specimens annually.

The laboratories consist of a series of rooms facing northward and westward, with special facilities for taxonomic, embryological and morphological investigations. Physiological and photographic dark-rooms, the experiment room for living plants and chemical laboratories offer especially ample opportunities for the record and development of practically all phases of plant physiology. The laboratories, library and herbarium are open to the graduate students from Columbia

In the Forest.

University, in addition to those from other institutions of learning who may register directly at the Garden. The latter, in return, have the privileges of students at Columbia University.

A weekly convention of all of the workers in botany in New York City is held in the museum, at which the results of recent researches are given or an address is made by an invited speaker from out of the city.

The area of the Garden presents a very irregular topography, comprising, as it does, a half mile of the valley of the Bronx River, low marshes and swamps, artificial lakes, open glades, with heavy peaty soil, upland plains with gravelly sandy soil, granite ridges, and about seventy acres of natural forest. About forty acres of this forest consist of a dense grove of hemlocks, which has never been seriously disturbed by the hand of man. It is truly remarkable that the City of New York should include within its boundaries a primitive forest of this size, and this invaluable feature is to be preserved forever by a special contract between the Garden and the Department of Public Parks. Since a hemlock forest is a climactic formation, and is not replaced by any other growth unless cut down, it may be expected to endure through the present geological epoch, barring the accidents of flood, storm and fire. The great diversity of conditions offered by the natural features of the Garden gives it a very rich population of indigenous plants. A census of the ferns and seed-plants at the time the tract was converted to its present purpose showed nearly a thousand species.

THE NORTH MEADOWS.

The entire area has been handled most sympathetically by those in charge of the architectural features of the Garden. The buildings were erected in the more open western part of the grounds, which offered the least valuable landscape features, and the surface around them has been improved by plantings. The natural beauties of the tract have been most zealously guarded from disturbances of all kinds. The attractive panoramas of wild woodland and stream offered to the artist and lover of nature have been left absolutely untouched, but made more valuable by increased ease and safety of access.

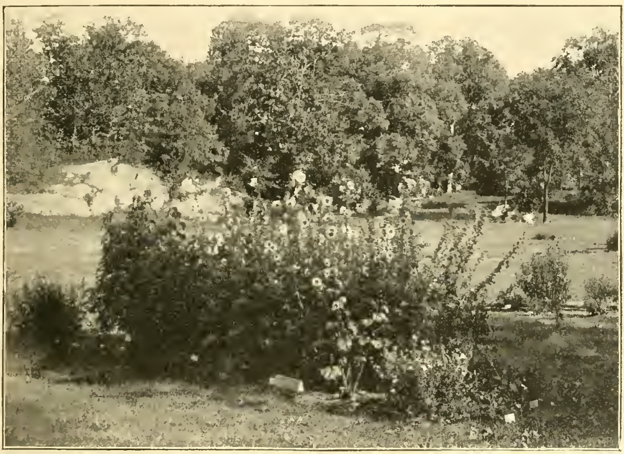
A number of special biological groups of plants have been established in suitable places in various parts of the Garden. The trees are in the arboretum east of the Bronx on the side and summit of a long ridge; unassorted and reserve material of all kinds is kept in the nurseries on the eastern slope of the same ridge; the salicetum is established on the border of the marsh in the northern end of the Garden, giving the willows and poplars the conditions under which they grow best. The fruticetum occupies an adjoining upland plain underlaid with gravel to a depth of twenty feet, affording space for the cultivation of a large number of shrubs, while the conifers are located on slopes to the westward of the hemlock forest. The viticetum is along the western edge of the forest, and the trellises of logs and timbers, extending for a length of six hundred feet, give suitable support to the

THE WATERFALL.

vines. The herbaceous plantation occupies an open glade to the westward of the forest, and lies between two granite ridges. It is traversed through the middle by a small stream widened at places into lagoons for aquatic forms. About twenty-two hundred species are now in cultivation in this plantation. The wide border plantations which are established along the boundaries also offer opportunities for the growth of a great variety of trees, herbs and shrubs.

The horticultural houses, also erected by the City for the Garden, are located in the western part of the grounds at some distance to the south of, and facing, the museum. A palm-house, with a total height of dome of ninety feet, is the central feature, from which lower ranges extend on either side, making a total length of front of five hundred and twelve feet. The horticultural houses, as well as the museum, are heated by steam furnished by a power house beside the railroad on the extreme edge of the Garden.

The collections of living plants in the plantations are arranged in the same system as the synoptic collection in the museum. Every plantation contains species of similar habit, and the horticultural houses are used for the cultivation of forms which may not endure the outdoor climate of this locality. Not only are the plants from warmer zones grown under glass, but when it is desired to develop native species out of their season, they may be forced and brought to full development and bloom in the winter.



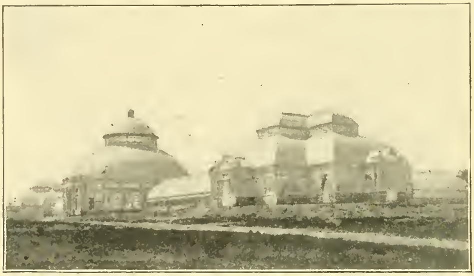
In the Herbaceous Plantation.

The construction of driveways and paths is being prosecuted by the Park Department with all available funds at their commands.

Public appreciation of the natural beauties of the Garden, and of the phases of botany illustrated by its collections has been most gratifying, as shown by the great and constantly increasing number of visitors. The series of popular lectures given in the museum on Saturday afternoons have been well attended. The Journal of the Garden, which serves as a means of communication with its members, brings to the notice of its readers interesting facts in botany, horticulture and forestry, and records a constantly swelling list of gifts of books, specimens and plants.

The library, herbarium and laboratories have been open for only a few months, yet twenty-two students have taken advantage of the facilities thus afforded during the collegiate year now closing. Investigations of importance have been carried forward by these students, by members of the staff, and by the members of the staff of Columbia University. The results of some of these investigations have been published in the Bulletin of the Garden, which also contains the official reports of the organization. Papers written by members of the staff or students are reprinted from the periodicals in which they appear as contributions, while a fourth series of Memoirs has been found necessary for the presentation of papers of great length.

Not the least important of the investigating functions of a garden consists in its participation in the exploration of remote or unknown parts of the world in an effort to obtain a better knowledge of the plant population of the earth. During the brief period of its activity the



Horticultural Houses.

Garden has already carried out work of this character in the Rocky Mountains and in Porto Rico.

The ordinary work of the Garden is maintained by the income from its endowment fund, by the annual dues of its members (now numbering over eight hundred) and by an annual appropriation by the City. Its board of managers is authorized to hold and administer trust funds, and it is hoped by the aid of gifts or bequests for special or general purposes to expand its usefulness in directing investigation. Already it has been favored by a bequest of a considerable sum of money by the late ex-Chief Justice Charles P. Daly, which may be devoted to any purpose determined by the board of managers.

GAS AND GAS METERS.

BY HUBERT S. WYNKOOP, M. E.

WHAT is the matter with our illuminating gas? Why is its quality so poor? Why is it that our bills are creeping up, in spite of the fact that the rate per thousand cubic feet is going down? These are questions that periodically recur to the mind of every householder.

Just why the public has not been educated into a correct understanding of the gas situation is hard to say, unless it be that an inbred prejudice against believing the word of any corporation has led to an utter repudiation of such explanatory statements as may emanate from time to time from the gas office. And it must be admitted that many of the explanations are misleading, either through the intention of the superior officials or by reason of the ignorance of their subordinates.

Hardly has the chill of shortening days driven us indoors in the early twilight before complaints of poor gas become epidemic. Now, what *is* 'poor' gas? Is the gas deficient in light-giving constituents, or is it merely burned in such a manner as not to afford a satisfactory illumination?

The charter of Greater New York requires that the illuminating gas supplied throughout the city shall be of at least twenty candle power, or illuminating quality, or richness—that is to say, if we burn this gas in a standard burner at the standard pressure (or at as near this pressure as may be), so that the rate of consumption is five cubic feet an hour, the flame thus produced shall be equivalent to twenty standard sperm candles, each burning at the rate of one hundred and twenty grains of sperm per hour, and all bunched—if such a thing were possible. There can be hardly any doubt but that all the gas sent out from modern gas works fulfills the above requirement. Indeed, my own tents give results ranging from twenty-two to twenty-eight candles, with an average of about twenty-four. Manifestly, the gas *sent out* is not 'poor.'

Nevertheless, the fact that the gas as manufactured is of the required candle power is no indication that the product as delivered to the consumer will give a similarly satisfactory test. Distribution of gas is attended with many perplexities, not the least of which is condensation. The illuminating hydrocarbons, or light-giving constituents held in suspension in the gas, are not so firmly fixed therein as to be unaffected by the size of the pipe, the character of the internal pipe surface, and barometric and thermometric variations. The transmission of gas causes, therefore, a loss of candle power ranging from a small fraction to several candles, although it is possible to conceive of conditions so extraordinarily favorable that the illuminating quality of the gas might be actually improved by distribution.

It will be readily understood from this explanation that tests made at the gas works, or even at points arbitrarily selected at a certain distance from these works, are hardly calculated to satisfy the consumer. For this reason I have preferred, in conducting these tests, to sacrifice to some degree the accuracy that obtains in laboratory experiments, in order to test gas samples *taken from the main directly in front of the complainant's own premises.* I argue that the consumer cares little or nothing as to whether the gas as manufactured complies with the law, or whether tests made at a point perhaps a mile away from the works show the required candle power; but that he does want to know what is the quality of the gas passing in at his service pipe. The method of collecting and transporting to a laboratory the gas samples enables one to say with positiveness that the gas at the point of complaint has an illuminating power of at least so many candles, and that it may be even one candle better than the tests indicate. The figures thus obtained range from twenty and a half to twenty-five. So, then, the gas *delivered to the consumer* is not 'poor.'

Hygienic reasons demand that the impurities in the gas shall not exceed a definite percentage. Whatever effect these impurities may have upon the candle power has been covered by the tests above explained, so that any further consideration of these impurities may be omitted here.

It is always a difficult matter to convince an indignant householder that the quality of the gas supplied to him is satisfactory. He knows perfectly well that he is not getting the desired result, and no explanation, however elaborate, as to candle power will placate him, unless it be supplemented by a further statement detailing the cause of the trouble. When you are trying to draw water in the bathroom while the cook is filling the washtubs in the basement, do you say the water is 'poor'? Why, then, should you characterize the gas as 'poor,' when people nearer to the gas works than you are happen to be drawing heavily upon the common gas main? Imagine, if you please, a long gas main, with consumers tapping in at points throughout its entire length, and with a gas holder forcing the gas in at one end. Since there is a loss of pressure, caused by the transmission, it follows that the pressure will be higher at the gas holder than anywhere else along the line, the *difference* in pressure depending, roughly, upon the size and length of the pipe and upon the amount of gas flowing. Now, for any one customer the size and length of pipe will remain constant, but the flow of gas along the line will vary from hour to hour, consequently the pressure at his house may be expected to vary from hour to hour.

The unit of measurement of gas pressure is that pressure which will cause a difference of water level of one tenth of an inch in the two legs of a V-shaped tube when one end is connected with the gas main and the other end is left open to the outer air. Ten tenths, or one inch, is the standard, or normal pressure.

Any appliance—even a gas-burner—operates to best advantage

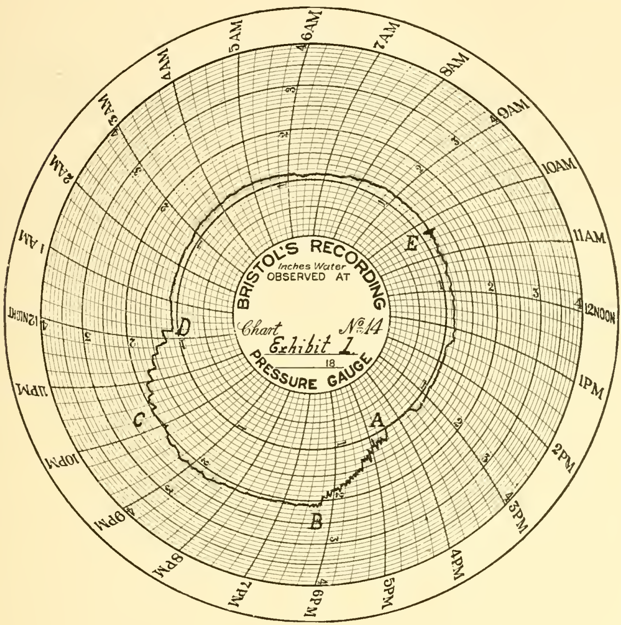


Exhibit 1.

under certain well-defined conditions. Depart from these conditions, and the efficiency of the device is impaired to an extent depending largely upon the nature of the appliance under consideration. For example, burn an incandescent lamp at fifty per cent. above normal voltage and it breaks down; burn a gas jet at two hundred per cent. above normal pressure, and it still operates—how satisfactorily 'deponent sayeth not.' Now, the gas-burner is supposed to operate to best advantage at ten tenths of an inch. At this pressure the flame is neither so wavering as to be affected by every chance draught, nor so rigid as to permit the gas to blow through without being properly consumed. Below the normal the flame decreases; above, the light is increased somewhat, but not by any means in proportion to the increase in the gas flow. Thus we see that the satisfactory employment of gas as an illuminant depends upon the maintenance of a pressure high enough to deliver the required amount of gas, but not so high as to cause wasteful consumption.

Turning back now to the gas main, let us consider the pressures

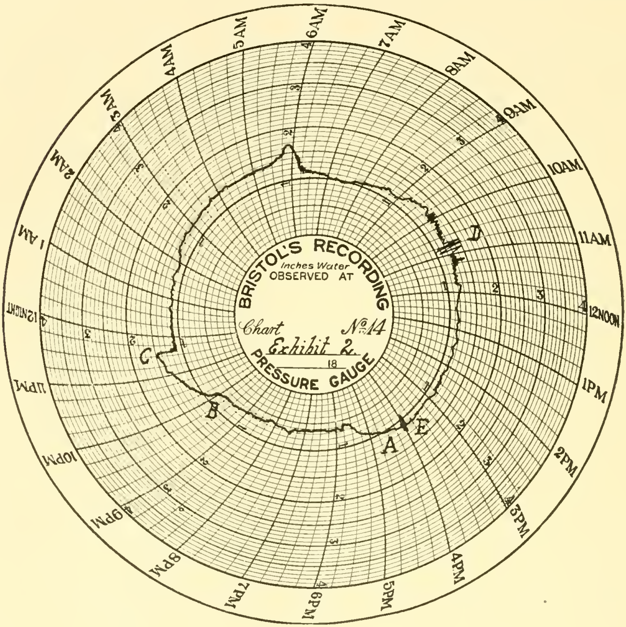


EXHIBIT 2.

actually existing. Exhibit 1 is a photograph of a twenty-four-hour record of pressure at a point not far from the works. The radial lines represent time, and there is a line for each quarter of an hour. The circles represent pressure, there being one circle for each tenth of an inch. Starting at *E*, the point at which the record begins, and following the irregular line clockwise, one may readily determine the fluctuations of pressure and the time of their occurrence. Interpreting the diagram, we find that the pressure was slightly above the normal until 4.30 P. M. *(A)*, when the works began to raise the pressure little by little, in order to compensate for the increased loss due to increased flow through the mains. At 6.15 P. M. *(B)*, the works ceased increasing the pressure. While this increase lasted—from 6.15 P. M. *(B)* to 10.15 P. M. *(C)*—our friend near the works suffered under twenty-one tenths pressure, the gas blowing merrily through the tips and the meter conscientiously registering gas wasted as well as gas utilized. From 10.15 P. M. *(C)* the pressure falls by steps during the ensuing two hours, finally reaching eleven tenths just after

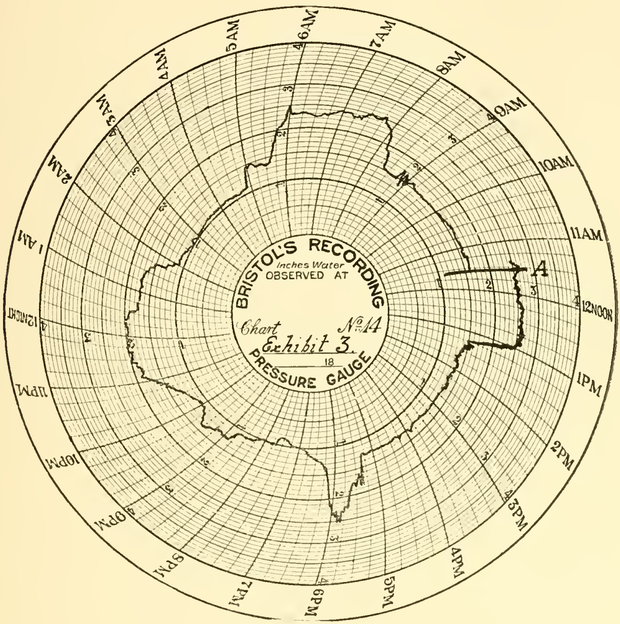


EXHIBIT 3.

midnight *(D)*, which latter pressure is quite steadily maintained until the following forenoon. The service from bedtime to dinner time should have proved quite satisfactory. One would naturally expect to find this consumer complaining of high bills, however.

Visiting the fellow at the distant end of the line, we find conditions widely at variance from those already considered. Exhibit 2 tells a new story. The recording gauge was placed in service at 4 P. M. *(E)*, and shortly afterward *(A)*, the pressure began to fall. The jets grew dimmer and dimmer, while the Welsbach mantles became petticoats of red, with hems of white at the bottom. No wonder this man complains of 'poor' gas, while some learned friend, dropping in for an evening cigar, explains that there is 'air in the pipes.' The one consolatory reflection is that, at all events, the poor fellow had a good light to undress by *(B to C)*.

Exhibits 3 and 4 come from my own residence. Together they form a 'before-taking' and 'after-taking' advertisement—not of medicine, but of a gas governor. The fact that I am located at a considerable

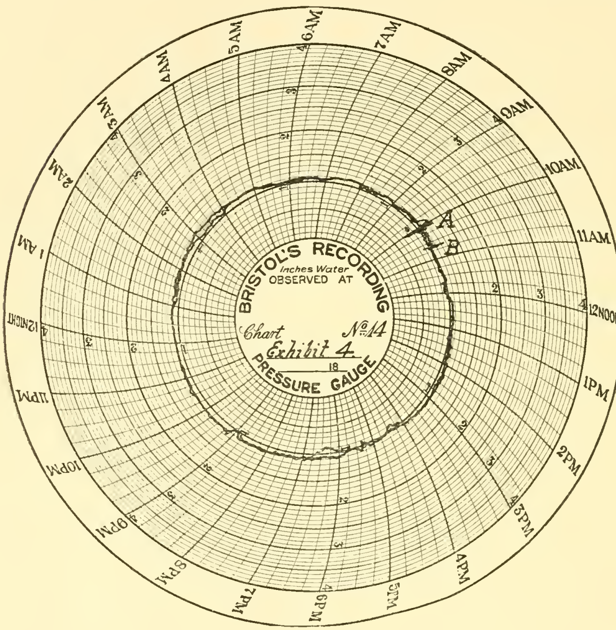


EXHIBIT 4.

distance—several miles—from the works, and am supplied through a main laid a number of years ago, when the territory was sparsely settled, enables me to present Exhibit 3. Comment on this record is unnecessary. After securing this diagram I installed a governor and set it at eleven tenths. Exhibit 4 shows what happened. I am now doing for myself, and at my own expense, that which the gas company fails to do for me. This governor, therefore, renders me almost entirely independent of the gas company; and, in order to demonstrate more clearly to what degree this independence extends, the gauge has been allowed to run for forty-eight hours without changing the card, thus super-imposing the record of the second day upon that of the first. Note how closely the readings for the two days agree. The governor is a protection against excess of pressure only; if the street pressure falls below eleven tenths—the point at which my governor is set—automatic regulation ceases, and my gas simply becomes subject to practically the same variations as exist on the main. Happily, the latter condition is infrequently realized in our neighborhood. No argument is needed to prove how successfully a governing device of this nature can cope with the trouble indicated by Exhibit 1, or how utterly inadequate it is to afford relief from the evil depicted in Exhibit 2. Increased pressure is the only remedy for the latter.

The gas company does not recommend the use of these house-to-house governors—presumably because such a recommendation would be in effect an admission that the service as now maintained by the company is not satisfactory. Indeed, the less enlightened officials—and it is these, unfortunately, with whom the consumer has generally to deal—positively and unreasoningly condemn all such regulating devices. In spite of this, there exist to-day several gas-reduction companies, whose sole occupation consists in exploiting various gas-pressure-regulating appliances, which are rented to consumers for a certain percentage of the monthly saving in the gas bills which their use effects.

It would appear to be a self-evident proposition that when one pays for gas delivered at his meter he is entitled to receive that gas under such a pressure as will afford the most satisfactory service. This pressure is found to be one inch. Making due allowance for reasonable fluctuations of a few tenths above the normal, any further departure from the standard may be taken as a sure indication of a disinclination on the part of the company to meet the expense of new pipes and regulating apparatus. The time is not far distant when the public will demand, not cheaper gas nor better gas, but a more satisfactory service. But before condemning the gas company one must look to his house piping. The company's responsibility ends just inside the meter, and from that point the consumer must provide satisfactory appliances, giving the same attention to the gas pipes as he gives to the plumbing. This is seldom done and the company is frequently blamed for the neglect of the householder.

The gas engineer, steering between the Scylla of 'poor' gas and the Charybdis of excessive pressures, finds himself still 'dangerous in the rapids' of financial expenditure. At present he is doing the best he can with the money doled out to him by the management.

It will be observed that up to the present point the gas meter itself has played no part in the discussion. The meter, although greatly maligned, is in reality an eminently satisfactory piece of mechanism.

Concerning this apparatus many erroneous notions prevail. One of these is that a householder may burn thousands of feet of gas without cost to himself, provided he keeps the company in blissful ignorance of the employment of gas for heating purposes upon his premises. The demonstration of the falsity of this idea lies within the reach of any one who will take the trouble to read his own meter on those days on which the company's indexer pays his monthly visits.

Figs. 1, 2 and 3 represent different states of the index usually employed on the three, five and ten light meters, the sizes commonly found in our dwellings. The smaller dial, placed centrally above the other, is known as the 'proving dial,' and, being used merely for testing purposes, is not considered in reading the gas consumption. Although the index dials vary in nomenclature as well as in number, it is generally safe to consider that if the name is placed *above* the

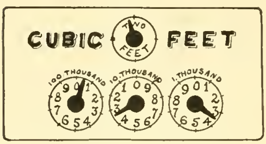


Fig. 1.—Reads 3,300 Cubic Feet.

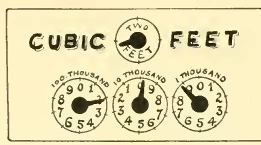


Fig. 2.—Reads 19,800 Cubic Feet. The apparent reading is 29,800. The gearing of the indexing mechanism is not especially delicate, and it frequently happens that the dial of one denomination begins to record before the hand of the next lower denomination has made a complete revolution.

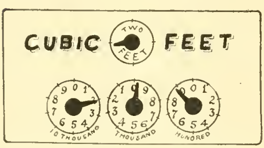


Fig. 3.—Reads 19,800 Cubic Feet.

dial a complete revolution of the pointer is required to register the amount of gas indicated by the name; whereas if the name is placed *below* the dial each numbered division of the dial represents the amount corresponding to the name. If doubt still exists as to the value of each division of the lowest or right-hand dial, remember that no meter index is designed to read less than one hundred cubic feet for each division of the circle.

After one has indexed his own meter for a month or two he is in a position to begin checking the bills presented. The 'present state of meter' and the 'previous state of meter' are always specified, and the mere subtraction of the former from the latter gives the consumption. This is not invariably the case, however. After a meter has registered its maximum reading—100,000 in the smaller sizes—it passes over the zero point and begins to build up a new record. This happens at intervals as long as the apparatus is kept in service. Before me lies a bill giving the 'present state' as 1,700 and the 'previous state' as 96,300. Since the meter was continuously employed, it must have registered up to 100,000, so that it registered 3,700 cubic feet on the old score before recording 1,700 cubic feet on the new. Consequently, adding 1,700 to the difference between 'previous state' and the highest possible reading gives 5,400 cubic feet—the amount consumed during

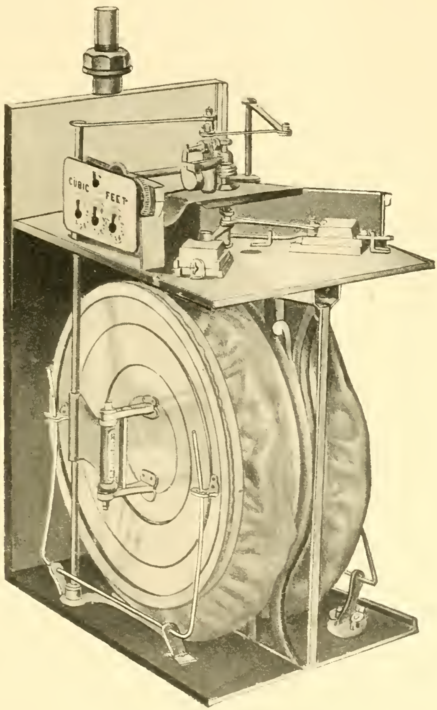


Fig. 4.—Interior of Common Gas Meter.

the month. By reading one's own meter the detection of any error on the part of the indexer or of the clerical force at the gas office becomes possible. Errors of this nature are of rare occurrence, as those who have adopted this plan of checking gas bills will testify. The responsibility for excessive bills is thus taken from the gas employees and thrown entirely upon the gas-registering mechanism itself. Those people, then, who chuckle furtively over the fact that the gas company has not 'caught on' to the surreptitious use of gas ranges are either the fortunate possessors of 'slow' meters or are deluding themselves as to the amount of gas which they actually consume.

Fig. 4 is a photograph of the common dry meter, with the front, back, top and left side removed. It is called a 'dry' meter to distinguish it from those meters, having little vogue in this country, which employ a liquid in place of a valve motion. The apparatus shown consists of a case divided into three compartments by a horizontal partition one fourth of the way down from the top, and by a vertical partition centrally placed and extending upward from the bottom of the casing to the horizontal partition. The upper compartment contains the registering mechanism and a small valve chamber, the latter corresponding to the steam chest of an engine. In each of the lower compartments is a metal disk attached to the central partition by well-oiled flexible leathers, each disk, leather and the

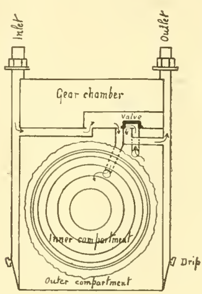


Fig. 5.

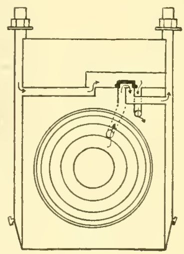


Fig. 6.

partition forming a bellows. As in a locomotive, the meter really consists of two separate mechanisms, set to operate out of phase and avoid dead centers.

Considering one mechanism only, recourse may be had to a diagrammatic representation of the action (Fig. 5). Gas entering the inlet passes into the valve chamber. Here an ordinary D-slide-valve closes two of the openings, leaving a third through which the gas may flow into the bellows or inner compartment. The bellows expands, gradually filling the outer compartment, and forcing the gas out under the valve into the outlet pipe, as indicated by the arrows. When the bellows is fully distended the valve shifts into the position shown in Fig. 6, admitting the inflowing gas to the outer compartment and collapsing the bellows, whose contents are forced into the outlet pipe by the paths traced by the arrows.

Thus, it will be observed, the meter is a volume measurer pure and simple, measuring cubic feet with as much deliberation as is required to deal water out of a cask by means of a pint dipper. Its percentage of error is the same at all pressures and under all loads within its capacity, and it measures cubic feet of gas regardless of whether that gas be expanded or compressed.

And so we are obliged to realize, as another fallacy is exposed, that the meter does not spin around most energetically under the higher pressures, cheerfully and accommodatingly serving its masters by adding a mythical cubic foot or two to the count at each revolution.

It remains, then, to consider the error of the meter. The custom is, in New York at least, not to set a meter that registers fast—that registers a greater volume of gas than actually passes through it. If it is found to be slow, however, and not more than three per cent., it is allowed to go out. As a result, the meter, when first placed, always favors the consumer, sometimes to the extent of recording only ninety-seven feet of gas for each one hundred feet actually passed. Owing to the aging of the mechanism and the drying out of the leathers, there exists a tendency to increase the registry for each cubic foot passed. In this way a slow meter may become a fast meter after a period of active service. From the meager data at my disposal, it would appear that every meter should be called in for a thorough overhauling and readjustment at periodic intervals of from three to five years.

Assuming that there are several million gas meters in Greater New York alone, it is but natural to expect that out of this vast number, in spite of any reasonable care that may have been exercised in their adjustment originally, many will be found subsequently to be defective —some because of mechanical injury, some through sheer old age. Unfortunately, it is not possible as yet to obtain a convincingly large array of figures; but in the Borough of Brooklyn, where there are in service nearly a quarter of a million meters, and where complaints against them have been studiously encouraged by the authorities, one hundred and eighty-seven meters have been carefully tested. Here are the results:

21 correct	
114 fast, average 3 per cent (recording 103 cubic feet for each 100 cubic feet actually passed)........................	3 more than 10 per cent. 42 between 3 and 10 per cent. 69 less than 3 per cent. — 114
52 slow, average 2¼ per cent (recording 97¾ cubic feet for each 100 cubic feet actually passed)....................	0 more than 10 per cent. 13 between 3 and 10 per cent. 39 less than 3 per cent. — 52
— 187	

When one remembers that these one hundred and eighty-seven meters are presumably the worst of their kind, having been put in evidence by a naturally suspicious public, it is but fair to assume that the figures overrate rather than underestimate the errors of the average gas meter. Quoting from *The Progressive Age,* a journal devoted largely to the interests of the gas industry: "The meters made to-day will remain a long while in service before they begin to register incorrectly, and when we consider the dampness, extremes of temperature and hard usage they receive as they are transferred from cellar to attic, from among the dust, cobwebs and litter of a basement closet to the corner shelf of some coal cellar, to be the playground of rats, spiders and cockroaches, to be drenched in summer by sweating or leaky water pipes and wear a venerable beard of icicles in winter—to be, in fact, the worst-used machine about a gas plant—we can not fail but express surprise that it registers at all correctly."

THE SUN'S DESTINATION.

By Professor HAROLD JACOBY,
COLUMBIA UNIVERSITY.

THREE generations of men have come and gone since the Marquis de Laplace stood before the Academy of France and gave his demonstration of the permanent stability of our solar system. There was one significant fault in Newton's superbly simple conception of an eternal law governing the world in which we live. The labors of mathematicians following him had shown that the planets must trace out paths in space whose form could be determined in advance with unerring certainty by the aid of Newton's law of gravitation. But they proved just as conclusively that these planetary orbits, as they are called, could not maintain indefinitely the same shapes or positions. Slow indeed might be the changes they were destined to undergo; slow, but sure, with that sureness belonging to celestial science alone. And so men asked: Has this magnificent solar system been built upon a scale so grand, been put in operation subject to a law sublime in its very simplicity, only to change and change until at length it shall lose every semblance of its former self, and end perhaps in chaos or extinction?

Laplace was able to answer confidently: No. Nor was his answer couched in the enthusiastic language of unbalanced theorists who work by the aid of imagination alone. Based upon the irrefragable logic of correct mathematical reasoning, and clad in the sober garb of mathematical formulæ, his results carried conviction to men of science the world over. So was it demonstrated that changes in our solar system are surely at work, and shall continue for nearly countless ages; yet just as surely will they be reversed at last, and the system will tend to return again to its original form and condition. The objection that the Newtonian law meant ultimate dissolution of the world was thus destroyed by Laplace. From that day forward, the law of gravitation has been accepted as holding sway over all phenomena visible within our planetary world.

The intricacies of our own solar system being thus illumined, the restless activity of the human intellect was stimulated to search beyond for new problems and new mysteries. Even more fascinating than the movements of our sun and planets are all those questions that relate to the clustered stellar congeries hanging suspended within the deep blue vault of night. Does the same law of gravitation cast its magic spell over that hazy cloud of Pleiads, binding them, like ourselves, with bonds indissoluble? Who shall answer, yes or no? We can only say that astronomers have as yet but stepped upon the threshold of the universe, and fixed the telescope's great eye upon that which is within.

Let us then begin by reminding the reader what is meant by that Newtonian law of gravitation. It appears all things possess the remarkable property of attracting or pulling each other. Newton declared that all substances, solid, liquid or even gaseous, from the massive cliff of rock down to the invisible air—all matter can no more help pulling than it can help existing. His law further formulates certain conditions governing the manner in which this gravitational attraction is exerted; but these are mere matters of detail; interest centers about the mysterious fact of attraction itself. How can one thing pull another with no connecting link through which the pull can act? Just here we touch the point that has never yet been explained. Nature withholds from science her ultimate secrets. They that have pondered longest, that have descended farthest of all men into the clear well of knowledge, have done so but to sound the depths beyond, never touching bottom.

This inability of ours to give a good physical explanation of gravitation has led numerous paradoxers to doubt or even deny that there is any such thing. But fortunately we have a simple laboratory experiment that helps us. Unexplained it may ever remain, but that there can be attraction between physical objects connected by no visible link is proved by the behavior of an ordinary magnet. Place a small piece of steel or iron near a magnetized bar, and it will at once be so strongly attracted that it will actually fly to the magnet. Any one who has seen this simple experiment can never again deny the possibility at least of the law of attraction as stated by Newton. Its possibility once admitted, the fact that it can predict the motions of all the planets, even shown to the minutest details, transforms the possibility of its birth into a certainty as strong as any human certainty can ever be.

But this demonstration of Newton's law is limited strictly to the solar system itself. We may indeed reason by analogy, and take for granted that a law which holds within our immediate neighborhood is extremely likely to be true also of the entire visible universe. But men of science are loath to reason thus; and hence the fascination of researches in cosmic astronomy. Analogy points out the path. The astronomer is not slow to follow; but he seeks ever to establish upon incontrovertible evidence those truths which at first only his daring imagination had led him to half suspect. If we are to extend the law of gravitation to the utmost, we must be careful to consider the law itself in its most complete form. A heavenly body like the sun is often said to govern the motions of its family of planets; but such a statement is not strictly accurate. The governing body is no despot; 'tis an abject slave of law and order, as much as the tiniest of attendant planets. The action of gravitation is mutual, and no cosmic body can attract another without being itself in turn subject to that other's gravitational action. If there were in our solar system but two bodies, sun and planet, we should find each one pursuing a path in space under the influence of the other's attraction. These two paths or orbits would be oval, and if the sun and planet were equally massive, the orbits would be exactly alike, both in shape and size. But if the sun were far larger than the planet, the orbits would still be similar in form, but the one traversed by the larger body would be small. For it is not reasonable to expect a little planet to keep the big sun moving with a velocity as great as that derived by itself from the attraction of the larger orb. Whenever the preponderance of the larger body is extremely great, its orbit will be correspondingly insignificant in size. This is in fact the case with our own sun. So massive is it in comparison with the planets, that the orbit is too small to reveal its actual existence without the aid of our most refined instruments. The path traced out by the sun's center would not fill a space as large as the sun's own bulk. Nevertheless, true orbital motion is there.

So we may conclude that as a necessary consequence of the law of gravitation every object within the solar system is in motion. To say that planets revolve about the sun is to neglect as unimportant the small orbit of the sun itself. This may be sufficiently accurate for ordinary purposes; but it is unquestionably necessary to neglect no factor, however small, if we propose to extend our reasoning to a consideration of the stellar universe. For we shall then have to deal with systems in which the planets are of a size comparable with the sun; and in such systems all the orbits will also be of comparatively equal importance.

Mathematical analysis has derived another fact from discussion of the law of gravitation which perhaps transcends in simple grandeur everything we have as yet mentioned. It matters not how great may be the number of massive orbs threading their countless interlacing curved paths in space, there yet must be in every cosmic system one single point immovable. This point is called the Center of Gravity. If it should so happen that in the beginning of things, some particle of matter were situated at this center, then would that atom ever remain unmoved and imperturbable throughout all the successive vicissitudes of cosmic evolution. It is doubtful whether the mind of man can form a conception of anything grander than such an immovable atom within the mysterious intricacies of cosmic motion.

But in general, we can not suppose that the centers of gravity in the various stellar systems are really occupied by actual physical bodies. The center may be a mere mathematical point in space, situated among the several bodies composing the system, but nevertheless endowed with the same remarkable property of relative immobility.

Having thus defined the center of gravity in its relation to the constituent parts of any cosmic system, we can pass easily to its characteristic properties in connection with the inter-relation of stellar systems with one another. It can be proved mathematically that our solar system will pull upon distant stars just as though the sun and all the planets were concentrated into one vast sphere having its center in the center of gravity of the whole. It is this property of the center of gravity which makes it preëminently important in cosmic researches. For, while we know that center to be at rest relatively to all the planets in the system, it may, nevertheless, in its quality as a sort of concentrated essence of them all, be moving swiftly through space under the pull of distant stars. In that case, the attendant bodies will go with it—but they will pursue their evolutions within the system, all unconscious that the center of gravity is carrying them on a far wider circuit.

What is the nature of that circuit? This question has been for many years the subject of earnest study by the clearest minds among astronomers. The greatest difficulty in the way is the comparatively brief period during which men have been able to make astronomical observations of precision. Space and time are two conceptions that transcend the powers of definition possessed by any man. But we can at least form a notion of how vast is the extent of time, if we remember that the period covered by man's written records is registered but as a single moment upon the great revolving dial of heaven's dome. One hundred and fifty years have elapsed since James Bradley built the foundations of sidereal astronomy upon his masterly series of star-observations at the Royal Observatory of Greenwich, in England. Yet so slowly do the movements of the stars unroll themselves upon the firmament, that even to this day no one of them has been seen by men to trace out more than an infinitesimal fraction of its destined path through the voids of space.

Travelers upon a railroad can not tell at any given moment whether they are moving in a straight line, or whether the train is turning upon some curve of huge size. The St. Gothard railway has several so-called 'corkscrew' tunnels, within which the rails make a complete turn in a spiral, the train finally emerging from the tunnel at a point almost vertically over the entrance. In this way the train is lifted to a higher level. Passengers are wont to amuse themselves while in these tunnels by watching the needle of an ordinary pocket compass. This needle, of course, always points to the north; and as the train turns upon its curve, the needle will make a complete revolution. But the passenger could not know without the compass that the train was not moving in a perfectly straight line. Just so we passengers on the earth are unaware of the kind of path we are traversing, until, like the compass, the astronomer's instruments shall reveal to us the truth.

But as we have seen, astronomical observations of precision have not as yet extended through a period of time corresponding to the few minutes during which the St. Gothard traveler watches the compass. We are still in the dark, and do not know as yet whether mankind shall last long enough upon the earth to see the compass needle make its revolution. We are compelled to believe that the motion in space of our sun is progressing upon a curved path; but so far as precise observations allow us to speak, we can but say that we have as yet moved through an infinitesimal element only of that mighty curve. However, we know the point upon the sky towards which this tiny element of our path is directed, and we have an approximate knowledge of the speed at which we move.

More than a century ago Sir William Herschel was able to fix roughly what we call the Apex of the sun's way in space, or the point among the stars towards which that way is for the moment directed. We say for the moment, but we mean that moment of which Bradley saw the beginning in 1750, and upon whose end no man of those now living shall ever look. Herschel found that a comparison of old stellar observations seemed to indicate that the stars in a certain part of the sky were opening out, as it were, and that the constellations in the opposite part of the heavens seemed to be drawing in, or becoming smaller. There can be but one reasonable explanation of this. We must be moving towards that part of the sky where the stars are separating. Just so a man watching a regiment of soldiers approaching, will see at first only a confused body of men. But as they come nearer the individual soldiers will seem to separate, until at length each one is seen distinct from all the others.

Herschel fixed the position of the apex at a point in the constellation Hercules. The most recent investigations of Newcomb, published only a few months ago, have, on the whole, verified Herschel's conclusions. With the intuitive power of rare genius, Herschel had been able to sift truth out of error. The observational data at his disposal would now be called rude, but they disclosed to the scrutiny of his acute understanding the germ of truth that was in them. Later investigators have increased the precision of our knowledge, until we can now say that the present direction of the solar motion is known within very narrow limits. A tiny circle might be drawn on the sky, to which an astronomer might point his hand and say: Yonder little circle contains the goal towards which the sun and planets are hastening to-day. Even the speed of this motion has been subjected to measurement, and found to be about ten miles per second.

The objective point and the rate of motion thus stated, exact science holds her peace. Here genuine knowledge stops; and we can proceed further only by the aid of that imagination which men of science need to curb at every moment. But let no one think that the sun will ever reach the so-called apex. To do so would mean cosmic motion upon a straight line, while every consideration of celestial mechanics points to motion upon a curve. When shall we turn sufficiently upon that curve to detect its bending? 'Tis a problem we must leave as a rich heritage to later generations that are to follow us. The visionary theorist's notion of a great central sun, controlling our own sun's way in space, must be dismissed as far too daring. But for such a central sun we may substitute a central center of gravity belonging to a great system of which our sun is but an insignificant member. Then we reach a conception that has lost nothing in the grandeur of its simplicity, and is yet in accord with the probabilities of sober mechanical science. We cease to be a lonely world, and stretch out the bonds of a common relationship to yonder stars within the firmament.

A BIOGRAPHICAL SKETCH OF AN INFANT*.

BY CHARLES DARWIN.

[Child-study has recently become a most active department of psychology. It is the serious pursuit of men of science and the fad of women's clubs; a late accession to the magazines devoted to it comes from Japan. In spite of this wide-spread zeal, few of the followers of child-study have ever heard of one of the most valuable contributions to it. And in spite of the eminence of the author, Darwin's observations on the mental growth of his child are practically unknown to most zoölogists and psychologists.

It is a witness to the breadth of Darwin's interests that he should have been among the few men who anticipated by a generation or more what is now so wide a movement in psychology. His retention of his notes for thirty-seven years before publishing them is thoroughly characteristic. In this respect there is a notable difference between Darwin and the present-day enthusiasts for child-study.]

M. TAINE'S very interesting account of the mental development of an infant, translated in the last number of *Mind* (p. 252), has led me to look over a diary which I kept thirty-seven years ago with respect to one of my own infants. I had excellent opportunities for close observation, and wrote down at once whatever was observed. My chief object was expression, and my notes were used in my book on this subject; but as I attended to some other points, my observations may possibly possess some little interest in comparison with those by M. Taine, and others which hereafter no doubt will be made. I feel sure, from what I have seen with my own infants, that the period of development of the several faculties will be found to differ considerably in different infants.

During the first seven days various reflex actions, namely sneezing, hickuping, yawning, stretching, and, of course, sucking and screaming, were well performed by my infant. On the seventh day, I touched the naked sole of his foot with a bit of paper, and he jerked it away, curling at the same time his toes, like a much older child when tickled. The perfection of these reflex movements shows that the extreme imperfection of the voluntary ones is not due to the state of the muscles or of the co-ordinating centers, but to that of the seat of the will. At this time, though so early, it seemed clear to me that a warm, soft hand applied to his face excited a wish to suck. This must be considered as a reflex or an instinctive action, for it is impossible to believe that

* Reprinted from *Mind*, July, 1877.

experience and association with the touch of his mother's breast could so soon have come into play. During the first fortnight he often started on hearing any sudden sound, and blinked his eyes. The same fact was observed with some of my other infants within the first fortnight. Once, when he was 66 days old, I happened to sneeze, and he started violently, frowned, looked frightened, and cried rather badly; for an hour afterwards he was in a state which would be called nervous in an older person, for every slight noise made him start. A few days before this same date, he first started at an object suddenly seen; but for a long time afterwards sounds made him start and wink his eyes much more frequently than did sight; thus, when 114 days old, I shook a pasteboard box with comfits in it near his face and he started, whilst the same box when empty or any other object shaken as near or much nearer to his face produced no effect. We may infer from these several facts that the winking of the eyes, which manifestly serves to protect them, had not been acquired through experience. Although so sensitive to sound in a general way, he was not able even when 124 days old, easily to recognize whence a sound proceeded so as to direct his eyes to the source.

With respect to vision—his eyes were fixed on a candle as early as the 9th day, and up to the 45th day nothing else seemed thus to fix them; but on the 49th day his attention was attracted by a bright-colored tassel, as was shown by his eyes becoming fixed and the movements of his arms ceasing. It was surprising how slowly he acquired the power of following with his eyes an object if swinging at all rapidly; for he could not do this well when seven and a half months old. At the age of 32 days he perceived his mother's bosom when three or four inches from it, as was shown by the protrusion of his lips and his eyes becoming fixed; but I much doubt whether this had any connection with vision; he certainly had not touched the bosom. Whether he was guided through smell or the sensation of warmth or through association with the position in which he was held, I do not at all know.

The movements of his limbs and body were for a long time vague and purposeless, and usually performed in a jerking manner; but there was one exception to this rule, namely, that from a very early period, certainly long before he was 40 days old, he could move his hands to his own mouth. When 77 days old, he took the sucking bottle (with which he was partly fed) in his right hand, whether he was held on the left or right arm of his nurse, and he would not take it in his left hand until a week later, although I tried to make him do so; so that the right hand was a week in advance of the left. Yet this infant afterwards proved to be left-handed, the tendency being no doubt inherited—his grandfather, mother, and a brother having been or being left-handed. When between 80 and 90 days old, he drew all sorts of objects into his mouth, and in two or three weeks' time could do this with some skill; but he often first touched his nose with the object and then dragged it down into his mouth. After grasping my finger and drawing it to his mouth, his own hand prevented him from sucking it; but on the 114th day, after acting in this manner, he slipped his own hand down so that he could get the end of my finger into his mouth. This action was repeated several times, and evidently was not a chance but a rational one. The intentional movements of the hands and arms were thus much in advance of those of the body and legs; though the purposeless movements of the latter were from a very early period usually alternate, as in the act of walking. When four months old he often looked intently at his own hands and other objects close to him, and in doing so the eyes were turned much inwards, so that he often squinted frightfully. In a fortnight after this time (i. e., 132 days old), I observed that if an object was brought as near to his face as his own hands were, he tried to seize it, but often failed; and he did not try to do so in regard to more distant objects. I think there can be little doubt that the convergence of his eyes gave him the clue and excited him to move his arms. Although this infant thus began to use his hands at an early period, he showed no special aptitude in this respect, for when he was two years and four months old, he held pencils, pens, and other objects far less neatly and efficiently than did his sister, who was then only fourteen months old, and who showed great inherent aptitude in handling anything.

ANGER.—It was difficult to decide at how early an age anger was felt; on his eighth day he frowned and wrinkled the skin round his eyes before a crying fit, but this may have been due to pain or distress, and not to anger. When about ten weeks old, he was given some rather cold milk, and he kept a slight frown on his forehead all the time that he was sucking, so that he looked like a grown-up person made cross from being compelled to do something which he did not like. When nearly four months old, and perhaps much earlier, there could be no doubt, from the manner in which the blood gushed into his whole face and scalp, that he easily got into a violent passion. A small cause sufficed; thus, when a little over seven months old, he screamed with rage because a lemon slipped away and he could not seize it with his hands. When eleven months old, if a wrong plaything was given him, he would push it away and beat it; I presume that the beating was an instinctive sign of anger, like the snapping of the jaws by a young crocodile just out of the egg, and not that he imagined he could hurt the plaything. When two years and three months old, he became a great adept at throwing books or sticks, etc., at any one who offended him; and so it was with some of my other sons. On the other hand, I could never see a trace of such aptitude in my infant daughters; and this makes me think that a tendency to throw objects is inherited by boys.

Fear.—This feeling probably is one of the earliest which is experienced by infants, as shown by their starting at any sudden sound when only a few weeks old, followed by crying. Before the present one was four and a half months old, I had been accustomed to make close to him many strange and loud noises, which were all taken as excellent jokes, but at this period I one day made a loud snoring noise, which I had never done before; he instantly looked grave and then burst out crying. Two or three days afterwards I made, through forgetfulness, the same noise, with the same result. About the same time (viz., on the 137th day), I approached with my back towards him and then stood motionless; he looked very grave and much surprised, and would soon have cried, had I not turned round; then his face instantly relaxed into a smile. It is well known how intensely older children suffer from vague and undefined fears, as from the dark, or in passing an obscure corner in a large hall, etc. I may give as an instance that I took the child in question, when two and one fourth years old, to the Zoölogical Gardens, and he enjoyed looking at all the animals which were like those that he knew, such as deer, antelope, etc., and all the birds, even the ostriches, but was much alarmed at the various larger animals in cages. He often said afterwards that he wished to go again, but not to see 'beasts in houses'; and we could in no manner account for this fear. May we not suspect that the vague but very real fears of children, which are quite independent of experience, are the inherited effects of real dangers and abject superstitions during ancient savage times? It is quite conformable with what we know of the transmission of formerly well-developed characters, that they should appear at an early period of life, and afterwards disappear.

Pleasurable Sensations.—It may be presumed that infants feel pleasure whilst sucking, and the expression of their swimming eyes seem to show that this is the case. This infant smiled when 45 days, a second infant when 46 days old; and these were true smiles indicative of pleasure, for their eyes brightened and eyelids slightly closed. The smiles arose chiefly when looking at their mother and were therefore probably of mental origin; but this infant often smiled then, and for some time afterwards, from some inward pleasurable feeling, for nothing was happening which could have in any way excited or amused him. When 110 days old he was exceedingly amused by a pinafore being thrown over his face and then suddenly withdrawn; and so he was when I suddenly uncovered my own face and approached his. He then uttered a little noise which was an incipient laugh.

Here surprise was the chief cause of the amusement, as is the case to a large extent with the wit of grown-up persons. I believe that for three or four weeks before the time when he was amused by a face being suddenly uncovered, he received a little pinch on his nose and cheeks as a good joke. I was at first surprised at humor being appreciated by an infant only a little above three months old, but we should remember how very early puppies and kittens begin to play. When four months old, he showed in an unmistakable manner that he liked to hear the pianoforte played; so that here apparently was the earliest sign of an æsthetic feeling, unless the attraction of bright colors, which was exhibited much earlier, may be so considered.

Affection.—This probably arose very early in life, if we may judge by his smiling at those who had charge of him when under two months old; though I had no distinct evidence of his distinguishing and recognizing any one, until he was nearly four months old. When nearly five months old he plainly showed his wish to go to his nurse. But he did not spontaneously exhibit affection by overt acts until a little above a year old, namely, by kissing several times his nurse who had been absent for a short time. With respect to the allied feeling of sympathy, this was clearly shown at six months and eleven days by his melancholy face, with the corners of his mouth well depressed, when his nurse pretended to cry. Jealousy was plainly exhibited when I fondled a large doll, and when I weighed his infant sister, he being then fifteen and one half months old. Seeing how strong a feeling jealousy is in dogs, it would probably be exhibited by infants at an earlier age than that just specified, if they were tried in a fitting manner.

Association of Ideas, Reason, Etc.—The first action which exhibited, as far as I observed, a kind of practical reasoning, has already been noticed, namely, the slipping his hand down my finger so as to get the end of it into his mouth; and this happened on the 114th day. When four and a half months old, he repeatedly smiled at my image and his own in a mirror, and no doubt mistook them for real objects; but he showed sense in being evidently surprised at my voice coming from behind him. Like all infants, he much enjoyed thus looking at himself, and in less than two months perfectly understood that it was an image; for if I made quite silently any old grimace, he would suddenly turn round to look at me. He was, however, puzzled at the age of seven months, when being out of doors he saw me on the inside of a large plate-glass window, and seemed in doubt whether or not it was an image. Another of my infants, a little girl, when exactly a year old, was not nearly so acute, and seemed perplexed at the image of a person in a mirror approaching her from behind. The higher apes which I tried with a small looking-glass behaved differently; they placed their hands behind the glass, and in doing so showed their sense, but far from taking pleasure in looking at themselves, they got angry and would look no more.

When five months old, associated ideas arising independently of any instruction became fixed in his mind; thus as soon as his hat and cloak were put on, he was very cross if he was not immediately taken out of doors. When exactly seven months old, he made the great step of associating his nurse with her name, so that if I called it out he would look round for her. Another infant used to amuse himself by shaking his head laterally; we praised and imitated him, saying, "Shake your head;" and when he was seven months old, he would sometimes do so on being told without any other guide. During the next four months the former infant associated many things and actions with words; thus when asked for a kiss he would protrude his lips and keep still—would shake his head and say in a scolding voice, "Ah," to the coal-box or a little spilt water, etc., which he had been taught to consider as dirty. I may add that when a few days under nine months old, he associated his own name with his image in the looking-glass, and when called by name would turn towards the glass, even when at some distance from it. When a few days over nine months, he learned spontaneously that a hand or other object causing a shadow to fall on the wall in front of him was to be looked for behind. Whilst under a year old, it was sufficient to repeat two or three times at intervals any short sentence to fix firmly in his mind some associated idea. In the infant described by M. Taine, the age at which ideas readily became associated seems to have been considerably later, unless, indeed, the earlier cases were overlooked. The facility with which associated ideas due to instruction and others spontaneously arising were acquired, seemed to me by far the most strongly marked of all the distinctions between the mind of an infant and that of the cleverest full-grown dog that I have ever known. What a contrast does the mind of an infant present to that of the pike, described by Professor Mobius,* who, during three whole months dashed and stunned himself against a glass partition which separated him from some minnows; and when, after at last learning that he could not attack them with impunity, he was placed in the aquarium with these same minnows, then in a persistent and senseless manner he would not attack them!

Curiosity, as M. Taine remarks, is displayed at an early age by infants, and is highly important in the development of their minds; but I made no special observation on this head. Imitation likewise comes into play. When our infant was only four months old, I thought that he tried to imitate sounds; but I may have deceived myself, for I was not thoroughly convinced that he did so until he was ten months

* 'Die Bewegungen der Thiere,' etc., 1878, p. 11.

old. At the age of eleven and a half months, he could readily imitate all sorts of actions, such as shaking his head and saying "Ah" to any dirty object, or by carefully and slowly putting his forefinger in the middle of he palm of his other hand, to the childish rhyme of "Pat it and pat it and mark it with T." It was amusing to behold his pleased expression after successfully performing any such accomplishment.

I do not know whether it is worth mentioning, as showing something about the strength of memory in a young child, that this one, when three years and twenty-three days old, on being shown an engraving of his grandfather, whom he had not seen for exactly six months, instantly recognized him and mentioned a whole string of events which had occurred whilst visiting him, and which certainly had never been mentioned in the interval.

Moral Sense.—The first sign of moral sense was noticed at the age of nearly thirteen months; I said, "Doddy (his nickname) won't give poor papa a kiss,—naughty Doddy." These words, without doubt, made him feel slightly uncomfortable; and at last, when I had returned to my chair, he protruded his lips as a sign that he was ready to kiss me; and he then shook his hand in an angry manner until I came and received his kiss. Nearly the same little scene recurred in a few days, and the reconciliation seemed to give him so much satisfaction that several times afterwards he pretended to be angry and slapped me, and then insisted on giving me a kiss. So that here we have a touch of the dramatic art, which is so strongly pronounced in most young children. About this time it became easy to work on his feelings and make him do whatever was wanted. When two years and three months old, he gave his last bit of gingerbread to his little sister, and then cried out with high self-approbation, "Oh, kind Doddy, kind Doddy." Two months later he became extremely sensitive to ridicule, and was so suspicious that he often thought people who were laughing and talking together were laughing at him. A little later (two years and seven and a half months old) I met him coming out of the dining-room with his eyes unnaturally bright, and an odd, unnatural or affected manner, so that I went into the room to see who was there, and found that he had been taking pounded sugar, which he had been told not to do. As he had never been in any way punished, his odd manner certainly was not due to fear, and I suppose it was pleasurable excitement struggling with conscience. A fortnight afterwards I met him coming out of the same room, and he was eyeing his pinafore, which he had carefully rolled up; and again his manner was so odd that I determined to see what was within his pinafore, notwithstanding that he said there was nothing, and repeatedly commanded me to "go away," and I found it stained with pickle-juice; so that here was carefully planned deceit.

As this child was educated solely by working on his good feelings, he soon became as truthful, open and tender as any one could desire.

Unconsciousness, Shyness.—No one can have attended to very young children without being struck at the unabashed manner in which they fixedly stare without blinking their eyes at a new face; an old person can look in this manner only at an animal or inanimate object. This, I believe, is the result of young children not thinking in the least about themselves, and therefore not being in the least shy, though they are sometimes afraid of strangers. I saw the first symptom of shyness in my child when nearly two years and three months old; this was shown towards myself, after an absence of ten days from home, chiefly by his eyes being kept slightly averted from mine; but he soon came and sat on my knee and kissed me, and all trace of shyness disappeared.

Means of Communication.—The noise of crying or rather of squalling, as no tears are shed for a long time, is of course uttered in an instinctive manner, but serves to show that there is suffering. After a time the sound differs according to the cause, such as hunger or pain. This was noticed when this infant was eleven weeks old, and I believe at an earlier age in another infant. Moreover, he appeared soon to learn to begin crying voluntarily, or to wrinkle his face in the manner proper to the occasion, so as to show that he wanted something. When 46 days old, he first made little noises without any meaning to please himself, and these soon became varied. An incipient laugh was observed on the 113th day, but much earlier in another infant. At this date I thought, as already remarked, that he began to try to imitate sounds, as he certainly did at a considerably later period. When five and a half months old, he uttered an articulate sound "da," but without any meaning attached to it. When a little over a year old, he used gestures to explain his wishes; to give a simple instance, he picked up a bit of paper, and, giving it to me, pointed to the fire, as he had often seen and liked to see paper burnt. At exactly the age of a year, he made the great step of inventing a word for food, namely, *mum*, but what led him to it I did not discover. And now, instead of beginning to cry when he was hungry, he used this word in a demonstrative manner or as a verb, implying "Give me food." This word, therefore, corresponds with *ham*, as used by M. Taine's infant at the later age of fourteen months. But he also used *mum* as a substantive of wide signification; thus he called sugar *shu-mum*, and a little later after he had learned the word 'black,' he called liquorice *black-shu-mum*—black-sugar-food.

I was particularly struck with the fact that when asking for food by the word *mum* he gave to it (I will copy the words written down at the time), "a most strongly marked interrogatory sound at the end." He also gave to "Ah," which he chiefly used at first when recognizing any person or his own image in a mirror, an exclamatory sound, such as we employ when surprised. I remark in my notes that the use of these intonations seemed to have arisen instinctively, and I regret that more observations were not made on this subject. I record, however, in my notes that at a rather later period, when between eighteen and twenty-one months old, he modulated his voice in refusing peremptorily to do anything by a defiant whine, so as to express, "That I won't;" and again his humph of assent expressed, "Yes, to be sure." M. Taine also insists strongly on the highly expressive tones of the sounds made by his infant before she had learned to speak. The interrogatory sound which my child gave to the word *mum* when asking for food is especially curious; for, if any one will use a single word or a short sentence in this manner, he will find that the musical pitch of his voice rises considerably at the close. I did not then see that this fact bears on the view which I have elsewhere maintained that before man used articulate language, he uttered notes in a true musical scale, as does the anthropoid ape Hylobates.

Finally, the wants of an infant are at first made intelligible by instinctive cries, which after a time are modified in part unconsciously, and in part, as I believe, voluntarily as a means of communication,—by the unconscious expression of the features—by gestures and in a marked manner by different intonations,—lastly by words of general nature invented by himself, then of a more precise nature imitated from those which he hears; and these are acquired at a wonderfully quick rate. An infant understands to a certain extent, and as I believe, at a very early period, the meaning or feeling of those who tend him, by the expression of their features. There can hardly be a doubt about this with respect to smiling; and it seemed to me that the infant whose biography I have here given understood a compassionate expression at a little over five months old. When six months and eleven days old, he certainly showed sympathy with his nurse on her pretending to cry. When pleased after performing some new accomplishment, being then almost a year old, he evidently studied the expression of those around him. It was probably due to differences of expression and not merely of the form of the features that certain faces clearly pleased him much more than others, even at so early an age as a little over six months. Before he was a year old, he understood intonations and gestures, as well as several words and short sentences. He understood one word, namely, his nurse's name, exactly five months before he invented his first word, *mum*; and this is what might have been expected, as we know that the lower animals easily learn to understand spoken words.

CORRESPONDENCE.

COMPARATIVE LONGEVITY AND GREATNESS.

Whether or not great men are favored by an increase of years above those allotted to more ordinary mortals has long been a question of interest, and has acquired a special importance in connection with the study of the natural history of men of genius, and the discussions of the possible relation of greatness to degeneracy and to insanity. Questions of this type can only be decided on the basis of extensive and carefully collected data, which unfortunately it is difficult and at times impossible to collect or to find. It is therefore natural that such evidence as seems to exist and to carry with it some degree of logical force should be brought forward in proof of a claim which on general principles is both pleasing and plausible. Of this type is the problem of the relation between longevity and greatness, and of this type is the evidence now and then brought forward to substantiate the belief that great men are, as regards longevity, an unusually favored class.

The most recent presentation of the topic (by Mr. Thayer in the Forum, February, 1900) collects a list of some five hundred prominent men and women of the nineteenth century and finds that these persons lived on an average sixty-eight years and eight months; that is, nearly thirty years longer than the population as a whole. And on the basis of this conclusion the writer combats the notion that nineteenth-century men of genius or of eminence exhibit signs of degeneracy. because longevity and the ability to do sustained work for a large number of years is in itself a sign of unusual vitality and vigor. As these conclusions are apt to be extensively quoted, and as they seem to me founded upon a serious fallacy, I shall attempt to present as simply as possible the nature of the desired evidence which alone could prove that great men are longer lived than others, and to show that the evidence thus far presented is inadequate to support the conclusion which has been drawn. Mr. Thayer is not the first one to present the average age at death of a number of eminent persons as evidence of unusual longevity. In an article which was reprinted in the Popular Science Monthly for May, 1884, the average age at death of 1,741 astronomers was given, and found to be sixty-four years and three months; and on the basis of this fact the author claimed that astronomers enjoyed unusual longevity. In a brief contribution published in Science, October 1, 1886 (and republished in Nature, November 4, 1886), I called attention to the fallacy inherent in such conclusions, and also presented some new contributions to the question of the longevity of great men. The materials of that article I shall utilize in the present discussion.

To reach the kernel of the matter at once, the reader must note that the fallacy consists in neglecting to consider that in dealing with astronomers or with great men, or with persons of eminence of the nineteenth century, one is dealing with a group which is already carefully selected, *and the selection of which inevitably involves the attainment of a certain age.* The result is that we are not dealing with average persons as regards longevity, but with persons who in the very nature of things have already reached a certain period of maturity. No one can become a poet, or a novelist, or a painter, or a philosopher, or a commander or a statesman unless he lives at least a sufficient number of years to acquire the development of an adult, and to have the opportunity of developing his abilities and distinguishing himself. If great men were great from their infancy, and if we had the means of ascertaining this fact, then, and only then, would the method used be correct.

It is ordinarily stated that the average duration of life is somewhere between thirty-three and forty years, and Mr. Thayer considers that in the present century it has moved forward towards the latter figure. What this means is that if we were to keep a record of the age at death of all Americans who are to be born within the first ten years of the coming century, we should find that their average age at death would be some thirty odd years. But this number can by no means be used as a standard with which to compare the average age at death of men of distinction, or indeed of any other class of men selected according to a standard which involves on their part the attainment of mature years. If we were investigating the longevity of twins, or of persons with supernumerary toes, or indeed of persons possessing any quality which one could detect in new-born infants, and if we could determine the average life-period of this class of persons and find that it markedly exceeded the average of the entire community, we should be entitled to conclude that twins, or persons who have supernumerary toes, are blessed with a greater longevity than the average man. But so long as men who are to acquire distinction bear no traces upon them of this power until they exhibit their powers and actually gain distinction, it is obvious that we are concerned with their longevity only from that moment when they have entered, or have become promising candidates for that class of selected individuals whose longevity we are investigating. Proceeding on this basis, I tried to determine the age at which, on the average, men of genius had accomplished a work sufficient to entitle them to be so denominated. This investigation was instigated by Mr. C. S. Peirce, then in charge of courses in logic at the Johns Hopkins University. Under his leadership a small company, of whom I was one, proposed to study certain traits of great men, and for this purpose we tried to select the three hundred greatest men of all times. The work was never carried on to completion, so that the final selection of the names, and particularly their use in the present connection, must rest on my sole responsibility. I mention these facts mainly to indicate the general representative character of the list which I used. I take from my previously published article the following essential facts: Omitting all doubtful names, about two hundred and fifty names remain, presenting a list which most persons would agree to be fairly representative of the greatest men of all times. Of these again I selected *at random* those about whom it was easiest to fix the age at which they had done work which would entitle them to a place on this list, or work which almost inevitably led to such distinction. It is a date about midway between the first important work and the greatest work. The average of over sixty such ages is thirty-seven years; which means that, on the average, a man must be thirty-seven years old in order to be a candidate for a place on this list. The real question, then, is, How does the longevity of this select class of thirty-seven-year-old men compare with that of more ordinary individuals? The answer is given by the expectation of life at thirty-seven years, which is twenty-nine years, making the average age at death sixty-six years. And this is precisely the age at death of these sixty great men; showing that, as a class (for these sixty may be considered a fair sample) great men are not distinguished by longevity from other men."

It will thus be seen that my own conclusion is entirely opposed to that of Mr. Thayer. But this opposition rests not upon a difference of data, but upon a difference of logic. To my mind the enumeration of ages at death of any number of great men cannot prove unusual longevity unless we take into consideration and can determine the number of years which, on the average, a person must have lived in order to become a candidate for the class under consideration. The comparison with the average age (that is, the period of about thirty-five or more years) is not only false; it is essentially absurd; for it would become possible only if we had among poets, and painters, and musicians, and historians, and scientists, and generals a goodly number who succumbed to the diseases of early infancy, or to some of the ills that juvenile flesh is heir to.

It may be well to illustrate at this point just what conclusions may be drawn from the data which Mr. Thayer and other writers have presented. The first conclusion is that it takes a considerable length of time to become eminent—on the whole a very natural and comprehensible statement. And with regard to the astronomers previously mentioned it is even possible to go farther; for these astronomers have been divided into four degrees of eminence, and it is found that astronomers of the first rank are longer-lived than those of the second, and these in turn are longer-lived than those of the third class, and these in turn are longer-lived than those of the fourth class. Therefore, the author concludes, the greatest astronomers have been most favored with length of years, and adds, as practical advice, "Be an astronomer and live long." Now, of course, the true conclusion is that it takes longer to accomplish work which will entitle one to pre-eminence amongst astronomers than to do work which will only achieve moderate distinction. And the practical conclusion would read, "Live long enough to become great as an astronomer and you will probably, with the ordinary expectation of life, have a good chance of completing your three score and ten." In the same way Mr. Thayer's list of nineteenth-century celebrities might fairly be said to suggest the conclusion that in the present century one must already have labored for a goodly number of years before one's name would be selected by a student of the longevity of great men. So far, then, these facts have an interesting interpretation.

It may also be worth while to note that if all the men whose longevity is to be compared are of a comparable class (that is, comparable with regard to the attainment of years which they assume), then the longevity of different groups of celebrities may be compared with one another. Thus it is possible to compare the longevity of musicians with that of scientists (of about equal eminence), and according to Mr. Thayer's lists the scientists lived ten years longer than the musicians. The same conclusion appears in my own study, in which the scientists appear amongst the longest-lived, and the musicians amongst the shortest-lived men of genius. This conclusion must not be pressed too far, but in a general way it certainly is a bit of evidence worthy of consideration as proving that distinguished scientists live longer than distinguished musicians. It would be wrong to draw rigid conclusions from comparisons of small groups, and therefore it is better to contrast the average age at death of the various men studied in as large and as general classes as possible; e. g., as men of thought, men of feeling and men of action. All of the studies with which I am acquainted point to the conclusion that men of thought live longer than those who achieve distinction through unusual qualities of their emotional natures.

We may now approach the question, whether or not it is possible to prove that the men of distinction of the nineteenth century are longer-lived or shorter-lived than their every-day contemporaries. It would be possible to do this had we statistics of the age at death of the various professions; and again, had we these deaths classed according to the distinction which the individuals attained. In addition to this it would be necessary to ascertain (with some rough approximation, as I have attempted to do with regard to the greatest men of all times) the age at which they had accomplished sufficient work to entitle them to be enrolled in their special class. To take concrete instances, let us suppose that we wish to investigate the longevity of American lawyers. Now to be a lawyer in name only requires the candidate to have lived twenty-one years, and the average number of years which the average person of twenty-one years of age will continue to live is about forty; so that the mere fact that a man is a lawyer would bring his average age at death up to sixty-one years. I find in Mulhall's Dictionary of Statistics the statement made that the lawyers of Frankfurt die at the average age of fifty-four years, while merchants live to be fifty-seven years old. I know nothing about the authority of these figures, and am using them for illustration only. Assuming all the data to be correct (and twenty-one seems not too high an age for this purpose), this would seem to suggest that the ordinary lawyer of Frankfurt is not favored with abundance of years. In passing, it is interesting to note that these Frankfurt statistics of lawyers and merchants and other classes show a uniformly lower age at death than those of the more eminent representatives of their professions. This is just what we should expect; for to be included in the one group one must have lived only long enough to prepare and establish one's self as a lawyer or as a merchant; while for the other group one must in addition have had opportunity to cultivate one's ability to a riper fruitage, and in a keen, and often long competition gain public recognition. It thus follows that the average longevity of the most distinguished lawyers will be greater than that of ordinary lawyers, because it takes longer to enter the more select class. But this argument, like many others, should not be pressed too far; innate ability may accomplish in a brief period what for more moderate powers is the work of many years. Nonetheless, in the study of comparative longevity it is the average that is significant; and it is the fluctuation of the average that we aim to discover. Thus, in the investigation of the longevity of an unwholesome occupation, such as would be accepted by a life insurance company only at special rates, we should expect to find the age at death of such individuals less than that of other classes involving an equal period of apprenticeship; but, of course, not less than that of the 'population as a whole.' And, to continue with the main argument, if we wish to investigate the longevity of shoemakers we should again have to decide upon some age at which on the average a person has probably already acquired the dexterity requisite to be a shoemaker. Even if we fix this so low as ten years, at which time the expectation of life is forty-eight years, it would bring the average age at death of shoemakers to fifty-eight years. It has thus become extremely obvious that if we compared these ages at death with the average life-period it would be just as easy to prove that lawyers and shoemakers and merchants enjoy exceptional longevity, as to prove that great men do. The average longevity is low because of the very large infant mortality, which enters into the composition of this average. When once the first ten years of life are passed the further expectation of life increases quite slowly. Roughly speaking, for every ten years between ten and fifty years the added expectation of life is but three years for each decade. We therefore see that in the very nature of things no one class of adults can possibly live as much as thirty years longer than 'the population as a whole.' The differences with which we are dealing are differences of a finer order, of a small number of years, and being slight differences, must be substantiated by a relatively large number of cases; the cases, moreover, must be collected in a wholly unobjectionable manner; that is, in a manner in which the principle of selection bears no influence upon the longevity. To my knowledge adequate statistics which exhibit the relative longevity of different classes do not exist, and they certainly do not exist with regard to great men. We may therefore conclude that the facts which have thus far been collected are not opposed to the conclusion that great men enjoy favorable longevity, but they certainly have not established or contributed to the establishment of this fact. While it is not impossible to collect material which may serve as corroborative evidence of the longevity of great men, it seems probable that we must be content with evidence of a far inferior character.

Although I regard Mr. Thayer's argument concerning longevity as entirely fallacious, I find myself in sympathy with his main contention. It seems to me that much of the evidence which has been brought forward to assimilate greatness with degeneracy is of questionable value and that the logical force of such evidence has been very much overrated. That genius and insanity are related is probably capable not of demonstration, but of a moderate degree of substantiation; but this evidence must be both judiciously collected and judiciously interpreted. It cannot be presented in a popular form without subjecting it to the danger of serious and harmful misrepresentation. In the same way the question of degeneracy and its bearing upon modern life has been frequently misstated, so that statements of protests such as Mr. Thayer offers are both opportune and likely to have a wholesome effect. But the present concern is only with the relation of longevity to greatness as an indication of the absence of degeneracy. That long life is inconsistent with a general degeneracy may be admitted; but that great men exhibit this quality to any unusual degree has certainly not been proven.

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SCHOOL REFORM.

School teachers and educational reformers undoubtedly take themselves and their ideas too seriously. Accordingly one rejoices to see an eminent man put his own affairs aside for a moment and discuss educational theories in a humorous vein. Even ridicule should be welcomed if it can relieve the sombre earnestness of the educational platform and press. Professor Münsterberg, in the *Atlantic Monthly* for May, has done pedagogy this service by subjecting the elective system and professional training for high-school teachers to considerable good-natured ridicule. His article is so readable that one is led to suppose that it was written to be read, not to be believed. Moreover, Professor Münsterberg's eminence as a psychologist should not be taken as a sign that he thinks he knows aught of education. He has himself warned us against the illusion that psychology can derive truth about teaching, or that the psychologist can inform the teacher or anything of value. It may be that the wholesome matters of fact, as well as the brilliant imaginative criticism of this article are only play. The very strenuousness of the teacher's nature, however, will probably lead him to try to extract some new gospel of reform from Professor Münsterberg's lightest pleasantry; consequently it seems wise to consider the article as a serious argument and provide a possible antidote for it.

Professor Münsterberg contends that it is unwise to give high-school teachers special professional education apart from knowledge of the subjects which they are to teach; that it is folly to replace a prescribed course of study by an elective system; that the salvation of our schools depends upon the scholarship of the teachers and the attitude of parents. As the reformers agree heartily with this last claim (unless it is made an exclusive aim), and as its meaning is so vague that almost anything can be urged as a corrolary to it, it may be dismissed. The first two contentions are about concrete matters of educational practice which need to be thought over. If professional preparation is a waste of time, there is every reason why we should omit it; if a prescribed course of study is better for the boys and girls, we can conscientiously lessen the expense and labor of administration in many schools.

The argument on the first point is, briefly, that Professor Münsterberg's teachers were good teachers and that they had no notion of even the vocabulary of educational theories. But obviously that may not have been the secret of their success. A majority of the high-school teachers in New England have had no professional training, yet no one has observed that they are superior to those of their class who have. The argument is really a bare assertion of an unverified guess. It is the hap-hazard opinion of an eminent psychologist who perchance is trying to furnish evidence of his previous theory that psychology does not give one knowledge about teaching. It is worth while to note here a certain interesting aspect of human nature. Training in one sphere of intellectual activity need not bring ability in other spheres. The habit and power of observation or reasoning acquired in connection with chemistry need not make a man a good observer or reasoner in politics or philology. So we should not be surprised that a man eminent for his scientific habits as a psychologist should, on a question in another field, offer imaginative hypotheses without an attempt to verify them, or to collect pertinent evidence or to eliminate factors outside those he discusses. We may be allowed to feel sorry. If a scientist wishes to really clear up the question of the value of professional training, why does he not find representatives of the classes, 'teachers with professional training' and 'teachers their equals in other respects, who have replaced the effort after professional training by equal effort after further scholarship,' and compare the work of the two classes? If other factors enter to disturb such an investigation, why not carefully look at the facts to ascertain their influence? Until he does so his dictæ will stand as mere opinions. It would be a blessing if scientific men would use the weight of their reputations, not to bolster up their after-dinner opinions about things in general, but to teach the public scientific methods of studying them.

Apart from the danger of offering pedagogy an unproved opinion as a fact, it seems poor economy to leave a question in such shape that only the opinion of another eminent man on the opposite side is required to destroy the result you have attained. Precisely this has occurred in the case of Professor Münsterberg's contributions to educational discussion two years ago. Another eminent man, Professor Dewey, has recently squarely denied what Professor Münsterberg affirmed. It only remains for some equally eminent German professor to rise and declare that his teachers were bad and that they had no professional training, or that his teachers were good and had it, and Professor Münsterberg's effect is neutralized.

Professor Münsterberg's argument against the elective system is more complex. He regards the elective system as partly a concession to the obvious need of fitting young people earlier for their occupations in life and partly an attempt to use the likes and dislikes of children as a guide to what is good for them. This is a very narrow view. The elective system has been in part the result of the progress of science and the consequent conviction that the scientific study of things and human affairs should be a part of one's education. The elective system furnished a compromise by which such studies found a place in the college and school curricula. If the student is left to choose among them, instead of having a new prescribed course made out on the basis of modern views of life's needs, it is partly because they are more easily introduced and retained as electives and partly because there is no agreement as to which studies will be the best to prescribe.

The idea that reformers desire to have a course containing studies good for children and studies not good for them and to trust the scholars' likes and dislikes to guide them to the former, is absurd. Whether they are right in assuming that what is best for one boy may not be best for another, that his teachers and parents can help him to pick out a course of study better for him than any inflexible course prescribed for all can be, is a question of importance, but one which Professor Münsterberg does not try to answer. Instead, he tells us about his gratitude to his parents and teachers for never letting him neglect his steady toil at prescribed Greek for the pursuits which he himself elected out of school, such as electrical engineering, botany, novel-writing, reading Arabic, writing books on the prehistoric anthropology of West Prussia, etc., etc. Now, this confession about his early life absolves us from paying any further attention to his experience as a lesson to our high-school youths. The youth Münsterberg and the average high-school student do not belong in the same class. For he was evidently an eminent boy as he is an eminent man. We must admit, however, that the rigorous discipline afforded by the prescribed Latin and Greek is evidenced in the present stern moral sense of the professor, who is willing to abandon his chosen and favorite pursuit, laboratory experimentation, and at the call of duty give himself to the hated but necessary tasks of writing philosophical disquisitions, political discussions and articles on school reform.

X.

SCIENTIFIC LITERATURE.

CHEMISTRY.

THE general interest which has been aroused the last few years in physical chemistry is reflected in the number of books which have appeared in this department. Some of these dwell more upon the older physical chemistry, devoting but relatively little space to the later developments, while others are chiefly concerned with the newer phases of the subject. Perhaps the most satisfactory book which has appeared along this line is Walker's 'Introduction to Physical Chemistry' (Macmillan). No attempt is made to exhaust the field but the subject is well covered. Especially commendable is the clearness of the book, which will render it useful to students. The non-mathematical treatment of the subject will also commend it to many who use it as an introduction to physical chemistry. A book of narrower scope is Dr. H. C. Jones's 'Theory of Electrolytic Dissociation and Some of Its Applications,' from the press of the same publishers. The author gives first a short review of the development of physical chemistry up to the days of van't Hoff, and then surveys the origin of the theory of electrolytic dissociation, its proofs and some of its applications. While making no pretense to cover the whole field of physical chemistry, the author furnishes a very readable account of the most important of the later generalizations. It is a book which should be read especially by those chemists and physicists who are working in other fields, that they may gain a fair view of the electrolytic dissociation theory written by one thoroughly competent for his task. Biologists, too, will find the latter part of the book, treating of the applications of the theory to animal and plant life, of especial interest. Dr. Jones, with S. H. King, has also translated Biltz on 'Practical Methods of Determining Molecular Weights.' This is a successful attempt to gather together the best of the different methods of real value, and it is very satisfactorily carried out, presenting a good guide book for students.

IN the production of text-books of general chemistry, there seems to be a little lull, very few books having appeared in recent months. The first part of what promises to be a somewhat original work on inorganic chemistry, by Dr. Sperber, has appeared. After the introduction on general chemical laws, the elements of the seventh group (chlorine, etc.), are first considered, and then their hydrogen compounds; the sixth group (oxygen, etc.) and its hydrogen compounds; fifth group (nitrogen, etc.), etc. The method used is purely inductive, each subject being introduced by experiments from which the underlying principles are developed.

A THIRD edition of Elliott and Ferguson's 'Qualitative Analysis' has appeared which is a considerable improvement upon the previous editions. The principal merit of this book, is in the opinion of many its greatest drawback. In clearness and minuteness of directions it is hardly equalled by any manual of qualitative analysis, and thus it is a particularly easy book for the instructor to use, especially with a large class. But this, on the other hand, cannot fail to encourage mere mechanical work on the part of the student and to discourage independence. With large classes, however, it is a difficult problem how best to cultivate individuality of work.

A LITTLE manual of 'Analysis of White Paints,' by G. H. Ellis, will prove of value to chemists to whom now and then paint samples are brought for analysis. It is a collection of notes by a chemist who has had much experience along this line.

In the field of applied chemistry quite a number of books have come out lately, the most useful of which is probably the seventh volume of 'The Mineral Industry.' The field of mineral resources and industries of the world is very thoroughly surveyed, and the volume is brought as closely down to date as possible. In this respect it has a great advantage over the corresponding publication of the United States Government. Among the subjects which are treated very thoroughly in the present volume are calcium carbid, fire brick and paving brick, coal mining methods and their economic bearing, progress in the metallurgy of copper and of gold, notes on the progress of iron and steel metallurgy (by Henry M. Howe), sulfuric acid, progress in ore dressing (by Robert H. Richards). It is a book necessary to the teacher, of great value to the economist and of much interest to the general reader. The second edition of McMillan's 'Electro-metallurgy' is a considerable improvement on the former edition, and is brought well down to date. The greater part of the book is devoted to the electro-deposition of metals, and is thorough and satisfactory. It is, however, unfortunate that the treatment of electro-metallurgical ore-extraction should be very inadequate, this whole subject, together with electro-refining, being confined to a single chapter of thirty pages.

Lange's 'Chemische-technische Untersuchungsmethoden' is passing through its fourth edition, of which the second volume is just out. This treats of metals and metallic salts, fertilizers, fodders, explosives, matches, gas manufacture, ammonia and coal tar and inorganic colors. The book aims at exhaustive treatment, and while some subjects are in parts weak, as is naturally the case where there are many different authors, it is as a whole the best work in its field.

A book in a new line is H. and H. Ingle's Chemistry of Fire and Fire Prevention' (Spon and Chamberlain). The book takes its origin from lectures delivered to an audience of insurance men. After three chapters on the history and theory of combustion, various industries more or less connected with fire are taken up; coal gas, dust explosions, fuel, illuminants, explosives, oils, volatile solvents, paints and varnish making, textile manufactures, spontaneous combustion, are some of the subjects treated. The last chapter is a quite useful one on fire prevention and extinction. The book contains much useful information and should prove of very considerable value outside of the rather limited audience to which it is addressed.

ZOOLOGY.

The past few months have witnessed the publication of many important works on zoölogical subjects, and among these it may not be amiss to note first Kingsley's 'Text-Book of Vertebrate Zoölogy,' since it adopts a new method, that of showing the bearing of embryology upon the morphology of vertebrates, and in turn, of morphology upon their classification. Its object is stated to be to "supplement both lectures and laboratory work, and to place in concise form the more important facts and generalizations concerning the vertebrates," and the author has succeeded in crowding a large amount of information into the 439 pages of the work. The illustrations are numerous, and for the most part very good, comprising some figures that have appeared in other text-books and some that are the outcome of Dr. Kingsley's own work. It is to be noted that in place of many of the standard European forms that have done morphological duty for years, we have such American types as Acanthias, Necturus, Amblystoma and Sceloporus, a change for which we are duly grateful.

Parker and Haswell's admirable 'Manual of Zoölogy' has been revised and adapted for the use of American schools and colleges. It aims to give an outline of the structure and morphology of certain typical members of the various classes of animals and also briefly discusses such zoölogical questions as evolution, descent and distribution. An 'Elementary Course of Practical Zoölogy,' by T. J. Parker and W. N. Parker, has been issued somewhat on the lines of Huxley and Martin's 'Biology,' aiming to give a rather detailed account of the structure of a few types instead of glancing at the animal kingdom as a whole.

Books on birds, and especially those devoted to the popularizing of ornithology, continue to be numerous, and among them may be mentioned Keeler's 'Bird Notes Afield,' which introduces us in a pleasant way to the better-known birds of California, a subject of which Mr. Keeler is well qualified to treat. Less attractive from a literary standpoint, but more important from a practical point of view, is Lange's 'Our Native Birds: How to Protect Them and Attract Them to Our Homes,' which discusses the various causes for the decrease of birds, and suggests methods by which this may be prevented. Of a totally different character is Shelley's 'Birds of Africa,' now in process of publication, the first part of Vol. II having recently appeared. While many undescribed forms may be expected from Africa in the future, this work brings the subject down to date. 'The Birds of South Africa' are described in one compact volume by Arthur C. Stark, and the Australian Museum is now issuing a new edition of 'A Catalogue of Nests and Eggs of the Birds of Australia,' by Alfred J. North, the original having long been out of print. It is to be hoped that the first volume of the new hand-list of birds, 'Nomenclator Avium tum fossilium tum viventium,' by R. Bowdler Sharpe, which was published last fall, may soon be followed by others, as the completed list will be a boon to all working ornithologists. Finally, it may not be known to all our readers that last year Newton's 'Dictionary of Birds' was issued in one volume at a reduced price.

The second and final part of 'Insects,' of the Cambridge Natural History, by David Sharp, gives us one of the most important, if not *the* most important work on entomology that has appeared for a long time, the two volumes forming a condensed encyclopædia of entomology that will be needed by all working entomologists. Another useful work on entomology is Carpenter's 'Insects, Their Structure and Life,' that portion devoted to the 'life' of insects being the best, particularly the chapter on 'Insects and Their Surroundings.' Of a strictly popular nature is Scudder's 'Every-day Butterflies,' which deals in a charming way with some sixty species of eastern North America.

BOTANY.

The beginning of the year has been marked by the appearance of the usual number of elementary and popular books dealing with some phase of botany. Among these Professor Barnes's 'Outline of Plant Life' (H. Holt & Co.) is a simplified edition of a high school text of a year earlier. Only the gross anatomy of the plant is considered and the ordinary routine of beginning with the simpler forms and advancing to ones of successively more complex structure is followed, and the principles of reproduction and physiology are presented. The student is given an insight into the adaptive processes of the plant by a study of the special forms which live in the water, dry soil, deserts, and other special conditions.

'Lessons in Botany,' by Professor Atkinson (H. Holt & Co.) is a similar edition of a high school text designed to meet the needs of students in half-year courses. The student is led to an interest in the plant by a consideration of seedlings and buds, then launched in a course dealing with types of varying morphological constitution with attention to physiology and morphology. The taxonomy of some of the more important families of seed plants is discussed in a special section. The author pays tribute to the present leaning toward ecology by chapters on seed distribution, the struggle for the occupancy of land, zonal distribution, soil formation in rocky regions and moors, plant communities, and adaptations of plants to climate.

In 'Nature and Work of Plants' (Macmillan) Dr. MacDougal approaches the subject of botany by a study of the functions of the plant, of the things which it must do to live and adapt itself to its surroundings. Such an introduction to the subject from the physiological point of view is a radical innovation in the matter of elementary texts. A second departure from the practice of current texts is the omission of illustrations, in order that the attention of the student may not be distracted from the plant at work by a picture of something it has done. The technique is simple and the book seems well-fitted to awaken enthusiastic interest and lead the student further into the subject. Chapters are devoted to such subjects as: composition and purposes of plants, the manner in which the different kinds of work are divided among the members of the body, the way in which new plants arise, and the relations of plants to each other.

Miss Alice Lounsberry's 'Guide to the Trees' (Stokes & Co.) is an example of a type of popular books in botany indispensable to the amateur, and of great value to the working botanist. Nearly two hundred species, including shrubs, have been described. "Among them are all those most prominent in northeastern America, and a few distinctive or rare species from the South and West. Several also that are not indigenous but which have become identified with the tree life of this country are presented." The author has grouped forms of similar habit together in such manner that sections are devoted to: Trees preferring to grow in moist soil, lowlands and meadows; trees preferring to grow near water, in swamps, and running streams; trees preferring to grow in rich soil, in forests and thickets, and trees preferring to grow in light, dry soil and upland places. The general notes of information appended to the technical descriptions add much to the reading value of the book, which is beautifully illustrated by sixty-four colored plates, after paintings by Mrs. Rowan, and a hundred sketches in black and white.

The amount of interest centered in the preservation of the forests of the national domain, and the establishment of forestry in the courses of several educational institutions, makes Mr. Bruncken's 'North American Forests and Forestry' (Putnam & Sons) most timely. The author discusses the sociological aspects of forestry, and the distribution of forests in North America. It is of interest to note that the forest is treated as a living plant formation subject to many vicissitudes in the struggle for existence with neighboring societies of plants, particularly with the bog and prairie. The fate of the forest in front of the advancing pioneer is well delineated, and forest finance management and protection are most sensibly considered. Perhaps no other work offers the citizen such a rational presentation of all aspects of the numerous questions involved in forestry as the one under discussion.

Sachs's 'Physiology of Plants' has long been a classic among botanists because of the immense amount of new results which were brought out in its pages, marking the dawn of a new epoch in the history of botanical investigation. A large share of its conclusions have become invalidated by the general advance of the subject, however, and the next most notable work, Pfeffer's 'Plant Physiology,' is one which is bound to exert even a more lasting influence in the guidance and furtherance of research. The first volume issued, dealing with the metabolism and sources of energy in plants, is cyclopedic in its completeness of review of investigations in this phase of the physiology without cumbering its bibliographical lists with titles of unimportant papers. In general, subjects yet under controversy are set forth with judicial fairness, and the author has made himself familiar with the work of Russian, English and American botanists in a manner not practiced by some of his contemporaries. The translation of this work by Dr. Ewart (Clarendon Press) has given opportunity for the correction of any slight omissions in the bibliography, and the completed book must be regarded as of the greatest value not only to the botanist but to the animal physiologist who would cover the domain of that illusive subject known as "general physiology."

ANTHROPOLOGY.

Probably the most striking sign of the increasing interest in the study of primitive man is the organization of well-equipped expeditions for the investigation of prehistoric remains and particular groups of existing savages. Of the latter class, the Cambridge expedition to Torres Straits, under the leadership of Professor A. C. Haddon, has returned to England, and various preliminary reports of the results of its work have already appeared. A new departure in the scheme of work of this expedition was the introduction of psychological observations under experimental conditions among the natives. The tests which were made were necessarily simple, but covered a fairly wide field. They included tests of visual acuteness, color vision and color blindness, acuteness and range of hearing, appreciation of tones and differences of rhythm, tactile acuteness and localization, estimation of weights, simple reaction-times to visual and auditory stimuli, estimation of intervals of time, memory and a number of tests of a more general character.

The detailed results have not yet appeared, but it is evident that there is much of interest to be expected. For example, of about two hundred and fifty individuals of different tribes tested for color blindness, not a case was found, except on one island, where three out of eight subjects suffered from ordinary red-green blindness. Reaction-times are said to be shorter than among the uneducated classes of European peoples, but no figures have as yet appeared. A fact, important if true, is the reported lack of suggestibility among the natives of the region. This is directly opposed to the general observations of most ethnographers and seems hardly probable. On all points the detailed reports are needed.

On this side of the world public attention has been called particularly to the admirable plans of the Jesup North Pacific Expedition, which has been at work for the past three years on the northwest coast of America and the opposite coast of Asia. During the year just past the first published accounts of its results have begun to appear in a series of handsome monographs from the American Museum of Natural History in New York. Professor Franz Boas, the director of the expedition, furnishes the first two memoirs, one on 'Facial Paintings of the Indians of British Columbia' and the other on the 'Mythology of the Bella Coola Indians.' The first named is of importance because of its bearing on the evolution of decorative designs. The Indians of the northwest coast differ from most other primitive groups in the matter of decoration by their failure to develop geometric designs and their tendency to retain realistic portrayals with certain characteristic modifications. In the adaptation of the decorations to the human face the problem has been difficult and a large number of examples are given showing the method of solution. The memoir on Bella Coola mythology is the first account of the complex conceptions of these Indians which can lay any claim to completeness. The Bella Coola conception of the universe is interesting. They believe in five worlds, one above the other, of which the middle one is the earth. Above this are spanned two heavens and beneath, two underworlds. In the upper heaven resides the supreme deity, who interferes little with the affairs of men; in the lower heaven dwell the Sun and all the other deities who are more intimately connected with mankind. The first underworld is inhabited by ghosts who may rise to the first heaven and be sent again to earth, and in the second underworld dwell the ghosts of those who have died a second death; from this there is no return. Other memoirs in the series are 'The Archæology of Lytton, B. C.,' by Harlan I. Smith, descriptive of the work of the expedition in that line; 'The Thompson Indians of British Columbia,' by James Teit, which is an exhaustive ethnographical account of that tribe, and 'The Basketry Designs of the Salish Indians,' by Livingston Farrand, in which is shown the development of geometric designs from realistic forms among the Indians of the Salish stock, a development which contrasts sharply with that of the neighboring stocks described by Boas.

With the results of field-work pouring in and the constant modifications of theory brought about thereby, it becomes a task practically impossible to write a general 'Anthropology' which will not be out-of-date before it issues from the press. Nevertheless, from time to time the attempt is made and one of the latest ventures is 'Man, Past and Present,' by Mr. A. H. Keane (University Press, Cambridge). It is a general classification and description of the races of man which is open to the same objections as to validity of classification as can be offered to any work on the subject at the present stage of knowledge. At the same time it contains much information in compact form, is not technical and will doubtless be useful. Of similar scope is 'The Races of Man,' by J. Deniker, which has just appeared in English form (Scribner's Contemp. Sci. Series). This work, also compact, is somewhat more technical than Keane's and also more accurate. It contains an appendix with brief tables of measurements and indices adapted for quick reference.

Of more special studies, unquestionably the most important work of the year is Messrs. Spencer and Gillen's 'The Native Tribes of Central Australia' (Macmillan). This extraordinarily minute account of the customs of the tribes with which it deals has already begun to attract the attention which it deserves. The problems upon which it throws light are numerous, but probably that of most general interest is Totemism, with its many social and religious bearings. The origin of this well-known savage custom has been a puzzle and heretofore not even a plausible suggestion has been made toward its solution. Messrs. Spencer and Gillen's account of the totemic ceremonies of the Arunta tribe, however, points irresistibly toward a definite economic origin, an attempt to preserve and increase the totemic animals and objects for the good of the tribe. The underlying relation between the clansman and his totem, as well as the social relations between the members of a clan, with the rules regarding marriage and the resultant modification of the family organization, are all analyzed with quite exceptional skill and in this and other fields the book is destined to become a classic.

THE PROGRESS OF SCIENCE.

Dr. Wolcott Gibbs presented his resignation from the presidency of the National Academy of Sciences at the recent Washington meeting, and the occasion permits the publication of his portrait and a few words in reference to his great contributions to science. Born in New York City in 1822, Dr. Gibbs graduated from Columbia College fifty-nine years ago. He studied abroad under Liebig, the founder of the first chemical laboratory, occupied a chair in the College of the City of New York, and was for twenty-four years Rumford professor at Harvard University. He became professor emeritus in 1887, and established a private laboratory at Newport, where he has continued his researches. Dr. Gibbs is one of the great chemists of the world. He is the only American honorary member of the German Chemical Society. Among other important ideas, his suggestion that the electrolytic deposition of copper be used as a means of quantitative analysis is one which has grown to a remarkable extent. There are now a number of volumes devoted solely to the amplification of this idea, which has been applied to numerous substances. Many other methods of quantitative analysis have been improved and simplified under his guidance, but perhaps his greatest work is his extended experimental study of complex salts, especially the cobaltamine compounds, and a great number of singularly complicated bodies, containing some of the rarer elements. Most of these substances are of no practical value, but they are of great theoretical interest, because they are only partially explained by the present theories of molecular structure. While the resignation of Dr. Gibbs from the presidency of the Academy is doubly regretted because it is owing to the fact that his health no longer permits the strain of the office, chemical science will profit all the more from his exclusive devotion to research.

The meetings of the National Academy of Sciences held annually at Washington during the third week of April, pass without the general attention that they deserve. For the Academy meets not only to listen to special scientific papers, but also as the official scientific adviser of the Government. As knowledge increases in range and exactness, it is evident that expert advice becomes more and more necessary, both for the enactment of legislation and for carrying it into effect. It may, indeed, be fairly claimed that the advisory or expert department of the Government should rank coördinate with its legislative, executive and judicial branches. The National Academy has on occasion been called to investigate scientific questions—thus it has recently presented a report to the Department of the Interior on a policy for the forested lands of the United States—but it has been of less service in this direction than was intended by the act of incorporation or than sound policy dictates. This limitation to the usefulness of the Academy seems to depend in part on the small membership, and the fact that it consists of the most eminent rather than the most efficient men of science of the country. The Academy has less than one hundred members, only one fourth as many as the Royal Society. Professor Jastrow shows in the present number of this journal that men of science do not become eminent until rather late in life, and the members of the Academy are apt to be somewhat lacking in initiative. University professors are now selected chiefly from younger men of promise, who are expected not only to attain scientific eminence, but also to possess executive ability and to exert personal influence. The National Academy needs a membership of this character, and has fortunately to some extent obtained it within recent years. Thus the members elected at the present meeting are Prof. James E. Keeler, director of the Lick Observatory; Prof. Franz Boas, of Columbia University and the American Museum Natural History; Prof. Henry F. Osborn, also of Columbia University and the American Museum, and Prof. Samuel L. Penfield, of Yale University.

There is perhaps no objection to regarding the National Academy of Sciences as a *quasi* hereditary upper house, whose functions are largely conservative, while the active duties on behalf of science devolve on a more democratic body—The American Association for the Advancement of Science. This association meets at Columbia University, New York City, during the last week of the present month, and with it some fifteen special societies devoted to different sciences. The association celebrated its fiftieth anniversary in Boston two years ago, when about half of its nearly two thousand members were present, and there is every reason to hope that the New York meeting will be as largely attended. The members will be welcomed by Governor Roosevelt and President Low, and after listening to addresses by the vice-presidents, will divide into nine sections, before which special papers will be presented. The address of the retiring president, Mr. G. K. Gilbert, of the United States Geological Survey, will be given at the American Museum of Natural History on Tuesday evening, while the president, Prof. R. S. Woodward, of Columbia University, will preside at the general sessions. The American Association has during its long history performed a useful service in bringing men of science together and in attracting the attention of the general public to scientific work, but in some respects it has been less influential than its sister associations in Great Britain, Germany and France. This has been in some measure due to the large area of the country and the heat of the summer, making it difficult for men of science to come together, but it probably represents chiefly a certain lack of organization of science in America. With the growth of university centers and of scientific work under the Government, the number of men of science has greatly increased, while with the establishment of special societies and journals their means of intercommunication have improved. There is every reason for the support of an association which can represent the whole body of scientific men and forward the scientific movements that are of such importance to the country. The membership of the association is of two classes, fellows and members. The former are selected from those who are actively engaged in advancing science, while all those who are interested in science are eligible for membership. Those who would like to have their names proposed for membership may address the local secretary of the New York meeting, Prof. J. McKeen Cattell, Columbia University, or the permanent secretary, Dr. L. O. Howard, Department of Agriculture, Washington, D. C.

A very ambitious project is on the stocks for the foundation of an 'International Association for the Advancement of Science, Arts and Education.' It will be remembered that there was last year an interchange of visits between the British Association meeting at Dover and the French Association meeting at Boulogne. Arrangements were then made resulting in the appointment of general committees for Great Britain and France, and it was decided to hold an international assembly at Paris during the Exposition. Prof. Patrick Geddes, secretary of the British Group, has since visited the United States, and a general committee has been formed with Dr. W. T. Harris, United States Commissioner of Education, and Prof. R. S. Woodward, president-elect of the American Association, as vice-presidents. M. Bourgeois, late French Minister of Education, is the general president, and M. Gréard, rector of the University of Paris, is president of the French Group. The plans for the Assembly this summer are based directly on the Paris Exposition. It is proposed to establish headquarters on the grounds of the Exposition, in the buildings of the University of Paris and at other places, where those interested in the scientific aspects of the Exposition and in the scientific and educational congresses may meet and receive information and guidance. Special visits to the Exposition and other excursions, special lectures and entertainments, special summaries of the work of the congresses, etc., are promised. The Association is not, however, limited to the Paris Exposition, but proposes a permanent organization for the holding of assemblies and the organization of relations between men of science of different nations. Those interested in the Paris Assembly may secure further information from Mr. Ely, secretary of the American Group, 23 East Forty-fourth street, New York City.

The Government of the United States does more to develop the resources of the country and advance science than any other nation. On these objects the sum of over $8,000,000 is spent annually and over 5,000 officers are employed. Yet in one direction it has fallen far behind the great European nations. Our Department of Agriculture, our Geological Survey and many other agencies surpass in range and efficiency the similar institutions eleswhere, but the applications of physics and chemistry to the arts have not enjoyed equal advantages. The Physikalische - Technische Reichsanstalt, the national physical laboratory of the German Empire, established under the direction of von Helmholtz, is conducted at an annual cost of $80,000, and there is in addition a German bureau of weights and measures on which the sum of $36,000 is annually expended. For similar purposes Great Britain spends annually $62,000, Austria, $46,000, and Russia, $17,500, whereas, our office of Standard Weights and Measures receives the meager appropriation of $10,400. We are very glad to learn that the Secretary of the Treasury has submitted an amendment to the pending sundry civil bill, creating in place of the present office a National Standardizing Bureau. According to the amendment the functions of the bureau shall consist in the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce and educational institutions with the standards adopted or recognized by the Government; the construction when necessary of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; the determination of physical constants and the properties of materials when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere. Provision is also made for the erection of a laboratory and its equipment, and for the employment of an adequate staff, with a director, whose salary shall be $6,000 per annum.

It is satisfactory that the Secretary of the Treasury should recommend a reasonable salary for the director of the proposed bureau. Men of science are, as a rule, but poorly paid, and the officers in the scientific departments of the Government receive in many cases salaries that are a small part of what they could earn as physicians or lawyers. There is, of course, danger that if salaries are large, the offices will be sought by 'practical' politicians, and it is probably the part of wisdom to offer the best facilities for research rather than large salaries. Still, if the scientific man has the salary of a clerk, he will be ranked in the same class by legislators and executive officers. The small salaries offered at Washington also lead to the continual loss of those whose services are of the greatest value to the Government. Thus, the recent call to the presidency of the Massachusetts Institute of Technology of Dr. Henry S. Pritchett, Superintendent of the United States Coast and Geodetic Survey, is a serious blow to the bureau and to science at Washington. Dr. Pritchett's scientific attainments and executive ability will find ample scope at the Massachusetts Institute of Technology, where he worthily succeeds Presidents Rogers, Runkle, Walker and Crafts. But he was also greatly needed in the Coast and Geodetic Survey, where, after the excellent administration of Dr. T. C. Mendenhall, there had been an unfortunate interregnum of three years. During the past three years, however, the work of the Survey has been placed on an excellent basis by Dr. Pritchett, and there is every reason to believe that the ground gained will not be lost.

The transition of Dr. Pritchett from the professorship of mathematics and astronomy in Washington University to the superintendency of the United States Coast and Geodetic Survey and now to the presidency of the Massachusetts Institute, calls attention to the fact that the only promotion possible to men of science or university professors is an executive position. The type of the German *Gelehrte*, still current in literature and on the stage, is not common in America. The modern methods of advancing science—the laboratory, the observatory, the museum, the expedition, with their complex equipment—demand administrative ability of a high order. Science has been able to supply presidents, not only to the great technical schools, but also to Harvard, Johns Hopkins, Stanford and other universities. Still, it is unfortunate that the man of science can not look forward to promotion in the direction of his own work. He becomes a college professor or the like at a comparatively early age with a moderate salary. He has now as a motive the increase of his reputation, rather likely to degenerate into vanity, and the nobler motive of contributing to the advance of science and of civilization. But these motives appeal differently to different men—in any case, they bake no bread and educate no children. The average salary of scientific men can not be greatly increased; there must be a certain relation between supply and demand, and the average earnings of other professional men are also small. But the lawyer may look forward to becoming a judge, the physician to a large city practice, the clergyman to a bishopric, etc. In Germany a university professor may look forward to being called to Berlin, to becoming a *Hofrat*, a *Geheimrat* and a 'von.' It seems that we need in each American university one or two chairs with very large endowments, the occupation of which would be a special honor.

The French Academy of Sciences and French Science have lost two of their most distinguished representatives in the deaths of Joseph Bertrand and of Alphonse Milne-Edwards. Bertrand was born in 1823, and was somewhat of a prodigy when a boy, having published a paper on the theory of electricity when but sixteen years old, and being the author of numerous mathematical papers before he was twenty-one. His original contributions to mathematics and mathematical physics are of great importance, and he was the author of standard works on algebra, on arithmetic and on the calculus. As permanent secretary of the Paris Academy of Sciences he was continually engaged in administrative work, preparing obituary notices, acting as judge in the annual awards of its prizes, etc. He also contributed a large number of biographies and other articles to non-technical journals. Milne-Edwards, born in 1835, was a son of the eminent zoölogist, Henri Milne-Edwards, and the grandson of Bryan Edwards, the historian and member of the British Parliament. Milne-Edwards published important researches in paleontology and in zoölogy, especially in relation to birds, and was at the time of his death professor of zoölogy at Paris and director of the Jardin des Plantes.

In the deaths of the Duke of Argyll and Prof. St. George Mivart, Great Britain loses two men of a type more common there than in the United States, Argyll was a man of great wealth, whose interests in science were only secondary, but who did much directly and indirectly for its advancement. His work, 'The Reign of Law,' published some twenty-five years ago, has been widely read, and he is the author of many books and articles concerned with the natural sciences. Mivart, although trained as a barrister, became perhaps a professional man of science, but he never occupied a regular university position. He published numerous contributions to comparative anatomy and zoölogy, but is perhaps best known for books and articles on general scientific subjects. Just before his death, it will be remembered, he was excommunicated from the Roman Catholic Church owing to articles which were supposed not to be in conformity with its tenets. Both Argyll and Mivart represented an attitude towards the doctrine of evolution which may be regarded as now practically extinct.

Two lectures have been recently delivered by Prof. James Dewar at the Royal Institution on the subject of liquid and solid hydrogen. These lectures have been illustrated by experiments and have attracted the attention of the most distinguished chemists and physicists of England. It is easy to understand such interest in the subject when we consider that even Clerk Maxwell thought it improbable that hydrogen would ever be liquified, and yet Dewar was able to exhibit not only liquid, but solid, hydrogen to his audience. Briefly recapitulated, the steps in the condensation of what were formerly called the permanent gases are these: in 1878 Cailletet, in Paris, and Pictet, at Geneva, by suddenly expanding gases which had been compressed to a high degree and cooled to a low temperature, succeeded in obtaining these gases in the shape of a mist or of a transitory liquid jet. In 1884 Wroblewski and Olszewski at Crakow obtained oxygen and nitrogen as static liquids. By expanding hydrogen from a compression of 190 atmospheres in a vessel cooled by liquid air evaporating under diminished pressure, this gas was obtained as a mist or momentary froth, though it was affirmed by Olszewski that he observed the liquid hydrogen in colorless drops and as a liquid running down the sides of the tube. In May, 1898, Dewar obtained hydrogen as a static liquid by allowing compressed hydrogen, cooled in a bath of boiling air, to escape rapidly at a jet, the liquid hydrogen being collected in a doubly isolated vacuum vessel. This liquid hydrogen is a colorless liquid, with a specific gravity of 0.07 or less than one sixth the weight of liquid marsh gas, the lightest liquid hitherto known. This is better realized by saying that while one gram of water has the volume of one cubic centimeter, one gram of liquid hydrogen has a volume of over 14 c. c. The boiling point of hydrogen is — 252° C. or 21° above the absolute zero, and by boiling in a vacuum the temperature of 15° can be obtained. Very recently by slowly evaporating, very perfectly isolated liquid hydrogen, solid hydrogen was obtained by Dewar as a white mass of solidified form, of the lowest temperature ever obtained, — 258° C.

Among the most suggestive results obtained through recent work in experimental embryology are those of Prof. Jacques Loeb, of the University of Chicago, on the chemical fertilization of the eggs of sea-urchins without participation of the male element. There has for some time been reason to suspect that cell-division, both in tissue cells and in the egg, is incited by chemical stimulus; and several observers before Loeb had shown that when unfertilized sea-urchin eggs are treated by the addition to the sea-water of various substances, such as strychnine or chlorides of sodium or magnesium, they may undergo some of the preliminary changes of development and may even segment. Loeb was able to induce complete and normal development by first bringing the eggs for about two hours into a mixture of sea-water and a weak solution of magnesium chloride, and then transferring them to normal sea-water. Eggs thus treated segmented and underwent a development which, though somewhat slower than usual, was otherwise normal and produced perfect larvæ. This effect can not properly be called fertilization in the ordinary sense of the word, but is rather to be regarded as artificially induced parthenogenesis. It points unmistakably, however, to the possibility, or rather probability, that in normal fertilization the spermatozoon incites the egg to development by bringing to it certain definite chemical substances; and Loeb gives reasons for the view that these substances are probably in the form of ions, concluding that these and not the nucleins are essential to the process of fertilization. A highly suggestive new field for work is opened by these experiments.

Astronomers can not bring the phenomena they study into the laboratory or test the behavior of the heavenly bodies under artificial conditions. They have to be satisfied with such opportunities as nature gives, even though she bestows them as meagerly as she does solar eclipses. Consequently, the total eclipse of the forenoon of May 28th has been the object of much preparation. Most of the important astronomical observatories in this country will have parties stationed along the path of the eclipse from New Orleans to Norfolk, Va. Many European parties will observe the eclipse in Portugal, Spain and North Africa. It has been pointed out by Prof. R. W. Wood and Mr. A. L. Rotch* that there are several important physical observations to be made apart from the astronomical observations on the sun's corona described by Professor Bigelow, in the May number of this magazine. Just before and after totality alternate bright and dark bands are observed sweeping across the country. It is hoped that by the coöperation of a number of observers more complete and exact data concerning this phenomena may be gathered and its explanation found. The changes in the wind noted during eclipses will also be observed to ascertain whether the sudden cooling of the atmosphere by the passage of the moon's shadow is a sufficient explanation of the so-called 'eclipse wind.' Those who know nothing about theories of the corona or of the 'eclipse wind' will be interested in the more obvious phenomena and in some cases, in the opportunity to take such a photograph as can not be duplicated in this country until 1918. The most favored ones are those who live in the fifty-mile belt of the total eclipse, but the sun will be seen nine tenths covered in the eastern and southern States, and will be six tenths covered to those in the least favorable locality of the United States, the extreme northwest. The proper methods of observing and photographing the corona were described in Professor Bigelow's article on the eclipse in the May number of the Popular Science Monthly.

* In 'Science,' Apr. 27th and May 11th.

PRESIDENT G. K. GILBERT,

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

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CHAPTERS ON THE STARS.

By Professor SIMON NEWCOMB.

I. Introductory.

IT would be difficult to name any subject of investigation, the progress of which during our time has been more remarkable than that in the field of stellar astronomy. Several features of this progress are especially noteworthy. One of these is the mere extension of research. A natural result of the northern hemisphere being the home of civilized peoples was that, thirty years ago, the study of the southern heavens had been comparatively neglected. It is true that the curiosity of the inquiring astronomers of the past would not be satisfied without their knowing something of what was to be seen south of the equator. Various enterprises and establishments had therefore contributed to our knowledge of the region in question. As far back as 1667, during a voyage to St. Helena, Halley catalogued the brighter stars in the region near the South Pole. About 1750 Lacaille, of France, established an observing station at the Cape of Good Hope, and made a catalogue of several thousand stars which has remained a handy book for the astronomer up to the present time. In 1834-38 Sir John Herschel made a special voyage to the Cape of Good Hope, armed with the best telescopes which the genius of his father had shown him how to construct, for the purpose of doing for the southern heavens as much as possible of what his father had done for the northern. The work of this expedition forms one of the most important and interesting chapters in the history of astronomic science. Not only is Herschel's magnificent volume a classic of astronomy, but the observations which it contains are still as carefully and profitably studied as any that have since been made. They may be said to form the basis of our present knowledge of the region which they included in their scope.

Herschel's work may be described as principally in the nature of an exploration. He had no instruments for accurately determining the positions of stars. In the latter field the first important contributions after Lacaille were made by Sir Thomas Brisbane, Governor of New South Wales, and Rumker, his assistant, at Paramata. Johnson, of England, about 1830, introduced modern accuracy into the construction of a rather limited catalogue of stars which he observed at St. Helena. About the same time the British Government established the observatory at the Cape of Good Hope, which has maintained its activity to the present time, though, at first, its means were extremely limited. About the middle of the century the Government of New South Wales established, first at Williamstown and then at Melbourne, an observatory which has worked in the same field with marked success.

An American enterprise in the same direction was that of Captain James M. Gilliss, who, in 1849, organized an astronomical expedition to Chili. The principal motive of this enterprise was the determining of the solar parallax by observations upon Venus and Mars near the time of their nearest approach to the earth. As these observations would take but a small part of his time, Gilliss determined to take with him instruments for determining the positions of the stars. He established his observatory at a point near Santiago, where he continued his observations for nearly three years. He was a practical observer, but an untoward circumstance detracted from the value of his work. His observatory was built upon a rocky eminence, a foundation which seemed to afford the best possible guarantee of the stability of his instruments. He made no attempt to reduce his observations till after his return home. Then it was found that the foundation, through the expansion and contraction due to the heat of the sun, was subject to a diurnal change which made it extremely difficult to derive good results from his careful work. It was not until 1896, more than thirty years after his death, that the catalogue of the stars observed by him was at last completed and published.

We do not derogate in any way from the merit of these efforts in saying that they could not lead to results comparable with those of the score of richly equipped northern observatories which the leading nations and universities of Europe had endowed and supported for more than a hundred years. Only within the last thirty years has it been possible to bring our knowledge of the southern heavens up to a satisfactory stage. Now, however, the progress of southern astronomy, if we may use the term, is such that in several points our knowledge of the southern heavens surpasses that of the northern ones. If we measure institutions by the importance of the work they are doing, there are several in the southern hemisphere which must to-day be placed in the first rank.

The history and work of the Cordova Observatory are of special interest. In 1870 Dr. B. A. Gould, who might fairly be considered as the father of modern American astronomy, conceived the idea of establishing an observatory of the first class in South America. He found the President and Governor of the Argentine Republic ready to support his scheme with a liberality well fitted to impress us with a high sense of their standard of civilization. In a year or two the observatory at Cordova was in active operation. A statement of its work belongs to a subsequent chapter. Suffice it to remark here that Dr. Gould continued in active charge until 1885, when he returned home, and was succeeded by Thome, the present director.

A few years after Gould went to Cordova, Gill was made director of the Royal Observatory at the Cape of Good Hope. The rapid growth of this institution to one of the first rank is due no less to the scientific ability of the new director than to the unflagging energy which he has devoted to the enlargement of the resources of the institution. The great fact which he sought to impress upon his supporters was that the southern celestial hemisphere was as large as the northern, and therefore equally worthy of study.

In any general review of the progress of stellar astronomy during the past twenty years, we should find Harvard University before us at every turn. What it has done will be seen, perhaps in an imperfect way, in subsequent chapters. Not satisfied with the northern hemisphere, it has established a branch at Arequipa, Peru, in which its methods of observation and research are extended to the south celestial pole. Its principal specialties have been the continuous exploration of the heavens. Celestial photography, photometry and spectroscopy sum up its fields of activity. For more than ten years it might be almost said that a sleepless watch of the heavens has been kept up by an all-seeing photographic eye, with an accuracy of which the world has hardly had a conception. The completeness with which its work has been done has recently been shown in a striking way. Our readers are doubtless acquainted with the singular character of the minor planet Eros, whose orbit passes through that of Mars, as one link of a chain passes through another, and which comes nearer the earth at certain times than any other celestial body, the moon excepted. When the character of the orbit became established, it was of interest to know whether the planet had ever been observed as a fixed star at former oppositions. Chandler, having computed the path of the planet at the most important of the oppositions, beginning with 1892-94, communicated his results to Director Pickering, and suggested a search of the Harvard photographs to see if the planet could be found on them. The result was the discovery of the planet upon more than a score of plates taken at various times during the preceding ten years. New stars were formerly supposed to be of very rare occurrence, but since the Harvard system of photographing the heavens has been introduced, no less than three have been known to break out.

The great revelations of our times have come through the application of the spectroscope to the measurement of motions in the line of sight from us to a star. No achievement of the intellect of man would have seemed farther without the range of possibility to the thinker of half a century ago, than the discoveries of invisible bodies which are now being made with this instrument. The revelations of the telescope take us by surprise. But, if we consider what the thinker alluded to might regard as attainable, they are far surpassed by those of the spectroscope. The dark bodies, planets, we may call them, which are revolving round the stars, must be forever invisible in any telescope that it would be possible to construct. They would remain invisible if the power of the instrument were increased ten thousand times. And yet, if there are inhabitants on these planets, our astronomers could tell them more of the motions of the world on which they live than the human race knew of the motions of the earth before the time of Copernicus.

The men and institutions which have contributed to this result are so few in number that it will not be tedious to mention at least the principal actors. The possibility of measuring the motions of the stars in the line of sight by means of the spectroscope was first pointed out by Mr. now Sir William Huggins. He actually put the method into operation. As soon as its feasibility was demonstrated it was taken up at Greenwich. In these earlier attempts, eye methods alone were used, and the results were not always reliable. Then spectrum photography was applied at the astrophysical observatory at Potsdam by Vogel. Thence the photographic method soon spread to Meudon and Pulkova. But, as often happens when new fields of research are opened, we find them ablaze in quarters where we should least expect. The successful application of the method requires not only the best spectroscope, but the most powerful telescope at command. Ten years ago the most powerful telescope in the world was at the Lick Observatory. Mr. D. O. Mills put at its eye end the best spectograph that human art could make at that time, the work of Brashear. It is Campbell, who, with this instrument, has inaugurated a series of discoveries in the line in question which are without a parallel.

A mere survey of what has been done in the various lines we have mentioned would be far from giving an idea of the real significance of the advance we are considering. Cataloguing the stars, estimating their magnitudes, recording and comparing their spectra and determining their motions, might be considered as, after all, barren of results of the highest human interest. When we know the exact position of every star in the heavens, the direction in which it is moving and the character of its spectral lines, how much wiser are we?

What could hardly have been foreseen fifty years ago, is that these various classes of results are now made to combine and converge upon the greatest problem which the mind of man has ever attempted to grasp—that of the structure of the universe. The study of variable stars has suddenly fallen into line, so to speak, so that now, it is uniting itself to the study of all the other subjects to give us at least a faint conception of what the solution of this problem may be.

One of the principal objects of the present chapter is to make a comparison of these various researches, and discuss the views respecting the constitution of the stars individually, as well as of the universe as a whole, to which they lead us. But there are a number of details to be considered singly before we can combine results in this way. Our early chapters will therefore be devoted to the special features and individual problems of stellar astronomy which have occupied the minds of astronomers from the beginning of their work to the present time. Keeping these details in mind, we can profitably proceed to the consideration of the general conclusions to be drawn from them.

We may begin by refreshing our memories on some points, an understanding of which must be taken for granted. What are familiarly known as the heavenly bodies belong to two classes. Those nearest to us form a sort of colony far removed from all the others, called the solar system. The principal bodies of this system are the sun and eight great planets with their moons, revolving round it. On one of the planets, small when compared with the great bodies of the universe, but large to our every-day conceptions, we dwell. The other planets appear to us as stars. Four of them, Venus, Mars, Jupiter and Saturn, are distinguished from the fixed stars by their superior brightness and characteristic motions. Of the remaining three, Mercury will only rarely excite notice, while Uranus and Neptune are as good as invisible to the naked eye.

The dimensions of the solar system are vast when compared with any terrestrial standard. A cannon shot going incessantly at its utmost speed would be a thousand years in crossing the orbit of Neptune from side to side. But vast as the dimensions are, they sink into insignificance when compared with the distance of the stars. Outside the solar system are spaces which, so far as we know, are absolutely void, save here and there a comet or a meteor, until we look far outside the region which a cannon shot would cross in a million of years.

The nearest star is thousands of times farther away than the most distant planet. Scattered at these inconceivable distances are the bodies to which our attention is directed in the present work. If we are asked what they are, we may reply that the stars are suns. But we might equally well say that the sun is one of the stars; a small star, indeed, surrounded by countless others, many of which are much larger and brighter than itself. We shall treat our theme as far as possible by what we may call the natural method, beginning with what, being most obvious to the eye, was first noticed by man, or will be first noticed by an observer, and tracing knowledge up step by step to its present state.

Several features of the universe of stars will be evident at a glance. One of these is the diversity of the apparent brightness, or, in technical language, of the magnitudes of the stars. A few far outshine the great mass of their companions. A greater number are of what we may call medium brightness; there is a yet larger number of fainter ones, and about one half of all those seen by a keen eye under favorable conditions are so near the limit of visibility as to escape ordinary notice. Moreover, those which we see are but an insignificant fraction of the number revealed by the telescope. The more we increase our optical power, the greater the number that come into view. How many millions may exist in the heavens it is scarcely possible even to guess. The photographic maps of the heavens now being made probably show fifty millions, perhaps one hundred millions or more.

Another evident feature is the tendency of the brighter stars to cluster into groups, known as constellations. The latter are extremely irregular, so that it is impossible to decide where one constellation should end and another begin, or to which constellation a certain star may belong. Hence, we can neither define the constellations nor say what is their number, and the division of the stars among them is a somewhat arbitrary proceeding.

A third feature is the Milky Way or Galaxy, which, to ordinary vision, appears as an irregular succession of cloud-like forms spanning the heavens. We now know that these seeming clouds are really congeries of stars too small to be individually visible to the naked eye. We shall hereafter see that the stars of the Galaxy form, so to speak, the base on which the universe appears to be constructed. Each of these three features will be considered in its proper place.

II. Magnitudes of the Stars.

The apparent brightness of a star, as we see it from the earth, depends upon two causes—its intrinsic brilliancy or the quantity of light which it actually emits, and its distance from us. It follows that if all the stars were of equal intrinsic brightness we could determine their relative distances by measuring the respective amounts of light which we receive from them. The quantity of light in such a case varies inversely as the square of the distance. This will be made evident by Fig. 1, where S represents the position of a star, regarded as a luminous point, while A and B are screens placed at such a distance that each will receive the same amount of light from the star. If the screen B is twice as far as the screen A, its sides must be twice as large as those of A in order that it shall receive all the light that would fall on A. In this case its surface will be four times the surface of A. It is then evident that any small portion of the surface of B will receive one fourth as much light as an equal portion of surface A. Thus an eye or a telescope in the position B will receive from the star one fourth as much light as in the position A, and the star will seem one fourth as bright.

The fact is, however, that the stars are very unequal in their actual brightness, and in consequence the apparent magnitude of a star gives us no clue to its distance. Among the nearer of the stars are some scarcely, if at all, visible to the naked eye, while among the brighter

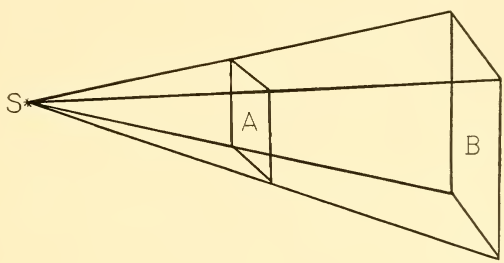

Figure 1.

ones are several whose distances are immeasurably great. A remarkable example is that of Caropes, the second brightest star in the heavens.

For these reasons astronomers are obliged to content themselves, in the first place, with determinations of the actual amount of light that the various stars send to us, or their apparent brilliancy, without regard to their distance or actual brilliancy. The ancient astronomers divided all the stars they could see into six classes, the number expressing the apparent brightness being called the magnitude of the star. The brightest ones, numbering in all about fourteen, were said to be of the first magnitude. The fifty next in brightness were said to be of the second magnitude. Three times as many, an order fainter, were of the third magnitude. The progression was continued up to the sixth magnitude, which included those which were barely visible.

As the stars are actually of every degree of apparent brilliancy, no sharp line of demarkation could be drawn between those of one magnitude and those of the magnitude next higher. Hence, different observers made different estimates, some calling a star of the second magnitude which others would call of the first, while others would designate a star of the third magnitude which others would call of the second. It is therefore impossible to state with absolute numerical precision what number of stars should be regarded of one magnitude and what of another.

An idea of the magnitude of a star can be readily gained by the casual observer. Looking at the heavens on almost any cloudless evening, we may assume that the two, three or more brightest stars which we see are of the first magnitude. As examples of those of the second magnitude, may be taken the five brightest stars of the Dipper, the Pole Star and the brighter stars of Cassiopeia. Some or all of these objects can be seen on any clear night of the year in our latitude. Stars of the third magnitude are so numerous that it is difficult to select any one for comparison. The brightest star of the Pleiades is really of this magnitude, but it does not appear so in consequence of the five other stars by which it is surrounded. At a distance of 15° from the Pole Star, Beta Ursa Minoris is always visible, and may be distinguished by being slightly redder than the Pole Star; it lies between two fainter stars, the brighter of which is of the third and the other of the fourth magnitude. The five readily visible but fainter stars of the Pleiades are about of the fourth magnitude. Of the fifth magnitude are the faintest stars which are easily visible to the naked eye, while the sixth comprises those which are barely visible with good eyes.

Modern astronomers, while adhering to the general system which has come down to them from ancient times, have sought to give it greater definiteness. Careful study showed that the actual amount of light corresponding to the different magnitudes varied nearly in geometrical progression from one magnitude to another, a conclusion which accords with the well-known psychological law that the intensity of sensation varies by equal amounts when the exciting cause varies in geometrical progression. It was found that an average star of the fifth magnitude gave between two and three times as much light as an average one of the sixth; one of the fourth gave between two and three times as much light as one of the fifth; and so on to the second. In the case of the first magnitude, the diversity is so great that it is scarcely possible to fix an average ratio. Sirius, for example, is really six times as bright as Altair, which is commonly taken as a standard for a first magnitude star. To give precision to their estimates, modern astronomers are gradually seeking to lay the subject of magnitudes on an exact basis by defining a change of one unit in the magnitude as corresponding to an increase of about two and one half times in the amount of light.

If the practice of separating the visible stars into only six orders of magnitude were continued without change, we should still have the anomaly of including in one class stars of markedly different degrees of brightness. Some more than twice as bright as others would be designated of the same magnitude. Hence, to give quantitative exactness to the results, a magnitude is regarded as a quantity which may have any value whatever, and may be expressed by decimals—tenths or even hundredths. Thus, we may have stars of magnitude 5.0, 5.1, 5.2, etc., or we may even subdivide yet farther and speak of stars having magnitudes 5.11, 5.12, etc. Unfortunately, however, there is as yet no way known of determining the amount of light received from a star except by an estimate of its effect upon the eye. Two stars are regarded as equal when they appear to the eye of equal brilliancy. In such a case the judgment is very uncertain. Hence, observers have endeavored to give greater precision to it by the use of photometers,—instruments for measuring quantities of light. But even with this instrument the observer must depend upon an estimated equality of light as judged by the eye. The light from one star is increased or diminished in a known proportion until it appears equal to that of another star, which may be an artificial one produced by the flame of a candle. The proportion of increase or diminution shows the difference of magnitude between the two stars.

As we proceed to place the subject of photometric measures of star light on this precise basis we find the problem to be a complex one. In the first place not all the rays which come from a star are visible to our eyes as light. But all the radiance, visible or invisible, may be absorbed by a dark surface, and will then show its effect by heating that surface. The most perfect measure of the radiance of a star would therefore be the amount of heat which it conveys, because this expresses what is going on in the body better than the amount of visible light can do. But unfortunately the heating effect of the rays from a star is far below what can be measured or even indicated by any known instrument. We are therefore obliged to abandon any thought of determining the total amount of radiation and confine ourselves to that portion which we call light.

Here, when we aim at precision, we find that light, as we understand it, is properly measured only by its effect on the optic nerve, and there is no way of measuring this effect except by estimation. Thus, all the photometer can do is to give us the means of increasing or diminishing the light from one star, so that we can make it equal by estimation to that from some other star or source of light.

The difficulty of reaching strict results in this way is increased by the fact that stars are different in color. Two lights can be estimated as equal with greater precision when they are of the same color than when their colors are different. An additional source of uncertainty is brought in by what is known as the Purkinje phenomenon, after the physicist who first observed it. He found that if we took two lights of equal apparent brightness, the one red and the other green, and then increased or diminished them in the same proportion, they would no longer appear equal. In other words, the geometrical axiom that halves or quarters of equal quantities are themselves equal, does not apply to the effect of light on the eye. If we diminish the two equal lights, we find that the green will look brighter than the red. If we increase them in the same proportion, the red will look brighter than the green. In other words, the red light will, to our vision, increase or fade away more rapidly with a given amount of change than the green light will.

It is found in recent times that this law of change does not extend progressively through all spectral colors. It is true that as we pass from the red to the violet end of the spectrum the yellow fades away less rapidly with a given diminution than does the red, and the green still less rapidly than the yellow. But when we pass from the green to the blue, it is said that the latter does not fade out quite so fast as the green.

One obvious conclusion from all this is that two stars of different colors which look equal to the naked eye will not look equal in the telescope. The red or yellow star will look relatively brighter in a telescope; the green or bluish one relatively brighter to the naked eye.

In recent times stars have been photographed on a large scale. Their magnitudes can then be determined by the effect of the light on the photographic plate, the impression of the star, as seen in a microscope, being larger and more intense as the star is brighter. But the magnitude thus determined is not proportional to the apparent brightness as seen by the eye, because the photographic effect of blue light is much greater than that of red light having the same apparent brightness. In fact, the difference is so great that, with the chemicals formerly used, red light was almost without photographic effect. Even now, what we measure in taking the photograph of a star is almost entirely the light in the more refrangible portions of the spectrum. It appears, therefore, that when a blue and a yellow star, equally bright to the naked eye, are photographed, the impression made on the negative by the blue star will be greater than that made by the yellow one. A distinction is therefore recognized between photographic and visual magnitudes.

The photographic magnitudes of the stars are now being investigated and catalogued on a scale even larger than that on which we have studied the visual magnitudes. Yet we have to admit the non-correspondence of the two systems. The bluer the star, the brighter will be its photographic as compared with its visual magnitude. The most that can be done is to bring about the best attainable agreement between the two systems in the general average of all the stars.

Fortunately the differences between the colors of the stars are by no means so great as those between the colors of natural objects around us. All the stars radiate light of all colors; and although the difference is quite appreciable either by the eye or by the photograph, it is not so great as it would have been were the variations in color as wide as in the case of terrestrial objects.

Two comprehensive surveys of the heavens, intended to determine as accurately as possible the magnitudes of all the brighter stars, have recently been undertaken. One of these is the Harvard photometry, commenced by Professor Pickering at the Harvard Observatory, and now extended to the Southern Hemisphere by the aid of a branch establishment at Arequipa, Peru.

The instrument designed by Professor Pickering for his purpose is termed a meridian photometer, and is so arranged that the observer can see in the field of his telescope a reflected image of the Pole Star, and, at the same time, the image of some other star while it is passing the meridian. By a polarizing apparatus the image of the star to be measured is made to appear of equal brightness with that of the Pole Star, and the position of a Nicol prism, which brings out this equality, shows the ratio between the magnitudes of the two stars.

The other survey, with the same object, is now being made at the Potsdam Astrophysical Observatory, near Berlin. In the photometer used by the German astronomers the image of one star is compared with an artificial star formed by the flame of a candle. The work is performed in a more elaborate way than at the Harvard Observatory, and in consequence, only that part of the heavens, extending from the equator to 40° north declination, has been completed and published. A comparison of the results thus obtained with those of Professor Pickering, shows a curious difference depending on the color of the star. In the case of the reddest stars, the estimates are found to be in fairly close agreement, Pickering's being a little the fainter. But in the case of the white or bluish stars, the estimates of the German astronomers are more than one fourth of a magnitude greater than those of Pickering. This corresponds to an increase of nearly one fifth in the brightness. Whether this difference is to be regarded as purely psychological or due to the instruments used, is an interesting question which has not yet been settled. It is difficult to conceive how different instruments should give results so different. On the other hand, the comparisons made by the Germans make it difficult to accept the view that the difference is due purely to the personality of the observers. There are two German observers, Drs. Müller and Kempf, whose results agree with each other exactly. On the other hand, Pritchard, at Oxford, made quite an extensive photometric survey, using an instrument by which the light of one star was cut down by a wedge-shaped dark glass, whereby any gradation of light could be produced. A comparison shows that the results of Pritchard agree substantially with those of Pickering. It is quite possible that the Purkinje phenomenon may be the cause of the difference, the source of which is eminently worthy of investigation.

This fact simply emphasizes the lack of mathematical precision in photometric measurements of star light. Even apart from this difference of color, the estimates of two observers will frequently differ by 0.2 and sometimes by even 0.3 of a magnitude. These differences correspond roughly to 20 or 30 per cent in the amount of light.

It must not be supposed from this that such estimates are of no value for scientific purposes. Very important conclusions, based on great numbers of stars, may be drawn even from these uncertain quantities. Yet, it can hardly be doubted that if the light of a star could be measured from time to time to its thousandth part, conclusions of yet greater value and interest might be drawn from the measures.

We have said that in our modern system the aim has been to so designate the magnitudes of the stars that a series of magnitudes in arithmetical progression shall correspond to quantities of light ranging in geometrical progression. We have also said that a change of one unit of magnitude corresponds to a multiplication or division of the light by about 2.5. On any scale of magnitude this factor of multiplication constitutes the light-ratio of the scale. In recent times, after much discussion of the subject and many comparisons of photometric measures with estimates made in the old-fashioned way, there is a general agreement among observers to fix the light ratio at the number whose logarithm is 0.4. This is such that an increase of five units in the number expressing the magnitude corresponds to a division of the light by 100. If, for example, we take a standard star of magnitude one and another of magnitude six, the first would be 100 times as bright as the second. This corresponds to a light ratio slightly greater than 2.5.

When this scale is adopted, the series of magnitudes may extend indefinitely in both directions so that to every apparent brightness there will be a certain magnitude. For example, if we assign the magnitude 1.0 to a certain star, taken as a standard, which would formerly have been called a star of the first magnitude, then a star a little more than 2.5 times as bright would be of magnitude one less in number, that is, of magnitude 0. The one next brighter in the series would be of magnitude —1. So great is the diversity in the brightness of the stars formerly called of the first magnitude that Sirius is still brighter than the imaginary star just mentioned, the number expressing its magnitude being —1.4.

This suggests what we may regard as one of the capital questions in celestial photometry. There being no limit to the extent of the scale, what would be the stellar magnitude of the sun as we see it when expressed this way on the photometric scale? Such a number is readily derivable when we know the ratio between the light of the sun and that of a star of known magnitude. Many attempts have been made by observers to obtain this ratio; but the problem is one of great difficulty, and the results have been extremely discordant. Amongst them there are three which seem less liable to error than others; those of Wollaston, Bond and Zöllner. Their results for the stellar magnitude of the sun are as follow:

Wollaston	—26.6
Bond	—25.8
Zöllner	—26.6

Of these, Zöllner's seems to be the best, and may, therefore, in taking the mean, be entitled to double weight. The result will then be:

Stellar magnitude of sun..........—26.4

From this number may be readily computed the ratio of sunlight to that of a star of any given magnitude. We thus find:

The sun gives us:

10,000,000,000, the light of Sirius.
91,000,000,000, the light of a star of magnitude 1.
9,100,000,000,000, the light of one of magnitude 6.

The square roots of these numbers show the number of times we should increase the actual distance of the sun in order that it might shine as a star of the corresponding magnitude. These numbers and the corresponding parallax are as follows:

Sirius;	Distance=	100,000:	Parallax=	2''.06
Mag. 1	"	302,000:	"	0''.68
" 2	"	479,000:	"	0''.43
" 3	"	759,000:	"	0''.27
" 4	"	1,202,000:	"	0''.17
" 5	"	1,906,000:	"	0''.11
" 6	"	3,020,000:	"	0''.07

These parallaxes are those that the sun would have if placed at such a distance as to shine with the brightness indicated in the first column. They are generally larger than those of stars of the corresponding magnitudes, from which we conclude that the sun is smaller than the brighter of the stars.

PREVENTIVE INOCULATION. (II.)

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In a previous paper I reviewed briefly the history of preventive inoculation and described the results of my attempts to secure a 'virus fixé' in the case of cholera. It will be remembered that the two vaccines finally obtained protected guinea pigs successfully against all possible forms of cholera infection.

It was now necessary to ascertain whether the same protection could be given to man which was observed in animals. For this purpose it was essential to first of all prove the perfect harmlessness of the operation. This was established by very careful observations of medical men and scientists who were inoculated in Europe soon after the results of the above investigations were published. The inoculation causes a rise of temperature and general discomfort, which lasts one or two days, and some pain at the seat of the injection, which disappears in a few days. The fever and discomfort induced are, on the whole, shorter in duration, though often more intense, than those caused by vaccination against smallpox. The effect disappears within a few days and the individual returns to his usual condition of health.

The next and all-important stage was to devise an experiment or a series of experiments on man so as to test the efficiency of the method against cholera attacks. This part of the investigation could only be done in a cholera-stricken country, where opportunities would arise of comparing the incidence of the disease in inoculated and uninoculated. Such opportunities are limited. Except in certain parts of India and China, cholera appears in localities unexpectedly and does not last long. In the places where the disease is endemic the cases are scattered over large areas. These features rendered the demonstration of the effect of the vaccine a matter of particular difficulty. In 1893 I went to India, and in the course of a year inoculated some twenty-three thousand people in the northern parts of the country; but no cholera appeared in their midst to show whether the vaccine was of value or not. In the spring of 1894 the inoculations were introduced into Bengal, and, with the assistance and co-operation of Prof. W. J. Simpson, of King's College, London, at that time Health Officer of Calcutta, and of his staff, efforts were made to induce the inhabitants of the *bustees* of Calcutta to get themselves inoculated. These bustees are isolated villages consisting of groups of mud huts inhabited by the poorer class.

Owing to the consumption of water from the ponds or tanks belonging to these villages, the inhabitants of the bustees are subject to periodic visitations of cholera. It was in one of these bustees that the first observation was made as to the effect of the cholera vaccines.

The spring is essentially the cholera season in Calcutta. About the end of March two fatal cases of cholera and two cases of choleraic diarrhœa occurred in Katal Bagan Bustee, in a population grouped around two tanks. This outbreak led to the inoculation of one hundred and sixteen persons in the bustee out of about two hundred. After the inoculation there occurred nine more cases of cholera, seven of which proved fatal, and one case of choleraic diarrhœa. All the ten cases occurred among the uninoculated portion of the inhabitants, which formed the minority, none of the inoculated suffering. The results were more interesting when analyzed in detail. Some of the cases had occurred in families in which some of the members had been inoculated and others not, and the disease selected the non-inoculated members, sparing the inoculated. Thus, in one house six members out of eight had been inoculated. The attack, a fatal one, occurred in one of the remaining two. In another house eleven members out of eighteen were inoculated. The eleven members remained free while four out of seven not inoculated were attacked.

Upon these observations the Calcutta municipality felt encouraged to vote funds for the continuance of the inoculations in an experimental farm, and appointed for that purpose a special staff. In 1896 the result of two years' observations were embodied by the health officer in a report to the Calcutta Municipal Corporation. It recorded a most satisfactory state of affairs. During the time under observation some eight thousand persons were inoculated. Cases of cholera occurred in seventy-seven huts in which some members of the family had been previously inoculated and others not. Comparing the incidence of the disease in the two groups, a striking advantage was found to be with the inoculated. I made an analysis of the cases according to the time which had elapsed between inoculation in each of these huts and the occurrence of cholera in them, and the following results were found. During the first four days after inoculation, apparently before the vaccine had time to produce its full protective effect, there were proportionately 1.86 times fewer deaths among the inoculated than among the non-inoculated members of the families. In a second period, extending from the fifth to the four hundred and twenty-ninth day—i. e., for fourteen months—there were 22.62 times fewer deaths among the inoculated; while in the last period—that is, between the four hundred and thirtieth and seven hundred and twenty-eighth day after the inoculation—there were only 1.54 fewer deaths among the inoculated, the immunity having evidently gradually disappeared. The net result was that for two years after inoculation, including the periods of incomplete protection, there was a reduction in mortality of 72.47 per cent among the inoculated; or in other words, in houses in which inoculations were performed and in which cholera subsequently occurred there were, even from the day of inoculation, before the full effect of it could be produced, eleven deaths among the non-inoculated to only three among the inoculated. Eight lives out of every eleven were saved.

At the end of my first cholera campaign, in August, 1895, there were altogether 31,056 natives of India, 125 Eurasians, 869 Europeans of the civil population, 6,627 native officers and sepoys, and 294 officers with 3,206 men of the British troops stationed in India, in all 41,787 people, who had submitted to inoculation. Observations instituted among them, especially among prisoners, soldiers and coolies in tea estates, with regard to whom detailed records could be kept, went to confirm the results as detailed above. In order to lengthen, if possible, the period of immunity, the plan was formed of inoculating stronger vaccines and in higher doses. The inoculations are now carried on in a Government laboratory, in Purulia, Bengal, chiefly among the people emigrating to the cholera districts of Assam, and there is no doubt that in the course of time a marked effect upon the prevalence of cholera in those districts will be produced and valuable theoretical data will be obtained.

There was one noticeable feature about the results of the inoculation against cholera which early attracted my attention, and this was that while the number of attacks and the absolute number of deaths was strikingly influenced by the operation, the proportion of deaths to those attacked did not appear to be changed. The case incidence was effectively checked, but the 'case mortality' was not reduced. The inoculation diminished the chances of an attack of cholera—that is, the chances of the cholera virus penetrating into the tissues of a man; but if it so happened that the patient was attacked and the virus found an entrance and started growing in the system notwithstanding the inoculation, the latter would not assist in mitigating the severity of the symptoms or reducing the fatality of the disease. In analyzing this result further, it seemed to me permissible to assume that the vaccine protected against the cholera microbes themselves, but did not protect against their poisonous products, which are the cause of the actual symptoms.

This interpretation of the facts found support in a set of laboratory experiments by Professor Pfeiffer and Dr. Kolle, of Koch's Institute, in Berlin, who showed that the blood serum of animals and persons inoculated with the cholera vaccine, as practiced in India, acquired an intense power of destroying cholera microbes, but exhibited no properties capable of counteracting the effect of their toxic products—no 'antitoxic properties.' Combined with those of previous experimenters these results tended to prove that two kinds of immunity could be produced separately, and it became incumbent to devise a plan which would secure not only a lowering of susceptibility to the disease, but also a reduction in the case mortality.

For that purpose it seemed rational to attempt the treatment with a vaccine containing a combination of bodies of microbes, together with their toxic products. I intended to test this plan experimentally in the cholera districts; but, plague having broken out in Bombay, the Government of India commissioned me to inquire into the bacteriology of that disease, and I determined that the knowledge gained in the cholera inoculations should be applied and tested in the preparation of a prophylactic against the new epidemic.

The experiments I had in view involved manufacturing a material on a large scale, and operating on it for weeks continuously. To do this it was essential to find a way of recognizing plague growth with certainty, so as to enable the officers engaged in the manufacture to control the process and know exactly when they were handling the proper stuff, and when an admixture and invasion of extraneous growth took place. When this was solved, a drug was prepared by cultivating the plague microbe in sterilized broth, to which a small quantity of clarified butter or of cocoanut oil had been added. The plague bacilli attach themselves to the drops of butter or oil floating on the surface, and grow down into the depth of the liquid, forming a peculiar threadlike appearance. While doing so they secrete toxic matter, which is gradually accumulated in the liquid; at the same time a large amount of microbial growth comes gradually down from the surface of the liquid and collects at the bottom of the flask. When shaken up the whole represents the desired combination of the bodies of microbes and of their toxic products. The process is continued for a period of five to six weeks. As the microbes of plague had been very little studied before, and as their exact effect on the human system was unknown, I decided not to use for the treatment living microbes, but to use at least at first 'carbolized' vaccines, though the result of the treatment might be less favorable or less lasting than that which could be expected from living vaccines. The microbes in the above plague growth were accordingly killed by heating them at a temperature ranging from 65° to 70° C., and then mixed with a small proportion of carbolic acid, to prevent the drug from subsequent contamination and decomposition. The dose of the prophylactic was regulated by measuring up the quantity to be injected. The requisite amount is determined by the degree of fever which it produces. The febrile reaction varies in different individuals, but a temperature reaching 102° and above in at least thirty per cent of those inoculated has been found to indicate a good material. In the cholera, rabies and smallpox vaccines, the microbes being employed in a living state, it was essential to fix the strength of the vaccine, for otherwise it was impossible to predict the behavior of the microbe when injected into the system. In the case of the plague prophylactic the activity of the microbes is arrested before it is inoculated, and the effect can be regulated, as mentioned above, by simply measuring up the doses in the same way as is done with any chemical drug.

The expectation formed when devising the plan for the plague prophylactic has been very fortunately justified, and an advance on the results from the cholera vaccines was obtained; but I can not yet say certainly whether this favorable result is indeed due to the particular provisions which I had made for obtaining it.

The effect of the plague prophylactic was first tested at the Byculla Jail, in Bombay, when the epidemic reached that establishment. From the first day after the inoculation till the end of the outbreak there were in the jail twelve cases and six deaths among one hundred and seventy-two uninoculated inmates, and two cases, with no deaths, among one hundred and forty-seven inoculated. A year later, almost exactly a similar result was observed when the plague attacked the so-called Umarkhadi Common Jail, in Bombay. In this case after the inoculation there were ten cases and six deaths among one hundred and twenty-seven uninoculated inmates, and three cases, with no deaths, among one hundred and forty-seven inoculated. These and other observations show that the vaccine for the plague begins to exercise its effect within some twenty-four hours after inoculation; that it is useful even in the case of persons already infected; that it is therefore applicable at any stage of an epidemic. Numerous further observations were soon collected on the working of the system.

At the small village of Uudhera, of the Baroda feudatory state, where plague broke out, inoculation was applied to a half of each family, the other half remaining uninoculated. After that there were twenty-seven cases and twenty-six deaths among sixty-four uninoculated, and eight cases, with three deaths, among seventy-one inoculated of the same households, the proportionate difference in mortality being over eighty-nine per cent. There followed observations on a far larger scale, demonstrating that the mortality of the inoculated, compared to that of the non-inoculated, was on an average between eighty and ninety per cent less. Sometimes this reduction reached ninety per cent. In the Punjaub, in a village called Bunga, there occurred, in two hundred and eighty-one not inoculated, ninety-seven cases of plague and sixty-five deaths, while among seventy-four inoculated there were six cases, but no deaths. In Bangalore, among 80,285 of the inhabitants not inoculated, there were 2,208 deaths from plague, while among 23,537 inoculated there were only 108. The observations at Lanowli, Kirkee, Daman, Hubli, Dharwar, Gadag, in the Bombay Presidency, gave the same results. At Hubli over forty-two thousand inhabitants out of some fifty thousand were inoculated. In Bombay city, out of a population of 821,764, 157,256 have now undergone the inoculation. The work proceeds here at present at the rate of one thousand to eleven hundred inoculations a day.

From plague hospitals the returns show that among those of the attacked who were previously inoculated the mortality is reduced to less than one half of that among patients who were not inoculated. The property of reducing the case mortality thus appears to belong to the plague prophylactic in an unmistakable degree.

By the anti-cholera and anti-plague inoculation the methods of preventive treatment by means of cultivated bacteria and their products have been rendered, so to say, a part of the daily policy in human medicine. The usefulness and practicability of those methods have become clearly apparent, and steps have been taken to extend further the field of their application. On the ground of the experiments made with the typhoid bacillus in the Pasteur Institute in 1889-'93, and of the results obtained from the anticholera inoculation in India, I was able to induce Professor Wright, of the Pathological Laboratory in Netley, whom I initiated in 1892 in the principles and technique of anti-cholera inoculation, to start a campaign of similar operations against typhoid among the British troops. The latter are stationed at different times of their service very nearly in all parts of the world, and yearly pay a very heavy tribute to that disease. The medical officers in charge of these troops pass through a course of training at Netley, and Professor Wright had rendered excellent services in connection with the cholera inoculations, by disseminating the knowledge of them among the probationers of the school. It seemed to me expedient, therefore, to start the typhoid inoculation also through the staff and pupils of that school. The following plan as to the preparation of the vaccine, and the way of carrying out the inoculation, was laid before Professor Wright. The typhoid bacillus was to be brought to a fixed stage of virulence by the inoculation in the peritoneal cavity of Guinea pigs, according to the exact rules prescribed for the anti-cholera inoculation. Once the virus was fixed, it was to be cultivated for twenty-four hours on a solid medium, and a first vaccine prepared by carbolizing that virus. As, however, the durability of the effect of carbolized vaccine alone was not known, this was to be followed up by the injection of a dose of the fixed living virus.

The inoculation was first to be made on volunteers among the physicians on probation at Netley; then on volunteers among the young officers of the army on the eve of their departure for the tropics; and then, with the approval of the military authorities, on volunteers among private soldiers. At the end of 1895, during my visit to England, I obtained from Sir William Mackinnon, then Director-General of the Army Medical Department, permission for Professor Wright to start the work upon the plan above detailed; and the first inoculations, in the way described above, were done in the middle of 1896. Soon after that, Pfeiffer and Kolle, recognizing the same similarity between the cholera and typhoid microbes, and pointing out that the results obtained by us in India were likely to be repeated when applying the method to typhoid, proposed and started a similar series of inoculations.

When the inoculation against plague was begun, and observation showed that dead vaccines alone were apparently sufficient to produce satisfactory results, a second inoculation with living virus appeared less urgently necessary; and as the effect of such an inoculation, which Professor Wright very courageously tried first on himself, seemed troublesome, it was decided to do for the time being the second inoculation also with the carbolized virus. Similarly, the plan which was adopted for the plague inoculation, of cultivating the vaccine in a liquid, instead of a solid medium, and of using cultures of several weeks' duration, has been subsequently adopted in the typhoid inoculation also.

Many thousands of British soldiers and civilians have already undergone the inoculation in question. The latter was done partly with vaccines cultivated on a solid medium, according to the older plan, and partly with vaccines prepared according to the plague inoculation method. The results so far observed are encouraging, and, I hope, will shortly be improved considerably. At the last Harveian dinner in London, Surgeon-General Jameson, Director-General of the Army Medical Department, summarized the results of the observations in India, where, among several thousands of young soldiers, the most prone to the disease, the incidence of typhoid since their inoculation was 0.7 per mille, while among the older, more resistant, not inoculated soldiers, the incidence was during the same period just double that. A large proportion of the force now on service in the South African campaign have been inoculated, some before embarking and others on their way out.

Such is the position of preventive inoculation, as applied, so far, to human communities. The very success of these operations is now apt to create some sort of feigned or earnest alarm, and one meets at present with the question, What is going to happen to our poor body if we are to be inoculated against *all* diseases? and with this other one, How do you expect us to make a *living* if you try to keep all of us alive? The humorous form of these questions usually permits of their dropping out of the conversation without a reply. The earnest answers are, however, obvious. The efforts of the bacteriologists in combating diseases are at present directed to a twofold aim: their prevention, by a prophylactic treatment, and their cure. The advantage of a curative treatment is that it is to be applied to a relatively small number of persons, to those who actually fall victims to an attack; while that of the preventive treatment is in the greater certainty with which safety and protection are secured by it. The relative position of the two treatments will, in practice, differ in different diseases—namely, according to the prevalence and fatality of a given disease, and according to the merits of the two treatments as they stand at the time. In diseases in which the risks of being attacked are smaller, or the consequences of an attack less serious, or for which a very effective and sure curative treatment has been discovered, the majority of people will prefer to wait for an actual attack rather than to undergo the discomfort of a preventive treatment; in diseases, on the contrary, in which the chances of being attacked are great, or in which the fatality is higher, the sequelæ of an attack more serious, and for which a successful and not very troublesome preventive treatment has been found, large numbers will undergo preventive inoculation. But, even in the latter case, a mutual co-operation between the two methods will exist always, as there will always be a number of people, either among those who have neglected to protect themselves by inoculation, or among those in whom the inoculation has proved unsuccessful, who will fall victims to an attack and require the benefits of a curative treatment, be those at the time little or great.

The answer to the second question is of course to be expected rather from the politico-economist, the wise administrator, the civilian, than from the bacteriologist. In any case it is clear already that if we are ever to be told that we must thin our ranks, we shall prefer not to leave the task in the hands of the indiscriminating microbe, but to have some voice in the matter ourselves. Inoculation marks only the conquest of another force which henceforth we shall be glad to control.

BOMBAY, INDIA, *March, 1900.*

COLONIES AND THE MOTHER COUNTRY. (II.)

BY JAMES COLLIER.

THE growth of the relations between a colony and the mother country closely follows the development of the relationship between an organism and its offspring, or (in higher species) between parents and children. When an infusorian subdivides into two cells, the new cell produced swims away and henceforth leads an independent life. Most of the Phœnician and most of the earlier Greek colonies were social infusoria which parted from the parent organism by segmentation and had no further relations with it. As we rise in the animal scale a new relationship, that between mother and young, and a new instinct, the maternal, come into existence. These begin as low down as the mollusks, and expand and heighten, though not without strange lapses, in both insects and birds as species develope; but we need not trace the evolution here. Let it suffice to note that there are successive degrees of specialization; a site is chosen suitable for depositing and hatching eggs; means are found for making them secure; a shelter is built for them; they are deposited near substances adapted to nourish the young; special food is prepared for them; they are reared through food disgorged or brought to them. The accession of the male to the family marks the dawn of the paternal instinct; it appears earliest among fishes. This evolution is repeated in the history of colonies, where, however, the maternal and paternal offices melt into one another insensibly.

The mother country founds and nurtures colonies. Most of the earliest colonies are the work of adventurous bands or navigating merchants or fishermen, who seek their own habitats, carry with them their own equipment and fight their own battles. Then the metropolis settles its surplus or discontented citizens in territories previously chosen, provides them with all that is necessary for their start, and often nourishes them during the infancy of the colony. Hispaniola was a state colony manned with miners and artisans who were provided with tools, and this at the cost of a loan and a draught from the confiscated property of the Jews. Nor was it until gold began to be found in large quantities that the receipts equalled the expenditure on the young colony. Louisiana was founded and fostered with a royal munificence that conferred on it "more than was contributed by all the English monarchs together for the twelve English colonies on the Atlantic." Georgia was a one-man foundation, but the British Parliament twice granted considerable sums to initiate it and carry it on; the Society for the Propagation of the Gospel aided, and the benevolence of philanthropic England contributed largely to its success. Not till 1818—more than half a century after the conquest—did the revenue of Canada balance its expenditure. The convict colony of New South Wales was, of course, entirely of state origin. Stores of every kind, together with cattle and seeds, were sent out at the beginning, and long continued to be sent out to it. The first governor was granted a space of two years to make it self-supporting, but the growth of a convict colony is abnormally slow, and the civil and military establishments for thirty-four years continued to be a drain on the British exchequer to the extent of over ten millions. Even now one of the oldest and best of existing British colonies, with an area of over three hundred thousand square miles, does not produce the breadstuffs needed for its own consumption. The Cape of Good Hope, of mixed Dutch and French origin, was first made a truly British colony by the dispatch of six thousand emigrants at the cost of the mother country—a cost much greater than was anticipated. When the Transvaal was forcibly annexed by England, the stepmother country advanced a sum of £90,000 to rescue the quondam republic from its financial difficulties. In 1895 Parliament voted three millions for the building of a railroad in British East Africa. Uganda is supported by a British subsidy. Algeria is a manufactured colony, which has all along had to be supported by its creator. Apart from the cost of their civil and military establishments, France has to subsidize her colonies to the extent of over four millions sterling, partially expended in reproductive public works. Even tiny New Caledonia costs France half a million, one half of which, it is true, is expended on the convict establishment.

Most colonies at their beginning are burdensome to the mother country. Years after its foundation South Australia fell into such embarrassment that its governors had to draw on the imperial exchequer for nearly a million. In 1834 the expenditure in Cape Colony was still in excess of the revenue. Sierra Leone had to be aided by a parliamentary grant year after year. No wonder the Colonial Office complained that colonies were expensive to keep up. In German Africa the revenue does not meet the expenditure. The Congo Free State does not pay its way. On the other hand, Congo Française has a substantial surplus. Western Australia was another exception to the rule. There the Imperial Government announced that it would contribute nothing to the foundation of the colony, which was to be self-supporting from the first. Private capitalists were to arrange for the emigration of ten thousand persons in four years. Lands were granted to the emigrants on a scale of extravagance which long hampered the progress of the colony. Companies likewise expend large sums in many colonies. French and English companies embarked on American, Indian, African and island adventures at ruinous loss. Law's company withdrew from Louisiana, the New Zealand Company from New Zealand, and the Canterbury Association from Canterbury with a balance on the wrong side of the account. Wealthy individuals bear their part. Mr. Rhodes annually subsidizes the British Central African Protectorate, and King Leopold the Congo Free State. Colonial bishoprics have also been endowed and colonial cathedrals built, largely with the aid of voluntary contributions by sympathizers in the mother country.

The mother state sometimes gives the colonies the benefit of her financial good name. In 1869 England withdrew her regiments from New Zealand when the colony was still at war with the Maoris, and to salve the wounded feelings of the colonists she agreed (under pressure) to guarantee a loan of a million in aid of emigration and public works. Before the Canadian Pacific Railway could be completed the Imperial Government had to guarantee a loan of £3,600,000. Mr. Rhodes proposes (unsuccessfully, it now appears) that the Imperial Government, which contributed £200,000 to the cost of a railway from Kimberley to Buluwayo, should guarantee a loan of an enormous amount for the continuation of the African trunk railway from Buluwayo to Lake Tanganyika.

The mother country supports or aids its self-governing colonies through its capitalists. In order to execute public works—roads, bridges and railways—to assist immigration, to build fortresses, and sometimes to pay the interest on previous loans, all the colonies have habitual recourse to the British Stock Exchange. There are good reasons for this. The colonies have little capital of their own, for all their money has been used up from day to day. The English investor has an almost unlimited amount—the savings mainly of one industrious century—and he is prepared to lend it at a lower rate of interest than would content the colonial capitalist. Of over two thousand millions sterling which John Bull has out at usury all over the world, the total public and private indebtedness of the seven Australasian colonies alone, with a population of four millions, is stated to exceed three hundred and twenty millions, or at the rate of eighty pounds per head of these daring colonists. One half of this sum is due from colonial governments for the purposes already named. The half of it, due from banks, building companies, mercantile associations and mortgage agencies, excites no misgivings; these institutions can always go bankrupt, as many of them did in the financial collapse of 1891-'93. But it is not open to a British colony to file its schedules, or at least so we used to think; and so the Times said till the oldest of British colonies went bankrupt the other day. At all events, it is harder, and we contemplate this enormous pile of public indebtedness in young and scantily peopled communities with the same feelings as made alarmists foresee impending ruin in the growing augmentation of the gigantic public debt of the United Kingdom. It is commonly said that while the imperial debt has been accumulated as the cost of "just and necessary wars," or of wars that were neither just nor necessary, the colonial debt has been contracted for the execution of reproductive public works. This is not altogether so. Eleven million pounds of the public debt of New Zealand were contracted to carry on war with the Maoris, who were defending their territory. The Seven Years' War, which was begun on the part of England to gain possession of the Ohio Valley and thus increase the extent of her colonies, doubled her public debt. Where is the difference between the two classes of expenditure? Then most of the self-governing colonies have expended large sums in fortifying ports, some in partly supporting a fleet, and one at least in purchasing war ships of its own. Nor has all the remainder been reproductively expended. The building of schools is a wise way of spending money, one's own or another's, but it can not be called a materially reproductive way. Governors' and ministerial residences, parliamentary and departmental buildings, are indispensable, but they can not be called 'assets,' especially if built of perishable and inflammable timber. Even railways, most profitable of public works, are not always true assets. In many of the colonies they are light railways, and when traffic increases and a higher speed is required they will have to be built over again and new rolling stock procured. Not a few of them, too, are 'political railways,' running through a sparsely populated country no-whither, and built to capture votes. Roads are only less valuable, but they were made (sometimes by graduates and men of scientific antecedents who were afterward cabinet ministers) at the wage rate of from two guinas to four pounds ten per week, and are an inadequate return on the outlay. Last century British loans were issued as prizes to friends of ministers, and a much reduced amount found its way to the treasury. Deduct an analogous, though not quite similar, item of waste in colonial loans, add this to all the other non-reproductive elements, and the genuinely reproductive proportion will shrink considerably. Every one of the colonies, even with the fee simple of territories only less than Europe in extent in their hands, would have sunk under the increasing burden. Happily or not, the ever-growing wealth of England has so cheapened money that the interest charge on the whole Australasian indebtedness sank in five years (1890-'96), mainly through conversion of loans, from fourteen millions to twelve and a quarter. It may be added that the colonies which have borrowed most recklessly have not been the most populous or those with largest resources, but rather the socialistic colonies with big schemes on hand.

A father may assist his son by supplying him with the capital needed to carry on his business. Thus it is entirely with the mother country's money that the first colonial banks are founded. As the colony grows wealthier and the business of the banks extends, colonial shareholders purchase stock in it, but the number of British shareholders remains considerable. A typical example is that of the Bank of New Zealand, from two fifths to one half of whose shares are (or in 1888 were) held in the United Kingdom. In the older or wealthier colonies of New South Wales and Victoria the number of English shareholders may be smaller, though still large. A still larger proportion of the shares of the great colonial steamship companies, amounting possibly to three fourths or nine tenths of the whole, is held (chiefly by commercial men and firms) in Great Britain. Many commercial undertakings in all the colonies are engineered entirely by English capital (not included in the two thousand millions). The Canadian transcontinental railway; railways, electric tramway lines and silver mines in Tasmania; the Midland Railway and also copper mines in New Zealand; the gold mines in western Australia to such an extent that much more English capital is said to pour into that colony than gold flows out of it—are only a few colonial enterprises that would never have been undertaken but for the mother country's aid. Some of these are lucrative, others not; some have been abandoned, and others belong to a still darker class. "Uncounted millions of capital have been raised in the central money market of London, only to be fooled away in ill-conceived and misdirected enterprises abroad," says Lord Brassey. Nor are the losses confined to questionable undertakings. Two great Australasian banks have frittered away their entire capital of four and three millions, respectively, and it may be assumed that the British investor has borne one half of the losses. Of half a dozen smaller colonial banks a similar tale might be told. Father and son have to share in one another's adversity, as in one another's prosperity.

The socialistic movement in England has lately so strongly reacted on the relations of the Imperial Government with the colonies that the Secretary of State is believed to be willing to employ the resources of the empire to assist backward colonies. He has invited English capitalists to aid the declining West Indies, and a leading firm has offered to invest a million in the sugar industry if a guarantee of sufficient returns is given. The constitution of the projected Australian Federation contains a novel analogous provision, permitting the commonwealth to aid its needy provinces. The growing unity in the social organism as a whole is accompanied by an increasing unity in its component parts.

The mother country continues to defend its colonies, as animals defend their young and parents their children. But the polyp does not defend its offspring, nor did the earliest colonizing powers succor their colonies. While not even the armed persuasion of Cambyses could induce Tyre to make war against Carthage, neither seems to have helped the other in its need. Carthage fought savagely for her Sicilian colonies, but in her own interests, not in theirs. Though the ties between a Greek metropolis and her colonies were closer, the one did not invariably defend the other. Corcyra refused the aid her daughter city Epidaurus sought, and the latter had to find it in the grandmother city of Corinth, who considered it *her* colony no less than that of Corcyra. The Dorian city was celebrated for her typical Greek patriotism, and she gladly assisted Syracuse to expel her Carthaginian conquerors. Rome fought for her colonies while her power lasted. France and England fought for their colonies, or rather for the possession of them, all through the eighteenth century. Spain has just fought for her last colonies, but as much against the colonists as against the foreign state that came to set them free. The mother country is also at the cost of keeping her colonies in a state of defence. The sum of £9,000 was in 1679 annually expended on the maintenance of English soldiers in Virginia and two West Indian colonies, and £1,000 on the fortifications of New York. Troops were often dispatched to assist the American colonies in special expeditions. The colonial military expenditure of Great Britain in 1859 amounted to nearly £1,200,000. In compliance with the findings of a Royal Commission, repeatedly reaffirmed by resolutions of Parliament, to the effect that the self-governing colonies ought to suffice for their own military defense, the troops were finally withdrawn in 1873, but she still maintains a garrison at Halifax and in Natal and a fleet in Australian waters, to which last the adjacent colonies contribute a fraction. Most of the self-governing colonies have at their own cost erected fortresses, and they maintain a defensive force. Two of them have stationary ships of war. They are willing and eager, moreover, to aid the mother country when she is in difficulties. When England was embroiled in Egypt or danger threatened in India and South Africa, several of these colonies offered to send, and one actually sent, troops to engage in wars in which they were not directly concerned. The head and the extremities are sometimes at variance because their interests conflict. The heart of such an empire is one. A stride has been taken toward organic unity.

Animals evolve special organs for the nursing of their young, and all colonizing countries seem to have created special departments for the supervision of their colonies. As the lacteal glands are only modified skin-glands, are in certain lower genera (the Monotremata) at first without teats and only in higher species develop into true mammæ, so the colonial department in the mother country is originally a mere adaptation of existing agencies. A rather perfect example of this stage is presented by the earliest of modern colonizing powers. The Casa de la Contratacion de las Indias, established soon after the discovery of South America, was organized in 1503. It granted licenses, equipped and despatched fleets, received merchandise for export and cargoes imported and contracted for their sale. It controlled the trade with Barbary and the Canaries and supervised the shipping business of Cadiz and Seville. Taking cognizance of all questions concerning marine trade, it was advised by two jurists. It also kept the Spanish government informed of all that concerned the colonies. It was a general board of colonial marine trade, and such it remained even when, a few years later, its more important colonial functions were absorbed by a higher department.

Where the colony has been founded by a commercial or by a colonizing company, the mother country controls the colony through the directors of the company; the office of the company is *pro tanto* the Colonial Office. Yet the later colonial department, as an organ of government, is not a development of these shipping, commercial or colonizing boards. It is a delegation of the sovereign authority. This is at first exercised directly by the sovereign as it was notably by Isabella and Ferdinand. It is next delegated, like almost all functions of the ruler, to his privy council, which assigns the business of colonies to a committee, which again may be set apart as an independent administrative body. The Spanish Council of the Indies, the separate English privy council for colonial affairs contemplated in the first Virginian charter, the Council of Nine appointed by the States-General of the Netherlands, the Swedish royal council, were such bodies. Their powers are everywhere the same. The superintendence of the whole colonial system is entrusted to them. They have supreme jurisdiction over all the colonies. They appoint and may recall viceroys, governors-general, governors and other local officers. They can veto laws and ordinances made by colonial rulers or legislatures. They frame constitutions for the colonies and enact laws. Through the governors and other officers sent out by them, they minutely supervise and incessantly interfere with the whole internal administration of each colony. The tendency of this supreme council is to divorce itself evermore from the privy council and become independent, till at last it is transformed into a ministerial department. Yet an amicable relationship (such as sometimes survives the divorce court) long remains. The Colonial Committee of the privy council in England was summoned as late as 1849, and the Judicial Committee still hears appeals from colonial courts of justice. The government of the commonwealth was naturally averse to the king's council, and a body of special commissioners (Cromwell and Pym and Vane among them) was appointed to govern the colonies.

The Restoration did not at once return to the old system. On the contrary, a remarkable democratic advance was made. Recognizing that though 'politics lie outside the profession of merchants' (as the Swedish and British governments declared), yet trade is eminently within their scope, the restored monarchy set up a Council of Trade and Plantations, of whose forty members twenty were elected representatives of the five merchant companies and the incorporated trades. But there was ever a tendency, at least under the despotic rule of the Stuarts, to revert to the privy council, and in 1674 a standing committee of it was appointed Lords of the Committee of Trade and Plantations. The change appears to have been unimportant. Trade still governed the committee and shaped its policy.

The Board of Trade set up in 1696, rather by the House of Commons than by the Ministry, marked the more popular character of the revolution of 1688, and lasted for ninety years. As if foreshadowing the despotic character of the English reaction against the greater French revolution, this board was abolished by an act introduced by the chief reactionary—Edmund Burke. A committee of the Privy Council for Trade and Plantations was in 1786 again resorted to, and this committee in a shadowy manner survived (perhaps it still survives) till 1849, when it was for the last time summoned by Earl Grey. But the real administration of the colonies had long been in the hands of a department of state, directly responsible to Parliament, though it was still a department that dealt with other affairs as well. Specialization began in 1702 by the colonies being assigned to the Secretary for the Southern Department. In 1768 a separate department with a secretary was created for America, where almost all of the colonies were then situated. After the loss of most of the American colonies the new department was abolished in 1782. The colonies were then annexed to the home department. In 1794 the newly created war department nominally included the colonies, though these were not actually united with it till the Committee for Trade and Plantations ceased to act, seven years later. In 1854 a separate colonial department, with an independent secretary of state, was finally created.*

As there were twenty-three secretaries in forty-one years, it will be readily understood that the practical work of administration remained with the permanent officials. With a longer tenure of office, previous training and thorough mastery of details, they held all the threads of colonial administration in their own hands. A newly-appointed minister, with little knowledge of the colonies and no acquaintance at all with the business of his department, was no match for an experienced officer who had colonial affairs at his fingers' ends.

*The history of the relations between the government of Great Britain and her colonies will be found in many books, but best in Mr. Egerton's comprehensive survey of British colonial policy.

A mere clerk, unknown outside his office, though well known in literature, could recall a governor; another, whose very name was unknown till he died, recommended (that is, commanded on pain of dismissal) a recent Governor of New Zealand to give away to his ministers on a crucial exercise of the prerogative.

Nor is it in matters of routine alone that the permanent officers shape the course of colonial administration. A strong-minded minister with a policy of his own, like Lord Grey or Lord Carnarvon, will force his subordinates to carry it out, but even here a still stronger-minded under-secretary will often have his way. In 1848 Lord Grey, then Secretary for the Colonies, summoned the aged and moribund Committee (of the privy council) on Trade and Plantations to advise with him on the policy to be adopted towards the Australian colonies. The report was drafted by Sir James Stephen and we have no difficulty in discovering in its far-sighted proposals and masculine style the mind as well as the hand of the author of the essay on 'Hildebrand.' It is often said that a state department is inevitably wedded to routine. In the report just mentioned the striking feature is the outline of a system of Australian federation that is only now on the point of being realized. So far was the pedantic Colonial Office then, as it has often been before and since, ahead of its subject colonies.

The other colonizing countries have followed the same line of development. Beginning as direct delegations of the sovereign power to a branch, first constituent and then separated, of the sovereign's council, the department of colonies has been in course of time made an independent ministry directly answerable to parliament. In bureaucratic France the colonies since 1854 have been associated with the navy. On the first of January, 1899, the empire on which the sun never set, having lost the last of the dependencies that were once its glory, abolished its colonial office. The sun had set on Spain to rise no more.

TECHNICAL EDUCATION AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

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WITH the enormous progress in the arts and sciences which has characterized especially the last half of the nineteenth century, education has kept well abreast, although its progress has been gradual and it is not always easy to recognize the great advances that have been made. In the sciences, a discovery is made or a machine invented that in the course of a few years forms the basis of a new industry, gives occupation to thousands and places within the reach of almost every one conveniences previously attainable only by the few. In education no such sudden revolutions occur, and great changes are introduced by degrees without producing any commotion or any surprise. From the days of Erasmus and Rabelais, if not earlier, educational reformers have urged the importance of studying things rather than books about things, of cultivating the hand and eye as well as the mind, of training the perceptive powers, of cultivating a habit of observation and discrimination, and of developing the faculty of judgment. Yet, notwithstanding all that has been said and written, progress in this direction has until recently been very slow. Carlyle, apparently looking at the matter almost from the old scholastic standpoint, expressed the opinion that the true university of modern times was a great library; books, not things, should be studied. It would conform more to the modern point of view to say that the true university of the twentieth century is a great laboratory. Even the function of a library in our modern institutions of learning is perhaps more that of a laboratory than that of a mere storehouse of facts and opinions.

It is perhaps not too much to say that the development in the direction indicated has been greatest in our own country; that the United States have taken the lead in the revolution against the old method of teaching, and that at the present time the higher schools of this country are examples of the best practice and the highest development of the laboratory method. It may, therefore, be of interest to give the readers of this magazine a brief account of the school which has in these respects been one of the foremost, if indeed it has not led the schools of this country, the Massachusetts Institute of Technology.

With the development of the natural sciences and the growth of the constructive arts, natural science long ago gained a place in the curricula of the great universities of Europe; and afterwards special schools were founded for teaching the applications of science to the arts. In France, the École des Ponts et Chaussées, originally started in 1747 as a drawing school, was organized in 1760 for the training of engineers. In the States of Germany, a number of similar schools were organized early in the present century. In America, the Rensselaer Polytechnic Institute, the pioneer in technical education, was founded in 1824, and was the only school devoted to applied science until the forties, when Joseph Sheffield and Abbot Lawrence established the schools which bear their names, in connection, respectively, with Yale and Harvard. With the development of railroads, which dates from the thirties, and of manufacturing, which began in this country

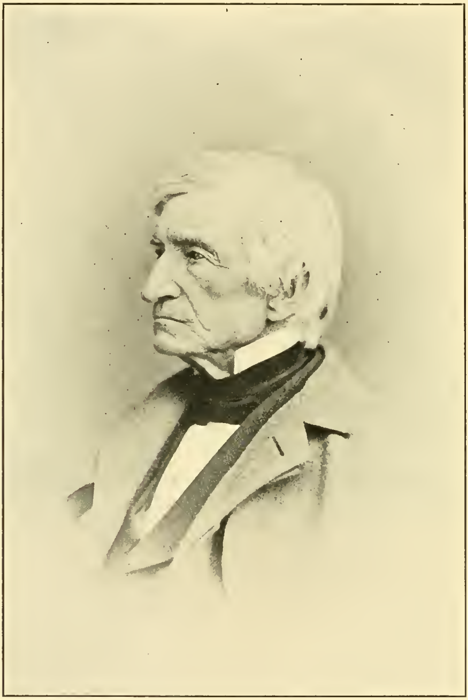
The Rogers Building, Massachusetts Institute of Technology, is at the right, the Walker Building at the left.

but a few years earlier, urgent need was felt for schools which should fit younger men to grapple with the problems which the new industries offered. These schools, however, maintained for many years but a precarious existence and were quite elementary in character. The Civil War interrupted their growth and absorbed for a time all the resources of the nation; but its termination set free an abundant store of energy, henceforward to seek its chief application in the development of trade, commerce, manufacturing and industrial pursuits of every kind. From this time he success of schools of technology was assured. They were needed to supply young men for the development of the arts; but, on the other hand, as in all things not purely material, they were to create a demand for such men by first furnishing a supply. Manufacturers and leaders of industrial enterprise soon found that they could not afford to do without the services of young men trained in scientific principles. In this way, by reversing the usual law of supply and demand, these schools contributed powerfully to advance the technical development of the country, far indeed beyond the measure that may be inferred from the mere number of their graduates.

The Massachusetts Institute of Technology was chartered in 1861, and first opened to students in 1865. Its claim to recognition as a leader in the development of technical education may perhaps be summarized as follows: It was the first school in the world to institute laboratory instruction in physics and chemistry to students in large classes as a part of the regular course of each candidate for a degree; the first to equip a mining and metallurgical laboratory for the instruction of students by actual treatment of ores in large quantities; the first to establish a laboratory for teaching the nature and uses of steam, and a laboratory for testing the strength of materials of construction in commercial sizes; and the first in America to establish a department of architecture. Later still, it was the first school in America to establish distinct and specialized courses of study in electrical engineering, in sanitary engineering, in chemical engineering and in naval architecture.

The success of the school has been commensurate with its progressiveness. It stands to-day the largest, most complete school of its class in the United States, and one of the largest in the world. The number of its students is 1,176, the number of its teachers, including lecturers, 175. Excluding lecturers, the number of students per teacher is only 8.7, a ratio which is a good general index of the character of the instruction. The students come from 40 States and Territories of the Union and from 12 foreign countries.

Before passing to a more detailed description of the work of its various departments, some general characteristics of the school should be mentioned. The first is the great variety of its courses and the specialization of its instruction. It is a college of general technology, embracing almost every branch of study which finds application in the arts. There are thirteen distinct courses of study: Civil and topographical engineering, mechanical engineering, mining engineering and metallurgy, architecture, chemistry, electrical engineering, biology, physics, general studies, chemical engineering, sanitary engineering, geology and naval architecture. These several departments mutually support and reinforce each other, and allow a specialization of the instruction which would be impossible in a smaller college with a less numerous staff of instructors. Thus, at the Institute of Technology, there are not only professors of civil engineering and of mechanical engineering, but professors of mechanism, steam engineering, railroad engineering, highway engineering, hydraulic engineering, topographical engineering, etc. Again, the chemical staff of twenty-four persons is distributed over general chemistry, analytical chemistry, organic chemistry, industrial chemistry and sanitary chemistry. There are separate laboratories for water analysis, for gas analysis, for food analysis, for dyeing and bleaching, etc. In each of these there are



William Barton Rogers, President, 1862–1870; 1878–1881.

teachers who are able to give their entire time to instruction and research in a single line.

The second characteristic of the Institute is the predominance of laboratory, shop and field practice, experiment and research. These are used wherever it is found practicable to supplement, illustrate or emphasize the work of the recitation or lecture-room.

The third characteristic of the Institute, and one which is absent in the case of many similar schools, is the fact that a not inconsiderable amount of general training has from the beginning been required of every candidate for the degree. In some technical or scientific schools there are no liberalizing studies, aside from those of a professional character. The faculty of the institute have insisted that such studies should be incorporated to a considerable extent in the curriculum of every course, recognizing the fact that few students in technical schools are graduates of colleges, and that the aim of the Institute should be first of all to graduate broadly trained men. Aside from the courses in liberal studies, a broad spirit is shown in the technical courses themselves. The study of general principles is always the chief end in view, and to it are strictly subordinated the acquirement of all knacks, tricks of the trade or merely practical rules.

These characteristics of the Institute were impressed upon it from the beginning by the master hand of its founder and first president, William B. Rogers. President Rogers aimed to establish 'a comprehensive, polytechnic college' which should provide a 'complete system of industrial education.' It is now generally recognized that a complete system of industrial education would consist of three parts: First, manual training schools, for developing the eye and hand, not with the object of producing artisans, but for training alone. Second, trade schools for special training in the technique of the different trades. Third, higher technical schools for training in the fundamental principles of the sciences, and fitting men in the broadest way to become leaders in the application of the sciences to the arts. Manual training is now generally recognized as a desirable addition to every scheme of public instruction and a powerful adjunct to every technical school. It was not indicated in the original scheme of the Institute, but was added in 1877 through the wisdom of President Runkle, as a result of the exhibition in Philadelphia of the results obtained in Russia by instruction of this kind. Trade schools, for the training of artisans, were never included in the scheme of President Rogers, and are not now, either in America or Europe, considered suitable adjuncts to so-called technical schools, although they are very desirable as special and independent institutions. The original plan for the Institute contemplated simply a school of the last-named kind, together with provision for evening lectures, to which outsiders should be admitted, and which it was expected would be of benefit to artisans; and also the establishment of a museum of arts, and of a society of arts which should hold regular meetings and which should be the medium for the communication to the public of scientific discoveries and inventions. It may be as well to state here that the museum of arts was never established except in so far as the separate departments of the Institute have accumulated collections; but that the society of arts, which held its first meeting in 1862, has been continued to the present time. Many important inventions, as for instance the earliest forms of the Bell telephone, were first publicly exhibited at its meetings.

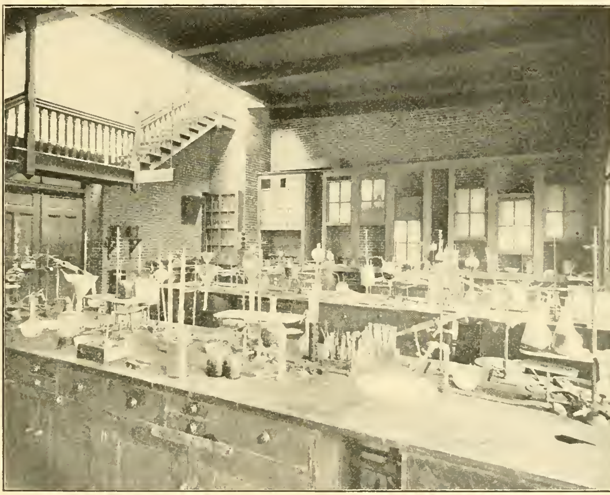
In outlining his plan, President Rogers showed wonderful keenness and foresight. With the added experience of the succeeding forty years, it would scarcely be possible to make a more complete statement of what experience has shown to be the best method of organization. In fact, his Scope and Plan of the School of Industrial Science of the Massachusetts Institute of Technology may be said to be the first step toward a new order of things in education, and contains the first clear statement of the desirability of teaching physics, mining, metallurgy and other branches by the laboratory method.

Let us now see what has been the result of the nearly forty years of development since President Rogers outlined his plan. Originally

THE HENRY L. PIERCE BUILDING AND ENGINEERING BUILDING.

confined to one building, the growing needs of the school have led to the erection of five others, in addition to a gymnasium. The original building, completed in 1865, is now known as the Rogers Building, after the founder of the school; while the one next erected, in 1883, is named after the third president, the late General Francis A. Walker. These two buildings each measure about 90 by 150 feet, and in addition to a building occupied by the Boston Society of Natural History, occupy one entire square nearly in the heart of the city, and in close proximity to the Public Library and the Art Museum. Three other buildings, which adjoin each other and now form one structure, are situated about six hundred feet distant and form the front and part of one side of what will some day be one large quadrangle. The first of these buildings to be erected was the Engineering Building, built in 1889, measuring 52 by 148 feet on the ground, adjoining which is a building erected in 1892, 58 by 68 feet on the ground, and now forming part of the Engineering Building. Adjoining this is the Henry L. Pierce Building, erected in 1898, and measuring 58 by 160 feet. In addition to these buildings are the workshops, about a quarter of a mile distant, covering 24,000 square feet, and a gymnasium and drill hall.

The first laboratory to be established at the institute was that of chemistry, and this leads us to speak first of the department of chemistry. The laboratory of general chemistry was opened in 1876 under the direction of Professors Eliot* and Storer, and is believed to be the first laboratory where instruction was given in general chemistry to classes of considerable size. From small beginnings, this depart-



One of the Chemical Laboratories.

ment has rapidly grown under the able direction of such men as James M. Crafts, (since 1897 president of the Institute), William Ripley Nichols, Charles H. Wing, Lewis M. Norton and Thomas M. Drown, until now the instructing force consists of five professors, thirteen instructors and six assistants, a total teaching force of twenty-four, in addition to seven or eight lecturers on chemical subjects. The department occupies the two upper floors in the Walker Building, together with about half of one floor in the Henry L. Pierce Building, devoted to industrial chemistry. The laboratories, which are said to be the

* Now President Eliot of Harvard.

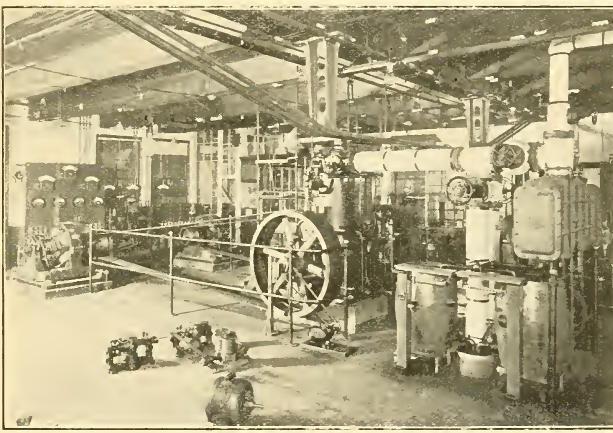
largest and best equipped in the United States, are known as the Kidder chemical laboratories, having been so named in recognition of the generosity of the late Jerome S. Kidder. They comprise twenty-two separate laboratories, three lecture-rooms, a reading-room and library, two balance-rooms, offices and supply-rooms, making forty rooms in all, with accommodation for seven hundred students. Besides the large laboratories for general chemistry and analytical chemistry, there are smaller laboratories for volumetric analysis, for organic chemistry, for sanitary chemistry with special reference to the analysis of water and air, for oil and gas analysis, for the optical and chemical examination of sugars, starches, etc., for the determination of molecular weights, and so on. In the industrial laboratories, the students are taught how to manufacture chemicals with due regard to emonomy of material, space and time. There is also a special laboratory for textile coloring, with printing machines and all the necessary equipment of baths, dryers, etc., for experimental dyeing and coloring. In this laboratory the preparation and use of coloring matters are taught with the object of fitting young men for positions in dye works. A course of lectures in textile coloring was first introduced in 1888 and the laboratory course in 1889.

A large amount of original work is accomplished each year in these laboratories, both by students and professors. During the year 1897-98, for instance, four books and sixteen articles on chemical subjects came from them. In the development of sanitary chemistry the Institute has been particularly prominent. Beginning with the careful and thorough investigations made by Professor Nichols for the State Board of Health, the reputation of the institute in this direction has been still further increased by the recent extensive investigations of Professor Drown and Mrs. Ellen H. Richards, made for the same board in connection with the examination of the purity of the water supplies of the State, and the experiments at Lawrence relating to the best methods for purifying water and disposing of the sewage of inland towns.

An illustration of the policy of the school in separating out a subject whenever it is found capable of complete theoretical and practical treatment and putting it into the hands of some assistant professor for development, is found in the laboratory for gas and oil analysis, which for some years has been in charge of Dr. Gill. In this laboratory, investigations are made relating to chimney gases, as well as questions of fuel, furnaces, gas firing, etc., while oils are tested and analyzed with reference to specific gravity, viscosity, friction, flashing and firing points, and liability to spontaneous combustion. The same policy is further illustrated in the establishment in 1894 of a well equipped laboratory devoted entirely to physical chemistry; that is to say, to the relations between chemical changes and heat, light and electricity.

This laboratory, under the charge of Dr. H. M. Goodwin, occupies a room measuring 28 by 29½ feet, and is devoted to photographic work, experiments in electrical conductivity, thermo-chemistry, molecular weight determinations and experiments in chemical dynamics. More recently still, a complete option in electro-chemistry has been established, to meet a growing demand.

Still another illustration of the policy of specialization is afforded by the action of the Institute in establishing new courses of study, extending through the entire four years, whenever the need is felt for men trained in a direction not hitherto specially provided for. Thus, in 1888 a new course was established in chemical engineering. The chemical engineer is not primarily a chemist, but a mechanical engineer



Part of the Electrical Engineering Laboratory.

—one, however, who has given special attention to such problems as the construction of dye works and bleacheries, sugar refineries, soap works, paper and pulp manufactories, fertilizer works, chemical works, and in general all the problems of chemical machinery and manufacturing. That this new course filled a real want was soon made evident. The first class, that of '91, contained seven graduates, while eighty-eight students in all have now been graduated and are for the most part engaged in chemical works.

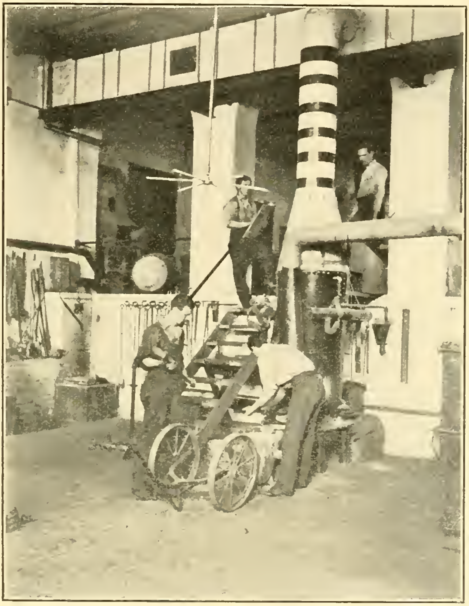
The physical laboratories of the Institute are now known as the Rogers laboratories. Although they formed perhaps the central feature of President Rogers' plan, financial and other exigencies prevented their being established when the school was opened. In 1869, Prof.

Edward C. Pickering, then in charge of the department of physics, submitted a scheme to the government of the Institute entitled 'Plan of the Physical Laboratory.' This plan was adopted and carried out in the autumn of 1869 and has been in use ever since. It is worthy of remark that the original statement of Professor Rogers with reference to laboratory instruction in physics contained no mention of electricity, then a subordinate branch, but one whose development since has caused it to occupy the leading place in any physical department. In 1882 the corporation established a course in electrical engineering, setting an example which has since been followed by almost every large technical school, and founding a course destined in a few years to become one of the largest in the Institute.

At present the department of physics and electrical engineering, under the head of Prof. Charles R. Cross, has an active teaching force of one professor, four assistant professors, six instructors and three assistants, a total of fourteen. In addition to these, there are twelve lecturers on special topics, including many men eminent in their profession. The Rogers laboratories occupy sixteen rooms in the Walker Building, including two lecture-rooms and ten laboratories. As in the case of the chemical department, these laboratories are highly specialized. There is a laboratory for general physics, one for electrical measurements, two rooms devoted to a laboratory for electrical engineering, containing two distinct power plants driven by steam engines of 100 and 150 horse-power, with a large number of dynamo machines, transformers and a great variety of other apparatus arranged for purposes of instruction, the mere enumeration of which would occupy several pages. Moreover, a lighting and power plant in the new building on Trinity Place is available for experiments and instruction. Besides these, there are rooms for photometry, for heat measurements, for acoustics, for optics and for photography. In fact, probably no department of the Institute is more fully equipped than this, the wealth of apparatus being so great that the casual visitor is confused by the network of wires and machinery which surround him.

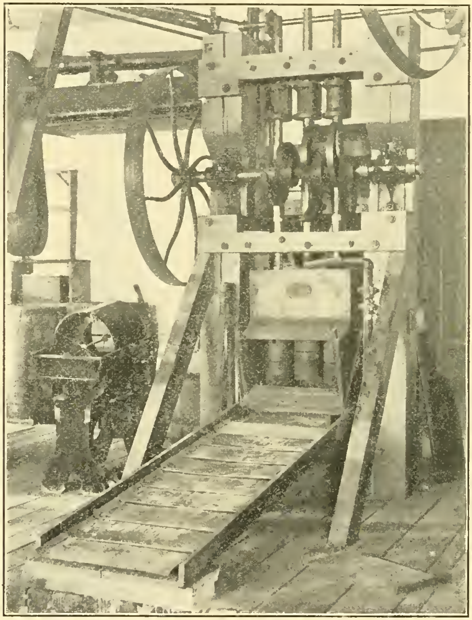
The interdependent and harmonious work of the various departments of the Institute is shown in the development of special lecture and laboratory courses, and is in marked contrast to the policy of departmental isolation sometimes practiced. Thus, in 1889, two new courses of instruction were established by the physical department in response to the demand of the department of mining; namely, the course in heat measurements, including measurements of high temperatures, the determination of the calorific power of fuels, etc., and a course on the applications of electro-metallurgy to chemical analysis, the reduction of ores and similar problems. The equipment of calorimeters, pyrometers, etc., in the heat laboratory is said to be so large as to permit a more complete examination of the efficiency of fuels than has hitherto been possible anywhere.

Perhaps the greatest innovation made by the Institute in the early days was in establishing a laboratory for the teaching of mining and metallurgy. Previous to 1871 metallurgical work was done in the chemical laboratories, but in that year the mining and metallurgical laboratory was put into operation through the efforts of President Runkle, Professor Richards and Professor Ordway. Prior to this date, there



SMELTING FURNACE IN JOHN CUMMINGS LABORATORY OF MINING AND METALLURGY.

were assaying or metallurgical laboratories at the École des Mines at Paris, the Royal School of Mines in London, the German Mining Schools at Freiberg and Clausthal and Berlin, and also in several technical schools in this country. The German mining schools were situated beside smelting works, but the plants could not often be used for experiments by professors or students in a way to alter the usual method of running. In all these laboratories, however, the apparatus was designed to treat quantities of ore not exceeding a few ounces for each test. The Institute laboratories were the first in the world which were designed for the treatment of ores in economical quantities of from five hundred pounds to three tons, and used entirely for purposes of instruction. They are now known as the John Cummings laboratories, in memory of one who for many years was treasurer of the Institute and one of its most devoted friends. They now occupy the entire basement of the Rogers Building, and include laboratories for milling, concentrating and smelting ores, as well as for testing them by assay and by blowpipe. The development of these laboratories from the



THREE STAMP MILL IN MINING LABORATORY.

small beginnings of 1871 has been mainly due to the efforts of Prof. R. H. Richards, past president of the American Institute of Mining Engineers, whose contributions on methods of ore dressing are well known to mining engineers. The staff of this department also includes Prof. H. O. Hofman, well known for his researches in metallurgy.

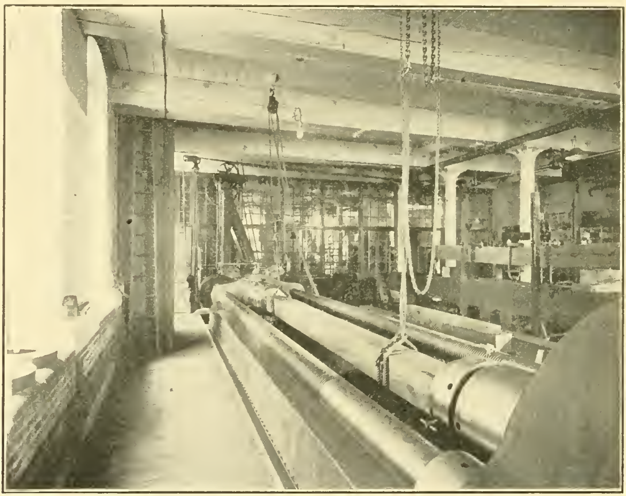
Mention should here be made of the department of geology, which is under the direction of Professors Niles, Crosby and Barton, and which now occupies commodious quarters comprising the greater part of a floor in the Henry L. Pierce Building. The collections of this department number many thousands, and are supplemented by those of the Society of Natural History, which are available for purposes of instruction. As would be expected in a school of applied science, the economic aspects of geology are kept closely in view, and the work is adapted to the particular object to be attained. The student in architecture, for instance, receives a course in geology in which the study of building stones is a prominent feature.

An engineering laboratory formed part of the original scheme of President Rogers, although he included it under the head of physics and did not anticipate the importance which has since attached to it. Such a laboratory, especially devoted to engineering, was established on a small scale in 1874, through the efforts of Professor Whitaker. An engine for experimental purposes was presented to the institute by Mr. G. B. Dixwell, and this, with other apparatus, constituted what is believed to have been the first engineering laboratory in the world for the regular instruction of classes. For lack of funds and space, it was not much developed until 1882, but since that time it has been brought to a high state of efficiency. To-day the engineering laboratories, as they are called, which include laboratories of steam engineering, hydraulics, for the testing of materials and a room containing cotton machinery, occupy a floor space of 21,380 square feet on the two lower floors of the Engineering and Pierce Buildings. In addition to this, there are workshops which will be referred to again. It would be tedious to enumerate the great variety of apparatus to be found in these laboratories, but a few important points may be mentioned. In the steam laboratory a 150 horse-power triple-expansion Corliss engine, the first of its kind of practical size ever arranged for experimental purposes, was purchased in 1890 and is regularly used for testing purposes. A second engine of 225 horse-power was added two years ago, transferring its power through a rope drive. Besides these two large engines, there are a number of smaller ones for experimental purposes and the study of valve setting, and, in addition, there are gas engines, hot-air engines and other apparatus. There is also a collection of cotton machinery sufficient to make clear to the student the mechanism of the various machines.

The hydraulic laboratory is well equipped for the study of the laws of flowing water, having a steel tank five feet in diameter and twenty-seven feet high, with a system of stand-pipes eighty-five feet high, reaching to the top of the building. This tank is furnished with gates and other apparatus suitable for experiments on the flow from orifices, and connected with a system of horizontal pipes by which a large variety of other investigations may be carried on. Among the other apparatus of interest may be mentioned two impact water wheels, placed in housings with glass sides so that the action of the water on striking the buckets can be observed.

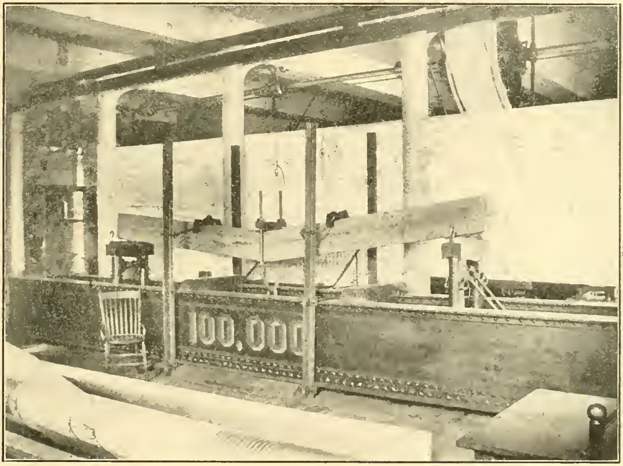
Some experiments have already been made in the laboratory on the flow of air, the results of which have been communicated by Professor Peabody to the American Society of Mechanical Engineers. It is now intended to continue the study of the flow of air and its use as a motive power in great detail, just as the flow of water is studied, and an air compressor of 100 horse-power, which will produce a pressure of twenty-five hundred pounds, is now being installed.

The laboratory for testing the strength of materials was established in 1881 by Prof. G. Lanza, and has since been extensively developed



Horizontal Emery Testing Machine of 300,000 Pounds Capacity in the Applied Mechanics Laboratory.

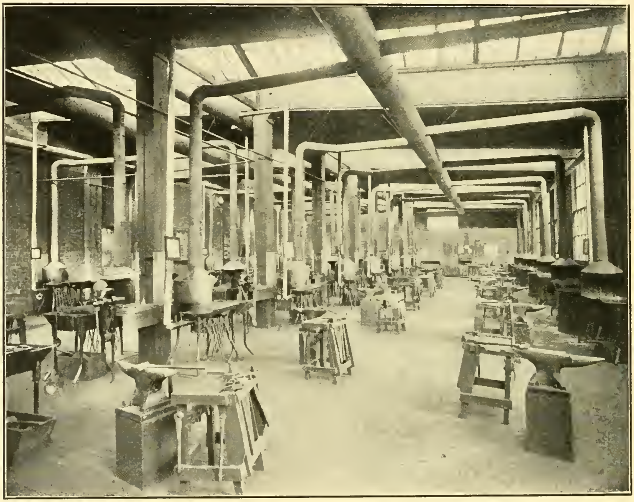
under his direction, until it is now one of the most complete in the world. It is perhaps not too much to say that the experiments made in this laboratory have in some respects revolutionized the ideas of engineers. Previous to its establishment, the only tests of timber that had been made were upon small selected specimens one or two inches square and a few feet long. The results of these tests had been used for years by architects and engineers, and they were given in all the engineering handbooks. In the Institute laboratory there were conducted the first systematic and extended tests of beams of commercial size. The results soon showed that the strength of such timber was a great deal less than previous tests on small beams had indicated, and the practice of engineers and architects has since that time been completely modified through the results obtained in this and similar laboratories. In this way does the work of such a laboratory become of direct and lasting value to the arts. The central piece of apparatus of the Institute laboratory is the Emery machine, similar to the great machine at the Watertown arsenal, with a capacity of three hundred thousand pounds. But in addition to this machine there are a dozen or more other machines designed to test beams, columns, rope, wire and, in fact, materials of every kind and in every form. An interesting machine is that for testing shafts in torsion, and it is instructive to see it twist



The 100,000 Pound Beam Machine in the Applied Mechanics Laboratory.

off with apparent ease a steel shaft three inches in diameter, twisting the fibers before they break till the rod resembles a barber's pole. There are also beam-testing machines with capacities up to one hundred thousand pounds, in which not only beams but wooden trusses may be tested to the breaking point. Some of the apparatus is of great delicacy; for instance, one instrument will measure the twist of a steel shaft two and a half inches in diameter and six feet long so delicately that the effect of a twist given by one's hand is distinctly visible; scientifically speaking, it will measure an angle of twist of two seconds. There is also a machine designed for testing stone arches, having a capacity of four hundred thousand pounds and suitable for an investigation of many questions concerning these uncertain structures; also machinery for studying the wear of brake shoes and wheel tires, a subject in regard to which there is room for much investigation. Finally, mention should be made of machinery for investigating the interesting subject of the effect of repetition of stress.

The tests performed in the engineering laboratory cover almost the entire range of mechanical science. Sometimes investigations are carried on through a number of years; for instance, during three successive years experiments were conducted and formed the subject of theses on the proper method of counterbalancing the reciprocating parts of a



FORGE SHOP.

locomotive. Nor are the tests performed by the Institute students as a regular part of their instruction confined to these laboratories, as is made evident by the fifty-hour test of the West End Street Railway power station and the twenty-four hour test of the pumping engine at Chestnut Hill, both recently carried out.

In connection with the engineering laboratories, brief mention may be made of the shops, which form an important adjunct of the laboratories. They consist of a shop for carpentry, wood-turning and pattern-making, equipped with forty carpenters' benches, thirty-six pattern-makers' benches and a full equipment of saws, planers, lathes, etc.; a foundry with a cupola furnace for melting iron, thirty-two moulders' benches, two brass furnaces and a core-oven; a forge shop with thirty-two forges, a power hammer, vises, etc.; a machine shop with about forty lathes, together with drills, planers and all the other necessary apparatus used in machine tool work.

The magnitude of the Institute laboratories is shown by the following statements: The total horse-power of steam and other engines is nine hundred and eighty-three; the total capacity of tension, compression and transverse testing machines is over eight hundred thousand pounds, and of torsion testing machines about one hundred and fifty-six thousand inch pounds; the total horse-power of hydraulic motors is sixty-two; and the total capacity of pumps is thirty-two hundred gallons per minute.

The engineering laboratories are used by students of all the engineering departments, that is to say, by a large majority of the students in the school. The benefit derived by this actual contact with materials and with machines of commercial size, under proper instruction, is believed to be very great.

The department of mechanical engineering, one of the original departments, is now the largest in the school, having a force of instruction of five professors and twelve instructors and assistants. As an offshoot of it, a department of naval architecture was established in 1893, after a preliminary experience of four years with an option in this direction. This was the first course of its kind established in this country. It is somewhat remarkable, considering the preëminence that America has long enjoyed in the building of ships and marine engines, that our technical schools should for so long have failed to offer specialized instruction in these important branches. Schools devoted to these subjects have long existed abroad. The French Government School of Naval Architecture was established in 1865 for the purpose of educating young men for the Government service. To this school foreigners are admitted under certain restrictions. In England the first school of naval architecture was opened in 1871, but no systematic instruction seems to have been provided until 1864. At present, however, the Royal Naval College, at Greenwich, gives excellent and thorough instruction to young men desiring to enter the Government service. There has also been for a number of years an excellent course of study in naval architecture at the University of Glasgow. The Institute of Technology established in 1888 an elementary course in ship construction, and this was followed in 1890 by a specialized option in naval architecture extending through the four years. Already forty-one men have graduated from this course.

One of the large departments of the school is that of architecture. Forming one of the original departments established at the beginning of the Institute in 1865, when there was no similar department in this country, it may fairly be affirmed to have led in the development of instruction in this important profession. It was for many years in charge of Prof. W. R. Ware, who left the Institute in 1880 to assume charge of the newly established department at Columbia College. In common with the other departments of the Institute, that of architecture has developed enormously within recent years. Three times since 1883 has the department been obliged to change its location in order

John D. Runkle, President, 1870–1878.

to meet the continued need of expansion. From the original small quarters in the upper floor of the Rogers Building, it has grown so that it now occupies two and one half floors in the Pierce Building, besides a large room for modelling in another building. The drawing-rooms now accommodate over two hundred students. The department has a magnificent library and a very large collection of photographs and lantern slides. Under the careful management of

Prof. F. W. Chandler, who at the same time is head of the Architectural Department of the city and member of the Fine Arts Commission, it has now attained a most enviable reputation. Institute students competed for several years for the prizes offered by the New York Société des Beaux Arts, and in each competition in which they entered they carried off the gold medal and the highest honors. In the three competitions of '94-'95, no less than seventy sets of drawings were submitted by all competitors. The two gold medals, four first mentions and two second mentions were awarded to Institute students. Of the nine designs sent from the Institute, six were placed by the jury among the first eight of the seventy designs submitted; two received second place and one was put out of competition because of too great deviation from the preliminary sketch. This great success is doubtless due to the rigorous training which the students receive in architectural design at the hands of Professor Despradelle, himself a graduate of the École des Beaux Arts, a winner of high honors in Paris, and of the third prize in the recent Phœbe Hearst world competition for the new buildings of the University of California, and within a few weeks the winner of the first medal in architecture in the Paris Salon of 1900. For three years the students are continually engaged upon architectural design, and the work of each student is examined and criticised before the class by a jury from the Boston Society of Architects. Students in architecture have also the opportunity, if they desire, of taking an option in architectural engineering, in which they are given a course in the theory and design of structures as rigid as that received by the students in civil engineering. The relations between architecture and engineering are exceedingly close and are becoming closer every year. The work of the architect, aside from the æsthetic design of his buildings, is becoming more and more like the work of the engineer, and requires a thorough knowledge of engineering construction.

During the past year, after very careful consideration, the faculty has also established an option in the course of architecture, devoted particularly to landscape architecture, including, besides a large amount of work in architecture proper, instruction in horticulture and landscape design, on the one hand, and in surveying, topographical drawing, drainage, etc., on the other hand. The landscape architect has heretofore had no opportunity to secure a thorough training in his profession, except by passing through an apprenticeship, as was formerly necessary in the older professions. On account of the steady increase in this country in the demand for trained landscape architects and the increasing attention which is now being paid by our municipalities to questions concerning public parks, and also by private individuals to the beautifying of private grounds, there seems now to be an unusual opportunity for young men to devote themselves to this branch of the profession. As usual, the Institute of Technology is early in the field with a course designed to this end.

The last of the engineering departments to be considered and one of the largest, is that of civil engineering, a department established when the Institute was founded, and until 1881 under the direction of that accomplished scholar and teacher, Prof. J. B. Henck, and since 1887 in charge of the writer. This department has grown since 1886 from four to eleven teachers, and from sixty to one hundred and fifty-three students in the three upper classes. It now occupies the two upper floors of the Engineering Building, or about twenty-three thousand square feet. In recognition of the increasing importance of sani-

HYDRAULIC SURVEYING IN THE ESSEX CANAL, LOWELL.

tary questions affecting the health of communities, a new branch of civil engineering was recognized by the Institute in 1889 by the establishment of a regular four years' course in sanitary engineering, in which particular attention is directed to such problems, and students are afforded opportunities of studying the bearing of chemistry and biology upon them. Here again the breadth and specialization of the work at the Institute was shown, rendering it possible with no change in the teaching force and with no disarrangement of studies, to establish such a course of instruction as soon as the need for it became apparent.

Interesting work has been done under the direction of Professor Burton, professor of topographical engineering, in connection with the measurement of base lines with the steel tape. After devising an apparatus for holding and supporting the tape, and measuring the coefficient of expansion of actual tapes, an application was recently made of the thermophone for determining the exact average temperature of the tape. This instrument, which was invented a few years ago by two Institute graduates, allows the average temperature of the tape to be measured within half a degree.

An interesting deparment of the Institute, and one that has of recent years assumed great practical importance, is that of biology. It was organized in 1882, as an outgrowth of what was prior to that date the course in natural history, and now has a teaching force of six, under the direction of Prof. William T. Sedgwick, and occupies, with its laboratories and lecture-rooms, one entire floor of the Pierce Building. There are five distinct laboratories, fully equipped, with private rooms, store and preparation rooms, and a library and reading-room, and it is perhaps safe to say that nowhere in the United States is there so compact or well arranged a series of laboratories devoted chiefly to the sanitary, hygienic and industrial aspects of biology. The great advances in sanitary science in recent years have made bacteriology one of the most important, as well as one of the most practical, of the biological sciences, and the biologist has taken his place beside the chemist and the engineer in the study of the science and art of public sanitation. But bacteriology is of importance, not only in sanitary science, but also in its industrial relations. Great industries, like those connected with food preserving, canning, vinegar making, tanning and brewing, depend upon the activity or the exclusion of micro-organisms. As might be expected in a school of applied science, the development of the biological department in the Institute has been mainly along sanitary and industrial lines, rather than in the direction of zoölogy. The biological work in connection with the recent important investigations of the State Board of Health regarding the purification of water and the disposal of sewage, was done at the Institute, and early led to special instruction in these directions. In 1894 a course was established in the micro-organisms of fermentation, not only new to the Institute, but, it is believed, to the United States. Important researches had been made in Denmark in these lines, and in order to become thoroughly familiar with them, one of the instructors of the department spent a summer in the laboratory of Alfred Jörgensen, in Copenhagen. In 1896, a more elaborate course, that in industrial biology, was established, and since that time special studies have been made in various lines, such as the efficiency of sterilizing processes, the preparation of canned goods and the cultivation of butter bacteria. This department is destined to still greater development in the near future, and its laboratories are finely equipped in every direction.

Reference to the different departments in the Institute would not be complete without brief mention of its department of general studies. It is perhaps seldom recognized, but it is nevertheless a fact that the Institute, although primarily a technical school, is better equipped for giving instruction in languages, in history, in economics and statistics and in political science than many classical institutions. Indeed, the only important department of study which is found in such institutions,

Francis A. Walker, President, 1881–1897.

and for which no provision is made at the Institute, is that of ancient languages. The force of instruction in the department of general studies, leaving out of consideration the department of modern languages, comprises two professors, one associate professor, three assistant professors, one instructor and one assistant, a total of eight, probably a larger number than is found in any but the very largest colleges. In the department of modern languages, there is one professor, one associate professor, one assistant professor and four instructors. There are offered ten distinct courses in English, eleven in modern languages, eight in history and twenty in economics and statistics and in political science. As already stated, it has been a fundamental principle in the government of the school that all regular students should receive a not inconsiderable amount of instruction in these subjects, but in addition to the engineering and other technical courses, there is a so-called course in general studies, designed to train young men for business occupations, in which, besides thorough courses in chemistry, physics and other sciences, a large amount of time is devoted to the general studies which have been referred to. The late president of the Institute, General Walker, whose principal work, aside from that relating to education, lay in the field of economics and statistics, took great interest in the development of this general course, and to him, more than to anybody else, is due its present high standard. Seventy-eight young men have graduated from the department, and in many respects its course of study offers advantages over the usual college course.

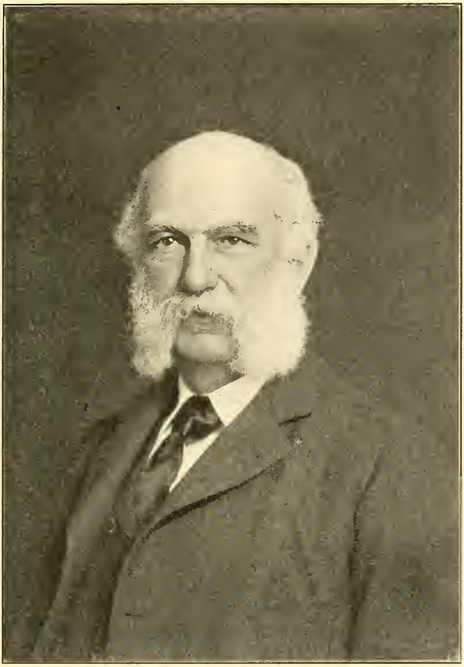
Summer schools are maintained by the Institute in the departments of civil engineering, mining engineering and architecture. That in civil engineering affords continuous field practice in geodesy and hydraulics during about a month. That in mining engineering affords students an opportunity to visit mining or metallurgical works and to become practically acquainted with the methods employed by actually taking part in them. These summer schools in mining and metallurgy have been held in all parts of the country, from Nova Scotia to Lake Superior and Colorado. The summer school in architecture consists not infrequently of a trip abroad, with detailed studies and sketches of special types of architecture.

The Institute also offers extended courses of free evening lectures, of which twenty courses of twelve lectures each were given during the past year. These courses, established by the trustee of the Lowell Institute under the supervision of the Institute, correspond to one portion of President Rogers's original plan, and are fully appreciated by young men who cannot afford the time for a complete and consecutive education. The trustee of the Lowell Institute also established in 1872, and has maintained ever since, a special school of practical design, under the supervision of the Institute, in which young men and women are given free instruction in the art of making patterns for prints, ginghams, silks, laces, paper hangings, carpets, etc.; the object being to fit them to engage in the textile industries especially, but also in other branches of manufacture in which taste in form and color is an essential element for success.

Mention may be made here of the fact that all work at the Institute is open to women on the same terms as to men. As early as 1867, among the Lowell free courses, there were two chemical courses open to both sexes, and soon afterward women were admitted to the regular work of the school. The first woman to graduate was Mrs. Ellen H. Richards, in 1873, and since that time forty-eight women have received the degree. This number, however, is no measure of the part which women have taken in the work of the school, for a large majority of those who attend are special students. During the year 1899-1900, there were fifty-three women studying at the school, principally in the departments of chemistry, biology, geology, physics and architecture. From the last-named course eleven young women have graduated, one of whom was the designer of the Woman's Building at the Chicago Exposition.

One peculiarity of the Institute which has not been mentioned is the sub-division of its libraries. Instead of having one general library, each department has its special library, conveniently located with reference to its rooms. This involves a slight duplication of books, but is of the greatest advantage to students and teachers for consultation. The Institute libraries are not large, compared with the libraries of many colleges and universities, but they are remarkably rich along the lines of the special topics to which they are of necessity principally devoted, and particularly in scientific periodicals. The total number of periodicals in all languages regularly received at the Institute, not including a large number of official reports, is eight hundred and forty-seven. In the engineering library alone there are one hundred and seventy-three. It is believed that this forms one of the largest collections of scientific journals to be found anywhere. The Institute publishes a scientific magazine, known as the Technology Quarterly, which was established in 1887, and is the official organ for the publication of the results of tests in the laboratories and of special investigations by members of the staff and by students and alumni. The Association of Class Secretaries also publishes the Technology Review, a more popular quarterly, established only two years ago, and devoted to the social and general interests of the Institute. In 1896 the Technology Club was started, occupying a building near the Institute and affording alumni and students the social advantages of a clubhouse. The alumni of the Institute now number two thousand three hundred and thirty-nine; they maintain an Alumni Association which holds annual meetings, and seven local branch associations which are scattered over the country from the Connecticut Valley to Colorado.

In reviewing the success which this school has attained, the question naturally presents itself: To what is this success due? Let me here record my conviction that it has been due mainly to the courage and devotion of its corporation and of the presidents who have directed its policy. In this respect no institution was ever more fortunate. With a guiding body possessed of the courage and faith that have animated the corporation of the institution from the earliest days, and especially with the able men who have been its presidents, success was assured. While the school was yet struggling for its very existence, with few friends and little money, they never faltered. They have not hesitated again and again to plunge the school deeply into debt when its needs required it, trusting to the generosity of New England



JAMES M. CRAFTS, PRESIDENT, 1897–1900.

that it should not be allowed to be crippled, and each time has their confidence been justified. Poverty has never been permitted to impair the efficiency of the school. As President Crafts remarked in a recent annual report, "We are less favored than many neighboring institutions in building space, but we have always followed the wise policy of keeping in the foremost rank and in some departments leading the way in supplying the best methods and apparatus for teaching and for making investigation. We have run in debt to buy them, and run still further in debt to build houses to hold them, but we have always had them when the head of a department told the government of the school that they were necessary to the most efficient teaching of his science." With a corporation acting on such a principle there could be no failure. It is true that the faculty have stood unfalteringly, even in the darkest days, for high scholarship; and equally true that the school has been remarkably fortunate in the character of the young men who have sought its halls, but no faculty and no body of students could have brought success with a corporation less broadminded and courageous. Let me here add my tribute to the work which was done by the late General Francis A. Walker, president of the Institute from 1881 till 1897. Probably no single person did more to secure the success of the school than he. His great administrative ability, his wide acquaintance, his accurate judgment of men, his magnificent courage and his splendid enthusiasm, were factors in the development of the school whose importance it is difficult to overestimate.

General Walker was succeeded by President James M. Crafts, who had been connected with the Institute for many years as professor of chemistry, and under whose energetic administration the progress of the Institute has been steadily continued. In fact, thanks to some unexpected additions to the funds of the school, its material resources and its equipment have been more enlarged and extended during the past three years than in many years previous. Only a few months ago, however, President Crafts, desiring to devote himself more uninterruptedly to the pursuit of the science which first awakened his enthusiasm and in which he has attained such eminent distinction, both in this country and abroad, decided to relinquish his office. The corporation has chosen as his successor, Dr. Henry S. Pritchett, for many years professor of astronomy in Washington University, St. Louis, and for the past few years superintendent of the Coast and Geodetic Survey at Washington. A more fortunate selection could not have been made, and the well-known scientific and administrative ability of Dr. Pritchett will no doubt be the means not only of maintaining the present high reputation of the school, but of extending and enlarging it.

Unfortunately, the Institute is still unendowed in the sense that its receipts from invested property constitute but a very small part of the means required to carry on the school. To quote from one of President Walker's reports, "No other institution of our size but has two, three or four times the amount of wealth to draw upon which we possess. It has only been exceeding good fortune, combined with extreme courage, energy and self-devotion on the part of its trustees and teachers that has more than once rescued the school from paralysis, if not from extinction." In 1898-'99, the total expenditures of the school were about $367,500, while the current receipts were about $347,500, showing a deficit of about $20,000. Of the current receipts, $207,000, or 59 per cent, were from students' fees. Dividing the total expenditures by the number of students, we find an expenditure of $314 per student, without counting interest on the value of land and buildings, while the tuition fee is $200. The invested funds of the Institute amount to but $1,917,000. All gifts and legacies, with the exception of this amount,

HENRY S. PRITCHETT, PRESIDENT-ELECT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

have had to go into land, buildings and equipment. Between 1888 and 1899 the Institute has been obliged to spend $350,000 for land, the purchase of which has been a great burden, and within a few years a further expenditure of $260,000 in this direction has been made.

The bearing of these figures will perhaps be realized by comparing them with similar figures regarding Cornell University, which is largely a technical school, since nearly one half of its students pursue technical courses similar to those in the Institute. In 1898 the total income of that university was $583,000, of which about $121,000, or only 20 per cent, was received from tuition fees. Its invested funds amounted to $6,446,818.

The State has generously given aid to the Institute in some of its most trying times; as in 1888, when it gave $200,000, one half unconditionally and the other half for the support of free scholarships; and again in 1895, when it granted unconditionally $25,000 a year for six years and $2,000 a year additional for scholarships. Although the school has a very inadequate endowment, yet the future looks bright. It is significant of the general appreciation of its work that men and women who have not received a technical education have devoted a large part of their fortunes to providing such education for others. Among the recent benefactors of the Institute we may name Henry L. Pierce, John W. Randall, Mrs. Julia B. Huntington James and Edward Austin, who, within less than three years have bequeathed nearly a million and a half dollars to the school. If the large gifts of recent years are continued, the school will before long be put financially upon a level with its neighbors. May we not hope that as the applications of science to the arts enrich the alumni and friends of the Institute, they may help to make the road easy for their successors by devoting a part of their riches to the advancement of technical education?

THE PSYCHOLOGY OF CRAZES.

BY PROFESSOR G. T. W. PATRICK,
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A WELL-KNOWN Washington newspaper correspondent, writing of the recent Congress of the Daughters of the American Revolution and its disorderly meetings, says: "It is the unanimous opinion of those who have attended the congress that, while the Daughters of the American Revolution, individually, are nearly all intellectual, refined and attractive women, collectively they are an uncontrollable mob." Why is the social conduct of human beings different from their conduct as individuals? This is the problem of the new science of social psychology. The following study of crazes and epidemics is offered as a slight contribution to this science.

By way of preface it might be said that a good deal of the confusion as to the subject matter of social psychology would be avoided if it were understood that this science is not the study of any mysterious entity called 'the social mind,' nor the mere study of those individual traits that make men social beings, such as imitation and suggestibility; but rather the study of the peculiar and characteristic behavior of the mind of the individual when under the influence of the social afflatus. Under this influence we do indeed find that he becomes a different being, and that his mental processes must be formulated by different laws; and we are convinced that, as thus understood, social psychology is just as distinct and legitimate a branch of study as is the psychology of the child or the psychology of sex.

Now, in what ways is the behavior of man as a social being different from his behavior as an individual? To answer this question in part, let us examine his behavior in mental epidemics and crazes. I select these because they illustrate in somewhat extreme form the influence of the social afflatus.

If, for the sake of comparison, we first consider the normal individual as such, we find that he is a perceiving, remembering, associating, judging, reflecting, reasoning being; that he is subject to certain feelings, emotions, desires and impulses, prompting him to action; that his action is more or less deliberative, and, when it finally occurs, is the result of a set of motives determined by the man's character, which in turn is the outcome of his heredity and education and his general ability to appreciate and reflect the moral ideals of the social order to which he belongs. If now we study this man in respect to his mental development, whether from the savage or the child, we find that the direction of change has been away from imitative, impulsive action, towards thought, reflection, deliberation. He continually makes more use of memory and, anticipating the future, regulates his action in the light of his past experience. This change from the imitative and impulsive to the reasoning man accompanies the development of the higher brain centers, particularly of the cerebral cortex, upon which depend the all-important functions of memory and association. As an experiment it is quite possible to reduce this highly developed reasoning being in a single moment to a condition resembling his primitive state by means of hypnotism. In hypnosis there is a temporary paralysis or sleep of the higher brain centers, upon which depends deliberative, rational action, and, the lower (older) centers alone being active, the subject becomes a mere ideo-motor machine acting out every suggestion. In various related states of automatism, where there is any spontaneity at all, the mentality and morality of the subject are of a lower type and may be called reversionary in character, owing, no doubt, to the fact that those brain centers which represent the most recent acquirements of the race are temporarily out of the circuit.

If again we study the mind of the child, we find that it presents many points of likeness to the mind of the hypnotic subject and to the mind of the primitive man. We learn from biology that the child is to some extent a recapitulation of the life of the race, passing through in his individual development the stages of race development. Physiologically speaking, the higher brain centers and the centers for association, which are late acquirements of the race, are last developed in the child. We are therefore not surprised to find that the child, like the savage and the hypnotic subject, is imitative, impulsive, non-reflective, incapable of much abstract thought, deliberation or reasoning, and that he acts with a view to immediate rather than remote ends.

If now we turn to the behavior of the normal adult man in mental epidemics and crazes of all kinds, from the Crusades to the Massacre of St. Bartholomew, from the tulip mania in Holland to the Dewey welcome in New York City, we observe that his behavior is to some extent similar to that of the hypnotic subject, and the child, and the primitive man. The general character of mental action in epidemics is as follows: Men become imitative beings and their actions are determined by suggestion from the actions of others. Memory and the association of ideas are inactive, and there is an inability to reason and an indisposition towards deliberation and calm reflection. Past experiences are disregarded, remote consequences are not seen and behavior is impulsive and spasmodic. Feeling is very strong and every kind of emotion is apt to be exaggerated. Calm observation is also lacking and mental images may be mistaken for objective reality, as in the case of the hallucinations that are frequent in these phenomena.

The moral peculiarities of an epidemic are of a similar kind. Under the influence of a craze, the moral character of a people suffers a reversion to a primitive type. In times of epidemic waves the moral standards of the crowd approach those of the savage. We observe the exhibition of primitive instincts, such as cruelty, revenge and bloodthirstiness, together with changeableness, fanaticism, self-sacrifice and enthusiastic devotion to a leader. All these moral traits were well illustrated in the Revolution crazes in France and in the persecution of witches in the sixteenth and seventeenth centuries. Even in our own times a striking example of the primitive character of the morality of a people under the influence of social excitement was seen in the battle-cry of our American sailors in the recent Spanish war, 'Remember the Maine,' the ethical motive being a precipitate impulse to seek revenge. An instance like this can not be explained upon the theory that it represented the actual individual morality of the sailors participating in the battles, for it was echoed and apparently endorsed by the press throughout the country and upon the platform and even in the pulpit. It is hardly conceivable that an Englishman of noble birth should openly boast of his joy in being revenged upon an enemy; yet collective England is wild with delight when 'Majuba Hill is avenged!'

We are thus led apparently to the theory that, for some reason not yet evident, under the influence of social excitement, something takes place in the brain of the individual not unlike the action of hypnotism, by which the higher centers representing the more recent moral and mental acquirements of the race are temporarily paralyzed, reducing the subject in a greater or less degree to the condition of the child and of the primitive man. The observation of certain physical phenomena which often accompany mental epidemics tends to confirm this theory and at the same time to suggest a possible explanation. Epidemics of the more extreme kind are apt to be accompanied by great muscular excitability, varying all the way from mere extreme mobility, such as shouting, jumping and throwing the arms, to convulsions like those of epilepsy. The dancing manias of the fourteenth and fifteenth centuries furnish the best illustrations of this, although these phenomena did not equal in intensity the frightful physical convulsions during the religious revivals in Kentucky at the beginning of this century. The particular character of these muscular movements is determined by imitation and suggestion. The movements themselves are no doubt due to congestion and irritation of the motor centers, or at least to a rapid overflow of nervous discharges at these centers, an accompaniment of the excessive emotion which attends all mental epidemics. In such a condition of the nervous system, thought, reasoning, memory and association can have little place, or, to express it physiologically, the unusual excitement in the lower centers of the brain accompanying excessive emotion may not only find expression in muscular movements, but may also exercise an inhibitory or paralyzing effect upon the higher centers, resulting in a kind of hypnotic condition. Neither is it difficult to understand the presence of this excessive emotion during mental epidemics or during any purely social movements, when we remember that war itself is the great original social movement, which even in this age always takes the form of a mental epidemic called the war spirit. The emotional effect of the mere physical congregation of a large number of men, the emotion increasing with the size of the assemblage, is known to all.

As we glance now at a few of the typical mental epidemics of history, we shall notice the ever-recurring presence of some or all of the mental and moral traits that I have pointed out. For illustrations of these phenomena we may turn indifferently to ancient, medieval or modern history. They abound at every period.

Very good examples may be found in Hecker's 'Epidemics of the Middle Ages.' In the Crusades, particularly in the Children's Crusades, we may observe all the mental, moral and physical peculiarities that have been mentioned. In the anti-Semitic mania, we see in its history of criminal horror the dehumanizing effects of the epidemic and the moral reversion which takes place under the influence of social excitement. The peculiar physical phenomena which have been referred to as characterizing epidemic excitement are best illustrated in the dancing manias of the Middle Ages and in the religious revival. Although epidemic 'revivals' have occurred in all countries, some of the best illustrations are seen in America in its early history and to some extent at the present day. At the time of the elder Edwards, revivals were accompanied by fainting, falling, tremor and numbness. In the Kentucky revivals the meetings, called camp meetings, were held in the open air. The interest in them spread in true epidemic form. At the height of the excitement, as many as 20,000 people, men, women and children, were gathered in a single camp at one time. Dr. Davidson, who writes a history of this revival, says that "the laborer quitted his task, age snatched his crutch, youth forgot his pastime, the plough was left in the furrow, business of all kinds was suspended, bold hunters and sober matrons, young men, maidens and little children flocked to the common center of attraction." The emotional tension was very great. A boy perhaps would spring to his feet and begin to rave, or some over-excited person would utter a piercing shriek, or a cry of triumph, and this would be the signal for a general hysterical outbreak, accompanied by many remarkable physical symptoms. Of these the most common were falling in convulsive spasms, jerking, dancing, barking like dogs, fainting, crying, singing, praying and cursing. Sometimes whole companies were seized with uncontrollable laughing fits, called the holy laugh. At a meeting in East Tennessee, six hundred began jerking at one time. In many instances sensibility would be lost and the extremities would be cold, while the face was flushed. In some places the sufferers were laid out in rows and squares in the churchyard until they should recover. From a medical point of view we should call this epidemic chorea, but its more exact physiology I have already referred to. When closely examined, the phenomena lose a part at least of their mysterious character. We must remember that religious emotions are powerful, deep and ancient. The effect, furthermore, is increased by the general epidemic excitement, by the element of large and unwonted gatherings of people, by imitation, by the stimulating music and by the fearfully exciting power of human shrieks and wild cries and prayers. Such a nervous condition induced in an individual must have two results: first, the escape of the unusual nervous excitement in motor channels, giving rise to the choreic movements; and second, the paralysis of the higher brain centers, resulting in various hypnotic phenomena and reversionary morality and mentality.

Many of these scenes were repeated in the great revival that swept New York and the Middle States, beginning in the year 1832. In these meetings preachers who kept cool and reasoned logically were not listened to. There was rather a demand for the wild, impetuous, vociferous, physically impassioned oratory of the rude man. As an example of reversionary morals in this epidemic, we may notice the fact mentioned by Albert Rhodes that in response to visions many men put away their own wives and took others from their neighbors.

From the psychological point of view perhaps the most instructive of all epidemics is the demonophobia or witchcraft mania which raged from the end of the fifteenth to the end of the seventeenth centuries. The savage's fear of demons and of unseen supernatural agencies lurking in every forest and moor now took hold of the modern world and turned the people, not into brutes and devils as we figuratively say, but simply into the original savages from which they came, whose basal instincts they still carried in their lower nervous centers, to be brought out under the influence of a social craze. The ecclesiastical authorities, both Roman and Protestant, led in this homicidal frenzy, while sedate judges, learned jurors and wise legislators lent their zealous aid. It spread in true epidemic form all over the Continent and into England and Scotland, even to America. Distinguished jurists declared that ordinary methods of trial should not be used for this offence, for so difficult is it to bring proof of the crime of witchcraft, that out of a million of witches not one could be convicted if the usual course of justice were followed. One contemporary of undoubted authority wrote that he saw a list of three thousand witches that had been put to death during the time of the Long Parliament alone. In this reign of demonophobia the psychological phenomena of the craze are well illustrated. The exciting cause was a widespread contagious and epidemic fear. The result was a recrudescence of the barbaric instincts of cruelty, torture and homicide, accompanied by a loss not merely of reasoning power, but apparently of common sense, so that intelligent men seemed to believe that old women blasted the crops in the fields and the offspring of animals, and raised storms and whirlwinds. The cruelty characteristic of the savage is again noticed in this case. In the witchcraft persecutions, the victims were commonly weak women, particularly the more helpless old and young, while the character of the inflictions was such as is peculiar to primitive people, viz., torture and burning alive. The perfidy of the savage is also noticed, as in innumerable instances the victims were led to believe that they would be spared if they made a confession, and were then put to death. To elude a legal requirement that torture should not be repeated, the most horrible tortures were 'continued' from day to day.

The psychology of crazes is clearly seen in certain of its aspects in the homicidal manias that have swept over communities or whole countries at frequent intervals in the world's history. The homicidal impulse itself is one of the most primitive and basal of all impulses. The reason for this is apparent. The history of man has been a history of warfare and of struggle for existence. It has been man against man, tribe against tribe, nation against nation. Habits like these are not quickly unlearned, and reversion to them in times of social disturbance is not strange. In the massacre of St. Bartholomew we have a typical instance of the homicidal mania. The necessary conditions were, first, great emotional excitement caused by religious fanaticism acting as an inhibitory agent upon the higher brain centers and allowing the primitive impulses to act unchecked; second, the removal of external and customary restraints, effected in this case by the royal decree; and third, the mental effects of imitation and suggestion. These conditions being all supplied, the French people resolved themselves speedily into assassins and cut-throats, and enjoyed a homicidal debauch. Begun in Paris, the massacre spread in true epidemic form throughout France, until fifteen or twenty thousand people had perished.

These homicidal manias have, of course, been very frequent in history. The decivilizing influence of the craze is, however, most perfectly illustrated in the various scenes of the French Revolution. Here the overturning of the social and religious order itself acted in part as the unsettling and emotionally exciting cause. The usual results followed. The effect of social excitement in paralyzing the intellect was shown in this case in the wholesale and useless destruction of women and children. Furthermore, this reversion to the manners of the savage carries with it its appropriate mood. The slaughterers are not like demons, as we imagine demons to be, but rather like thoughtless children. There is merriment and much gayety, and there is dancing and singing around the corpses, and seats are arranged for the ladies, who are eager to enjoy the spectacle; and finally the victims are made to pass through a double row of executioners, who carve them into pieces gradually, so that all can saturate themselves with the sight of the bloodshed.

Although in some cases wars may be coolly planned by the people's leaders for personal or political reasons or for purposes of national conquest, still they all depend for their successful issue upon the homicidal impulse in the masses of people. This is called the war spirit and is always of an epidemic character. It may have any degree of ferocity or mildness. It has a tendency to be periodic, so that if it has slumbered for a considerable period a very slight cause is sufficient to awaken it. A mere boundary line in Venezuela, in which this country had but a remote interest, was sufficient a few years ago to excite this war spirit in a milder form, when a curious craze for a war with Great Britain flowed like a wave across this country.

Any war will furnish instructive material to the student of social psychology. In the late Spanish-American war, for instance, we all felt the war spirit which flowed in epidemic form across the country and engulfed it. The first motive of the war, the altruistic desire to free an oppressed people, was of the ideal glittering kind, well fitted to excite the emotions of the masses. A dramatic event further fans this emotional flame, and at once the aggregate personality of the nation is in a condition of automatism, where primitive instincts, such as revenge and lust for the paraphernalia of war, are no longer checked by the more lately acquired moral principles. Congressmen, editors, members of peace societies, ministers of the gospel, forget their long and patient efforts to establish means for settling national differences by arbitration and join lustily in the war cry, and the psychologically curious spectacle is presented of a great nation, priding itself as a leader in the world's morals, giving to the appeal of a weaker nation for the arbitration of a dispute the answer of shot and shell. Although the motive of blood for blood is a moral motive belonging to a bygone age and in individual ethics has long been outgrown, yet collectively, under the influence of the war craze, we revert to it, and it is shamelessly proclaimed from platform and editorial room and vigorously applauded by the people. We have seen that cruelty and the persecution of the weak by the strong were among the reversionary symptoms of the social epidemic in many instances. We may notice curiously enough a trace of these qualities here, where the fact that our enemy was a greatly inferior power does not detract in our eyes from the brilliancy of our victories, though in the ethics of the individual such a circumstance would put us to shame. In all this we proceed strictly in accordance with international law, but international law itself is only international custom and is the mere expression of the wonted behavior of the aggregate personality, particularly in times of war. As such it does not represent the highest ethical development of man, but that lower stage of development to which he reverts in times of social excitement. From this point of view it is possible to understand why international ethics is so far behind individual ethics. Personal disputes were once settled by brute force as international disputes are now settled. There is no reason to doubt that the latter will, somewhat later in the history of civilization, be settled by courts of arbitration and enforced by a system of police as the former now are.

The considerations now before us show the futility of peace congresses in that part of their work which contemplates the enforced substitution of arbitration for war. Peace congresses are not social movements. They spring from the efforts of individual men, leaders in social reform. They belong to the upward ethical movements led by individuals, the slow, painful climbing towards higher moral and intellectual standards. These congresses may meet and discuss arbitration and perfect an international program, but they labor in vain, for they forget that social man has a double personality and that the personality that meets and deliberates in the peace congress is not the personality that, under the influence of the war craze, thrills with emotion and acts from ancient and deep rooted impulses and motives. When the war spirit sweeps over a country the social personality passes into a condition not unlike that of hypnosis and is ruled by a different set of moral principles. It should not be understood from this that peace congresses are useless. They are a part of an educative system whose influence in the end will be strong enough to react upon the secondary social personality and determine its behavior.

Among crazes of a different kind, we may notice financial crazes as an interesting type, falling under the same laws as those mentioned. Both in panics and in speculative manias we observe again a species of hypnotization. In the case of the latter the ordinary business shrewdness which characterizes the dealings of the individual in a normal state and which depends upon the activity of late developed association tracts in the brain, is to a large extent lost. The memory is impaired and what in general we may call prudence is lacking.

The psychology of the speculative mania is very simple. There is first, greed, furnishing the necessary emotional excitement; then imitation; then precipitate, unreasoning action. In the panic, the psychological sequence is the same, except that fear takes the place of greed. The stampede among animals may be taken as the type of all panics. It is a reflex phenomenon consisting merely of contagious fear and precipitate, unintelligent flight. Fear and flight constitute a most primitive form of mental action, equalled in primitive character only by that other form whose survival we have seen illustrated in wars and homicidal manias, viz., anger and combat. Although the individual has long outgrown these simple reflexes, yet in social excitement he reverts to them. The recrudescence of the first of these two forms is seen in the case of panics in theatres and burning buildings, where social fear is followed by unintelligent flight, there being a temporary paralysis of reason, prudence, the power of choosing means to ends, respect for women and consideration for the weak and feeble.

The limits of this paper permit me only to refer to other forms of the craze illustrating the same laws. In fads and fashions of all kinds, the behavior of the social personality is different only in degree from that already described in the more serious epidemics. The law of imitation is the same, but there is less excitement and emotional disturbance and consequently a lesser paralysis of the higher mental faculties and a lesser return to barbaric impulses. Whereas the others may be called forms of social paranoia, these may be called forms of social monomania. A single idea fills the public mind, and as a result this idea is unduly exalted as to its importance and worth. The higher mental powers are paralyzed only so far as that there is a perverted judgment as to the relative importance of things and consequently a more or less distorted view of the world and its values. Perhaps the simplest form of this craze is seen in the epidemic character of children's games. At different times of the season different games completely fill the social consciousness of the child-world, so that for the moment there is no interest in any other game. New and interesting sports, such, for instance, as golf, often fill the social adult consciousness in the same way. Then there are social and literary fads, crazes in musical airs, fashions in dress, furniture, houses and carriages, without number. Crazes of all kinds have found a prolific soil in America. The American mind is highly suggestible. One fad after another rages over the country and in some cases reduces the aggregate mind to a condition of idiocy. The Dewey craze in New York City last year is an illustration of this. Nothing but a sort of hypnotic distortion of intellectual vision could cause grown men to stand in line for an hour in order that they might sit for an instant in the chair in which the hero sat during the review, or to fight for shreds of the flags and awnings that decorated the platform.

Sporadic social reform movements take the form of crazes and illustrate the same laws. One recalls the Woman's Crusade in 1873, the result not of a rational plan but of imitation, and the Granger movement and the Farmers' Alliance and the greenback craze and the silver craze and many others.

Since Aristotle we have been told that man is a social animal and that to study him as he really is we must not isolate him from society. The evident truth of this may lead us to forget that it is but a half truth and the uncritical acceptance of it will lead us wholly astray in our sociological study. The inference which we seem compelled to draw from studies in social psychology is that social man is, in his ethical and intellectual development, many stages behind the individual man. The progress of civilization is a slow, painful, upward climbing, in which individuals are the thinkers, the planners, the promoters and the leaders. The mind of society, on the other hand, using the phrase in the sense defined, is an imitative, unreflective, half-hypnotic, half-barbaric mind, always acting as a drag upon the upward and forward movement, and, in times of crazes, epidemics and social cataclysms, gaining temporary dominance and causing disastrous relapses to a lower plane of civilization.

SOME PHASES OF THE EARTH'S DEVELOPMENT IN THE LIGHT OF RECENT CHEMICAL RESEARCH.

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IN the following pages an effort is made to apply some of the results of recent chemical research to the earlier history of the earth. It is hoped that the main facts brought out may be readily grasped by those who have never studied chemistry, and that each link in the chain of events will be made evident to those who have mastered the rudiments of this science.

Chemical action involves change of composition. Substances more or less complex may be broken down into simpler substances, or from several simpler substances a complex substance may be built up. From the complex ore of copper found in nature the simple element copper is obtained. From the elements sulphur and oxygen and the simple substance water the complex sulphuric acid is built up. Within the last few years the high temperature of the electric arc—the heat generated by a powerful electric current playing between two carbon poles—has been employed in bringing about chemical changes which do not occur at ordinary temperatures nor at those obtainable by burning fuel. The electric furnace is used industrially to make calcium carbide from lime and coke, carbon silicide (carborundum) from coke and sand, and the metal aluminum from its compounds.

Chemical changes at high temperatures have long been an object of research, but it was not until the introduction of the electric furnace that it was possible to command temperatures high enough to make exhaustive studies. In the last few years several chemists, especially Moissan, of Paris, and his pupils, have done systematic work with the aid of the arc furnace. The furnace used in the laboratory for high temperature work is a small and simple apparatus; Moissan's furnace is a block of quick lime a little longer and wider than a page of this magazine and about three inches thick. A rectangular cavity is cut on the upper surface of this block. A similar block forms the cover. In opposite grooves between the top and bottom piece are placed the carbons, such as are used in ordinary arc lights. The arc plays across the cavity in such a manner that the substance to be heated is not brought into the arc itself, which is vaporized carbon, but below it. The cavity thus represents a tiny reverberatory furnace; the arc heats the roof and sides to an intense heat, which is radiated on the open dish or closed crucible or tube containing the substance heated. This is the simplest form of laboratory furnace. Various modifications are used, but in all the size is small and the arrangement simple. A powerful arc plays in the smallest possible cavity with the object of attaining the maximum of temperature, expense and duration of material being secondary considerations. Lime and magnesia are the best materials, because they are at the same time the most refractory substances available and are poor conductors of heat. A furnace top one and one half inches thick may be heated by so powerful an arc that the melted quick lime drips from the inner surface, while the outer surface is scarcely warm to the touch of the hand. Moissan has utilized in these little furnaces currents of electricity of varied strength, the lowest being that given by a four horse power dynamo, the highest that generated by three hundred horse power. The highest temperatures obtained were about 3,500° centigrade (6,300° Fahrenheit), with the heat constantly increasing; the limit to the obtainable temperature—as far as the experimental evidence showed—was merely the lack of any known substance refractory enough to bear the heat; for at the temperature mentioned quick lime and magnesia not only melt but are changed into gases, so that the furnace was filled with the vapors of its own material.

The effect of the heat on single substances is very interesting. Refractory metals, such as iron, manganese, uranium, platinum, melt rapidly and then become gaseous; the most refractory non-metallic elements, silicon, boron, carbon, are also changed into the gaseous form. Very refractory compounds are broken down into simpler ones. Magnesium pyrophosphate yields phosphorus, magnesium oxide and oxygen. Asbestos—a magnesium silicate—gives as chief product magnesium silicide; the other substances formed being silicon, silicon dioxide and a little magnesium oxide.

Such are the astounding changes wrought by simple heat upon those substances which we are accustomed to regard as infusible. It must be remembered that the range of temperature which chemists employ in ordinary laboratory work is not very great and that the conditions of work in the laboratory and of nature's work on the earth's surface at the present day favor the formation of two classes of compounds—the oxides and their hydrates. Although air is a mixture consisting mainly of four parts of nitrogen and one of oxygen, atmospheric nitrogen is generally inert at ordinary temperatures, and it is the oxygen of the air which is the more important factor in the growth of living things and in changes in lifeless matter. Water, a compound of oxygen and hydrogen, is present everywhere, either in the liquid form or as vapor in the air; even in the flame of the hottest fires there is water vapor in abundance, since water is one of the chief products of combustion of most forms of fuel. Is it a wonder that under such conditions we find the earth's crust to contain the elements chiefly compounded with oxygen? Was this always so? Are we justified in supposing that conditions may have prevailed—nay, must have prevailed—in former times on the earth's surface, which gave to other elements as important or more important functions than to oxygen? The answer to these questions must be sought in the results of the chemistry of high temperatures.

First let us consider the conditions of existence of the omnipresent water. Water begins to break down into its components, hydrogen and oxygen, at 934° centigrade; at 2,500° centigrade (4,500° Fahrenheit) the decomposition is complete. In other words, water vapor cannot exist at temperatures above 2,500°, but the hydrogen and oxygen exist in the free state.

Astronomers tell us that refractory elements like iron, silicon and carbon, perhaps disassociated into still simpler substances, are present as vapor in the atmosphere of the sun and that many others of our well-known elements, including hydrogen, are also present in this glowing atmosphere, while the heat of the sun's surface and that of the hotter stars is vastly higher than that of the electric furnace. Geologists believe that the evidence at their disposal points to a similar period of great heat in the early history of the earth. It may be considered, then, that temperatures higher than those of the electric furnace prevailed in former times on the earth's surface.

Let us now return to the study of the results obtained with the electric furnace. The following reactions are especially important. If metals, or refractory non-metals, or metallic or non-metallic oxides, or complex silicates, are heated to the higher temperatures in contact with carbon, boron, silicon or compounds of these three elements with oxygen, the result generally is that very refractory carbides, borides or silicides of the metals or non-metals are formed. In other words, those complex substances which form the chief constituents of the outer crust of the earth at the present day are decomposed at high temperatures, and simple compounds of two elements—so-called binary compounds—are formed. Four classes of these binary substances seem to be especially stable at high heat—the carbides, borides, silicides and oxides; but the oxygen of the metallic oxides tends to pass off as an oxide of carbon, if carbon be present.

At somewhat lower temperatures nitrogen is very active and the nitrides of many metals are readily formed. An excellent example is shown by heating a mixture of carbon and of an oxide of titanium (titanic acid). When heated by a feeble current the acid is simply reduced, forming a lower oxide of titanium; with a more powerful current the mass is completely changed into the nitride of titanium, the nitrogen coming from the air; with a very powerful current this is changed into pure carbide, as the nitride cannot exist at the higher temperature, and the nitrogen escapes, carbon taking its place. At still higher temperatures hydrogen acts on many metals, forming hydrides. The carbides and other compounds of some metals are not stable at high temperatures, being reduced by gaseous carbon to the free metals, which remain then in the gaseous form.

At that period of the earth's history when the temperature was as high as that easily obtained in the electric furnace, we have the sanction of geologists for picturing the earth's surface as an ocean of molten matter surrounded by a glowing atmosphere. This molten surface must have consisted of binary compounds such as those mentioned above, and probably contained some refractory elements, metals and non-metals, in the free state. The atmosphere contained free hydrogen, oxygen and nitrogen, gaseous binary compounds like the oxides of carbon, metals in the gaseous form and many non-metallic elements like sulphur and chlorine. In the atmospheric region furthest removed from the molten surface violent chemical reactions occurred between the heated elements, forming compounds which were again dissipated into their elements by the heat given off in the act of formation or radiated from the glowing surface below.

Under the enormous pressure of this atmosphere the liquid surface of the earth solidified at very high temperature. Whether the earth's mass solidified from the centre outward or by forming a solid crust over a liquid interior, is a question to be decided by physicists and geologists. We will consider only the outer crust and the atmosphere. As the surface and the atmosphere above it gradually cooled, the formation of nitrides, and later of hydrides, sulphides and chlorides, occurred.

The conditions now attained may have been fairly stable as long as the temperature of the surface and lower regions of the atmosphere were high enough to prevent the union of the atmospheric oxygen and hydrogen, or to decompose the water forming in the outer regions of the atmosphere. As soon, however, as by further cooling, water came into contact with the earth's surface, very violent reactions occurred, which were supplemented by other equally violent reactions when the cooling process permitted the formation of the ordinary mineral acids.

The reactions of water and of acids on many of the binary compounds are so important in determining the present composition of the earth's crust that they must be considered in detail. The carbides, nitrides, chlorides, sulphides and hydrides of most elements, and some silicides, are decomposed by water, or else by dilute acids, forming the hydrogen compounds of carbon, nitrogen, chlorine, sulphur and silicon respectively, and the oxide or hydroxide of the other element. Thus calcium carbide and water give calcium hydroxide and acetylene, a hydro-carbon. Aluminum carbide yields alumina and methane (marsh gas), another hydro-carbon, the chief constituent of 'natural gas.' Other carbides yield crude petroleum. The nitrides yield ammonia, which is the hydrogen composed of nitrogen. The chlorides give hydrochloric acid, the sulphides sulphuretted hydrogen and the silicides the hydrogen silicide. The metallic hydrides yield free hydrogen.

The violence and the magnitude of some of these reactions almost baffle the imagination. Let the reader drop a piece of calcium carbide as large as a small marble into a little water in a cup; there is a rapid action, a gas (acetylene) is given off, which burns with a smoky flame if a lighted match is held over the cup. (The experiment should be tried in the open air.) So much heat is generated in the reaction that the cup becomes hot. Nearly four per cent. of the earth's outer crust is calcium; all this was at this period of the earth's history in the form of carbide. Imagine all the vast limestone mountain ranges of the present day as carbide, and try to realize the effect when water fell on any considerable area. The heat generated would be so enormous that in a moment the acetylene would ignite and burn, forming oxides of carbon and water vapor, which would in turn decompose, throwing the jets of glowing hydrogen and oxygen vast distances into the atmosphere, there to cool and reunite to water. The decomposition of other carbides, of the hydrides and silicides, as well as the formation of hydroxides by the action of the lighter metals on water, would produce similar phenomena, as the substances formed are combustible gases, or liquids or solids easily volatilized. This is no wild fantasy, but a conservative statement. Similar reactions are taking place at the present day in those stars whose cooling process has advanced far enough; a case in point is that of the so-called 'temporary stars.'

Extremely violent reactions are taking place constantly in the atmosphere of the sun. The sun's chromosphere, or outer layer of its atmosphere, consists mainly of hydrogen, and jets of glowing hydrogen are thrown to great heights above the chromosphere; these jets or 'prominences' have been frequently observed to have a height of 100,000 miles, and prominences of more than double this height are reported by observers. The most conservative estimates assume temperatures of the sun's surface so enormous that that of the electric furnace is insignificant in comparison, and we can have no conception of the chemical changes occurring under such conditions. Whether one believes, with Lockyer, that the chemical 'elements' are disassociated by the sun's heat into simpler substances or not, it is clear that very violent chemical reactions are in progress, and if we realize that the known chemical reactions increase in intensity with increase in temperature, it does not seem strange that at the sun's temperature the reactions occurring should cause disturbances like those observed.

Returning to the earth, let us consider the products of these violent reactions. The hydrogen and hydrides of boron, silicon, sulphur and carbon, combined with the oxygen of the atmosphere, forming water and boric, silicic, sulphurous and carbonic acids, which in turn acted on the metallic oxides and hydroxides, forming sulphites, carbonates, borates and simple and complex silicates; some quickly, some slowly, some at low temperatures and atmospheric pressure, others at high temperatures in liquid or semi-liquid condition and under the pressure of rock masses above. To determine the relative age of existing rock layers, or the mode of their formation, whether by eruptive action, by surface heat, by deposition of finely divided material under water, or by metamorphic changes of the cooled silicate under subsequent action of water, pressure and heat, is the province of the geologist. The present writer refrains from an opinion whether any of the first formed solid crust could or could not survive to the present day in its primary form, considering the exposure to water, acids, heat and pressure which it suffered.

Yet an idea may be formed of the condition of the earth's surface when it had cooled so far that the more violent chemical action had ceased. It consisted chiefly of silicates, simple and complex; of some of the original binary compounds, which are scarce affected by water or acids, such as the silicide of carbon (carborundum), of stable oxides, chlorides and sulphides, with other compounds in smaller proportion, and free elements in greater proportion than at the present day. Everywhere, from crevices in the surface, hydrocarbons, phosphoretted hydrogen (phosphine) and ammonia were issuing as gases; the atmosphere was heavy with these gases and with carbon dioxide.

No scientific observations thus far show *how* or from what definite compounds plant life or animal life was first evolved from lifeless matter; but it is certain that the materials were much more abundant and the conditions more favorable at the period when it *was* evolved than at the present day. An ocean much warmer and less saline than now, a damp atmosphere like that of a hothouse, an abundance of plant food and a choice of raw material, were at hand. The chief foods required for plant life are nitrogen in the form of ammonia or nitrates, carbon dioxide, phosphorus as phosphates, sulphates of lime, of magnesia and of the alkalies, and water. As to the raw material for the first formation of the living cell, it is impossible to say what compounds of carbon were employed; suffice it to note that the known simple and complex binary compounds of carbon were there ready for use; the hydrocarbons, carbon monoxide and carbon dioxide were oozing from the earth's surface, from the ocean floor as well as from the land, or hanging heavy in the air above it. If warmth or increased pressure were desiderata, an ocean warm to its greatest depths could afford any pressure required. From the decomposition of the nitrides and phosphides below the surface, ammonia and phosphine were escaping into the ocean and into the air. The conditions then during long periods of time were especially favorable for marine life, and as sand and mud accumulated on the rocky surface of the earth, for land plants; the absence of a thick soil being more than compensated for by the abundance of plant food, notably of carbon dioxide and ammonia.

The statement may be found in excellent modern text-books of chemistry that ammonia is always formed by the decomposition of plants and animals, accompanied by the further statement that ammonia is a requisite for plant food. No plants—no ammonia; no ammonia—no plants. If this were true, the beginning of plant life would indeed have been a struggle for existence; that it is not true is shown above. This decomposition of nitrides has ceased practically on the actual surface of the earth at the present day because the nitrides have all been decomposed; yet it may be mentioned that specimens of rock freshly quarried in Sweden were recently found to give off ammonia when wet with water, showing the presence of nitrides. Below the actual earth's surface it is probable that nitrides still exist in large quantity, for ammonia is one of the constituents of volcanic gases; to believe that volcanic ammonia is a product of plant or animal decomposition is difficult; to suppose it formed by the action of steam on nitrides in the earth's interior is simple.

Much the same may be said of the presence of carbides. While they no longer exist on the surface, there is no doubt of their existence in the interior of the earth, and the volcanic gases contain their decomposition products. In this connection the theory—first put forward by Mendelèeff and since supported by Moissan—of the origin of petroleum, may be mentioned. These writers favor the hypothesis that it was formed by the decomposition of carbides by water under pressure; and while the evidence at hand perhaps favors the belief that the petroleum of the more important oil fields owes its origin to decomposition of the lower forms of marine animal life, yet there can be no doubt that petroleum may be formed by carbide decomposition, and it seems probable that natural gas is in part at least a result of the same action.

A PRELIMINARY ACCOUNT OF THE SOLAR ECLIPSE OF MAY 28, 1900, AS OBSERVED BY THE SMITHSONIAN EXPEDITION.

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PARTLY in deference to the report of the United States Weather Bureau, from which it appeared that the chance of a fair eastern sky on the morning of the eclipse was about 8 to 1, and after examination by Mr. Abbot of many stations in North Carolina, Wadesboro, of that State, was selected early in April as the site of the Smithsonian observations. The advantages of Wadesboro being also recognized by Professor Young, of Princeton, Professor Hale, of Yerkes Observatory, and the Rev. J. M. Bacon, of the British Astronomical Association, it came about that four large observing parties, besides several smaller ones and numerous excursionists from the surrounding country, were all joined to produce at Wadesboro one of the largest company of eclipse observers ever assembled for scientific purposes. It is a matter for congratulation that the sky at Wadesboro upon the day of the eclipse was cloudless and clearer than the average, so that the efforts of the observing forces were not thwarted by any circumstances beyond their control. The provisions of the Mayor and authorities of Wadesboro for preventing intrusion before and during the eclipse, and thus securing an undisturbed field of operations, deserve especial recognition. Further than this, the many acts of courtesy and hospitality to the visiting astronomers on the part of the townspeople will long be remembered by the recipients.

The Smithsonian party proper consisted of thirteen observers, and included Mr. Langley, Mr. Abbot, aid acting in charge of the Smithsonian astrophysical observatory; Mr. Smillie, in charge of photography; Mr. Putnam, of the United States Coast Survey; Mr. Fowle, Mr. Mendenhall, Mr. Child, Mr. Draper, Mr. Gill, Mr. Kramer and Mr. Smith. Included with these, the Rev. Father Searle and the Rev. Father Woodman gave most valuable assistance. Mr. Hoxie, of Port Royal, S. C., and Mr. Little, of Wadesboro, rendered valued assistance to Mr. Putnam during totality.

Professor Hale, of the Yerkes Observatory, was a member of the party, while still in general charge of the Yerkes expedition, and his counsel and aid were of the greatest service. Mr. Clayton, of Blue

Hill Meteorological Station, occupied a part of the grounds of the Smithsonian party.

The main object of investigation was, of course, the corona, and of this, (first) a photographic and visual study of its structure; with, (second) a determination by the bolometer whether appreciable heat reaches us from it, and, if possible, an examination of the form of its spectrum energy curve.

The writer had been particularly struck, when observing the eclipse of 1878 on Pike's Peak, by the remarkable definiteness of filamentary structure close to the sun's limb, and had never found in any photographs, not even in the excellent ones of Campbell taken at the Indian eclipse of 1898, anything approaching what he saw in the few seconds which he was able to devote to visual observations at the height of fourteen thousand feet. His wish to examine this inner coronal region with a more powerful photographic telescope than any heretofore used upon it, was gratified by the most valued loan by Prof. E. C. Pickering of the new 12-inch achromatic lens of 135 feet focus, just obtained for the Harvard College Observatory. This lens, furnishing a focal image of more than 15 inches diameter, was mounted so as to give a horizontal beam from a cœlostat clock-driven mirror by Brashear, of 18 inches aperture, and used with 30-inch square plates. To supplement this great instrument, a 5-inch lens of 38-feet focus, loaned by Professor Young, was pointed directly at the sun. This formed images upon 11 x 14 plates moved in the focus of the lens by a water clock. Specially equatorially mounted lenses of 6, 4 and 3-inch aperture, driven by clock work, were provided for the study of the outer corona, and the search for possible intra-mercurial planets.

For the bolometric work, the massive siderostat with its 17-inch mirror, and a large part of the delicate adjuncts employed at the Smithsonian Institution in recent years, to investigate the sun's spectrum, was transported to Wadesboro. The excessively sensitive galvanometer reached camp without injury even to its suspending fibre, a thread of quartz crystal 1-15,000 inch in diameter.

Besides these two chief aims (the photography and bolometry of the inner corona), several other pieces of work were undertaken, including the automatic reproduction of the 'flash spectrum' by means of an objective prism with the 135-foot lens, the photographic study of the outer coronal region, including provision for recognizing possible intra-mercurial planets, already alluded to, visual and photographic observations of times of contact, and sketches of the corona, both from telescopic and naked-eye observations.

The assignment of the observers was as follows: Mr. Langley, in general charge of the expedition, observed with the same 5-inch telescope used by him on Pike's Peak in 1878, which was most kindly lent for this special comparison by Professor Brown, of the United States Naval Observatory; C. G. Abbot, aid acting in immediate charge, assigned with C. E. Mendenhall to the bolometer; T. W. Smillie, having general direction of the photographic work, made exposures at the 135-foot telescope; F. E. Fowle, Jr., assigned to the 38-foot telescope; Father Searle, directing the assembled telescopes for the outer coronal region, and for intra-mercurial planets, assisted by P. A. Draper and C. W. B. Smith, exposed two cameras of 3-inch aperture and 11 feet focus, and two of 4½-inch aperture and 3½ feet focus, all four of these telescopes being mounted on a single polar axis driven by an excellent clock; De Lancey Gill, assisting Mr. Smillie, removed the flash spectrum objective prism at second contact, and made a single long exposure with a 6-inch photographic lens of 7½ feet focus equatorially mounted; Assistant G. R. Putnam, who, by the kindness of the superintendent of the United States Coast Survey, was detailed for latitude,* longitude† and time observations, also observed contacts, directed the striking of signals by Mr. Little, and rendered other valuable services. Mr. Putnam was assisted in recording contacts by Mr. Hoxie. R. C. Child, observing with a 6-inch telescope of 7½ feet focus, made sketches with special reference to inner coronal detail, and was in addition charged with all electrical circuits for chronograph and automatic photographic apparatus. Father Woodman, with 3½-inch telescope, observed contacts and made sketches.

The first detachment, consisting of Messrs. Abbot, Fowle, Kramer (instrument maker) and Smith (carpenter), reached Wadesboro May 4th, and were soon joined by Messrs. Draper and Putnam. The latter returned to Washington after a short but satisfactory latitude and longitude campaign, reaching Wadesboro again just before the eclipse. Other members of the party reached camp on and after the middle of the month. The first comers found a very satisfactory shed already erected and piers begun. Not a day passed from the time of the arrival of the apparatus, May 7th, to the day before the eclipse, that was not fully occupied in perfecting the arrangements.

The most striking portion of the installation was the line beginning at the northwest pier, with its equatorial and cœlostat, continued from thence south of east by the two great diverging tubes of the 135-foot telescope and spectroscope. These tubes were covered with white canvas, presenting the appearance of two immensely prolonged 'A' tents, ending beyond the photographic house, where the 38-foot telescope tube pointed east and upward at an angle of 42° with the horizon. When the equatorial, with its large special conical tube camera, with all this long-branching extent of white canvas ending in the uplifted tube of

* 34°, 57′, 52″ N. † 5h., 20m., 17.8s. W.

the 38-foot telescope, was seen in the light of the moon, the extensive field with these preparations, exhibited a still more picturesque scene than by day.

Less imposing, and perhaps more ungainly was the combination of four great cameras under the main shed, designed to search for new planets and to depict the outer corona. These might well be described as like a cabin and outbuilding, mounted on a polar axis, yet, despite their awkward proportions, they were made to follow very accurately.

The morning of the eclipse dawned cloudless and very fairly clear. Deep blue sky, such as the writer had seen on Pike's Peak, of course, is not among the ordinary possibilities of an eclipse, but the milkiness of the blue was less pronounced than is usual in the summer season, and all felt that the seeing promised well.

At fifteen minutes before totality a series of rapid strokes on the bell called every one to his post, and one minute before the expected contact five strokes were given as a final warning. Coincidentally with the actual observation of the second contact by Mr. Putnam, the first two strokes upon the bell sounded, and the work began. After 82 seconds (the duration of totality from the Nautical Almanac was 92 seconds), three strokes were given as a signal to stop the long photographic exposures. Scarcely more than five seconds after this the sun's crescent reappeared. The duration of totality, as observed by Mr. Putnam, was approximately 88 seconds.

To visual observers the sky was notably not a dark one. No second magnitude stars were observed with the naked eye, and most of the on-lookers saw only Mercury conspicuously, though Venus was distinguished at a low altitude and Capella also was seen. So high a degree of sky illumination can not but have operated unfavorably in the study of the outer corona or in the search for intra-mercurial planets, and this is to be remembered in connection with what follows.

Before Totality.

A deepened color in the sky, a fall of temperature and a rising breeze were distinctly noticeable. No change in direction of the wind was noted. Shadow bands were seen, but those who attempted to measure their velocity found them too rapid and flickering for any great exactness in this determination. There was tolerable unanimity among independent observers as to their size and distance apart (about five inches), though some thought this less as totality approached.

It was noticed that the birds grew silent just before and during totality, but true to their nature, the English sparrows were last to be still and first to begin their discussion of the eclipse, after the return of light.

During Totality.

The attention of all visual observers was at once caught by the equatorial streamers. Father Woodman's comparison of the appearance of a structure of mother of pearl was generally recognized as good, but different observers differed on the color estimate. A yellowish green tinge was noted by the artist of the party, Mr. Child, while to others the light was straw colored or golden.

The general coronal form to the naked eye was nearly that of the small annexed photograph, which, though taken by one of the smaller objectives, gives a good view of the relative intensities. The same ex-

FIG. 1. GENERAL VIEW OF THE CORONA. TAKEN WITH 6 INCH LENS OF 7½ FEET FOCUS. 82 SECONDS EXPOSURE.

tensions of the equatorial corona could be followed by the naked eye from 3 to $3\frac{1}{2}$ solar diameters.

The visual telescopic observations of the writer gave little indication of the finely divided structure of the inner corona which he had noticed at Pike's Peak. Structure, to be sure, was evident, but not in such minute subdivision as had then been seen, and though one remarkable prominence as well as several smaller ones was visible, the coronal streamers did not give to the writer the impression of being connected with these prominences, though the relationship of some of them to the solar poles was abundantly manifest.

AFTER TOTALITY. *Results.*

Comparing notes after totality, all observers reported a successful carrying out of the programme. The greatest interest centers in the direct coronal negatives taken with the 135-foot telescope. Mr. Smillie exposed six 30 x 30 plates during totality, with times ranging from one half a second to sixteen seconds, and three others were exposed by him immediately after the third contact.

At this writing only a part of the negatives taken have been developed. Their general quality may be inferred from the examples here given, after due allowance for the great loss suffered by translation onto paper even with the best care.

Fig. 1 is a view taken with one of the smaller objectives (6 inches),

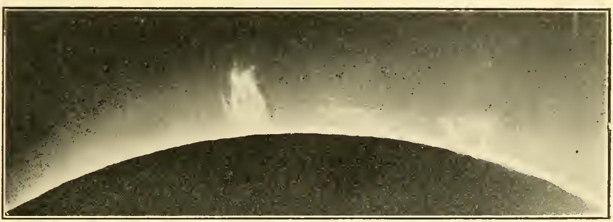


FIG. 2. PROMINENCES ON SOUTHWEST LIMB OF SUN. TAKEN WITH 12 INCH LENS OF 135 FEET FOCUS. 8 SECONDS EXPOSURE.

given here to afford the reader an idea of the general disposition of the coronal light. The upper part is the vertex in the inverted field.

Fig. 2 is a portion of one of the great 15-inch circular images obtained with the 135-foot focus telescope. It was obtained in the great disc in the last exposure during totality of 8 seconds, showing one of the principal prominences then on the sun's dics, with the disposition of the lower filaments near it.

Fig. 3 is a portion of one of the same set of plates, but taken with a 16-second exposure. The part near the sun has, of course, been intentionally over-exposed, in order to better exhibit the remarkable polar streamers, extending here to a distance of about six minutes from the sun, but seen still further in Mr. Child's telescopic drawing (not given.)

Fig. 4 is a view of a small part of the great apparatus on the field, including the terminus of the horizontal tube with its canvas covering, which has been described as like an extended 'A' tent. The photographic room is seen at the end of the tube, and beyond that the tube containing the lens loaned by Professor Young pointing directly skyward.

That it will be impracticable to give here all of the disc of the moon in the large photographs, will be evident when it is considered that the lunar circumference on each plate is about 4 feet; but it will be inferred from the examples that the prominences and polar streamers as well as their features, appear in imposing magnitude and detail.

Many of what it is hoped will be the most interesting photographs still await development, but Mr. Smillie's thorough preparation is promising adequate results.

Heat of the Corona.

Mr. Abbot, with aid of Mr. Mendenhall, appears to have meas-

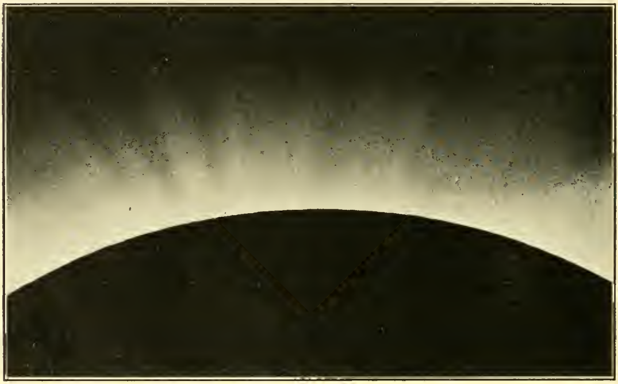


Fig. 3. North Polar Coronal Streamers. Taken with 15 inch Lens of 135 feet Focus. Exposure 16 Seconds.

ured the heat of the corona, and in spite of previous efforts, this is probably the first time that it has been really shown to exist. For five minutes before second contact, the bolometer was successfully exposed to the region of the sky close to the narrowing crescent of the sun where the corona was shortly to appear. A diaphragm was interposed in the beam having an aperture of only 0.4 sq. cm. Deflections, rapidly diminishing from 80 to 6 mm. were obtained, the last being about 40 seconds before totality. Then the diaphragm was opened to 290 sq. cm. and a negative deflection of 13 mm. was observed after totality, where these positive deflections had just been found, showing that the corona was actually cooler than the background which had been used at the room temperature. Next the black surface of the moon was allowed to radiate upon the bolometer, and the still larger negative deflection of 18 mm. was observed.

The important result was that the corona gave a positive indication of heat as compared with the moon.

This heat, though certain, was, however, too slight to be sub-divided by the dispersion of the prism with the means at hand.

The negatives taken to depict the outer corona show from three to four solar diameters extension for the longest streamers. The equatorial 'wings,' as they recede from the sun, are finally lost in an illuminated sky, without any indication of having actually come to an end.

No attempt to carefully examine the plates taken for intra-mercurial

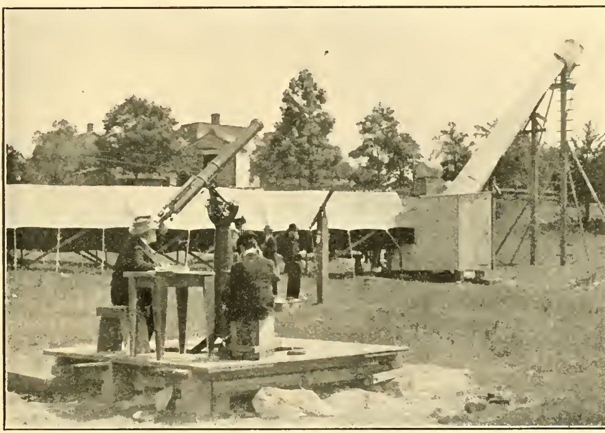


FIG. 4. DARK ROOM AND TUBES OF 135 FOOT AND 38 FOOT TELESCOPES. 5 INCH EQUATORIAL IN FOREGROUND, PROF. LANGLEY OBSERVING.

planets has yet been possible. It is, however, as has been remarked, doubtful if the very faintest objects will be found, in consideration of the considerable sky illumination during totality. However, Pleione in the Pleiades (a star of the 6.3 magnitude), is plainly seen on one of the plates, and some smaller ones are discernible.

On the whole, the expedition may be considered as promising to be very satisfactory in its results, and that it was so is largely owing not only to the efficient care of Mr. Abbot, but to the many gentlemen who have assisted me with the loan of valuable apparatus, with counsel, with voluntary service and with painstaking observation, to one and all of whom I desire to express my obligations.

MALARIA AND THE MALARIAL PARASITE.*

By PATRICK MANSON, M. D., LL. D.,
LECTURER ON TROPICAL DISEASES AT ST. GEORGE'S HOSPITAL AND CHARING-CROSS HOSPITAL MEDICAL SCHOOLS AND AT THE LONDON SCHOOL OF TROPICAL MEDICINE.

THIS lecture is devoted to a description of the parasite and of its life cycles. The existence of a parasite in malarial disease has been suspected for a long time, but only very recently have we had absolute assurance that such a parasite exists. Some time in the thirties Meckel described in the human blood certain black particles which he found in leucocytes and in certain pale, leucocyte-like bodies the nature of which he did not know. When he saw these bodies he certainly saw the malarial parasite. His observations were repeated and extended in the forties and the fifties by Frerichs and Virchow, and they, too, undoubtedly saw the malarial parasite. But it is one thing to see and quite another to recognize; discovery is recognition.

The discoveries of Laveran, Golgi, Marchiafava, Bignami and others resulted in considerable knowledge of the life history of the malarial parasite and of the correspondence between its life cycle and the clinical cycle of the disease. Laveran discovered the parasite; Golgi described the cycle of the tertian and quartan forms; the others added new data, especially concerning the more malignant parasites. The malarial parasite in its mature form has the appearance—I shall take the tertian parasite as a type—of a mass of pale protoplasm occupying practically the whole of the red blood corpuscles. Scattered through this mass of protoplasm are a number of black specks or little rods of intensely black pigment. Later in the life of the parasite a peculiar thing happens: all these little specks of black pigment concentrate usually towards the center of the organism whilst the pale protoplasm arranges itself into little spherules, the whole constituting what is known as the 'rosette body.' Later in the life of the parasite the surrounding blood corpuscle breaks away and this rosette body floats free in the liquor sanguinis and then breaks up into its constituent spores, setting free at the same time the black pigment clump. Phagocytes attack many of these free spores and probably absorb most of them, as well as the little pieces of pigment. The result is the pigmented leucocyte, so characteristic of malarial blood. A few of the spores escape and in virtue of some peculiar faculty, which is not at present

* Abstract of a lecture delivered at the Medical Graduates' College and Polyclinic, and printed in the *Lancet* of May 19.

understood, enter fresh blood corpuscles and appear there as pale specks in the hæmoglobin. These pale specks, if watched in perfectly fresh blood, are seen to be possessed of very active amœboid movement. They throw out pseudopodia in various directions and wander about through the hæmoglobin of the corpuscle. After a time they increase in size by assimilating the hæmoglobin. By and by there appear somewhere in the parasite those specks of black pigment which we saw in the mature animal. Later they increase still further in size until they come to occupy half, and finally nearly the whole, of the blood corpuscle. Again there is concentration of pigment and the formation of little sporules. This is the cycle, as described by Golgi, of the tertian and quartan parasite. The cycle of the tropical or æstivo-autumnal parasite corresponds in plan almost exactly with that of the quartan and ordinary tertian parasite.

It was found that the life cycles of these parasites ran parallel with the clinical cycle of malarial disease. It was found that when the parasite had arrived at maturity the apyretic interval in an ague was about to conclude, and that when the parasite had arrived at the sporulating stage the patient had entered on the shivering stage of his fever. During that and the succeeding hot and sweating stage the spores had entered the red blood corpuscles, and when the parasite had ensconced itself in the red blood corpuscle and begun to grow, the fever had come to an end. It was found in tertian fever that the cycle of the parasite took forty-eight hours to complete, exactly the length of the cycle of the clinical phenomena. In quartan fever the cycle took seventy-two hours, exactly the length of the clinical cycle of that form of malarial disease. In the malignant or tropical fevers there was found to be a similar correspondence between the cycle of the parasite and the cycle of the disease. It was found that with each recurring paroxysm of fever there was a renewal of the life of the parasite, and that in this way the life of the parasite was continued from period to period and from cycle to cycle for weeks or even, especially in the case of quartan malaria, for months. Now this explains very well the way in which the malaria parasite contrives to maintain its existence in the human body, but it does not explain how it passes from host to host, neither does it explain certain appearances that Laveran and everybody else who has studied the subject have witnessed. In malarial blood you sometimes see that peculiar body, the flagellated body, which I have already alluded to as consisting of a sphere surrounded by from one to six or seven long tentacles or arms in a state of continual agitation. Neither does it explain the peculiar crescent-shaped body which also so pointedly arrested Laveran's attention. . . . . Golgi's scheme leaves the passage of the parasite from host to host and also the nature of these two bodies unexplained. What relation have these two bodies to the life of the parasite? Their nature and purpose do not receive any illumination from Golgi's theory. You will find in all forms of malarial infection, if you look enough, the flagellated body; but, strange to say, you will not find it in malarial blood immediately after it is withdrawn from the body. It is only after an interval of minutes, perhaps a quarter of an hour, after the blood is withdrawn that these flagellated bodies appear. Whence do they come? If you make a preparation of malarial blood from a patient by pricking the finger and spreading a little of the blood on a slide, fixing it immediately with heat or alcohol and staining it, you will never see any of these flagellated organisms. But if the slip be kept moist and in a warm temperature for half an hour and then stained, the flagellated bodies will be seen, proving that they develop only after the escape of the parasite from the human body. Such a fact is very interesting and obviously has some significance in connection with the life of the parasite. Whence, I ask, come these flagellated bodies? If one of the crescent-shaped bodies is observed continuously, the following changes of shape may often be observed: It becomes shorter, loses its crescent shape and gives off flagella, which may break off and swim about by themselves. When they come in contact with a blood corpuscle they straighten themselves out and indulge in a peculiar vibratory movement, as if endeavoring to penetrate the corpuscle.

Many years ago King, in America, and others too numerous to mention suspected that the mosquito had something to do with malaria, but in what way they could not say. Not only civilized observers had this suspicion, but the savage natives of certain tropical countries had the same idea. Koch tells us that certain natives of German East Africa who lived in a mountainous, and therefore non-malarial, part noticed that when they descended to the malarial regions on the coast they acquired a fever which they called 'mbu.' They said that they were bitten there by certain insects which they also called 'mbu'—mosquito or gnat. They give the same name to the mosquito and to the fever, therefore obviously these savages associate the insect and the fever as cause and effect. Peasants in certain parts of Italy have the same idea, believing that the bite of the mosquito may be followed by the development of malarial fever.

Laveran, some years ago, in one of his numerous works on malarial fever, said that possibly the malarial parasite was cared for by the mosquito in the same way that the latter cares for the filaria of the blood. He did not, however, formulate a definite theory on the subject.

In 1894 I was engaged in working at malaria, following out Golgi's work and that of other Italians. I was particularly struck by the phenomena of exflagellation and more particularly by the fact that it occurred only when the blood had been removed from and was outside the human body. I reasoned that if this exflagellation occurs only outside the body, the purpose of the flagellated body must lie outside the human body, and that therefore the flagellated body must be the first phase of the malarial parasite outside the body, must be the first step that the malarial parasite takes in passing from one human host to another. There seemed to me to be a sort of logic in this. But how was the malarial parasite to pass from one human being to another? It was not provided while inside the human body with any organs of locomotion or penetration; as far as we know the parasite is never extruded in the excreta, neither does it habitually escape in hæmorrhages. Therefore, the idea of a spontaneous escape of the parasite from the human body had to be dismissed. I therefore concluded that some extraneous agency must remove the parasite from the human body, so as to afford the opportunity for this flagellation which I had concluded must constitute the first step in its extra-corporeal life. In casting about for an organism which could effect this removal I, for many reasons similar in some respects to those that influenced the savage African, the Italian peasant, King, Laveran and others, came to the conclusion that the medium of removal and transit must be the mosquito. I was so impressed with the probabilities of this double hypothesis and with its extreme practical value, should it prove to be correct, that I endeavored to leave England for a time and to visit British Guiana or some such suitable malarial country where I might work out the idea. Unfortunately, that could not be accomplished, so I published my theory in the hope that it would appeal to someone who might enjoy the opportunities denied to me. At that time Surgeon-Major Ross was at home from India and we had many conversations on the subject. I described to him my hypothesis, the probabilities of which and the possibilities of which powerfully appealed to his highly logical and practical mind. He undertook, when he returned to India, to do his best either to establish or confute it. Accordingly he set to work in India experimenting with mosquitoes and malaria.

Ross was stationed in Secunderabad, in the south of India, where there was abundant opportunity for experimental work—plenty of patients and plenty of mosquitoes. He got patients with crescent parasites in their blood and he got mosquitoes to bite them. He found that in the course of a few minutes after the blood had entered the insects' stomachs the crescent parasites proceeded to the formation of sphere and flagellated body. But he got no further. This experiment was repeated hundreds of times. Many of his preparations were sent to me, and I could confirm from them the accuracy of his statements on the subject. Ross was encouraged, for obviously we were on the right track. One day Ross, whose station had in the meantime been changed, caught some mosquitoes which had been feeding on a patient the subject of tertian malaria. He kept the mosquitoes and after a few days dissected them. He took the stomach out and placed it on a slip with a little salt solution, covered it with a cover-glass and examined it with a microscope. He was gratified to find lying amongst the transverse and longitudinal muscular fibres a number of spherical bodies, very sharply defined, and including a great many grains of intensely black pigment exactly like those of the malaria parasite. Ross was at once struck with the similarity. After years of labor he believed he had at last seen the malaria parasite in the tissues of the mosquito, where we reasoned it ought to be; and he was right. At a subsequent experiment on the malarial patient he found exactly the same bodies, and on dissecting several mosquitoes at different intervals of time he found that the parasite, which originally was six micro-millimetres in diameter only, grew to sixty or eighty micro-millimetres, each parasite, notwithstanding its growth and the lapse of time, still containing the peculiar and most characteristic black pigment. Ross was now quite sure that he had found the extra-corporeal phase of the malarial parasite. Some of these preparations he sent home. I examined them and showed them to a number of friends in London familiar with the malarial parasite; they agreed with me, as Laveran also did, in believing that probably this indeed was the long-sought-for extra-corporeal phase of the malarial parasite. Ross at that time had great difficulty in getting opportunities for experiment on the human subject and in procuring proper mosquitoes. He found that the mosquitoes in which he had discovered these pigmented bodies were of a different species to those on which he had formerly experimented, and that in this circumstance lay the explanation of his lack of success earlier as well as the secret of his ultimate success. Failing to get sufficient opportunity for experimenting on human malaria he turned to bird malaria. He found that the sparrow of Calcutta, in a large proportion of instances, contained in its blood a malaria-like parasite. Ross procured a number of infected sparrows and let loose upon them a number of mosquitoes of a species belonging to the genus *culex*. These mosquitoes, after from one to ten days, he dissected and examined their stomachs. He found in the stomach-wall pigmented bodies exactly similar to those which he found in the stomach-walls of mosquitoes fed on human malarial blood. He found that they increased in size and in a week or ten days grew from six to eighty micro-millimetres in diameter. When they became of considerable size they protruded like warts from the surface of the insect's stomach and were included in a very definite capsule. At this stage the capsule was filled with a vast number of very minute rod-like bodies. These capsules, which now projected into the body cavity of the insect, being over-distended, ruptured and discharged the rod-like bodies into the body cavity of the mosquito. For a time Ross could get no further than this. He could not find what became of the rod-like bodies. One day, in dissecting the head of a mosquito, he encountered two small trilobed glands the ducts from which united to form a main duct. The glands lay on either side of the head and the common duct he traced to the base of the proboscis of the mosquito. This was the salivary gland of the mosquito. He found that the cells of the gland contained rod-like bodies exactly like those which he had found inside the parasitic capsules in the stomach-wall. He concluded that somehow these 'germinal rods' (for so he called them) had managed to find their way into the salivary gland of the mosquito. It immediately occurred to him that this might be the route by which the parasite escaped from the mosquito into its vertebrate host. No sooner had the idea occurred to Ross than he put it to the test of experiment. He selected a number of sparrows in whose blood he satisfied himself that there were no parasites and let loose upon them a number of mosquitoes which he had already infected with malarial parasites. He found after a week or ten days that the sparrows which were experimented upon sickened and many of them died; and in their blood he found the malarial parasite.

We now understand why the flagellated body is developed outside the human host: because its function lies outside the human host. We now understand why the flagella break away and enter the granular sphere: they impregnate it and start it on the road of development. We now understand why MacCallum's vermicule is beaked and endowed with powers of locomotion and penetration: that it may approach and penetrate the stomach of the mosquito. And we now know why the sporozooites, the 'germinal rods,' enter the mosquito's salivary gland: that they may be injected into vertebrate issue and so pass the parasite from vertebrate to vertebrate.

This is one of those fairy tales of science which people are inclined to doubt, but any one who has worked at the subject and taken the trouble to go through the long series of preparations which have been sent home from India can not for a moment have the slightest doubt that what Ross stated was absolutely true, and that not only for bird but for human malaria. So soon as the idea got abroad that the key to the way in which the malarial parasite is propagated had been found the Italians immediately set to work with renewed vigor and with the utmost skill. Almost at once they demonstrated that what happened in the case of Ross's sparrows happened also with the human subject: that the appropriate species of mosquito fed upon the human malarial subject and subsequently allowed to feed upon a non-malarial subject conveyed the malarial parasite and malarial disease, and that the appropriate species of mosquito belonged to the genus anopheles. There can not be the slightest doubt that the mosquito acts the part of transmitting agent as well as definitive host of the malarial parasite.

This is a piece of knowledge of the utmost importance to mankind, for we know that malarial disease in tropical countries—which, after all, in the future will be the most important parts of the world, seeing that they can produce more food than temperate countries and can therefore support a larger population—causes more deaths and more disposition to death by inducing cachectic states predisposing to other affections than all the other parasites affecting mankind put together. We know now in what way this parasite is acquired. Depend upon it, in time, in virtue of this knowledge, we will get enormous power over the disease and sooner or later we will be able to prevent the infection of man by the parasite. It is only a question of study and the application of the knowledge already acquired, only a question of money and perseverance and a little ingenuity, and these results will come. It may not be in ten years or twenty years, but sooner or later the energies of a considerable portion of scientific mankind now being expended in endeavoring to devise means for preventing the infection of men with the malarial germ by the mosquito will bear valuable fruit.

You can readily understand that it is of great importance to be able to recognize the special species of mosquito which convey malaria. The effective species as regards human malaria belong to the genus anopheles; species of the genus culex are effective in the case of sparrow malaria. Fortunately, these two genera are easily recognized even by the amateur zoölogist. If you find a mosquito clinging to the wall or other surface you can tell which genus it belongs to by its posture. If the body is stuck out nearly at right angles to the surface on which the insect is resting, it is an anopheles. If the body is almost parallel to the surface, it is a culex. There is another test which is easily applied if you have a pocket lens; in culex the two organs known as palpi are rudimentary and very short; whereas in anopheles those organs are almost as long as the proboscis. It should be remembered that the male mosquito is not a blood-sucker and therefore is not dangerous. It is the female anopheles which transmits the disease. The mosquito larvæ inhabit stagnant or slow-running water. If a mosquito larva be found with its head downwards, the body hanging at right angles to the surface of the water, it is a culex; if the body lies parallel to the surface of the water, it is an anopheles. There are other points of difference with which I need not now trouble you; those referred to suffice for diagnosis between the innocuous and the dangerous mosquitoes.

The facts regarding the malaria parasite which I have described are of great importance for many reasons. First, because they help us to understand the pathology and etiology of malaria. Secondly, they help us in diagnosis. Thirdly, our knowledge of the parasite is invaluable in directing treatment. Lastly, a knowledge of the life-history of the malarial parasite is of extreme value for the prevention of malarial disease, for could we by mechanical or other arrangements prevent the mosquito attacking the human body, we could prevent the malarial parasites from entering the human body; or if we could abolish the mosquito by drainage or other means from a country, then we might be sure that we would abolish the malaria of that country also.

Attempts are being made to solve these practical problems. At the present moment such attempts are being actively made in Rome by Professor Celli and elsewhere by others. I have no doubt that in the course of a few years we shall get some very valuable results in this direction and that, thanks to this new-born knowledge about the malarial parasites, better times are rapidly approaching for malarial countries.

NEW SOURCES OF LIGHT AND OF RÖNTGEN RAYS.

BY HENRY CARRINGTON BOLTON, PH. D.

AMONG the general laws of physical science, none seems more firmly established than that of the conservation and correlation of energy; according to this the various forms of energy that constitute the domain of experimental physics, heat, light, electricity, magnetism and chemical action, have reciprocal dependence and "can not originate otherwise than by devolution from some preëxisting force," or rather energy. That motion is convertible into heat, heat into light and both the former into electricity are phenomena familiar to every one who uses incandescent bulbs or rides in a trolley, and we do not usually recognize any production of light unaccompanied by heat. True, the little fire-fly is possessed of a mysterious power that enables it to emit light without enough heat to affect Langley's most sensitive bolometer, but the eminent Secretary of the Smithsonian has to admit that the "cheapest form of light" is produced by "processes of nature of which we know nothing." This little understood property called phosphorescence is shared by many living organisms, both animal and vegetable, as well as by substances of the mineral kingdom; to the former belong coelenterates, mollusks, crustacea, fishes and insects, and decaying wood, certain mushrooms, etc.; to the latter the Bologna stone, so-called, and the commercial article called 'Balmain's paint.'

In the case of the mineral substances, barium or calcium sulfids and the like, the light-giving power is not an innate property, but is set in operation by exposure to the energy of sunlight, the light of burning magnesium or to some other source of actinism; moreover, the power thus acquired by insolation is a fugitive one, the substances exercising it after three or four hours become 'dead' and lose their activity. Excepting then these living beings and these phosphorescent bodies, light as commonly known to us is always correlated with heat; within the last four years, however, discoveries have been made in France that seem to modify the position taken by philosophers and to necessitate new views concerning the manifestations of that energy with which the universe is endowed. A group of French savants have found mineral substances that apparently give out light perpetually without any exciting cause, realizing the dream of the alchemists—a perpetual lamp consuming no oil. These substances also emit rays having the penetrating properties of X-rays, other rays affecting a photographic plate, and fourthly, rays causing air to become a conductor of electricity. The history of these discoveries can be briefly given.

Röntgen's discovery of the rays that pass through metals and solids opaque to light was made in 1895, and in the following year, Becquerel, a distinguished French academician, discovered that salts of the metal uranium (substances that had long been used in coloring china and glass) emit invisible radiations capable of discharging electrified bodies and of producing skiagraphic images on sensitive plates; he found that potassio-uranic sulfate emits rays that pass through black paper and give photographic impressions in the same way as Röntgen rays. This property is not limited to the brilliantly fluorescent uranic salts, but is shared by the non-fluorescent uranous salts, and is exhibited by compounds whether phosphorescent or not, whether crystalline, melted or in solution, as well as by the metal itself. The permanence of this activity is amazing, substances kept in a double leaden box more than three years continuing to exert the power.

Shortly after the announcement by Becquerel, experimenters found that other substances have the power of emitting 'Becquerel Rays,' such as calcium and zinc sulfids and compounds of thorium. In 1898 Mme. Sklodowska Curie, working in the laboratory of the Municipal School of Industrial Physics and Chemistry in Paris, devised a special apparatus for measuring the electrical conductivity of the air when under the influence of 'radio-active bodies,' and by its means studied the behavior of pitchblende (uraninite), and of other uranium minerals; finding that some specimens of pitchblende had three times as much energy as uranium itself, she came to the conclusion that the peculiar property is due to some unknown body contained in the minerals and not to uranium. Examining the mineral with the aid of her husband, the two found a substance analogous to bismuth, four thousand times stronger than uranium, which was named 'Polonium,' in honor of the native land of Mme. Curie. In December of the same year, the lady received the Gegner prize of 4,000 francs awarded by the Academy of Sciences, as a substantial appreciation of her discovery, and later in the same month Mme. and M. Curie announced that they had found a second body in pitchblende, which they named 'Radium.' More recently, M. Debierne, working under the auspices of Mme. Curie, has discovered a third body, which he calls 'Actinium,' an unfortunate appellation because 'actinium' has already been used for an element announced by Dr. Phipson and since discarded.

These three 'radio-active' substances do not possess identical properties; their rays are unequally absorbed and are differently affected in a magnetic field; moreover radium emits visible rays, while polonium does not. Nor have they the same chemical affinities; polonium belongs to the bismuth group, radium to the barium and actinium to the titanium series. They have not been separated perfectly from their analogues, and consequently their chemical properties and the actual intensity of their physical activities is very imperfectly known. The difficulties of securing even small quantities of crude materials are enormous; Fritz Giesel obtained from one thousand kilograms of raw material only fifteen grams of active compounds, and Mme. Curie, operating on half a ton of the residues of uranium from a chemical manufactory, got about two kilograms of barium chlorid rich in radium, but the percentage of active substances in these mixtures is unknown.

Radium is spontaneously luminous, and all the bodies emit rays that excite phosphorescence in gems, fluorite and other minerals; they communicate radiant energy to inactive substances, and they exert chemical action, transforming oxygen into ozone and producing changes in the color of glass and of barium platino-cyanid.

Through the enterprise and liberality of the Smithsonian Institution, and by the courtesy of Professor Langley, I have enjoyed the opportunity of studying small specimens of these rare and costly substances; they comprised ten grams of 'radio-active substance' prepared by a manufacturing chemist of Germany and smaller quantities of 'radium' and of 'polonium' from Paris. On removing the wrappings of the German specimens in a dark room, they were seen to emit greenish-white light that gave to the enveloping papers a peculiar glow, similar to the fluorescence produced by Röntgen rays. Simple tests of the radium showed that it gave the usual reactions of barium; on boiling it with water it lost its luminosity, but on heating to dull redness this property returned in the dark. It also caused a barium platino-cyanid screen to fluoresce.

Experiments to test the actinic power of these bodies gave interesting results; on exposing sections of photographic plates, at distances of five inches, from two to twelve minutes, bands were obtained varying in intensity with the duration of action. By exposing sensitive plates behind negatives to the radiant materials from two to three hours, excellent transparencies were secured; on substituting Eastman's bromide paper good prints were obtained.

The penetrating power of the rays emitted permits the production of skiagraphs; the plates were enveloped in Carbutt's black paper (impermeable to light), and on them were laid pieces of tinfoil cut in openwork pattern; after one hour's exposure negatives were secured plainly showing the pattern. Analogous experiments were carried on with the specimens from Paris, but they were only one fifth as strong in effects; that labelled 'polonium sub-nitrate' had positively no action on the plates used.

The primary source of the energy manifested by these extraordinary substances has greatly puzzled physicists, and as yet remains a mystery.

Mme. Curie, speculating on the matter, conjectured that all space is continually traversed by rays analogous to Röntgen rays, but far more penetrating, and not capable of being absorbed by certain elements of high atomic weight, such as uranium and thorium. Becquerel, reflecting on the marvellous spontaneous emission of light, said: "If it can be proved that the luminosity causes no loss of energy, the state of the uranium is like that of a magnet which has been produced by an expenditure of energy and retains it indefinitely, maintaining around it a field in which transformation of energy can be effected; but the photographic reductions and the excitation of phosphorescence require an expenditure of energy, of which the source can only be in the radio-active substances." Somewhat later, Becquerel hazarded the opinion that the radiation is composed at least in part of cathodic rays; but these have been proved to be material, hence the induced activity must be caused by material particles impinging upon the substances excited. This materialistic theory seems to be confirmed by the results of ingenious experiments made by Mme. and M. Curie; they placed a sensitive plate beneath a salt of radium supported on a slab of lead, in the vicinity of an electro-magnet. Under these conditions, when the current was passing, the rays emitted were bent in curved lines upon the sensitive plate, making impressions.

It may be objected, says a French writer, that the materialistic theory requires us to admit actual loss of particles of matter, nevertheless the charges are so feeble that the most intense radiation yet observed would require millions of years for the removal of one milligram of substance.

While writing these lines, we have news of experiments that seem to throw doubt on the elementary character of these radio-active bodies; Bela von Lengyel, of Budapest, claims to have prepared the so-called 'radium' synthetically. By fusing with the heat of electricity uranium nitrate mixed with a small percentage of barium nitrate, and treating the mass with acids, he obtained a substance that gives out actinic rays, Röntgen rays, excites platino-cyanid screens and causes air to conduct electricity; in short, the Hungarian chemist gets material possessing all the properties characteristic of the 'element' announced by Mme. Curie.

Admitting that radio-active bodies can be manufactured to order, are we any nearer explaining their mysterious powers?

Speculations as to the future history and applications of these wonder-working bodies press upon even the dullest imagination; if a few grams of earth-born material, containing only a small percentage of the active body, emit light enough to affect the human eye and a photographic plate, as well as rays that penetrate with X-ray power, what degree of luminosity, of actinism and of Röntgenism (if the term may be allowed), is to be expected from an hundred weight of the quintessence of energy purified from interfering matter? And to what uses is this light-generating material to be applied? Are our bicycles to be lighted with discs of radium in tiny lanterns? Are these substances to give us the 'cheapest form of light?' Are we about to realize the chimerical dream of the alchemists?

Seriously, in what direction is profound study of these substances going to lead us? Will it not greatly extend our knowledge of physical manifestations of energy and their correlation? In what corner of the globe will be found the cheap and convenient supply of the raw material yielding the radio-active bodies? Will not chemists be obliged to re-examine much known material by laboratory methods conducted in the dark? Many of us have worked up pounds of pitchblende to extract the uranium oxids, and in so doing have poured down the waste-pipe or thrown into the dust-bin the more interesting and precious bodies.

Whatever the future may bring, scientists are deeply indebted to Becquerel and to Mme. and M. Curie for placing in their hands new methods of research and for furnishing a novel basis for speculation destined to yield abundant fruits.

DISCUSSION AND CORRESPONDENCE.

WASHINGTON AS AN EXPLORER AND SURVEYOR.

Washington was a surveyor and explorer before he entered upon the fields of war and statecraft, and his honesty of purpose, sincerity of action and accuracy of statement and method, so manifest throughout his career as a soldier and statesman, are found also in the earlier record. At the age of sixteen he crossed the Blue Ridge on horseback and made a series of successful surveys in the Shenandoah valley, overcoming physical obstacles with the method and system of a modern scientist. At twenty-two he led a party into the wilderness of the valley of the Ohio to treat with the French and Indians. He then became acquainted with the great resources of the interior, and saw that the valleys of the James and Potomac afforded unusual facilities for lines of transportation for the trade 'of a rising empire.' In 1754 he reported in favor of a scheme of communication between the Atlantic states and the great west. Sixteen years later he suggested that the project of opening up the Potomac be 'recommended to public notice.' The idea contained in the Potomac scheme was of far-reaching import, and only the present generation can fully realize its significance.

Washington was not only the first to map and recommend the general route of the great highways called the National Pike and the Chesapeake and Ohio Canal, which are now in truth 'becoming the channels of conveyance of the extensive and valuable trade of a rising empire,' but he was also the first to predict the commercial success of that route through the Mohawk valley which was afterwards taken by the Erie Canal and the New York Central Railroad.

One hundred and fifteen years ago he asked: "Would it not be worthy of the wisdom and attention of Congress to have the western waters well explored, the navigation of them fully ascertained and accurately laid down, and a complete and perfect map made of the country. . . . . The advantages would be unbounded, for sure I am that nature has made such a display of her bounties in those regions that the more the country is explored the more it will rise in estimation, consequently greater will the revenue be to the Union." Again he declared, "I shall not rest contented until I have explored the western country and have traversed those lines which have given bounds to a new empire."

Washington did not do this as fully as he wished, but his ambition has been and is being realized through the medium of hundreds of enterprises under both national and private encouragement. The result of a trip made in the fall of 1784 was the real historic beginning of the Potomac enterprise. On his return he wrote to Benjamin Harrison, Governor of Virginia, "I shall take the liberty now, my dear sir, to suggest a matter which would mark your administration as an important era in the annals of this country if it should be recommended by you and adopted by the Assembly." He reached far out for those days, assuming Detroit as a point of departure for the trade of the northwest territory. His confidence in the practical abilities of the American people is shown by the remark, "A people who are possessed with the spirit of commerce, who see and will pursue their destinies, may achieve almost anything. No person who knows the temper, genius and policy of this people as well as I do can harbor the smallest doubt."

In urging the Potomac scheme, he

later asked that commissioners be appointed to make a careful survey of the Potomac and James rivers to their respective sources, and that a complete map of the country intervening between the seaboard, the Ohio waters and the Great Lakes be presented to the people. "These things being done," he says, "I shall be mistaken if prejudice does not yield to facts, jealousy to candor and finally, if reason and nature, thus aided, do not dictate what is right and proper to be done."

He introduced his plan to the notice of Congress, thus making the first suggestion to that body of the policy of national improvements which the present generation is carrying on, as well as of the policy of exploration and national surveys to which our Government so firmly adheres. To-day the Government is carrying forward surveying work by means of the largest and most thoroughly equipped organizations in existence, and thus is Washington honored.

The scientific men of to-day owe to Washington profound respect and gratitude for the scientific spirit he cultivated in his work. The Government once established on so high a plane, it necessarily followed that all true science should be encouraged and be enlisted in the development of the citizen and of the material resources of the nation.

Charles D. Walcott,
U. S. Geological Survey,
Washington, D. C.

SCIENCE AND FICTION.

The leading article of the June number of the *Century Magazine* is entitled "The Problem of increasing Human Energy," and is written by Nikola Tesla. Mr. Tesla offers the reader some naive verbal analogies between the causes of human progress and the 'energy' of theoretical physics, and a eulogy of a number of inventions which he expects to make. He intersperses these with sundry remarkable statements such as, "our own earth will be a lump of ice;" "Though this movement is not of a translatory character, yet the general laws of mechanical movement are applicable to it;" "That we can send a message to a planet is certain, that we can get an answer is probable;" "It is highly probable that if there are intelligent beings on Mars they have long ago realized this very idea [the transmission of electrical energy for industrial purposes without wires], *which would explain the changes on its surface noted by astronomers.*" (The italics are our own.)

Mr. Tesla's doctrine of human energy is in some ways as original as the inventions and discoveries which he expects to make. Each of us is, he says, a part of a unitary whole, 'man.' "This one human being lives on and on. . . . . Therein . . . . is to be found the partial explanation of many of those marvelous phenomena of heredity which are the result of countless centuries of feeble but persistent influence." Now we may "assume that human energy is measured by half the product of man's mass with the square of a certain hypothetical velocity. . . . . the great problem of science is, and always will be, to increase the energy thus defined. . . . This mass is impelled in one direction by a force F, which is resisted by another partly frictional and partly negative force R, acting in a direction exactly opposite, and retarding the movement of the mass."

Unhappily Mr. Tesla in his enthusiasm to progress to recommendations of religion, vegetarianism, the old régime for women and the artificial preparation of nitrogen compounds, neglects to state which direction is the proper one for the human mass to follow, north, south, east, west, toward the moon or Sirius or to Dante's Satan in the centre of the earth. Nor does he explain how 'enlightenment' makes the mass of human bodies go in an exactly opposite direction to that toward which 'visionariness' impels them, nor reveal why, if his account be true, he and a 'visionary' can walk in the same direction. Of course the whole notion that the 'velocity' of the human 'mass,' *i.e.* the space it traverses in a given time, has any connection with human progress or is of any value to anybody or anything, is absurd.

Mr. Tesla has enjoyed considerable, excellent repute as a gifted student of certain electrical phenomena and one expects a good deal from his "electrical experiments, now first published." Mr. Tesla, too, expects a good deal from them. It would take too long to even note here all the important scientific discoveries which Mr. Tesla expects to make or all the benefits which he expects to thereby confer upon mankind in general and in particular upon those who exploit his inventions. Some samples may be given. War will be rendered harmless by being reduced to a sort of game between 'telantaumata,' machines which behave "just like a blind-folded person obeying instructions received through the ear," any one of which is "enabled to move and to perform all its operations with reason and intelligence."

Says Mr. Tesla: "I purpose to show that, however impossible it may now seem, an automaton may be contrived which will have its 'own mind,' and by this I mean that it will be able, independent of any operator, left entirely to itself, to perform, in response to external influences affecting its sensitive organs, a great variety of acts and operations as if it had intelligence. It will be able to follow a course laid out or to obey orders given far in advance; it will be capable of distinguishing between what it ought and what it ought not to do, and of making experiences or, otherwise stated, of recording impressions which will definitely affect its subsequent actions. In fact, I have already conceived such a plan."

Inasmuch as the interest in this telautomatic warfare is to be purely æsthetic, it would seem as if international bull-fights or kite-flying or spelling matches or potato-races might do as well, and have the added advantage of leaving Mr. Tesla's expectations free to wander among the following prospective discoveries.

New sources of energy, Mr. Tesla thinks, may be opened up, such as a wheel which shall perform work without any further effort on our part than that of constructing it. "Imagine a disc of some homogeneous material turned perfectly true and arranged to turn in frictionless bearings on a horizontal shaft above the ground. This disk, being under the above conditions perfectly balanced, would rest in any position. Now, it is possible that we may learn how to make such a disk rotate continuously and perform work by the force of gravity without any further effort on our part. . . . . To make the disk rotate by the force of gravity we have only to invent a screen against this force. By such a screen we could prevent this force from acting on one half of the disk, and the rotation of the latter would follow."

Into further particulars concerning the nature of such a screen Mr. Tesla does not enter, though it would seem a matter well fitted to engage his peculiar gifts. The 'screen against gravity' idea has already entered into a popular story, but scientific men have probably not given it much consideration.

By producing a 'sink' or reservoir of a low temperature, thereby inducing the heat of the ambient medium to transform itself in part into other forms of energy *(e.g.* electrical), Mr. Tesla hopes to "get any amount of energy without further effort" beyond the amount needed to create the 'sink.' We should thus employ "an ideal way of obtaining motor power," and incidentally rebuke the narrow-minded physics of Carnot and Lord Kelvin.

By means of his electrical oscillator Mr. Tesla has satisfied himself that he can transmit electrical energy in large quantities without wires. He expects that this can be done to great economic advantage. Then would come the golden age. "Men could settle down everywhere, fertilize and irrigate the soil with little effort, and convert barren deserts into gardens, and thus the entire globe could be transformed and made a fitter abode for mankind."

The golden age figures largely in Mr. Tesla's article; he offers us all that is entrancing and wonderful. He is generous. We ask for the bread of definite facts of science and intelligible evidence, but he gives us the amethyst and topaz and diamonds of an ambient medium doing all our work and the atmosphere transporting all our motive power and the tyrant gravity held powerless by a screen, and Mr. Tesla correcting Lord Kelvin's errors. Still amethyst and topaz and diamonds are only stones. They may dazzle the magazine reader, but they do not nourish the student of science.

The editorial department of the *Century Magazine* perhaps felt that these jewels were a bit too bright. We read there that "much that must seem speculative to the layman can take its proper place only in the purview of the scientist." Some conservative scientists will feel like growling, "And much that must seem bosh to the man of science can take its proper place only in the purview of the editorial departments of popular magazines." Leaving aside the present case, it is a fact that the same care which is exercised by editors to secure in their contributions excellence of style and syntax, a proper moral tone and freedom from advertisement of business ventures, is not exercised to secure accuracy in statements of fact or decent credibility in matters of theory. The editors apparently impute to their readers a desire to be entertained at all costs. They descend to a footing with the Sunday newspaper instead of trying to rise to the level of such scientific literature as Huxley or Tyndall gave us. They evidently often do not know science from rubbish and apparently seldom make any effort to find out the difference. They should at least submit their scientific literature to competent men for criticism and revision.

The general public is helpless before any supposedly scientific statement. It may judge vaguely by the standing of the paper or magazine or book containing it, by the name of the writer or by the general tone in which the article is written. But it cannot judge definitely by comparison with relevant facts or by critically examining the logic of the deductions, for the general public lacks both knowledge of the relevant facts and training in logical criticism. That a man should invent a microscope which will enable one to see objects a million times as small as can be seen with the naked eye seems no more questionable to the general public than that a man should cause unfertilized eggs to develop. Yet the first would be impossible while the second has been possible, probable, and still more lately proved. Guidance in scientific matters should be welcome if only for the protection thus given against fraudulent medicines, bogus inventions and nonsensical enterprises.

PHYSICIST.

SCIENTIFIC LITERATURE.

MATHEMATICAL PHYSICS.

THE memoirs presented to the Cambridge Philosophical Society on the occasion of the jubilee of Sir George Stokes, have been published in a stately volume by the Cambridge University Press. A year ago some four hundred men of science met at Cambridge to celebrate the fiftieth anniversary of the appointment of Sir George Stokes to the Lucasian professorship of mathematics, a chair held by Newton and a distinguished line of mathematicians. An official account of the proceedings, with a portrait of Professor Stokes, is given in the volume now issued. The seventy-two institutions sending delegates are arranged chronologically in the order of their foundation, and it is not unworthy of note that among the sixteen oldest institutions, the United States has five representatives, whereas Great Britain has thirteen universities and colleges younger than the Johns Hopkins University. The Rede lecture given by M. Alfred Cornu and entitled 'La théorie des ondes lumineuses,' is published in French, even the quotations from Newton's 'Opticks' being translated into that language. M. Cornu states that by 'une étude approfondie' of the 'Opticks,' his lecture shows that Newton favored Descartes's undulatory theory of light, rather than the emission theory usually attributed to him. The twenty-two memoirs that follow cover a wide range of subjects, nearly all of which have, however, a connection with the researches of Professor Stokes. They include three contributions from the United States, mathematical papers by Profs. E. W. Brown and E. O. Lovett, and a description by Professor Michelson of his echelon spectroscope.

In addition to this memorial volume, the Cambridge University Press, which is represented in America by The Macmillan Company, is at present publishing the collected papers of three eminent students of mathematical physics. The first volume of Lord Rayleigh's 'Scientific Papers' contains seventy-eight contributions published from 1869 to 1881. The early papers show the influence of Maxwell, Lord Rayleigh's predecessor in the chair of experimental physics at Cambridge, but it was apparently not until 1881 that he fully appreciated the importance of Maxwell's electro-magnetic theory of light. The papers on acoustics were followed by the publication in 1877 of the classical work on the 'Theory of Sound.' Lord Rayleigh, at an early period, treated various optical subjects, including some of the phenomena of color vision. His explanation of the blue color of the sky and his treatment of the resolving power of telescopes are well known. The contributions on optics and acoustics have been continued to the present time, but they by no means limit his interests. There are important papers on hydrodynamics and mathematics, and longer and shorter contributions on a great range of subjects in mathematical physics, the science which at the present day is perhaps of supreme importance.

The second volume of Professor Tait's 'Scientific Papers' contains those published since 1881. The first volume consisted of sixty papers, and this volume, which has followed with but little delay, adds seventy-three. As must be the case in collected papers, some are elaborate treatises while others fill only part of a single page; some are extremely technical while others were first published in the 'Encyclopædia Britannica' and the 'Contemporary Review.' Among the more elaborate papers are those on the physical properties of water contributed to 'The Voyage of H. M. S. Challenger,' on the kinetic theory of gases, on impact and on quaternions.

The third series just published by the Cambridge Press is the 'Papers on Mechanical and Physical Subjects', by Prof. Osborne Reynolds, of Owens College. The first volume contains forty papers from transactions and journals issued from 1869 to 1882. The most elaborate memoir is that on certain dimensional properties of matter in the gaseous state, which includes experiments on thermal transpiration of gases through porous plates and a theoretical extension of the dynamic theory of gas. Many of the papers, such as those on meteorological phenomena and the steering of vessels, are of popular interest. The Cambridge University Press is performing a work of the utmost value to science in undertaking the publication of these great volumes, and we can only regret that, in spite of the beginnings made at Johns Hopkins, Chicago, Pennsylvania and Columbia, American men of science have no such opportunities for the publication of their works as those afforded at Cambridge and Oxford.

BOTANY.

THAT a large amount of popular interest centers in the study of tree life and all subjects incidental to forestry and horticulture is evidenced by the appearance of a second book on the subject under the title of 'Our Native Trees and How to Identify Them' (Scribners), by Harriet L. Keeler. The volume in question takes up the trees native of northern United States east of the Rocky Mountains, together with a few well-known foreign species which have become naturalized in this region.

The book opens with a key to the families of dicotyledonous species based upon leaf characters, and every species receives not only a full technical description, but also comes in for interesting comments upon habit and general ecological relations. Numerous drawings and half-tones add to the accuracy and clearness of the descriptions. It is not too much to say that the photographic reproductions surpass in beauty and presentation of detail any recent botanical publication, and the venation of leaves is shown in most instances by this method quite as well as it might be done by means of pen and ink sketches. The value of the descriptions is heightened by the inclusion of notes of economic interest. It is not unexpected that some errors should creep into the discussions on almost all phases of botany which are interspersed throughout the volume.

The appearance of a new botanical dictionary is most timely, and it is fortunate that the task of its preparation should be undertaken by such a skilful bibliographer as Mr. B. D. Jackson. His 'Glossary of Botanical Terms' (Lippincott) contains fifteen thousand words, or three times as many as have been included in any previous work of this character. This is indicative of a most energetic pursuit of investigations in all departments of the subject, and also of a lamentable tendency to the coinage by botanists of new and unnecessary terms upon the slightest pretext. A legitimate factor in the increase of the contents of such a work consists in the inclusion of words in common use which take on a technical meaning in botany; such, for instance, as altitude, abnormal, abrupt, absolute, accidental back, etc.

Derivations are given, but the history of the terms has not been attempted. According to the author, 'anlage' may be variously rendered as *rudiment*, *inception* or *primordium*. 'Chlorophyll' receives the double consonant at the end of the last syllable against the popular extra-botanical practice. Regarding 'medullary' the author says: "I have given the accent as it is always spoken (medul'-lary) though all of the dictionaries *(botanical?)* accent it as med'-ullary except Henslow's." In this the author had in mind the practice among his insular colleagues only, since the latter pronunciation is given in the Standard, Century and Webster's Dictionaries and is followed by nine tenths of the American botanists. "Mycorhizome = mycorrhiza-like structures in Corallorhiza and Epipogum roots," and "Mycorrhiza = symbiotic fungi on the roots of plants, prothallia, etc.," are not only incongruous with orthography and botanical fact, but also with the usage of all recent writers on this subject.

While many other errors of this character could be adduced, the general value of the book is scarcely lessened, and it will be of the greatest service to the working botanist, not only in raising the general literary tone of his writings, but also in placing at his command a choice of all of the established terms dealing with any phase of the subject; an aid which will be greatly conducive to increased accuracy of statement.

A decade since, the majority of the botanists engaged in the study of the distribution of plants on this continent, as well as the strict systematists, were quite unanimously of the opinion that the territory within the boundaries of the United States had been quite thoroughly explored, and that the task of the collector are well-nigh done. Despite this discouraging conclusion a few enthusiastic workers have not intermitted their labors in a more critical consideration of the floras of the newer and less thickly settled regions, with the result that scores and hundreds of new species have been brought to light each year, and the awakening interest in the subject promises a re-exploration of the great West.

A striking example of the results awaiting the student in this line is afforded by Dr. Rydberg's 'Flora of Montana and the Yellowstone Park' (New York Botanical Garden), which has recently appeared. Although the first collections of plants in this region were made by the Lewis and Clarke expedition nearly a century ago, Dr. Ryberg finds 163 new species and varieties in the 1,976 which he lists in this volume. Of this number 487 are found on both the eastern and western slopes of the continental divide, 268 on the eastern side only, 520 on the western side only, 42 of which are arctic and inhabit the high mountain summits, and 659 which have originated in the exact region under discussion. Seven hundred and seventy-six of the species listed were not included in Coulter's 'Rocky Mountain Botany,' published a few years ago.

The symposium on the 'Plant Geography of North American,' to be given at the coming meeting of the American Association for the Advancement of Science, will do much to systematize investigations of this character and broaden the method of treatment accorded the subject in the future.

BIOLOGY.

The 'Biological Lectures from the Marine Laboratory of Woods Holl, 1899,' make up a volume of about three hundred pages which represent fairly the present tendencies of biological investigation in this country. The most striking things about the lectures are the wide range of topics which they treat, and the first-hand quality of the subject matter in each case. This is most clearly seen by a careful reading of the text, but a mere enumeration of a few of the sixteen titles and lectures makes it fairly obvious. Thus, D. P. Penhallow writes on 'The Nature of the Evidence Exhibited by Fossil Plants, and its bearing upon our Knowledge of the History of Plant Life;' D. T. MacDougal writes on the 'Significance of Mycorrhizas,' Edward Thorndike on 'Instinct,' Herbert S. Jennings on 'The Behavior of Unicellular Organisms,' Alpheus Hyatt on 'Some Governing Factors usually neglected in Biological Investigations,' T. H. Morgan on 'Regeneration,' C. B. Davenport on 'The Aims of the Quantitative Study of Variation,' Jacques Loeb on 'The Nature of the Process of Fertilization.'

To the professed scientist these lectures will furnish expert opinion on certain important topics; the general reader will find in them a presentation not too technical or detailed. Professor Loeb's lecture, for example, is for such readers the best account yet given of his experiments in artificial fertilization.

The range and originality which characterize these lectures are really characteristic of the general work and spirit of the Woods Holl Laboratory. Few people realize the amount of research work which is done there from summer to summer. Yet last year there were seventy-one investigators there. Moreover, these represent a superior selection from among the instructors and students of the various colleges.

It is a symptom of a healthy, vigorous condition in biological science that the best workers of the country are glad to devote their vacation season to research, and it is highly creditable to the Woods Holl management that it offers them such attractive facilities. Similar summer laboratories are now being established in other parts of the country, and are to be reckoned with as very important factors in the progress of biology.

CYTOLOGY.

It is a somewhat surprising fact that among educated people of scientific training there prevails generally the greatest ignorance as to some of the most important problems of biology. We refer to those problems connected with the structure and functions of the animal and plant cell. Men who can understand and appreciate recent discoveries in astronomy, physics, chemistry and geology are usually wholly lost in cytology. In fact, in general writing or speech it is not safe to use this name without at once defining it, since it is commonly supposed to be a mispronunciation or a stupid misspelling of 'psychology,' while to most people *nuclei, chromosomes, centrosomes* and *mitotic spindles* are words without meaning, signifying nothing.

The reason for this is twofold: First, cytology is one of the newest of the biological sciences and it has but recently found its way into college curricula, and second, there have been few text-books or general works on this subject to which an intelligent layman could turn for information.

And yet, in spite of this fact, there are few fields of scientific work possessing more general interest than that of cytology. At the present day the greatest problems of biology are centered in the cell. Assimilation, growth, metabolism, reproduction, differentiation, inheritance and variation—these are at bottom cellular phenomena, the result of the structure and functions of cells. It is not surprising, therefore, that "all the searchlights of science have been turned upon the cell," and that cell studies during the past ten years have received an amount of attention which is comparable only to that devoted to evolution under the stimulus of Darwin's work.

Professor Wilson's book on the cell,* the second edition of which has just appeared, is a work of more than ordinary interest, not only to the biologist, but to all persons who are interested in the general advance of science. Although there are several other good text-books of cytology which have appeared during the past five or six years, Professor Wilson's book, in thoroughness of treatment, in philosophical insight, in clearness and forcefulness of style and in wealth and beauty of illustrations, easily surpasses them all.

It is impossible in this brief note to give any adequate summary of the volume or of the position of the author on questions of general interest; the subjects of the chapters, however, may serve to give some idea as to the scope of the work. After an introduction which gives a brief historical sketch of the cell theory and its relation to the

* The Cell in Development and Inheritance. Edmund B. Wilson. Second Edition Revised and Enlarged. Columbia University Biological Series IV. New York and London, The Macmillan Co., 1900. Pp. xxi, 483 with 194 Figures in the Text. $3.50

evolution theory, there are taken up in successive chapters a general sketch of cell structure, cell division, the germ cells, fertilization of the ovum, the formation of the germ cells and the halving of their nuclei preparatory to fertilization, cell organs and their relations to each other and to the nfe of the cell, cell chemistry and cell physiology, cell division in its relation to the development of the egg, and finally, some theories of inheritance and development. In addition, there is appended an excellent glossary and a list of all the most important literature on the subject up to the current year.

While the work is undoubtedly intended as a reference book for investigators and advanced students in biology, being marked by the thoroughness of treatment of an original communication, it is yet so well written and so copiously illustrated as to make it not only intelligible but also intensely interesting to the general reader.

EDUCATION.

The most important recent book on education is undoubtedly 'Education in the United States,' a book prepared in connection with the educational exhibit of this country at the Paris Exposition. It consists of a series of monographs which cover all the important phases of educational endeavor in the United States. The two volumes include nearly a thousand pages, almost all of which present definite and reliable facts. Only rarely is there any indulgence in expressions of private opinion, and still more rarely is such opinion questionable. The editor is justified in his statement that the book is 'a cross-section view of education in the United States in 1900.' It will be of great value to the student of American institutions or of education in general, and should be of interest to any citizen who desires to be well informed about his country. The quality of the monographs will be evident from the list of the author's names. For instance, those writing on higher education are Prof. A. F. West, of Princeton; Prof. E. D. Perry, of Columbia; President Thomas, of Bryn Mawr; Director Parsons, of the University of the State of New York; President Mendenhall, of the Worcester Polytechnic Institute, and Prof. H. B. Adams, of Johns Hopkins.

THE PROGRESS OF SCIENCE.

THE conditions in the United States have been favorable to the development of geology. The varied forms of the land have offered abundant opportunities for research, whereas the practical value of the work has led to the establishment of surveys, the magnitude of whose contribution to geology is only known to special students. The Geological Society of America has about two hundred and fifty members, nearly all of whom are actively engaged in geological research, perhaps a larger number than in any other science. The U. S. Geological Survey is the center of this movement, and its great efficiency is in large measure due to Mr. G. K. Gilbert, now president of the American Association for the Advancement of Science. He was born in Rochester, N. Y., in 1843, and after graduating from the university in that city, acted for five years as assistant in the Ward Museum, where a number of eminent naturalists have been trained. He then became geologist in the Ohio Survey under Newberry, was engaged in the Wheeler and Powell Surveys, and has been geologist in the U. S. Geological Survey since its establishment in 1879. In the arid west, where the face of the earth is bare, Mr. Gilbert made the observations and discoveries in dynamical and physical geology which have done so much toward the making of the science of physiography. His monographs on the Henry Mountains and on Lake Bonneville, the name he gave to the ancient lake that once filled the Utah basin, are models, both in regard to their original discoveries and the methods of presentation. He has extended his studies to the basins of the Laurentian Lakes and to other regions, always with important results. Mr. Gilbert has been president of the American Society of Naturalists, the Geological Society of America and the Philosophical Society of Washington, and has received the Wollaston Medal of the Geological Society of London. His presidential address before the American Association will be given at the American Museum of Natural History, New York City, on the evening of June 26, his subject being 'Geological Rhythm.'

THE meeting of the American Association in New York City, opening as this issue of the MONTHLY is published, promises to be of more than usual importance. The preliminary programs of the different sections show long lists of valuable papers and promise the attendance of leading men of science from all parts of the country. A movement of interest is the increasing tendency of special scientific societies to meet in conjunction with the Association. No less than fifteen societies will this year hold their sessions at Columbia University, some of them joining with the sections of the Association, and others holding independent meetings. The members of these different societies have the advantage of the reduced railway rates and other arrangements which can be made once for all, and the still greater advantage of meeting scientific men in other departments. As science grows in details and in range, there is on the one hand an increased specialization, making it desirable for small groups of experts to meet together to discuss their special problems, while, on the other hand, almost every scientific question has ramifications extending to many sciences. Hence, the need of many separate societies and at the same time of a common meeting ground. When the American Association was organized, in 1848, its members could meet in one body; later they divided into two sections, one for the exact sciences and one for natural history. In 1882 nine sections were organized, but it was not until 1892 that botany was separated from zoölogy. At present the sections no longer suffice, and there must be either a further subdivision and a more efficient organization of the sections, or the American Association must become an administrative body, that will arrange for the simultaneous meetings of independent societies and the union of these societies in support of their common interests.

The obvious advantages of meeting together have now led nearly all the national scientific societies to select either the time of the American Association or Christmas week for joint meetings. It is unfortunate that they should be divided into two groups, and it must be admitted that neither midsummer nor the Christmas holidays are altogether suitable for the meetings. The American Association has this year made the experiment of selecting the end of June, immediately after the close of the college sessions, instead of a week in August. This has some advantages, but even at the beginning of the summer many men of science are either abroad or are engaged in scientific expeditions. The heat is apt to be excessive, interfering not only with the meetings, but also requiring some self-sacrifice on the part of scientific men when they leave their comfortable summer homes to travel through heat and dust to a hot and dusty city. Christmas week, divided by Sunday, is too short for a series of scientific meetings, especially for those who must travel from a distance. This led to the organization last winter of the Cordillerean Geological Society, the Western Society of Naturalists and the Western Philosophical Association. Local associations are, of course, valuable, but they should not interfere with one central meeting in the course of the year. The plan has been suggested of taking one week, either immediately after the New Year or in the early spring, for a general scientific gathering, which would include not only the exact and natural sciences, but also philology, history, etc. The plan would be to secure an adjournment of exercises or leave of absence in the case of universities, colleges, museums, Government departments, etc., with the understanding that it would be the duty of all those who were released from their regular work to attend the meetings.

The American Association last met in New York City in 1887, though there was a meeting in Brooklyn in 1894. The past thirteen and even the past six years have witnessed an extraordinary development in the educational and scientific institutions of the city. Columbia College and New York University have developed into great universities, each having found a new site and erected upon it buildings which might have been expected to come only as the growth of a century. The American Museum of Natural History has become one of the great museums of the world, millions of dollars having been spent on buildings. A botanical garden and a zoölogical park have been established, which promise to rival those of any of the European capitals. A well-equipped aquarium has been opened under the auspices of the city; the Metropolitan Museum of Art has been entirely rebuilt to accommodate its increasing collections; a magnificent building is in course of erection for the Public Library to contain its great assemblage of books, which with its endowment is largely the result of recent years. While Boston and Philadelphia have made great advances within the last few years, and Washington has become the chief scientific center of the United States, it is especially noteworthy that New York City has enjoyed an educational and scientific development commensurate with its material resources.

Jonas G. Clark, who ten years ago established at Worcester a university and christened it with his name, has died and left to the university several hundred thousand dollars, and on certain conditions practically the whole of his estate, which is said to be between five and ten million dollars. The will is a complicated document with numerous codicils, somewhat difficult to interpret and likely to give rise to legal complications. The history of Clark University has been curious and interesting. As in the case of the Johns Hopkins University, there was a difference of opinion between the founder and the president as to the scope of the institution. In both cases the founder had in view a more or less local college, while the president believed that we had colleges in sufficient number, but needed in the United States universities on German models, but going even further than Germany in making research rather than instruction the primary object of the institution. Johns Hopkins died very soon after the establishment of his university, and though there was for a while a good deal of difference of opinion in the board of trustees, the university idea triumphed. A college was, however, established in connection with it. At Clark University the founder lived for ten years, and appears to have altered several times his point of view. He withdrew his support, and the university work which began brilliantly was much reduced in range and quality. The greater part of the faculty removed in a body to the University of Chicago. It appears that at this time Mr. Clark bequeathed his money to the university only on condition that the president should resign, but later devised a compromise by which the university should continue as at present, while a partly independent college should be established in conjunction with it. The interpretation of the will, the value of the estate and the development of the university open problems that will only be settled in the course of time.

Europeans who look upon the United States as a material and commercial nation must find it difficult to interpret the great gifts that are continually made for the cause of higher education. Twenty-five years ago there were in America no universities in the sense in which the term is most properly employed. During this comparatively brief period the older institutions have become universities, and the great increase in expenditure has been met chiefly by voluntary contributions. The annual expenditure, for example, at Harvard and Columbia Universities is about a half million dollars beyond the tuition fees, and the money invested in grounds and buildings is in the case of either university many millions. Then this period has witnessed the establishment of new universities, rivaling in endowment the older institutions. The Johns Hopkins University and Clark University have been mentioned above, but the most noteworthy instances are the University of Chicago, to which one benefactor still living has given eight million dollars, and Leland Stanford Junior University, the endowment of which reaches the enormous sum of thirty-five million dollars. At the same time, the State universities, directly supported by the people, are beginning to rival privately endowed institutions. It may be confidently asserted that no nation has ever so liberally supported higher education, and the wisdom of this liberality is now demonstrated, even from the most mercenary point of view, by the place the United States has taken in the world's commerce. It will be still further demonstrated in the course of the next twenty-five years. It is possible that existing conditions are not favorable to literature and to art, but the future of science in the United States is assured beyond question.

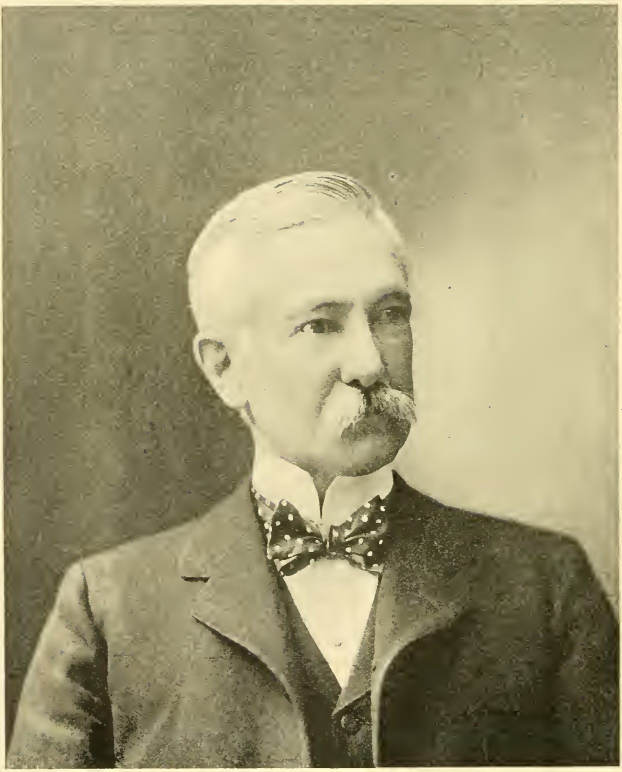
It is sometimes said that Government control and individual initiative can not be united, but there is no justification for this view in the development of the educational and scientific institutions of the United States. Institutions established by private initiative have been assisted by the State, and State institutions have received large sums from private individuals. The New York institutions referred to above—the American Museum of Natural History, the Metropolitan Museum of Art, the Public Library, the Botanical Gardens and the Zoölogical Park—are in almost equal measure supported by the city and by citizens of the city. Johns Hopkins University, the University of Pennsylvania, Cornell University and other privately endowed institutions have received assistance from the State, without any decrease in private gifts, while the State universities, California for example, are receiving large private endowments in addition to their support from the State. These conditions may not last, but at all events they obtain at the present time, and we find the country in which the largest gifts from private individuals are made for education and science to be the country in which they are most liberally supported by the Government.

Never before has any government made such great appropriations for the development of the resources of the country or for the advance of science as the Congress which has just adjourned. We may take for example the Department of Agriculture, for which the appropriation is $4,023,500, an increase of more than $280,000 over the appropriation for the preceding year. Every one familiar with the conditions at Washington and throughout the country will know that this large sum of money is expended with the utmost economy, and there is no doubt but what the money invested by the nation is returned to the people many fold in the course of every year. Some of the items of the bill deserve special notice. Thus, a new agricultural experiment station is to be established in the Hawaiian Islands, and the work of the Weather Bureau is to be extended to them. The agricultural resources and capabilities of Porto Rico are to be investigated, and bulletins of information in English and in Spanish are to be distributed to the inhabitants. The division of chemistry is to investigate the use of food preservatives and coloring matter, determine their relations to health and establish the principles which should guide their use. The division of forestry receives an increase of $40,000 and the Weather Bureau an increase of over $35,000. Other items of the appropriation act are as follows: Biological Survey, $30,300, an increase of $2,740; Division of Botany, $43,080, an increase of $14,280; Nutrition Investigation, $17,500, an increase of $2,500; Division of Pomology, $18,400; Public Road Inquiry, $14,000, an increase of $6,000; Division of Statistics, $146,160; Library, $14,000; and Museum, $2,260.

While American men of wealth have given freely of their means for the promotion of education and science, they have not so often devoted their own time to its service. This is natural, as the wealth has in most cases been acquired by the present generation, and it is in succeeding generations, when families have been established, that leisure and wealth will give a class similar to that which has accomplished so much for Great Britain and to a lesser extent for Germany and France. Still, it is the case that the heads of two of our chief universities are men of great wealth, who have devoted not only their means, but also their services to the cause of education, and there are in our universities and other institutions many who hold their positions purely out of interest in their work, not as a means for their support. In the next generation there will probably be more representatives of a class to which belonged the Duke of Argyll, whose death we were compelled to record last month. Another man has since died of a somewhat similar type. When Colonel Lane-Fox somewhat unexpectedly succeeded to large estates in Wiltshire and Dorsetshire and assumed the name Pitt-Rivers, his chief interest seemed to be in the earth works and tumuli of Cranbourne Chase, and the extensive memoirs he has published and the museum he has established show what good use he made of the excavations. Some of the results of his earlier work will be found at Oxford, but he built at Farnham, in Dorsetshire, a museum which contains collections of the greatest possible value.

The communication in this issue signed 'Physicist' is worthy of note. If what its writer says is true, it is evident that a reputation as a brilliant inventor does not insure that its possessor is a safe writer about general physics. Our correspondent, who represents fairly the opinion of scientific men in general, finds fault with Mr. Tesla's article in the June *Century* in many important particulars. During the years since Mr. Tesla's notable invention of the polyphase alternate current transformer, he seems to have become less definite and exact in his thinking, and less productive as an inventor. The speculation and rhetoric of the *Century* article are certainly disappointing to every one who is trying to bring about an intelligent and sound view of science on the part of non-scientific people. Men of science everywhere should certainly make it their business to instruct people in general about the progress, and even the prospects, of science through the press, but it takes wisdom on the part of both writers and editors to know what is instructive and what is misleading. Honest criticism such as that of our correspondent is therefore highly desirable.

It is generally agreed that the most important advance of last year in the science of medicine was the discovery that the parasite causing malaria was transmitted from person to person by mosquitoes. Dr. Manson describes this discovery fully in this number of the Popular Science Monthly. This summer a crucial experiment is being made of a somewhat dramatic character. A mosquito-proof tent has been constructed, which is located in Italy, in the Campagna. In this Dr. Luigi Sambon, lecturer of the London Tropical School of Medicine, and Dr. G. C. Low will live until October, taking the utmost care not to be bitten by mosquitoes. If they escape malaria it will serve as corroborative evidence that the mosquito is the means of infection. On the other hand, several Englishmen, including Dr. Manson's son, have offered themselves as subjects for the complementary experiment. They will live in a healthy district, but will definitely allow themselves to be bitten by mosquitoes which are known to be infected. These experiments will probably be particularly useful in demonstrating to the public at large the validity of the hypothesis derived last year from technical bacteriological evidence.



PROFESSOR R. S. WOODWARD,

PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE

POPULAR SCIENCE

MONTHLY.

AUGUST, 1900.

RHYTHMS AND GEOLOGIC TIME.*

By G. K. GILBERT,

UNITED STATES GEOLOGICAL SURVEY.

CUSTOM dictates that in complying with the rule of the association I shall address you on some subject of a scientific character. But before doing so I may be permitted to pay my personal tribute to the honored and cherished leader of whose loss we are so keenly sensible on this occasion. His kindly personality, the charm which his earnestness and sincerity gave to his conversation, the range of his accomplishment, are inviting themes; but it is perhaps more fitting that I touch this evening on his character as a representative president of this body. The association holds a peculiar position among our scientific organizations of national or continental extent. Instead of narrowing its meetings by limitations of subject matter or membership, it cultivates the entire field of research and invites the interest and coöperation of all. It is thus not only the integrating body for professional investigators, but the bond of union between these and the great group of cultured men and women—the group from whose ranks the professional guild is recruited, through whom the scientific spirit is chiefly propagated, and through whose interest scientific research receives its financial support. Its aims and form of organization recognize, what pure science does not always itself recognize, that pure science is fundamentally the creature and servant of the material needs of mankind, and it thus stands for what might be called the human side of science. Edward Orton, throughout his career as teacher and investigator, was conspicuous for his attention to the human side of science. His most ab-

*Read to the American Association for the Advancement of Science, at New York, June 26, 1900, as the address of the retiring President.

stract work was consciously for the benefit of the community, and he ever sought opportunity to make its results directly available. In promoting the interests of the people of his adopted State he incidentally accomplished much for a larger community by helping it to an appreciation of the essential beneficence of the scientific study of nature and man. As an individual he was a diligent and successful laborer in the field which the association cultivates, and when the association selected him as its standard-bearer it made choice of one who was peculiarly its representative.

The subject to which I shall invite your attention this evening is by no means novel, but might better be called perennial or recurrent; for the problem of our earth's age seems to bear repeated solution without loss of vigor or prestige. It has been a marked favorite, moreover, with presidents and vice-presidents, retiring or otherwise, when called upon to address assemblies whose fields of scientific interest are somewhat diverse—for the reason, I imagine, that while the specialist claims the problem as his peculiar theme of study, he feels that other denizens of the planet in question may not lack interest in the early lore of their estate.

The difficulty of the problem inheres in the fact that it not only transcends direct observation, but demands the extrapolation or extension of familiar physical laws and processes far beyond the ordinary range of qualifying conditions. From whatever side it is approached, the way must be paved by postulates, and the resulting views are so discrepant that impartial onlookers have come to be suspicious of these convenient and inviting stepping stones.

That vain expectation may not be aroused, I admit at the outset that I have not solved the problem and shall submit to you no estimates. My immediate interest is in the preliminary question of the available methods of approach, and it leads to the consideration of the ways, or the classes of ways, in which the measurement of time has been accomplished or attempted.

Of the artificial devices employed in practical horology there are two so venerable that their origins are lost in the obscurity of legendary myth. These are the clepsydra and the taper. In the clepsydra advantage is taken of the approximately uniform rate at which water escapes through a small orifice, and time is measured by gaging the loss of water from a discharging vessel or the gain in a receiving vessel. The hour-glass is one of its latest forms, in which sand takes the place of water. The taper depends for its value as a timepiece on the approximate uniformity of combustion when the area of fuel exposed to the air is definitely regulated. It survives chiefly in the prayer stick and safety fuse, but the graduated candle is perhaps still used to regulate monastic vigils.

The pendulum, a comparatively modern invention, excelling the clepsydra and taper in precision, has altogether supplanted them as the servant of civilization. Its accuracy results from the remarkable property that the period in which it completes an oscillation is almost exactly the same, whatever the arc through which it swings. It regulates the movements not only of our clocks, watches and chronometers, but of barographs, thermographs and a great variety of other machines for recording events and changes in their proper order and relation in respect to time.

I must mention also a special apparatus invented by astronomers and called a chronograph. It consists ordinarily of a revolving drum about which a paper is wrapped and against which rests a pen. As the drum turns the pen draws a line on the paper. Through an electric circuit the pen is brought under the influence of a pendulum in such a way that at the middle of each swing of the pendulum the pen is deflected, making a mark at right angles to the straight line. The series of marks thus drawn constitutes a time scale. The electric arrangements are so made that the pen will also be disturbed in consequence of some independent event, such as the firing of a gun or the transit of a star; and the mark caused by such disturbance, being automatically platted on the time scale, records the time of the event.

No attempt has been made to characterize these various timepieces with fullness, because they are already well known to most of those present, and, in fact, the chief motive for giving them separate mention is that they may serve as the basis of a classification. In the use of the clepsydra and taper, time is measured in terms of a continuous movement or process; in the use of the pendulum time is measured in terms of a movement which is periodically reversed. The classification embodies the fundamental distinction between continuous motion and rhythmic motion.

Passing now from the artificial to the natural measures of time, we find that they are all rhythmic. It is true that the spinning of the earth on its axis is in itself a continuous motion, but it would yield no time measure if the earth were alone in space, and so soon as the motion is considered in relation to some other celestial body it becomes rhythmic. As viewed from, or compared with, a fixed star, the period of its rhythm is the sidereal day; compared with the sun, it is the solar day, nearly four minutes longer; and compared with the moon, it is the lunar day, still longer by 49 minutes. As the sun supplies the energy for most of the physical and all the vital processes of the earth's surface, the rhythm of the solar day is impressed in multitudinous ways on man and his environment, and he makes it his primary or standard unit of time. He has arbitrarily divided it into hours, minutes and seconds, and in terms of these units he says that the length of the sidereal day is a little more than 23 hours, 56 minutes and 4 seconds, and the average length of the lunar day is a little less than 24 hours and 49 minutes. The lunar day finds expression in the tides and is of moment to maritime folk, but the sidereal is known only to astronomers.

Next in the series of our natural time units is the month, or the rhythmic period of the moon regarded as a luminary. By our savage ancestors, who credited the moon with powers of great importance to themselves, much use was made of this unit, but as progress in knowledge has shown that the influence of the satellite had been vastly overrated, less and less attention has been paid to the returning crescent, and it is only in ecclesiastic calendars that the chronology of civilization now recognizes the natural month. Its shadow survives, without the substance, in the calendar month; and the week possibly represents an early attempt to subdivide it.

In passing to our third natural unit, the year, we again encounter solar influence, and find the rhythm of the earth's orbit echoed and re-echoed in innumerable physical and vital vibrations. As the attitude of the earth's axis inclines one hemisphere toward the sun for part of the year and the other hemisphere for the remainder, the whole complex drama of climate is annually enacted, and the sequence of man's activities is made to assume an annual rhythm. The year is second only to the day as a terrestrial unit of duration; and as the day is man's standard for the minute division of time, so the year is his standard for larger divisions, and the decade, the century and the millenium are its multiples.

But the rhythms of day and night, of summer and winter, are not the only tides in the affairs of men. At birth we are small, weak and dependent, we grow larger and stronger, we become mature and independent, and then by reproducing our kind we complete the cycle, which begins again with our children. The cycle of human life is the *generation*, a time unit of somewhat indefinite length and varying in phase from family to family, but holding a place, nevertheless, in human chronology.

Still less definite is the rhythm of hereditary rulership, progressing from vigor through luxury to degeneracy, and closing its cycle in usurpation; yet it makes an epoch in the life of a nation or empire, and so the *dynasty* is one of the units of the historian.

The generation and the dynasty are of waning importance in human chronology, and they can claim no connection with the problem of geologic time; but here again I have turned aside for a moment in order to illustrate a principle of classification. The daily rhythm of waking and sleeping, of activity and rest, does not originate with man, but is imposed on him by the rhythm of light and darkness, and that in turn springs from the turning of the earth in relation to the shining sun. The yearly rhythm of sowing and harvesting, of the fan and the furnace, does not originate with man, but is imposed on him by the rhythm of the seasons, and that in turn springs from certain motions of the earth in relation to the glowing sun. But the rhythm of the generation and the rhythm of the dynasty have origin in the nature of man himself. The rhythms of human chronology may thus be grouped according to source in two classes, the *imposed* and the *original;* and the same distinction holds for other rhythms. The lunar day is an original rhythm of the earth as seen from the moon; the ground swell is an original rhythm of the ocean; but the tide is an imposed rhythm of the ocean, being derived from the lunar day. The swing of the pendulum is an original rhythm, but the regular excursion of the chronograph pen, being caused by the swing of the pendulum, is an imposed rhythm.

In giving brief consideration to each of the more important ways by which the problem of the earth's age has been approached, I shall mention first those which follow the action of some continuous process, and afterward those which depend on the recognition of rhythms.

The earliest computations of geologic time, as well as the majority of all such computations, have followed the line of the most familiar and fundamental of geologic processes. All through the ages the rains, the rivers and the waves have been eating away the land, and the product of their gnawing has been received by the sea and spread out in layers of sediment. These layers have been hardened into rocky strata, and from time to time portions have been upraised and made part of the land. The record they contain makes the chief part of geologic history, and the groups into which they are divided correspond to the ages and periods of that history. In order to make use of these old sediments as measures of time it is necessary to know either their thickness or their volume, and also the rate at which they were laid down. As the actual process of sedimentation is concealed from view, advantage is taken of the fact that the whole quantity deposited in a year is exactly equalled by the whole quantity washed from the land in the same time, and measurements and estimates are made of the amounts brought to the sea by rivers and torn from the cliffs of the shore by waves. After an estimate has been obtained of the total annual sedimentation at the present time, it is necessary to assume either that the average rate in past ages has been the same or that it has differed in some definite way.

At this point the course of procedure divides. The computer may consider the aggregate amount of the sedimentary rocks, irrespective of their subdivisions, or he may consider the thicknesses of the various groups as exhibited in different localities. If he views the rocks collectively, as a total to be divided by the annual increment, his estimate of the total is founded primarily on direct measurements made at many places on the continents, but to the result of such measurements he must add a postulated amount for the rocks concealed by the ocean, and another postulated amount for the material which has been eroded from the land and deposited in the sea more than once.

If, on the other hand, he views each group of rocks by itself, and takes account of its thickness at some locality where it is well displayed, he must acquire in some way definite conceptions of the rates at which its component layers of sand, clay and limy mud were accumulated, or else he must postulate that its average rate of accretion bore some definite ratio to the present average rate of sedimentation for the whole ocean. This course is, on the whole, more difficult than the other, but it has yielded certain preliminary factors in which considerable confidence is felt. Whatever may have been the absolute rate of rock building in each locality, it is believed that a group of strata which exhibits great thickness in many places must represent more time than a group of similar strata which is everywhere thin, and that clays and marls, settling in quiet waters, are likely to represent, foot for foot, greater amounts of time than the coarser sediments gathered by strong currents; and studying the formations with regard to both thickness and texture, geologists have made out what are called *time ratios*—series of numbers expressing the relative lengths of the different ages, periods and epochs. Such estimates of ratios, when made by different persons, are found to vary much less than do the estimates of absolute time, and they will serve an excellent purpose whenever a satisfactory determination shall have been made of the duration of any one period.

Reade has varied the sedimentary method by restricting attention to the limestones, which have the peculiarity that their material is carried from the land in solution; and it is a point in favor of this procedure that the dissolved burdens of rivers are more easily measured than their burdens of clay and sand.

An independent system of time ratios has been founded on the principle of the evolution of life. Not all formations are equally supplied with fossils, but some of them contain voluminous records of contemporary life; and when account is taken of the amount of change from each full record to the next, the steps of the series are found to be of unequal magnitude. Though there is no method of precisely measuring the steps, even in a comparative way, it has yet been found possible to make approximate estimates, and these in the main lend support to the time ratios founded on sedimentation. They bring aid also at a point where the sedimentary data are weak, for the earliest formations are hard to classify and measure. It is true that these same formations are almost barren of fossils, but biologic inference does not therefore stop.

The oldest known fauna, the Eocambrian, does not represent the beginnings of life, but a well-advanced stage, characterized by development along many divergent lines; and by comparing Eocambrian life with existing life the paleontologist is able to make an estimate of the relative progress in evolution before and after the Eocambrian epoch. The only absolute blank left by the time ratios pertains to an azoic age which may have intervened between the development of a habitable earth crust and the actual beginning of life.

Erosion and deposition have been used also, in a variety of ways, to compute the length of very recent geologic epochs. Thus, from the accumulation of sand in beaches Andrews estimated the age of Lake Michigan, and Upham the age of the glacial lake Agassiz; and from the erosion of the Niagara gorge the age of the river flowing through it has been estimated. But while these discussions have yielded conceptions of the nature of geologic time, and have served to illustrate the extreme complexity of the conditions which affect its measurement, they have accomplished little toward the determination of the length of a geologic period; for they have pertained only to a small fraction of what geologists call a period, and that fraction was of a somewhat abnormal character.

Wholly independent avenues of approach are opened by the study of processes pertaining to the earth as a planet, and with these the name of Kelvin is prominently associated.

As the rotation of the earth causes the tides, and as the tides expend energy, the tides must act as a brake, checking the speed of rotation. Therefore the earth has in the past spun faster than now, and its rate of spinning at any remote point of time may be computed. Assuming that the whole globe is solid and rigid, and that the geologic record could not begin until that condition had been attained, there could not have been great checking of rotation since consolidation. For if there had been, it would have resulted in the gathering of the oceans about the poles and the baring of the land near the equator, a condition very different from what actually obtains. This line of reasoning yields an obscure outer limit to the age of the earth.

On the assumption that the globe lacks something of perfect rigidity, G. H. Darwin has traced back the history of the earth and the moon to an epoch when the two bodies were united, their separation having been followed by the gradual enlargement of the moon's orbit and the gradual retardation of the earth's rotation; and this line of inquiry has also yielded an obscure outer limit to the antiquity of the earth as a habitable globe.

One of the most elaborate of all the computations starts with the assumption that at an initial epoch, when the outer part of the earth was consolidated from a liquid condition, the whole body of the planet had approximately the same temperature; and that as the surface afterward cooled by outward radiation there was a flow of heat to the surface by conduction from below. The rate of this flow has diminished from that epoch to the present time according to a definite law, and the present rate, being known from observation, affords a measure of the age of the crust. The strength of this computation lies in its definiteness and the simplicity of its data; its weakness in the fact that it postulates a knowledge of certain properties of rock—namely, its fusibility, conductivity and viscosity—when subjected to pressures and temperatures far greater than have ever been investigated experimentally.

A parallel line of discussion pertains to the sun. Great as is the quantity of heat which that incandescent globe yields to the earth, it is but a minute fraction of the whole amount with which it continually parts, for its radiation is equal in all directions, and the earth is but a speck in the solar sky. On the assumption that this immense loss of heat is accompanied by a corresponding loss of volume, the sun is shrinking at a definite rate, and a computation based on this rate has told how many millions of years ago the sun's diameter should have been equal to the present diameter of the earth's orbit. Manifestly the earth can not have been ready for habitation before the passage of that epoch, and so the computation yields a superior limit to the extent of geologic time.

Before passing to the next division of the subject—the computations based on rhythms—a few words may be given to the results which have been obtained from the study of continuous processes. Realizing that your patience may have been strained by the kaleidoscopic character of the rapid review which has seemed unavoidable, I shall spare you the recitation of numerical details and merely state in general terms that the geologists, or those who have reasoned from the rocks and fossils, have deduced values for the earth's age very much larger than have been obtained by the physicists, or those who have reasoned from earth cooling, sun cooling and tidal friction. In order to express their results in millions of years the geologists must employ from three to five digits, while the physicists need but one or two. When these enormous discrepancies were first realized it was seen that serious errors must exist in some of the observational data or else in some of the theories employed; and geologists undertook with zeal the revision of their computations, making as earnest an effort for reconciliation as had been made a generation earlier to adjust the elements of the Hebrew cosmogony to the facts of geology. But after rediscussing the measurements and readjusting the assumptions so as to reduce the time estimates in every reasonable way—and perhaps in some that were not so reasonable—they were still unable to compress the chapters of geologic history between the narrow covers of physical limitation; and there the matter rests for the present.

The rocks which were formed as sediments show many traces of rhythm. Some are composed of layers, thin as paper, which alternate in color, so that when broken across they exhibit delicate banding. In the time of their making there was a periodic change in the character of the mud that settled from the water. Others are banded on a larger scale; and there are also bandings of texture where the color is uniform. Many formations are divided into separate strata, as though the process of accretion had been periodically interrupted. Series of hard strata are often separated by films or thin layers of softer material. Strata of two kinds are sometimes seen to alternate through many repetitions. Borings in the delta of the Mississippi show soils and remains of trees at many levels, alternating with river silts. The rock series in which coal occurs are monotonous repetitions of shale and sandstone. Belgian geologists have been so impressed by the recurrence of short sequences of strata that they have based an elaborate system of rock notation upon it.

Passing to still greater units, the large aggregates of strata sometimes called systems show in many cases a regular sequence, which Newberry called a "circle of deposition." When complete, it comprises a sandstone or conglomerate, at base, then shale, limestone, shale and sandstone. This sequence is explained as the result of the gradual encroachment, or transgression, as it is called, of the sea over the land and its subsequent recession.

In certain bogs of Scandinavia deep accumulations of peat are traversed horizontally by layers including tree stumps in such way as to indicate that the ground has been alternately covered by forest and boggy moss. The broad glaciers of the Ice age grew alternately smaller and larger—or else were repeatedly dissipated and reformed—and their final waning was characterized by a series of halts or partial readvances, recorded in concentric belts of ice-brought drift. Of these belts, called moraines of recession, Taylor enumerates seventeen in a single system.

In explanation of these and other repetitive series incorporated in the structure of the earth's crust, a variety of rhythmic causes have been adduced; and mention will be made of the more important, beginning with those which have the character of original rhythms.

A river flowing through its delta clogs its channel with sediment, and from time to time shifts its course to a new line, reaching the sea by a new mouth. Such changes interrupt and vary sedimentation in neighboring parts of the sea. Storms of rain make floods, and each flood may cause a separate stratum of sediment. Storms of wind give destructive force to the waves that beat the shore, and each storm may cause the deposit of an individual layer of sediment. Varying winds may drive currents this way and that, causing alternations in sedimentation.

To explain the forest beds buried in the Mississippi silts it has been suggested that the soft deposits of the delta from time to time settled and spread out under their own weight. Various alternations of strata, and especially those of the coal measures, have been ascribed to successive local subsidences of the earth's crust, caused by the addition of loads of deposit. It has been suggested also that land undergoing erosion may rise up from time to time because relieved of load, and the character of sediment might be changed by such rising. Subterranean forces, of whatever origin, seemingly slumber while strains are accumulating, and then become suddenly manifest in dislocations and eruptions, and such catastrophes affect sedimentation.

A more general rhythm has been ascribed to the tidal retardation of rotation and the resulting change of the earth's form. If the body of the earth has a rather high rigidity, we should expect that it would for a time resist the tendency to become more nearly spherical, while the water of the ocean would accommodate itself to the changing conditions of equilibrium by seeking the higher latitudes. Eventually, however, the solid earth would yield to the strain and its figure become adjusted to the slower rotation, and then the mobile water would return. Thus would be caused periodic transgressions by the sea, occurring alternately in high and low latitudes.

Another general rhythm has been recently suggested by Chamberlin in connection with the hypothesis that secular variations of climate are chiefly due to variations of the quantity of carbon dioxide in the atmosphere.* The system of interdependent factors he works out is too complex for presentation at this time, and I must content myself with saying that his explanation of the moraines of recession involves the interaction of a peculiar atmospheric condition with a condition of glaciation, each condition tending to aggravate the other, until the cumulative results brought about a reaction and the climatic pendulum swung in the opposite direction. With each successive oscillation the momentum was less, and an equilibrium was finally reached.

Few of these original rhythms have been used in computations of geologic time, and it is not believed that they have any positive value for that purpose. Nevertheless, account must be taken of them, because they compete with imposed rhythms for the explanation of many phenomena, and the imposed rhythms, wherever established, yield estimates of time.

The tidal period, or the half of the lunar day, is the shortest imposed rhythm appealed to in the explanation of the features of sedimentation.

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* An attempt to frame a working hypothesis of the cause of glacial periods on an atmospheric basis. *Journ. Geol.*, Vol. VII., 1899.

It is quite conceivable that the bottom of a quiet bay may receive at each tide a thin deposit of mud which could be distinguished in the resulting rock as a papery layer or lamina. If one could in some way identify a rock thus formed, he might learn how many half-days its making required by counting its laminæ, just as the years of a tree's age are learned by counting its rings of growth.

The next imposed rhythm of geologic importance is the year. There are rivers, like the Nile, having but one notable flood in each year, and so depositing annual layers of sediment on their alluvial plains and on the sea beds near their mouths. Where oceanic currents are annually reversed by monsoons, sedimentation may be regularly varied, or interrupted, once a year. Streams from a glacier cease to run in winter, and this annual interruption may give a definite structure to resulting deposits. It is therefore probable that some of the laminæ or strata of rocks represent years, but the circumstances are rarely such that the investigator can bar out the possibility that part of the markings or separations were caused by original rhythms of unknown period.

The number of rhythms existing in the solar system is very large, but there are only two, in addition to the two just mentioned, which seem competent to write themselves in a legible way in the geologic record. These are the rhythms of precession and eccentricity.

Because the earth's orbit is not quite circular and the sun's position is a little out of the center, or eccentric, the two hemispheres into which the earth is divided by the equator do not receive their heat in the same way. The northern summer, or the period during which the northern hemisphere is inclined toward the sun, occurs when the earth is farthest from the sun, and the northern winter occurs when the earth is nearest to the sun, or in that part of the orbit called perihelion. These relations are exactly reversed for the southern hemisphere. The general effect of this is that the southern summer is hotter than the northern, and the southern winter is colder than the northern. In the southern part of the planet there is more contrast between summer and winter than in the northern. The sun sends to each half the same total quantity of heat in the course of a year, but the difference in distribution makes the climates different. The physics of the atmosphere is so intricate a subject that meteorologists are not fully agreed as to the theoretic consequences of these differences of solar heating, but it is generally believed that they are important, involving differences in the force of the winds, in the velocity and course of ocean currents, in vegetation, and in the extent of glaciers.

Now, the point of interest in the present connection is that the astronomic relations which occasion these peculiarities are not constant, but undergo a slow periodic change. The relation of the seasons to the orbit is gradually shifting, so that each season in turn coincides with the perihelion; and the climatic peculiarities of the two hemispheres, so far as they depend on planetary motions, are periodically reversed. The time in which the cycle of change is completed, or the period of the rhythm, is not always the same, but averages 21,000 years. It is commonly called the precessional period.*

Assuming that the climates of many parts of the earth are subject to a secular cycle, with contrasted phases every 10,500 years, we should expect to find records of the cycle in the sediments. A moist climate would tend to leach the calcareous matter from the rock, leaving an earthy soil behind, and in a succeeding drier climate the soil would be carried away; and thus the adjacent ocean would receive first calcareous and then earthy sediments. The increase of glaciers in one hemisphere would not only modify adjacent sediments directly, but, by adding matter on that side, would make a small difference in the position of the earth's center of gravity. The ocean would move somewhat toward the weighted hemisphere, encroaching on some coasts and drawing down on others; and even a small change of that sort would modify the conditions of erosion and deposition to an appreciable extent in many localities.

Blytt ascribed to this astronomic cause the alternations of bog and forest in Scandinavia, as well as other sedimentary rhythms observed in Europe; and it has seemed to me competent to account for certain alternations of strata in the Cretaceous formations of Colorado. Croll used it to explain interglacial epochs, and Taylor has recently applied it to the moraines of recession.

The remaining astronomic rhythm of geologic import is the variation of eccentricity. At the present time our greatest distance from the sun exceeds our least distance by its thirtieth part, but the difference is not usually so small as this. It may increase to the seventh part of the whole distance, and it may fall to zero. Between these limits it fluctuates in a somewhat irregular way, in which the property of periodicity is not conspicuous. The effect of its fluctuation is inseparable from the precessional effect, and is related to it as a modifying condition. When the eccentricity is large the precessional rhythm is emphasized; when it is small the precessional effect is weak.

The variation of eccentricity is connected with the most celebrated of all attempts to determine a limited portion of geologic time. In the elaboration of the theory of the Ice age which bears his name, Croll correlated two important epochs of glaciation with epochs of high eccentricity computed to have occurred about 100,000 and 210,000 years ago. As the analysis of the glacial history progresses, these correlations will

*Strictly speaking, 21,000 years is the period of the precession of the equinoxes as referred to perihelion; but the perihelion is itself in motion. As referred to a fixed star the precession of the equinoxes has an average period of about 25,700 years.

eventually be established or disproved, and should they be established it is possible that similar correlations may be made between events far more remote.

The studies of these several rhythms, while they have led to the computation of various epochs and stages of geologic time, have not yet furnished an estimate either of the entire age of the earth or of any large part of it. Nevertheless, I believe that they may profitably be followed with that end in view.

The system of rock layers, great and small, constituting the record of sedimentation, may be compared to the scroll of a chronograph. The geologic scroll bears many separate lines, one for each district where rocks are well displayed, but these are not independent, for they are labeled by fossils, and by means of these labels can be arranged in proper relation. In each time line are little jogs—changes in kind of rock or breaks in continuity—and these jogs record contemporary events. A new mountain was uplifted, perhaps, on the neighboring continent, or an old uplift received a new impulse. Through what Davis calls stream piracy a river gained or lost the drainage of a tract of country. Escaping lava threw a dam across the course of a stream, or some Krakatoa strewed ashes over the land and gave the rivers a new material to work on. The jogs may be faint or strong, many or few, and for long distances the lines may run smooth and straight; but so long as the jogs are irregular they give no clue to time Here and there, however, the even line will betray a regularly recurring indentation or undulation, reflecting a rhythm and possibly significant of a remote pendulum whose rate of vibration is known. If it can be traced to such a pendulum there will result a determination of the rate at which the chronograph scroll moved when that part of the record was made; and a moderate number of such determinations, if well distributed, will convert the whole scroll into a definite time scale.

In other words, if a sufficient number of the rhythms embodied in strata can be identified with particular imposed rhythms, the rates of sedimentation under different circumstances and at different times will become known, and eventually so many parts of geologic time will have become subject to direct calculation that the intervals can be rationally bridged over by the aid of time ratios.

For this purpose there is only one of the imposed rhythms of practical value, namely, the precessional; but that one is, in my judgment, of high value. The tidal rhythm can not be expected to characterize any thick formation. The annual is liable to confusion with a variety of original rhythms, especially those connected with storms. The rhythm of eccentricity, being theoretically expressed only as an accentuation of the precessional, can not ordinarily be distinguished from it. But none of these qualifications apply to the precessional. It is not liable to confusion with the tidal and annual because its period is so much longer, being more than 2,000 times that of the annual. It has an eminently practical and convenient magnitude, in that its physical manifestation is well above the microscopic plane, and yet not so large as to prevent the frequent bringing of several examples into a single view. It is also practically regular in period, rarely deviating from the average length by more than the tenth part.

From the greater number of original rhythms it is distinguished, just as from the annual and tidal, by magnitude. The practical geologist would never confuse the deposit occasioned by a single storm, for example, with the sediments accumulated during an astronomic cycle of 20,000 years. But there are other original rhythms, known or surmised, which might have magnitudes of the same general order, and to discriminate the precessional from these it is necessary to employ other characters. Such characters are found in its regularity or evenness of period, and in its practical perpetuity. The diversion of the mouth of a great river such as the Hoang Ho or the Mississippi might recur only after long intervals; but from what we know of the behavior of smaller streams we may be sure that such events would be very irregular in time as well as in other ways. The intervals between volcanic eruptions at a particular vent or in a particular district may at times amount to thousands of years, but their irregularity is a characteristic feature. The same is true of the recurrent uplifts by which mountains grow, so far as we may judge them by the related phenomena of earthquakes; and the same category would seem to hold also the theoretically recurrent collapse of the globe under the strains arising from the slowing of rotation. The carbon-dioxide rhythm, known as yet only in the field of hypothesis, is hypothetically a running-down oscillation, like the lessening sway of the cradle when the push is no longer given.

But the precessional motion pulses steadily on through the ages, like the swing of a frictionless pendulum. Its throb may or may not be caught by the geologic process which obtains in a particular province and in a particular era, but whenever the conditions are favorable and the connection is made, the record should reflect the persistence and the regularity of the inciting rhythm.

The search of the rocks for records of the ticks of the precessional clock is an out-of-door work. Pursued as a closet study it could have no satisfactory outcome, because the printed descriptions of rock sequences are not sufficiently complete for the purpose; and the closet study of geology is peculiarly exposed to the perils of hobby-riding. A student of the time problem cannot be sure of a persistent, equable sedimentary rhythm without direct observation of the characters of the repeated layers. He needs to avail himself of every opportunity to study the series in its horizontal extent, and he should view the local problem of original *versus* imposed rhythm with the aid of all the light which the field evidence can cast on the conditions of sedimentation.

Neither do I think of rhythm seeking as a pursuit to absorb the whole time and energy of an individual and be followed steadily to a conclusion; but hope rather that it may receive the incidental and occasional attention of many of my colleagues of the hammer, as other errands lead them among cliffs of bedded rocks. If my suggestion should succeed in adding a working hypothesis or point of view to the equipment of field geologists, I should feel that the search had been begun in the most promising and advantageous manner. For not only would the subject of rhythms and their interpretations be advanced by reactions from multifarious individual experiences, but the stimulus of another hypothesis would lead to the discovery of unexpected meanings in stratigraphic detail.

It is one of the fortunate qualities of scientific research that its incidental and unanticipated results are not infrequently of equal or even greater value than those directly sought. Indeed, if it were not so, there would be no utilitarian harvest from the cultivation of the field of pure science.

In advocating the adoption of a new point of view from which to peer into the mysterious past, I would not be understood to advise the abandonment of old stand-points, but rather to emulate the surveyor, who makes measurement to inaccessible points by means of bearings from different sides. Every independent bearing on the earth's beginning is a check on other bearings, and it is through the study of discrepancies that we are to discover the refractions by which our lines of sight are warped and twisted. The three principal lines we have now projected into the abyss of time miss one another altogether, so that there is no point of intersection. If any one of them is straight, both the others are hopelessly crooked. If we would succeed we should not only take new bearings from each discovered point of vantage, but strive in every way to discover the sources of error in the bearings we have already attempted.

THE PHOTOGRAPHY OF SOUND WAVES.

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ANY one who has stood near a large naval gun during its discharge, will, I think, be prepared to admit that the sound of the explosion affects not only the ears, but the whole body as well, which experiences something not unlike a sudden blow. This blow, or concussion, as it is generally termed, is merely the impact of the wave of compressed air, spreading out in all directions around the gun. In the case of ordinary sounds, the compression of the air in the wave is so slight that only the delicate auditory nerves respond to the impact, hence we naturally conclude that sounds are perceived only by the ear. When dealing with sounds of very great intensity, this notion must be somewhat modified, for they certainly can be felt as well as heard. In some extreme cases, in fact, the sensation of feeling may be stronger than that of hearing, as in the case of which I shall speak presently. Is it also possible that we can perceive sound through the medium of any other sense organ, say the eye? 'To see a noise' certainly sounds like an absurdity; yet under certain conditions, sound waves in air can be made as distinctly visible as the ripples on a pond surrounding the splash of a stone. That they are not seen under ordinary conditions does not justify us in assuming them to be invisible. We all know that the currents of hot air rising from a stove, while not usually conspicuous,can be made visible by properly regulating the illumination, as by looking along the surface of the stove towards a window. The hot air is visible because in its optical properties it is different from the cold air surrounding it. The rays of light, passing through the unequally heated portions of the air, are bent in different directions, causing a distortion of objects seen through the heated currents. What we see, strictly speaking, is not the hot air itself, but a wavering and swimming of the objects seen through it. Yet I think we are justified in saying that the eye perceives the hot air.

Now sound waves in air, which are merely regions where the air is somewhat compressed, differ in their optical properties from the uncompressed portions, just as the hot air differs from the cold. As the pictures illustrating this article testify, they may be seen and photographed under proper conditions of illumination as readily as solid objects. We must remember, in the first place, that a sound wave travels with a velocity something greater than a thousand feet a second, rather less than the speed of a modern rifle ball, yet ten times faster than the fastest express train. The wave, even if it were stationary, could be seen only by adjusting the illumination with far greater care than was necessary in the case of the hot air, and we consequently can easily understand why we never see the waves under ordinary conditions.

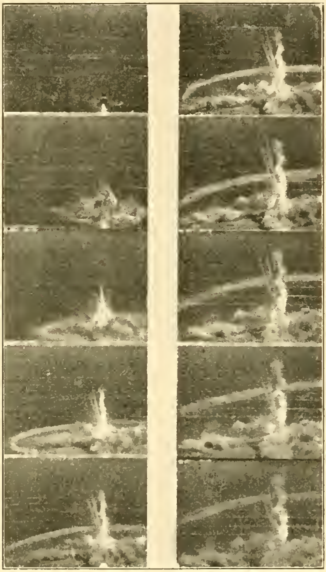
While it is true that laboratory appliances are generally required to render them visible, I should like at the outset to cite an example to show that in the case of very loud sounds occurring in the open air the wave can be perceived by the eye, without the aid of any apparatus whatever. I will quote from an article by Prof. C. V. Boys, which appeared in 'Nature,' June 24, 1897. Mr. Boys first cites the following letter from Mr. E. J. Ryves: "On Tuesday, April 6th, I had occasion, while carrying out some experiments with explosives, to detonate one hundred pounds of a nitro-compound. The explosive was placed on the ground in the center of a slight depression, and in order to view the effect, I stationed myself, at a distance of about three hundred yards, on the side of a neighboring hill. The detonation was complete, and a hole was made in the ground five feet deep and seven feet in diameter. A most interesting observation was made during the experiment. The sun was shining brightly, and at the moment of detonation the shadow of the sound wave was most distinctly seen leaving the area of disturbance. I heard the explosion as the shadow passed me, and I could follow it distinctly in its course down the valley for at least half a mile; it was so plainly visible that I believe it would photograph well with a suitable shutter."

Professor Boys at once made preparations for photographing the phenomenon at the first opportunity. On May 19th the experiment was made. One hundred and twenty pounds of a nitro-compound were exploded, and an attempt made to photograph the sound shadow, both with the camera and the kinematograph, the latter instrument designed and operated by Mr. Paul. Writing of the experiment, Professor Boys says: "On the day on which I was present, about one hundred and twenty pounds of a nitro-compound were detonated, and ten pounds of black powder were added to make sufficient smoke to show on the plate. As the growth of the smoke cloud is far less rapid than the expansion of the sound shadow, no confusion could result from this. At the time of the explosion my whole attention was concentrated upon the camera, and for the moment I had forgotten to look for the 'Ryves ring,' as I think it might be called; but it was so conspicuous that it forced itself upon my attention. I *felt*, rather than *heard*, the explosion at the moment that it passed. We stationed ourselves as near as prudence would allow, at a distance of one hundred and twenty yards, so that only about one third of a second elapsed between the detonation and the passage of the shadow. The actual appearance of the ring was that of a strong, black, circular line, opening out with terrific speed from the point of explosion as a center. It was impossible to judge of the thickness of the shadow; it may have been three feet, or it may have been more at first, and have gradually become less in thickness, or possibly in depth of shade."

Unfortunately, Professor Boys's apparatus did not work satisfactorily, but a most interesting series of pictures was secured by the kinematograph. This instrument had been constructed especially for taking ipctures at a very high rate of speed, viz., eighty exposures a second, or four times the usual number. The sound wave appears in the first dozen pictures as a hazy ring of light, opening out from the center of explosion. The ring, though not very conspicuous when the pictures are viewed singly, becomes a striking object when they are projected in rapid succession on the screen. We see the rush of smoke along the ground to the box in which the explosion is confined (the smoke of the quick fuse); then comes the burst of the explosion with such startling reality that we involuntarily jump. The image of the sound wave flies out in the form of a white ring, and is gone in a moment; and there remain only the rolling clouds of smoke. It is interesting to observe the development of the explosion by running the machine quite slowly, and by thus magnifying time to follow the changes which ordinarily occur in such rapid succession that the eye is unable to perceive them.

Of this series of pictures, Professor Boys says: "The kinematograph fails to show any *black* ring; and this is not surprising, as with the exposure of about one one hundredth of a second the shadow would have to be at least eleven feet thick in order that some part should remain obscured during the whole exposure. As a fact, there is clearly seen a circular light shading, which does—so far as one can judge from the supposed rate of working and the known distances—expand at about the same rate as the observed shadow, but it is lighter than the ground and shaded, instead of being dark and sharp, as seen by the eye."

So much for the visibility of sound under ordinary conditions. In the laboratory, by means of an optical contrivance due to the German physicist Toepler, we can secure a means of illumination so sensitive that the warm air rising from a person's hand appears like dense black smoke. Moreover, since we are working on a small scale, we can use the electric spark as the source of light, and dispense with the photographic shutter. This is a great advantage, for the time of the exposure is, under these conditions, only about one fifty-thousandth of a second, during which time the sound wave will move scarcely a quarter of an inch. During the past year I have made a very complete series of photographs of sound waves, which illustrate in a most beautiful manner the fundamental principles of wave motion. It is not practicable to give here a full description of the apparatus used, but a brief outline may make the method intelligible. The sound photographed in each case is the crack of an electric spark, which is illuminated and photographed by the light of a second spark, occurring a brief instant later. In front of a large lens (a telescope objective, for example) two brass balls are mounted, between which the 'sound spark,' as I shall call it, passes. The instant the spark jumps across the gap, a spherical wave of condensed air starts out, which, when it reaches our ear, gives the sensation of a snap. The object is to photograph this wave before it gets beyond the limits of the lens. The camera is mounted in front of the lens and focussed on the



Kinetoscope Film of Explosion.

brass balls, which appear in line in the picture, so that the sound spark is always hidden by the front one. The spark, on jumping between the balls, charges a Leyden jar, which instantly discharges itself between two wires placed behind the lens, producing the illuminating spark. This second spark can be made to lag behind the first just long enough to catch the sound wave when it is but a few inches in diameter, notwithstanding the fact that the spherical wave is expanding at the rate of eleven hundred feet a second. The photographs show in every case the circle of the lens filled up with the light of the illuminating spark, the brass balls (in line) and the rods that support them, and the sound wave, which appears in the simplest case as a circle of light and shade surrounding the balls. By placing an obstacle in the way of the wave we get the reflected wave or echo, and we shall see that the form of this echo may be very complicated.

It will be well at the outset to remind the reader of the close analogy between sound and light. A burning candle gives out spherical light waves, just as the snapping sparks give out sound waves. The form of the reflected light wave will be identical with that of a sound wave reflected under similar conditions. As we can not see the light waves themselves, we can only determine their form by calculation, and it is interesting to see that the forms photographed are identical in every case with the calculated ones. The object in view was to secure acoustical illustrations of as many of the phenomena connected with light as possible. We will begin with the very simplest case of all: the reflection of a spherical sound wave from a flat surface, corresponding to the reflection of light from a plane mirror. It can be shown by geometry that the reflected wave or echo will be a portion of a

FIG. 1. SOUND WAVE REFLECTED FROM A PLANE SURFACE.

sphere, the center of which lies as far below the reflecting surface as the point at which the sound originates is above it. In the case of light, this point constitutes the image in the mirror. Referring to the photograph, we see the reflected wave in three successive positions, the interval between the sound spark and the illuminating spark having been progressively increased. The brass balls are shown at A, and beneath them the flat plate B, which acts as a reflector. In the first picture the sound wave C appears as a circle of light and shade, and has just intersected the plate. The echo appears at D. In the next two pictures the original wave has passed out of the field, and there remains only the echo.

It may, perhaps, be not out of place to remind the reader of the relation between rays of light and the wave surface. What we term light rays have no real existence, the ray being merely the path traversed by a small portion of consecutive wave surfaces. Since the wave surface always moves in a direction perpendicular to itself, the rays are always normal to it. For instance, in the above case of a spherical wave diverging from a point, the rays radiate in all directions from the point; the same is true in the case of the echo, the rays radiating from the image point below the reflecting surface. In all subsequent cases the reader can, if interested in tracing the analogy between sound and light, draw lines perpendicular to the reflected wave surfaces representing the system of reflected waves.

We will now consider a second case of reflection. We know that if a lamp is placed in the focus of a concave mirror, the rays, instead of diverging in all directions, issue from the mirror in a narrow beam. The headlight of a locomotive and the naval searchlight are examples of the practical use made of this property. If the curvature of the mirror is parabolical, the rays leaving it are parallel; consequently mirrors of this form are employed rather than spherical ones. But what has the mirror done to the wave surface which is obviously spherical when it leaves the lamp, and what is its form after reflection? The wave surface, I have said, is always perpendicular to the rays; consequently in cases where we have parallel rays we should expect the wave to be flat or plane.

Examine the second photograph, which shows a spherical sound wave

FIG. 2. SPHERICAL SOUND WAVE.

starting at the focus of a parabolic mirror. The echo appears as a *straight line,* instead of a circle as in the previous case, which shows us that the wave surface is flat.

If now our mirror is a portion of a sphere instead of a paraboloid, our reflected wave is not flat, and the reflected rays are not all parallel, the departure from parallelism increasing as we consider rays reflected from points farther and farther away from the center of the mirror. A photograph illustrating the reflection of sound under these conditions is next shown, the echo wave being shaped like a flat-bottomed saucer. As the saucer moves upward the curved sides converge to a focus at the edge of the flat bottom, disappearing for the moment (as is shown in the fourth picture of the series), and then reappearing on the under side after passing through the focus, the saucer turning inside out.

If, instead of having a hemisphere, as in the last case, we have a complete spherical mirror, shutting the wave up inside a hollow ball, we get exceedingly curious forms; for the wave can not get out, and is bounced back and forth, becoming more and more complicated at each reflection. This is illustrated in our next photograph, the mirror being a broad strip of metal bent into a circle.* Intricate as these wave surfaces are, they have all been verified by geometrical constructions, as I shall presently show.

Another very interesting case of reflection is that occurring inside an elliptical mirror. When light diverges from one of the two foci of such a mirror, all the rays are brought accurately to the other focus. If rays of light come to a focus from all directions, it is evident that the wave surface must be a sphere, which, instead of expanding, is collapsing. This is very beautifully shown in the photographs. The sound wave starts in one focus and the reflected wave, of spherical form also, shrinks to a point at the other focus. (See fig. 5.)

In the next series the wave starts outside of the field of the lens,

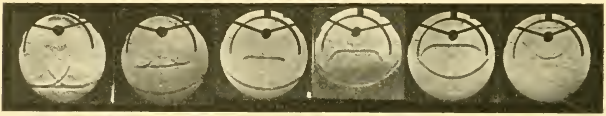


FIG. 3. A WAVE REFLECTED FROM A PORTION OF A SPHERE.

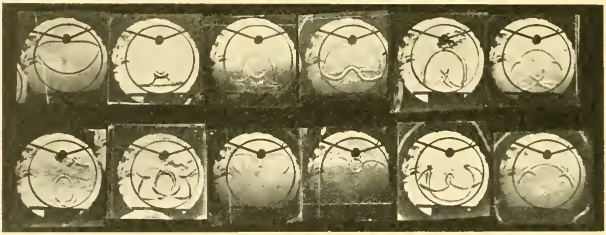


FIG. 4. A WAVE FROM A CYLINDRICAL MIRROR

and enters a hemispherical mirror. We know that a concave mirror has the power of bringing light to a focus at a point situated half-way between the surface of the mirror and its center of curvature. If the light comes from a very distant point, and the mirror is parabolic in form, the rays are brought *accurately* to a focus; which means that the reflected wave is a converging sphere,—a condition the opposite of that in which spherical waves start in the focus of such a mirror. If, however, the mirror is spherical, only a portion of the light comes to a focus. On examining the pictures we see that the reflected wave has a form resembling a volcanic cone with a bowl-shaped crater.

* Cylindrical mirrors have been used instead of spherical, for obvious reasons. A sectional view of the reflected wave is the same in this case as when produced by a spherical surface.

See the third and fourth pictures of the series. The bowl of the crater shrinks to a point half-way between the surface of the mirror and its center of curvature, and represents that portion of the light which comes to a focus, while the sides of the cone run in under the collapsing bowl, and eventually cross. (No. 6 of the series.) From now on the portion which has come to a focus diverges, uniting with the sides of the cone, the whole passing out of the mirror in the form of a horseshoe.

We will now consider a case of refraction, and show the slower

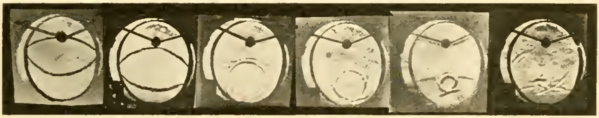


Fig. 5. A Wave from an Elliptical Mirror.

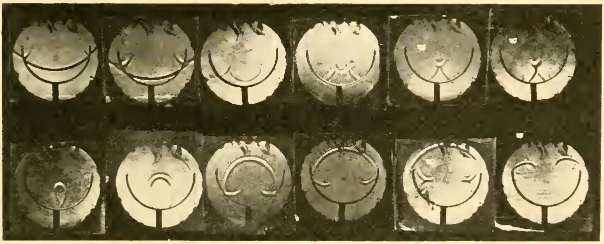


Fig. 6. A Wave Starting Outside the Field of the Lens.

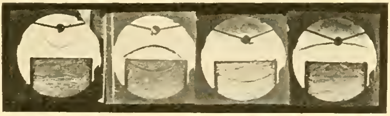


Fig. 7. A Case of Refraction.

velocity of the sound wave in carbonic acid. A narrow glass tank, covered with an exceedingly thin film of collodion, was filled with the heavy gas and placed under the brass balls. When the sound wave strikes the collodion surface, it breaks up into two components, one reflected back into the air, the other transmitted down through the carbonic acid. An examination of the series shows that the reflected wave in air has moved farther from the collodion film than the transmitted wave, which, as a matter of fact, has been flattened out into a hyperboloid. Exactly the same thing happens when light strikes a block of glass. We have rays reflected from the surface, and rays transmitted through the block, the waves which give rise to the latter moving slower than the ones in air.

A complete discussion of all of the cases that have been studied in this way would probably prove wearisome to the general reader. Prisms and lenses of collodion filled with carbonic acid and hydrogen gas have been made, and their action on the wave surface photographed. Diffraction, or the bending of the waves around obstacles, and the very complicated effects when the waves are reflected from corrugated surfaces, are also well shown. I shall, however, omit further mention of them and speak of but one other case, possibly the most beautiful of all.

In all the cases that we have considered, it must be remembered that we have been dealing with a single wave—a pulse, as it is called. Musical tones are caused by trains of waves, the pitch of the note corresponding to the distance between the waves, or to the rate at which the separate pulses beat upon the drum of the ear. For studying the changes produced by reflection, wave trains would have been useless,

Fig. 8. A Musical Tone.

owing to the confusion which would have resulted from the superposition of the different waves. Moreover, it is doubtful whether an ordinary musical tone could be photographed in this way; for the distance between the waves, even in the shrillest tones, is four or five inches, and the abrupt change in density, necessary for the perception of the wave, is not present. It is possible, however, to create a wave train or musical tone which can be photographed. The reader may perhaps have noticed that on a very still night, when walking beside a picket fence or in front of a high flight of steps, the sounds of his footsteps are echoed from the palings as metallic squeaks. Each picket, as the single wave caused by the footfall sweeps along the fence, reflects a little wave; consequently a train of waves falls on the ear, the distance between the waves corresponding to the distance between the pickets. The closer together the pickets, the shriller the squeak. In point of fact, the distance between the waves in such a train is twice the distance between the palings, since they are not struck simultaneously by the footstep wave, but in succession.

This phenomenon, of the creation of a musical tone by the reflection of a noise, was reproduced by reflecting the crack of the spark from a little flight of steps. In the first picture the wave is seen half way between its origin and the reflecting surface. In the second it has struck the top stair, which is giving off its echo, the first wave of our artificially constructed musical tone. In the third we find the original wave at the sixth step, with a well-developed train of five waves rising from the flight. The following three pictures show the further development of the wave train. The height of each step was about a quarter of an inch; consequently the distance between the waves was half an inch. This would correspond to a note about three octaves above the highest ever used in music.

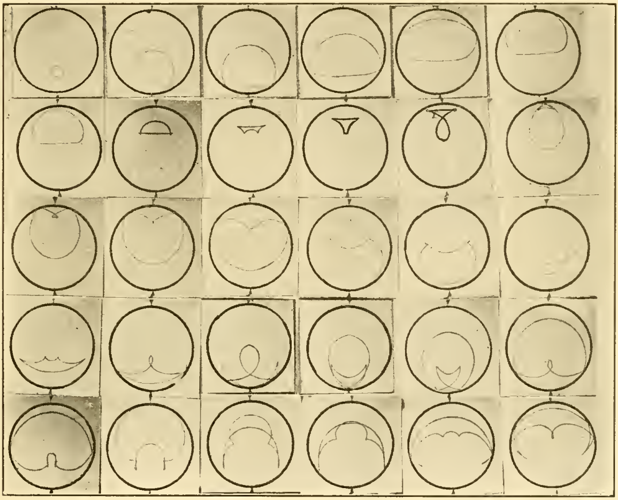


FIG 9. THE REFLECTION INSIDE THE HOLLOW SPHERE.

While experimenting with the complete circular mirror, which, it will be remembered, gave the most complicated forms, it occurred to me that a very vivid idea of how these curious wave surfaces are produced could be obtained by preparing a complete series in proper order on a kinetoscope film, and then projecting them in succession on the screen. The experimental difficulties were, however, too great to make it seem worth while to attempt to obtain a series of pictures of the actual waves, it being very difficult to accurately regulate the time interval between the two sparks. The easier method of making a large number of geometrical constructions, and then photographing them in succession on the film, was accordingly adopted. Three complete sets of drawings, to the number of about one hundred each, were prepared for three separate cases of reflection;—viz.: the entrance of a plane wave into a hemispherical mirror, the passage of a spherical wave out from the focus of a hemispherical mirror, and the multiple reflection of a spherical wave inside of a complete spherical mirror. Special methods were devised for simplifying the constructions, and much less labor was required in the preparation of the diagrams than one would suppose. The results fully justified the labor, the evolutions of the waves being shown in a most striking manner. These films I exhibited before the Royal Society in February last, and a more complete description of the manner of preparing them may be found in the Proceedings of the Society.

A portion of one of these series is reproduced, about one in four or five of the separate diagrams being given. The series runs from left to right in horizontal rows. When projected on the screen, the spherical wave is seen gradually to expand from the focus point, like a swelling soap bubble; it strikes the surface, and the bowl-shaped echo bounces off and follows the unreflected portion across the field; these two portions are then reflected in turn, and the curiously looped wave flies back and forth across the mirror, changing continuously all the time, and becoming more complicated at each reflection. These diagrams should be compared with the photographs shown in the fourth series.

One must not suppose that these beautiful forms exist only in the laboratory. Every time we speak, spherical waves bounce off the floor, ceiling and walls of the room, while in any ordinary bowl or basin the curious crater-shaped echoes are formed. Glance once more at the wave surfaces produced within a hollow sphere, and try to imagine the complexity of the aerial vibrations caused by a fly buzzing around in an empty water-caraffe! The photographs enable us to realize what is going on around us all the time—this our perceptions are fortunately too dull to perceive. Life would be a nightmare if we were obliged to see the myriads of flying sound waves bounding and rebounding about us in every direction, and combining into grotesque and ever-changing forms. It is just as well, on the whole, that the light of the electric spark and the delicate optical device of Toepler are necessary to bring them into view.

THE PSYCHOLOGY OF RED.

By HAVELOCK ELLIS.

AMONG all colors, the most poignantly emotional tone undoubtedly belongs to red. The ancient observation concerning the resemblance of scarlet to the notes of a trumpet has often been repeated, though it was probably unknown to the young Japanese lady who, on hearing a boy sing in a fine contralto voice, exclaimed: "That boy's voice is red." On the one hand, red is the color that idiots most easily learn to recognize; on the other hand, Kirchhoff, the chemist, called it the most aristocratic of colors; Pouchet, the zoölogist, was inclined to think that it was a color apart, not to be paralleled with any other chromatic sensation, and recalled that the retinal pigment is red; Laycock, the physician, confessed that he preferred the gorgeous red tints of an autumn sunset to either musical sounds or gustatory flavors. Artists more cautious than men of science in expressing such a preference—knowing that a color possesses its special virtue in relation to other colors, and that all are of infinite variety—yet easily reveal, one may often note, a predilection for red by introducing it into scenes where it is not naturally obvious, whether we turn to a great landscape painter like Constable or to a great figure painter like Rubens, who, with the development of his genius, displayed even greater daring in the introduction of red pigments into his work.

In all parts of the world red is symbolical of joyous emotion. Often, either alone or in association with yellow, occasionally with green, it is the fortunate or sacred color. In lands so far apart as France and Madagascar scarlet garments were at one time the exclusive privilege of the royal family. A great many different colors are symbolical of mourning in various parts of the world; white, gray, yellow, brown, blue, violet, black can be so used, but, so far as I am aware, red never. Everywhere we find, again, that red pigments and dyes, and especially red ochre, are apparently the first to be used at the beginning of civilization, and that they usually continue to be preferred even after other colors are introduced. There is indeed one quarter of the globe where the allied color of yellow, which often elsewhere is the favorite after red, may be said to come first. In a region of which the Malay peninsula is the center and which includes a large part of China, Burmah and the lower coast of India, yellow is the sacred and preferred color, but this is the only large district which presents us with any exception to the general rule, among either higher or lower races, and since yellow falls into the same group as red, and belongs to a neighboring part of the spectrum, even this phenomenon can scarcely be said to clash seriously with the general uniformity.*

If we turn to Australia, whither the anthropologist often turns in order to explore some of the most primitive and undisturbed data of early human culture still available for study, we find the preference for red very well marked. In times of rejoicing the tribes at Port Mackay, Curr remarked, paint themselves red; in times of mourning, white. In describing the paintings and rock carvings of the Australians, Mathews states that red, white, black and occasionally yellow pigments were used, precisely the four pigments which Karl von den Steinen found in use in Central Brazil. Prof. Baldwin Spencer and Mr. Gillen, in their valuable work on the natives of Central Australia, have pointed out the significance and importance of red ochre. One of the most striking and characteristic features, they say, of Central Australians' implements and weapons is the coating of red ochre with which the native covers everything except his spear and spear-thrower. The hair is greased and red-ochred, and red ochre is the most striking feature in decoration generally. For ages past the Australian native has been accustomed to rub this substance regularly over his most sacred objects, and then over ordinary objects.

There is, however, no need to go so far afield in order to illustrate the primitive use of red ochre. Our own European ancestors followed exactly the same methods, and the German woman of early ages used red and yellow ochre to adorn her face and body, while the finds of the ice age at Schussenquelle, described by Fraas, included a brilliant red paste (oxide of iron with reindeer fat) evidently intended for purposes of adornment. Moreover, the early artists of classic times had precisely the same predilections in color as the aboriginal Australian artists. Red, white, black and yellow are the dominant colors in the *Iliad*, and Pliny mentions that the most ancient pictures were painted in various reds, while at a later date red and yellow predominated. He also mentions that yellow was the favorite color of women for garments, and was specially used at marriages, while red being a sacred color and apt to provoke joy, was used at popular festivals, in the form of minium and cinnabar, to smear the statutes of Jupiter.

This well-nigh universal recognition of the peculiarly intense emotional tone of red is reflected in language. The color words of civilized and uncivilized peoples have been investigated with interesting and on the whole remarkably harmonious results. It is only necessary here to refer to them briefly in so far as they are related to our present subject.

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* A further partial exception is furnished by the tendency to prefer green which may be found in certain countries, now or formerly Mahommedan, such as North Africa and to a large extent Spain, which have an arid and more or less desert climate.

It seems that in every country the words for the colors at the red end of the spectrum are of earlier appearance, more definite and more numerous, than for those at the violet end. On the Niger it appears that there are only three color words, red, white and black, and everything that is not white or black is called red. The careful investigation of the natives of Torres Straits and New Guinea by Dr. W. H. R. Rivers, of the Cambridge Anthropological Expedition, has shown that at Murray Island, Mabuiag and Kiwai there were definite names for red, less definite for yellow, still less so for green, while any definite name for blue could not be found. In this way as we pass from the colors of long wave-length towards those of short wave-length we find the color nomenclature becoming regularly less definite. In Kiwai and Murray Island the same word was applied to blue and black, and at Mabuiag there was a word (for sea-color) which could be applied either to blue or green, while Australian natives from Fitzroy River seemed limited to words for red, white and black. In a neighboring region of Northern Queensland Dr. Walter Roth has reached almost identical results, the tribes having distinct names for red and yellow, as applied to ochre, while blue is confounded in nomenclature with black. In Brazil, again, while all tribes use separate words for red, yellow, white and black, only one had a word for blue and green. Even so æsthetic a people as the Japanese have no general words for either blue or green, and apply the same color word to a green tree and the unclouded sky.

Here again we may trace similar phenomena in Europe; the same greater primitiveness, precision and copiousness of the color vocabulary at the long wave end of the spectrum are found among Europeans as well as among the lowest savages. The vagueness of the Greek color vocabulary, especially at the violet end of the spectrum, has led to much controversy. Latin was especially rich in synonyms for red and yellow, very poor in synonyms for green and blue. The Latin tongue had even to borrow a word for blue from Teutonic speech; *caeruleus* originally meant dark. Even in the second century A. D. Aulus Gellius, who knew seven synonyms for red and yellow, scarcely mentions green and blue. Magnus has pointed out that a preference for the colors at the violet end of the spectrum coincided with the spread of Christianity, to which we owe it, he believes, that yellow ceased to be popular and was treated with opprobrium.* Modern English bears witness that our ancestors, like the Homeric poets, resembled the Australian aborigines in identifying the color of the short wave end of the spectrum with entire absence of color, for 'blue' and 'black' appear to be etymologically the same word.

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*In this connection I may mention that the preference for green, which, as I have shown elsewhere ("The Color Sense in Literature," *Contemporary Review*, May, 1896), developed in English literature with the rise of Puritanism in the seventeenth century.

At this point we come across an interesting and once warmly debated question. It was maintained some twenty years ago by writers who had been impressed by the defectiveness of the color vocabulary at the short wave-length end of the spectrum, that primitive man generally, and early Hellenic man in particular, were insensitive to the colors at that end of the spectrum, and unable to distinguish them. On investigation of individuals belonging to savage races it appeared, however, that no marked inferiority in color discrimination could be demonstrated. Hence it became clear that the vague and defective vocabulary for blue and green must be due to some other cause than vague and defective perception, and that sensation and nomenclature were not sufficiently parallel to enable us to argue from one to the other.

That, in the main, is a conclusion which still holds good. In all parts of the world it has been found that color discrimination, even amongst the lowest savages, is far more accurate than color nomenclature. Thus of an African Bantu tribe, the Mang'anja, Miss Werner states that they can discriminate all varieties of blue in beads, but call them all black. The sky is black; so is any green, brown or grey article, though a very bright grey counts as white. Violet or purple is black. Yellow is either red or white. A word supposed sometimes to mean green really means raw, unripe or even wet. Thus the Mang'anja only have three colors—black, white and red. In quite a different region, the Zulus, more advanced in color nomenclature, have not only black, white and red, but a word which may mean either green or blue, and another which means yellow, buff or grey, or some shade of brown. At the same time it now appears that the earlier scientific writers on this subject were not entirely wrong in stating that among savages there is some actual failure of perception at the short wave end of the spectrum, although they were wrong in arguing that it was necessarily involved in the defects of color vocabulary, and in imagining that it could be as extensive as that hypothesis demanded. It now appears that the conclusions reached by Hugo Magnus of Breslau, as expressed in 1883 in his study 'Ueber Ethnologische Untersuchungen des Farbensinnes,' fairly answer to the facts. In large measure relying on the examination of 300 Chukchis made by Almquist during the Nordenskiold Expedition, Magnus concluded that although the color vision of the uncivilized has the same range from red to violet as that of the civilized and all the colors can usually be separately distinguished, there is sometimes a certain dullness, a diminished energy of sensation, as regards green and blue, the shorter and more refrangible waves of the spectrum, while the colors at the other end are perceived with much greater vividness. Stephenson, more recently, among over one thousand Chinese, examined at various places, found only one case of color blindness, but a frequent tendency to confuse green and blue and also blue and purple, while

Dr. Adele Fielde, of Swatow, China, among 1,200 Chinese of both sexes examined by Thomson's wool test, found that more than half mixed up green and blue, and many even seemed to be quite blind to violet. Ernest Krause also has argued that primitive man was most sensitive to the red end of the spectrum, hence setting about to obtain red pigments and acquiring definite names for them, an explanation which is accepted by Karl von den Steinen to account for the phenomena among the Central Brazilians. The recent investigations of Rivers at Torres Straits have confirmed the conclusions of Magnus. He found that, corresponding to the defect of color terminology, though to a much less degree, there appeared to be an actual defect of vision for colors of short wave-length; in testing with colored wools no mistake was ever made with reds, but blues and greens were constantly confused, as were blue and violet.

It may even be argued that the same defect exists to a minor degree not only among the peoples of Eastern Asia whose æsthetic sense is highly developed, but among civilized Europeans when any kind of color blindness is altogether excluded. This was noted long since by Holmgren, who remarked that some persons, though able to distinguish between blue and green wools when placed together, were liable to call the blue wool green, and the green blue, when they saw them separately. Magnus also showed that such an inability is apt to appear at a very early stage in some persons when the illumination is diminished, although the perception of red and yellow remains perfectly distinct. He further showed that blue and green at certain distances are often much more difficult to recognize than red. Most people probably are conscious of difficulty in distinguishing blue and green pigments with diminished light and find that blue easily passes into black. Violet also appears for many people to be merely a variety of blue; the word itself, we may note, is recent in our language, and plays a very small part in our poetic literature, and in fact the color itself, if we rigidly exclude purple, is extremely rare in nature. It is a noteworthy fact in this connection that in normal persons the color sense may be easily educated; this is not merely a fact of daily observation, but has been exactly demonstrated by Féré, who by means of his chromoptoscopic boxes, containing very dilute colored solutions, found that with practice it was possible to recognize solutions which had previously seemed uncolored. It is also noteworthy that in the achromatopsia of the hysterical, as Charcot showed and as Parimand has since confirmed, the order in which the colors usually disappear is violet, green, blue, red; sometimes the paradoxical fact is found that red will give a luminous sensation in a contracted visual field when even white gives no luminous sensation. This persistence of red vision in the hysterical is only one instance of a predilection for red which has often been noted as very marked among the hysterical. Red also exerted a great fascination over the victims of the mediæval hysterical epidemics of tarantism in Italy, while the victims of the German mediæval epidemic of St. Vitus's dance imagined that they were immersed in a stream of blood which compelled them to leap up.

It may be noted that red and perhaps yellow have been stated to be the only colors visible in dreams; this is possibly due to the blood-vessels. Such an explanation is probable with regard to the various subjective visual sensations which constitute an aura in epilepsy, among which, as Gowers notes, red and reddish yellow are most frequently found. Féré has further noted that in various emotional states somewhat resembling epilepsy, and even in mystic exaltation, red may be subjectively seen. Simroth has gone so far as to argue that not only is red fundamental in human color psychology, but that in living organisms generally, even as a pigment, red is the most primitive of colors, that since the algæ at the greatest sea-depths are red it is possible that protoplasm at first only responded to rays of long wave-length, and that with increased metabolism colors became differentiated, following the order in the spectrum.

If it is really the case that in the evolution of the race familiarity with the red end of the spectrum has been earlier and more perfectly acquired than with the violet end, and that red and yellow made a more profound impression on primitive man than green and blue, we should expect to find this evolution reflected in the development of the individual, and that the child would earlier acquire a sensitiveness for red and orange and yellow than for green and blue and violet. This seems actually to be the case. The study of the color sense in children is, indeed, even more difficult than in savages; and many investigators have probably succumbed to the fallacies involved in this study. Doubtless we may thus account for some discrepancies in the attempts to ascertain the facts of color perception and color preference in children, while doubtless also there are individual differences which discount the value of experiments made on only a single child. A few careful and elaborate investigations, however, especially that of Garbini on 600 North Italian children of various ages, have thrown much light on the matter. There is fairly general agreement that red is the first color that attracts young children and which they recognize. That is the result recorded by Uffelmann in Germany, while Preyer found yellow and red at the head; Binet in France concluded that red comes first; Wolfe in America reached the same result, and Luckey noted that his own children seemed to enjoy red, orange and yellow very much earlier than they could perceive blue, which seemed to come last. Baldwin, indeed, found in the case of his own child that blue seemed more attractive than red; his methods have, however, been criticised, and his experiments failed to include yellow. Mrs. Moore found that her baby, between the sixteenth and forty-fifth weeks, nearly always preferred a yellow ball to a red ball; this was doubtless not a matter of color, but of brightness, for there is no reason to suppose chromatic perception at so early an age. Red, orange and yellow, it may be added, are perceived by a slightly lower illumination than green, blue and violet, the last being the most difficult of all to perceive, so that it is not surprising that the colors at the violet end should be inconspicuous to young infants. Garbini, whose experiments are worth noting in more detail, found that the order of perception is red, green, yellow, orange, blue and violet, and as he experimented with a large number of children and used methods which so competent a judge as Binet regards as approaching perfection, his results may be considered a fair approach to the truth. He found that for the first few days after birth the infant shuns the light; then, about the fourteenth day, he ceases to be photophobic and begins to enjoy the light, as is shown by his being quieted when brought into a bright light and crying when taken from it; this may sometimes begin even about the fifth day. Between the fifth week and the eighteenth month children show signs of distinguishing white, black and grey objects. It is not until after the eighteenth month that their chromatic perception begins, any preference for red and yellow objects at an earlier age being due merely to their greater luminosity. Garbini considers that it is the center of the retina, or the portion most sensitive to red and yellow, which is most exercised in young infants. Between the second and third years children, both boys and girls, were found to be most successful in the recognition of red, then of green, but they very often confused orange with red, and mixed up yellow, blue, violet and green; he thinks they tend to confuse a color with the preceding color in spectral order. Under the age of three children may be said to be color-blind, and they are liable to confuse rosy tints with green. Between the ages of three and five they are able to distinguish red in any gradation, green nearly always, with an occasional confusion with red, while yellow is sometimes confused with orange, orange sometimes replaced by rose, blue often not recognized in its gradations, and violet often selected in place of blue. At this age, also (as in hysterical anæsthesia of the retina), blue seems dark or black. In the fifth and sixth years red, green and yellow are always correctly chosen; orange gradations are not always recognized, and blue and violet come last, being sometimes confused. In the sixth year children are perfecting their knowledge of orange, blue and violet and completing their knowledge of color designations. Garbini has reached the important result that color perceptions and verbal expression of the perceptions follow exactly parallel paths, so that in studying verbal expression we are really studying perception, with the important distinction that the expression comes much later than the perception.* These investigations of Garbini are very significant, and there can be little doubt that the evolution of the child's color sense repeats that of the race.

In dealing with the color perceptions of savages and children we are, of course, to some extent dealing more or less unconsciously with their color preferences. There is some interest from our present point of view in considering the conscious color preferences of young and adult civilized persons. Red, as we have seen, is the color that fascinates our attention earliest, that we see and recognize most vividly; it remains the color that attracts our attention most readily and that gives us the greatest emotional shock. It by no means necessarily follows that it is the most pleasurable color. As a matter of fact, such evidence as is available shows that very often it is not. There seems reason to think that after the first early perception of red, and early pleasure in it, yellow or orange is frequently the favorite color, the preference often lasting during several years of childhood; Preyer's child liked and discriminated yellow best, and Miss Shinn was inclined to think that it was the favorite color of her niece, who in the twenty-eighth month showed a special fondness for daffodils and for a yellow dress. Barnes found that in children the love of yellow diminishes with age. Binet's child was specially preoccupied with orange. Aars in an elaborate and frequently varied investigation into the color preferences of eight children (four of each sex), between four and seven years of age, found that with the boys the order of preference was blue and yellow (both equal), then red, lastly green; while with the girls the order was green, blue, red and yellow; in combinations of two colors it was found that combinations of blue come first, then of yellow, then green, lastly red. It was found (as J. Cohn has found among adults and cultivated people) that the deepest and most saturated color was most pleasing; and also that the love of novelty and of variety was an important factor. It will be observed that at this age green was the girls' favorite color and that least liked by the boys, whose favorite color, in combination, was blue; the number of individuals was, however, small. This was in Germany. In America, among 1,000 children, probably somewhat older on the average (though I have not details of the inquiry), Mr. Earl Barnes found, like Dr. Aars, that more boys than girls selected blue, while the girls preferred red more frequently than the boys; Barnes considers that with growing years there is a growing tendency to select red; as is well known, girls are more precocious than boys. Among 100 students at Columbia University, the order of preference was found to be blue (34 per cent), red (22.7 per cent), and then at a more considerable distance violet, yellow, green. It is noteworthy

*Garbini, "Evoluzione del senso cromatico nella infanzia," *Archivio per l'Antropologia*, 1894. I.

that among 100 women students at Wellesley College the order of preference was not very different, being blue (38 per cent), red (18 per cent), yellow, green, violet; in a later investigation the order remained the same, there being only some increase in the preference for red; it was considered that association accounted for the preference for blue, while more conscious as well as more emotional elements entered into the preference for red.

By far the most extensive investigation of color preference was that carried on at Chicago by Professor Jastrow on 4,500 persons, mostly adults, of both sexes and various nationalities.* Blue was found to be the favorite color, less than half as many persons preferring red; of every thirty men ten voted for blue and three for red, while of every thirty women five voted for red and four for blue. The men also liked violet and on the whole confined their choice to but few colors, the women also liked pink, green (very seldom chosen by men) and yellow, and showed a tendency to choose light and dainty shades. There was on the whole a decided preference for dark shades; the least favorite colors were yellow and orange. It is evident that, as we should expect, within the elementary field of popular æsthetics, women show a more trained feeling for color than men.

It is not quite easy to coördinate the various phenomena of color predilection. Careful and extended observations are still required. It seems to me, however, that the facts, as at present ascertained, do suggest a certain order and harmony in the phenomena. It is difficult not to believe that there really is, both among many uncivilized peoples and also many children at an early age, even to a slight extent among civilized adults, a relative inability, by no means usually absolute, to recognize and distinguish the tones of color at the more refrangible end of the spectrum. The earliest writers on the subject were wrong when they supposed that color nomenclature at all accurately corresponded to color perception, and it is well recognized that there are no peoples who are wholly unable to distinguish between green and blue and black. But as Garbini has clearly shown, there really is a parallelism between color nomenclature and color recognition, and Garbini's wide investigation has confirmed the experiments of Preyer on a single child by showing that there is a certain hesitancy and uncertainty in recognizing the colors at the more refrangible end of the spectrum, long after children are familiar with the less refrangible end. In the same way the important investigations of Rivers have confirmed the earlier observations of Magnus and Almquist in showing that savages in many cases exhibit a certain difficulty in recognizing and distinguishing blue and green, such as they never experience with red and yellow. The vague-

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* J. Jastrow, "The Popular Æsthetics of Color," *Popular Science Monthly*, 1897.

ness of color nomenclature as regards blue and green thus indicates, though grossly exaggerating, a real psychological fact, and in this way we have an explanation of the curious fact that in widely separated parts of the world (at Torres Straits, among the Esthonians at Rome, etc.) as civilization progressed it was found necessary to borrow a word for blue from other languages.

There is almost complete harmony among a number of observers, now very considerable, in many countries, showing that the colors children first take notice of and recognize are red and yellow, most observers putting red first. There is no true predilection for these colors at this early age because the other colors do not yet seem to have been perceived. At first, doubtless, all colors appear to the infant as light or dark, white or black. That this is so is indicated by the experience of Dr. George Harley, who at one period of his life, in order to cure an injury to the retina caused by overwork at the microscope, resolutely spent nine months in absolutely total and uninterrupted darkness. When he emerged he found that, like an infant, he was unable to appreciate distance by the eye, while he had also lost the power of recognizing colors; for the first month all light colors appeared to him perfectly white and all dark colors perfectly black. He fails to state the order in which the colors reappeared to him. It is well recognized, however, that eyes long unexposed to light become color-blind for all colors except red. Preyer's child in the fourth year was surprised that in the twilight her bright blue stockings looked grey, while for some time longer she always called dark green black. By the sixth year all colors are seen and known with fair correctness. Among young children at this age, so far as the evidence yet goes, red is rarely the preferred color, this being more often yellow, green or blue. There is doubtless room here for a great amount of individual difference, but on the whole it appears that children prefer those colors which they have most recently learnt to recognize, the colors which have all the charm of novelty and newly-won possession. It is probable, too, that (as Groos has also suggested) the stimulation of red is too painfully strong in this stage of the development of the color sense to be altogether pleasurable, in the same way that orchestral music is often only a disturbing noise to children.

One may note in this connection that hyperæsthesia to color is nearly always an undue sensibility to red and very rarely to any other color. The case has been recorded of a highly neurotic officer who, for more than thirty years, was intolerant of red-colored objects. The dazzling produced by scarlet uniforms, especially in bright sunshine, seriously interfered with the performance of his duties, and in private life red parasols, shawls, etc., produced similar effects; he was often overcome in the streets by giddiness, sometimes almost before he realized that he was looking at a red object. Many years ago Laycock referred to the case of a lady who could not bear to look at anything red, and Elliston also had a lady patient to whom red was very obnoxious, and who, when put into a room with red curtains, drank seven quarts of fluid a day. I am not aware that any such hyperæsthesia exists in the case of other colors. It is also noteworthy that the morbid affection in which color is seen when it does not exist is most usually a condition in which red is seen (erythropsia), yellow being the color most frequently seen after red (a condition called xanthopsia); the other colors are very rarely seen, and Hilbert, in his monograph on the pathology of the color sense, considers that this is due to the fact that red and yellow make the most intense effect on the sensorium, which thus becomes liable not only to direct but to reflected irritation, in the absence of any external color stimulus. There are other facts which show that of all colors red is that which acts as the most powerful stimulus on the organism. Münsterberg, in some interesting experiments which he made to illustrate the motor power of visual impressions as measured by their arresting action on the eye-muscles, found that red and yellow have considerably more motor power in stimulating the eye than the other colors. It may be added also that, as Quantz has found, we overestimate the magnitude of colors of the less refrangible part of the spectrum and underestimate the others.

After puberty blue seems still to maintain its position, but red has now come more to the front, while yellow has definitely receded; although so favorite a color in classic antiquity, it is rarely the preferred color among ourselves. J. Cohn in Germany found that among a dozen students it was never in any degree of saturation the preferred color, while at Cornell Major found that all the subjects investigated considered yellow and orange either unpleasant or among the least pleasant colors.

While blue seems to be the color most usually preferred by men, red is more commonly preferred by women, who also show a more marked predilection for its complementary green. Whether the feminine love of red shows a fine judgment we could better decide if we knew among what classes of the population red lovers and blue lovers respectively predominate; it may be noted, however, that the necessities of dress give the most ordinary woman an acquaintance with the elementary æsthetics of color which the average man has no occasion to acquire. In any case it might have been anticipated that, even though the typically 'cold' color should appeal most strongly to men, the most emotional of colors should appeal most strongly to women.

CHAPTERS ON THE STARS.

BY PROFESSOR SIMON NEWCOMB, U. S. N.

CONSTELLATIONS AND STAR NAMES.

IN ancient times the practice was adopted of imagining the figures of heroes and animals to be so outlined in the heavens as to include in each figure a large group of the brighter stars. In a few cases some vague resemblance may be traced between the configurations of the stars and the features of the object they are supposed to represent; in general, however, the arrangement seems quite arbitrary. One animal or man could be fitted in as well as another. There is no historic record or trace as to the time when the constellations were mapped out, or of the process by which the outlines were traced. The names of heroes, such as Perseus, Cepheus, Hercules, etc., intermingled with the names of goddesses, show that the constellations were probably mapped out during the heroic age. No maps are extant showing exactly how each figure was placed in the constellation; but in the catalogue of stars given by Ptolemy in his 'Almagest,' the positions of particular stars on the supposed body of the hero, goddess or animal are designated with such precision as he had at command, in some fairly precise position of the figure. For example, Aldebaran is said to have formed the eye of the Bull. Two other stars marked the right and left shoulders of Orion, and a small cluster marked the position of his head. A row of three stars in a horizontal line showed his belt, three stars in a vertical line below them his sword. In this way the position of the figure can be reproduced with a fair degree of certainty.

In the well-known constellation *Ursa Major*, the Great Bear, familiarly known as the Dipper, three stars form the tail of the animal, and four others a part of his body. This formation is not unnatural, yet the figure of a dipper fits the stars much better than that of a bear. In Cassiopeia, which is on the opposite side of the pole from the Dipper, the brighter stars may easily be imagined to form a chair in which a lady may be seated without further difficulty. As a general rule, however, the resemblances of the stars to the figure are so vague that the latter might be interchanged to any extent without detracting from their appropriateness.

In any case, it was impossible so to arrange the figures that they should cover the entire heavens; blank spaces were inevitably left in which stars might be found. In order to include every star in some constellation, the figures have been nearly ignored by modern astronomers, and the heavens have been divided up, by somewhat irregular lines, into patches, each of which contains the entire figure as recognized by ancient astronomers. But all are not agreed as to the exact outlines of these extended constellations, and, accordingly, a star is sometimes placed in one constellation by one astronomer and in another constellation by another astronomer.

The confusion thus arising is especially great in the southern hemisphere, where it has been intensified by the subdivision of one of the old constellations. The ancient constellation *Argo* covered so large a region of the heavens, and included so many conspicuous stars, that it was divided into four, representing various parts of a ship—the sail, the poop, the prow and the hull.

Dr. Gould, while director of the Cordoba Observatory, during the years 1870 to 1880, constructed the 'Uranometria Argentina,' in which all the stars visible to the naked eye more than 10 degrees south of the celestial equator were catalogued and mapped. He made a revision of the boundaries of each constellation in such a way as to introduce greater regularity. The rule generally followed was that the boundaries should, so far as possible, run in either an east and west or a north and south direction on the celestial sphere. They were so drawn that the smallest possible change should be made in the notation of the conspicuous stars; that is, the rule was that, if possible, each bright star should be in the same constellation as before. The question whether this new division shall replace the ancient one is one on which no consensus of view has yet been reached by astronomers. Simplicity is undoubtedly introduced by Gould's arrangement; yet, in the course of time, owing to precession, the lines on the sphere which now run north and south or east and west will no longer do so, but will deviate almost to any extent. The only advantage then kept will be that the bounding lines will generally be arcs of great circles.

When the heavens began to be carefully studied, two or three centuries ago, new constellations were introduced by Hevelius and other astronomers to fill the vacant spaces left by the ancient ones of Ptolemy. To some of these, rather fantastic names were given; the Bull of Poniatowski, for example. Some of these new additions have been retained to the present time, but in other cases the space occupied by the proposed new constellation was filled up by extending the boundaries of the older ones.

At the present time the astronomical world, by common consent, recognizes eighty-nine constellations in the entire heavens. In this enumeration *Argo* is not counted, but its four subdivisions are taken as separate constellations.

NAMES OF THE STARS.

A glance at the heavens will make it evident that the problem of designating a star in such a way as to distinguish it from all its neighbors must be a difficult one. If such be the case with the comparatively small number of stars visible to the naked eye, how must it be with the vast number that can be seen only with the telescope? In the case of the great mass of telescopic stars we have no method of designation except by the position of the star and its magnitude; but with the brighter stars, and, indeed, with all that have been catalogued, other means of identification are available.

It is but natural to give a special name to a conspicuous star. That this was done in very early antiquity we know by the allusion to Arcturus in the Book of Job. At least two such names, Castor and Pollux, have come down to us from classical antiquity, but most of the special names given to the stars in modern times are corruptions of certain Arabic designations. As an example we may mention Aldebaran, a corruption of Al Dabaran—The Follower. There is, however, a tendency to replace these special names by a designation of the stars on a system devised by Bayer early in the seventeenth century.

This system of naming stars is quite analogous to our system of designating persons by a family name and a Christian name. The family name of a star is that of the constellation to which it belongs. The Christian name is a letter of the Greek or Roman alphabet, or a number. As a number of men in different families may have the same Christian name, so the Greek letter or number may be given to a star in any number of constellations without confusion.

The work of Bayer was published under the title of 'Uranometria,' of which the first edition appeared in 1601. This work consists mainly of maps of the stars. In marking the stars with letters on the map, the rule followed seems to have been to give the brighter stars the earlier letters in the alphabet. Were this system followed absolutely, the brighter stars should always be called α; the next in order β, etc. But this is not always the case. Thus in the constellation *Gemini*, the brighter star is Pollux, which is marked β, while α is the second brightest. What system, if any, Bayer adopted in detail has been a subject of discussion, but does not appear to have been satisfactorily made out. Quite likely Bayer himself did not attempt accurate observations on the brightness of the stars, but followed the indications given by Ptolemy or the Arabian astronomers. As the number of stars to be named in several constellations exceeds the number of letters in the Greek alphabet, Bayer had recourse, after the Greek alphabet was exhausted, to letters of the Roman alphabet. In this case the letter *A* was used as a capital, in order, doubtless, that it should not be confounded with the Greek α. In other cases smaller italics are used. In several catalogues since Bayer, new italic letters have been added by various astronomers. Sometimes these have met with general acceptance, and sometimes not.

Flamsteed was the first Astronomer Royal in England, and observed at Greenwich from 1666 to 1715. Among his principal works is a catalogue of stars in which the positions are given with greater accuracy than had been attained by his predecessors. He slightly altered the Bayer system by introducing numbers instead of Greek letters. This had the advantage that there was no limit to the number of stars which could be designated in each constellation. He assigned numbers to all the brighter stars in the order of their right ascension, irrespective of the letters used by Bayer. These numbers are extensively used to the present day, and will doubtless continue to be the principal designations of the stars to which they refer. It is very common in our modern catalogues to give both the Bayer letter and the Flamsteed number in the case of Bayer stars.

The catalogues by Flamsteed do not include quite all the stars visible to the naked eye, but various uranometries have been published which were intended to include all such stars. In such cases the designations now used frequently correspond to the numbers given in the uranometries of Bode, Argelander and Heis.

In recent times these uranometries have been supplemented by censuses of the stars, which are intended to include all the stars to the ninth or tenth magnitude. I shall speak of these in the next section; at present it will suffice to say that stars are very generally designated by their place in such a census.

There is still here and there some confusion both as to the boundaries of the constellations and as to the names of a few of the stars in them. I have already remarked that, in drawing the imaginary boundaries on a star map, as representing the celestial sphere, different astronomers have placed the lines differently. One of the regions in which this is especially true is in the neighborhood of the north pole, where some astronomers place stars in the constellation Cepheus which others place in Ursa Minor. Hence in the Bayer system the same star may have different names in different catalogues. Again, in extending the names or numbers, some astronomers use names which others de not regard as authorative. The remapping of the southern constellation by Dr. Gould changed the boundaries of most of the southern constellations in a way already mentioned.

I have spoken of the subdivision of the great constellation *Argus* into four separate ones. Bayer having assigned to the principal stars in this constellation the Greek letters α, β, γ, etc., the general practice among astronomers since the subdivision has been to continue the designation of the stars thus marked as belonging to the constellation

Argo. Thus, for example, we have *Argus*, which after the subdivision belonged to the constellation *Carina*. The variable star η Argus also belongs to the constellation *Carina*. But in the case of stars not marked by Bayer, the names were assigned according to the subdivided constellations, *Vela*, *Carina*, etc. Confusing though this proceeding may appear to be, it is not productive of serious trouble. The main point is that the same star should always have the same name in successive catalogues. Still, however, it has recently become quite common to ignore the constellation *Argus* altogether and use only the names of its subdivisions. The reader must therefore be on his guard against any mistake arising in this way in the study of astronomical literature.

In star catalogues the position of a star in the heavens is sometimes given in connection with its name. In this case the confusion arising from the same star having different names may be avoided, since a star can always be identified by its right ascension and declination. The fact is that, so far as mere identification is concerned, nothing but the statement of a star's position is really necessary. Unfortunately, the position constantly changes through the precession of the equinoxes, so that this designation of a star is a variable quantity. Hence the special names which we have described are the most convenient to use in the case of well-known stars. In other cases a star is designated by its number in some well-known catalogue. But even here different astronomers choose different catalogues, so that there are still different designations for the same star. The case is one in which action of uniformity of practice is unattainable.

Cataloguing and Numbering the Stars.

A catalogue or list of stars is a work giving for each star listed its magnitude and its position on the celestial sphere, with such other particulars as may be necessary to attain the object of the catalogue. If the latter includes only the more conspicuous stars, it is common to add the name of each star that has one; if none is recognized, the constellation to which the star belongs is frequently given.

The position of a star on the celestial sphere is defined by its right ascension and declination. These correspond to the longitude and latitude of places on the earth, in the following way: Imagine a plane passing through the center of the earth and coinciding with its equator, to extend out so as to intersect the celestial sphere. The line of intersection will be a great circle of the celestial sphere, called the celestial equator. The axis of the earth, being also indefinitely extended in both the north and the south directions, will meet the celestial spheres in two opposite points, known as the north and south celestial poles. The equator will then be a great circle 90° from each pole. Then as meridians are drawn from pole to pole on the earth, cutting the equator at different points, so imaginary meridians are conceived as drawn from pole to pole on the celestial sphere. Corresponding to parallels of latitude on the earth we have parallels of declination on the celestial sphere. These are parallel to the equator, and become smaller and smaller as we approach either pole. The correspondence of the terrestrial and celestial circles is this:

To *latitude* on the earth's surface corresponds *declination* in the heavens.

To *longitude* on the earth corresponds *right ascension* in the heavens.

A little study of these facts will show that the zenith of any point on the earth's surface is always in a declination equal to the latitude of the place. For example, for an observer in Philadelphia, in 40° latitude, the parallel of 40° north declination will always pass through his zenith, and a star of that declination will, in the course of its diurnal motion, also pass through his zenith.

So also to an observer on the equator the celestial sphere always spans the visible celestial hemisphere through the east and west points.

In the case of the right ascension, the relation between the terrestrial and celestial spheres is not constant, because of the diurnal motion, which keeps the terrestrial meridians in constant revolution relative to the celestial meridians. Allowing for this motion, however, the system is the same. As we have on the earth's surface a prime meridian passing from pole to pole through the Greenwich Observatory, so in the heavens a prime meridian passes from one celestial pole to the other through the vernal equinox. Then to define the right ascension of any star we imagine a great circle passing from pole to pole through the star, as we imagine one to pass from pole to pole through a city on the earth of which we wish to designate the longitude. The actual angle which this meridian makes with the prime meridian is the right ascension of the star as it is the longitude of the place on the earth's surface.

There is, however, a difference in the unit of angular measurement commonly used for right ascensions in the heavens and longitude on the earth. In astronomical practice, right ascension is very generally expressed by hours, twenty-four of which make a complete circle, corresponding to the apparent revolution of the celestial sphere in twenty-four hours. The reason of this is that astronomers determine right ascension by the time shown by a clock so regulated as to read 0 hrs., 0 min., 0 sec. when the vernal equinox crosses the meridian. The hour hand of this clock makes a revolution through twenty-four hours during the time that the earth makes one revolution on its axis, and thus returns to 0 hrs., 0 min., 0 sec. when the vernal equinox again crosses the meridian. A clock thus regulated is said to show sidereal time. Then the right ascension of any star is equal to the sidereal time at which it crosses the meridian of any point on the earth's surface. Right ascension thus designated in time may be changed to degrees and minutes by multiplying by 15. Thus, one hour is equal to 15°; one minute of time is equal to 15′ of arc, and one second of time to 1″ of arc.

It may be remarked that in astronomical practice terrestrial longitudes are also expressed in time, the longitude of a place being designated by the number of hours it may be east or west of Greenwich. Thus, Washington is said to be 5h. 8m. 15s. west of Greenwich. This, however, is not important for our present purpose.

The first astronomer who attempted to make a catalogue of all the known stars is supposed to be Hipparchus, who flourished about 150 B.C. There is an unverified tradition to the effect that he undertook this work in consequence of the appearance of a new star in the heavens, and a desire to leave on record, for the use of posterity, such information respecting the heavens in his time that any changes which might take place in them could be detected. This catalogue has not come down to us—at least not in its original form.

Ptolemy, the celebrated author of the 'Almagest,' flourished A.D. 150. His great work contains the earliest catalogue of stars which we have. There seems to be a certain probability that this catalogue either may be that of Hipparchus adopted by Ptolemy unchanged, or may be largely derived from Hipparchus. This, however, is little more than a surmise, due to the fact that Ptolemy does not seem to have been a great observer, but based his theories very largely on the observations of his predecessors. The actual number of stars which it contains is 1,030. The positions of these are given in longitude and latitude, and are also described by their places in the figure of the constellation to which each may belong. Not unfrequently the longitude or latitude is a degree or more in error, showing that the instruments with which the position was determined were of rather rough construction.

So far as the writer is aware, no attempt to make a new catalogue of the stars is found until the tenth century. Then arose the Persian astronomer, Abd-Al-Rahman Al-Sufi, commonly known as Al-Sufi, who was born A.D. 903 and lived until 986. Nothing is known of his life except that he was a man celebrated for his learning, especially in astronomy. His only work on the latter subject which has come down to us is a description of the fixed stars, which was translated from the Arabic by Schjellerup and published in 1874 by the St. Petersburg Academy of Science. This work is based mainly on the catalogue of Ptolemy, all the stars of which he claimed to have carefully examined. But he did not add any new stars to Ptolemy's list, nor, it would seem, did he attempt to redetermine their positions. He simply used the longitudes and latitudes of Ptolemy, the former being increased by 12° 42′ on account of the precession during the interval between his time and that to which Ptolemy's catalogue was reduced. The translator says of his work that it gives a description of the starry heavens at the time of the author and is worthy of the highest confidence. The main body of the work consists of a detailed description of each constellation, mentioning the positions and appearances of the stars which it contains. Here we find the Arabic names of the stars, which were not, however, used as proper names, but seem rather to have been Arabic words representing some real or supposed peculiarity of the separate stars, or arbitrarily applied to them.

Four centuries later arose the celebrated Ulugh Beigh, grandson of Tamerlane, who reigned at Samarcand in the middle of the fifteenth century. Bailey says of him: "Ulugh Beigh was not only a warlike and powerful monarch, but also an eminent promoter of the sciences and of learned men. During his father's lifetime he had attracted to his capital all the most celebrated astronomers from different parts of the world; he erected there an immense college and observatory, in which above a hundred persons were constantly occupied in the pursuits of science, and caused instruments to be constructed of a better form and greater dimensions than any that had hitherto been used for making astronomical observations."

His fate was one which so enlightened a promoter of learning little deserved; he was assassinated by the order of his own son, who desired to succeed him on his throne; and in order to make his position the more secure, also put his only brother to death. A catalogue of the stars bears the name of this monarch; he is supposed to have made many or most of the observations on which it is founded. Posterity will be likely to suppose that a sovereign used the eyes of others more than his own in making the observations. However this may be, his catalogue seems to have been the first in which the positions of the stars given by Ptolemy were carefully revised. He found that there were twenty-seven of Ptolemy's stars too far south to be visible at Samarcand, and that eight others, although diligently looked after, could not be discovered. It is curious that, like Al-Sufi, he does not seem to have added any new stars to Ptolemy's list.

Next in the order of time comes the work of Bayer, whose method of naming the stars has already been described. The main feature of this work consists of maps of all the constellations. Previous to his time, celestial globes, made especially for the use of the navigator, took the place of maps of the stars. The first edition of this book was published in 1603, and is distinguished by the fact that a list of stars in each constellation is printed on the backs of the maps. Bayer did not confine himself to the northern hemisphere, but extended his list over the whole celestial sphere, from the north to the south pole.

The catalogue of the celebrated Tycho Brahe, prepared toward the end of the sixteenth century, though of great historic value, is of no special interest to the general reader at the present time. A supplement to it, continuing its list of stars to the south pole, was published by Halley, who made the necessary observations during a journey to St. Helena in 1677.

The catalogue of Hevelius, published in 1690, offers no feature of special interest, except the addition of several new constellations which he placed between those already known. Having the aid of the telescope, he was able to include in his catalogue stars which had been invisible to his predecessors.

Modern catalogues of the stars may be divided into two classes: Those which include only stars of a special class, or stars of which the observer sought to determine the position or magnitude with all attainable precision; and catalogues intended to include all the stars in any given region of the heavens, down to some fixed order of magnitude. It may appear remarkable that no attempt of the latter sort was seriously made until more than two centuries after the telescope had been pointed at the heavens by Galileo. A reason for the absence of such an attempt will be seen in the vast number of stars shown by the telescope, the difficulty of stopping at any given point, and the seeming impossibility of assigning positions to hundreds of thousands of stars. The latter difficulty was overcome by the improved methods of observation devised in modern times.

About the middle of the present century the celebrated Argelander commenced the work of actually cataloguing all the stars of the northern celestial hemisphere to magnitude 9½. This work was termed a *Durchmusterung* of the northern heavens, a term which has been introduced into astronomy generally to designate a catalogue in which all the stars down to a certain magnitude are supposed to be mustered, as if a census of them were taken. The work fills three quarto volumes and contains more than 310,000 stars, of each of which the magnitude and the right ascension and declination are given. This work was extended by Schönfeld, Argelander's assistant and successor, to 22° of south declination.

In the latitudes in which most of the great observatories of the world are situated, that part of the celestial sphere within 40° or 50° of the south pole always remains below the horizon. Around this invisible region a belt of somewhat indefinite breadth, 10° or more, can be only imperfectly observed, owing to the nearness of the stars to the horizon, and the brevity of the period between their rising and setting. Up to the middle of the nineteenth century, the few observatories situated in the southern hemisphere were too ill-endowed to permit of their undertaking a complete census of this invisible region.

The first considerable work emanating from the Cordoba Observatory, under Gould, was a catalogue of all the stars from the south pole to 10° of north declination which could be seen with the naked eye. Another work, which was not issued until after Dr. Gould's death, was devoted to photographs of southern clusters of stars.

The work of the Cordoba Observatory, with which we are more especially concerned in the present connection, consists of a 'Durchmusterung' of the southern heavens, commencing at 22° of south declination, where Schönfeld's work ended, and continued to the south pole. This work is still incomplete, but two volumes have been published by Thome, extending to 41° of south declination. It is expected that the third is approaching completion. This catalogue is, in one point at least, more complete than that of Argelander and Schönfeld, as it contains all the stars down to the tenth magnitude. The two volumes give the positions and magnitudes of no less than 340,000 stars, and therefore more than the catalogue of Argelander gives for the entire northern hemisphere. If the remaining part of the heavens, from 42° to the south pole, is equally rich, it will contain nearly half a million stars, and the entire work will comprise more than 800,000 stars.

The Royal Observatory of the Cape of Good Hope, under the able and energetic direction of Dr. David Gill, has undertaken a work of the same kind, which is remarkable for being based on photography. The history of this work is of great interest. In 1882 Gill secured the aid of photographers at the Cape of Good Hope to take pictures of the brilliant comet of that year, with a large camera. On developing the pictures the remarkable discovery was made that not only all the stars visible to the naked eye, but telescopic stars down to the ninth or tenth magnitude were also found on the negatives. This remarkable result suggested to Gill that here was a new and simple method of cataloguing the stars. It was only necessary to photograph the heavens and then measure the positions of the stars on the glass negatives, which could be done with much greater ease and certainty than measures could be made on the positions of the actual stars, which were in constant apparent motion.

As soon as the necessary arrangements could be made and the apparatus put into successful operation, Gill proceeded to the work of photographing the entire southern heavens from 18° of south declination to the celestial pole. The results of this work are found in the 'Cape Photographic Durchmusterung,' a work in three quarto volumes, in which the astronomers of all future time will find a permanent record of the southern heavens towards the end of the nineteenth century. The actual work of taking the photographs extended from 1887 to 1891.

This, however, was far from being the most difficult part of the enterprise. The most arduous task of measuring the positions of a half-million of stars on the negatives, including the determining of the magnitude of each, was undertaken by Professor J. C. Kapetyn, of the University of Groningen, Holland, and brought to a successful completion in the year 1899.

What the work gives is, in the first place, the magnitude and approximate position of every star photographed. The determining of the magnitude of a star is an important and delicate question. There is no difficulty in determining, from the diameter of the image of the star as seen in the microscope, what its photographic magnitude was at the time of the exposure, as compared with other stars on the same plate. But can we rely upon similar photographic magnitudes on a plate corresponding to similar brightnesses of the stars? In the opinion of Gill and Kapetyn we cannot. The transparency of the air varies from night to night, and on a very clear night the same star will give a stronger image than it will when the air is thick. Besides, slightly different instruments were used in the course of the work. For these reasons a scale of magnitude was determined on each plate by comparing the photographic intensity of the images of a number of stars with the magnitudes as observed with the eye by various observers. Thus on each plate the magnitude was reduced to a visual scale.

It does not follow from this that the magnitudes are visual, and not photographic. It is still true that a blue star will give a much stronger photographic image than a red star of equal visual brightness. In a general way, it may be said that the catalogue includes all the stars to very nearly the tenth magnitude, and on most of the plates stars of 10.5 were included. In fact, now and then is found a star of the eleventh magnitude.

A feature of the work which adds greatly to its value is a careful and exhaustive comparison of its results with previous catalogues of the stars. When a star is found in any other catalogue the latter is indicated. Most interesting is a complete list of catalogued stars which ought to be on the photographic negatives, but were not found there. Every such case was inexhaustibly investigated. Sometimes the star was variable, sometimes it was so red in color that it failed to impress itself on the plate, sometimes there were errors in the catalogue.

The great enterprise of making a photographic map of the heavens now being carried on as an international enterprise, having its headquarters at Paris, is yet wider in its scope than the works we have just described. One point of difference is that it is intended to include all the stars, however faint, that admit of being photographed with the instruments in use. The latter are constructed on a uniform plan, the aperture of each being 34 centimetres, or 13.4 inches, and the focal length 343 c. m. Two sets of plates are taken, one to include all the stars that the instrument will photograph near poles, and the other only to take in those to the eleventh magnitude. Of the latter it is intended to prepare a catalogue. Some portions of the German and English catalogues have already been published, and their results will be made use of in the course of the present work.

NUMBERING THE STARS.

Closely connected with the work of cataloguing the stars is that of enumerating them. In view of what may possibly be associated with any one star—planets with intellectual beings inhabiting them—the question how many stars there are in the heavens is one of perennial interest. But beyond the general statement we have already made, this question does not admit of even an approximate answer. The question which we should be able to answer is this: How many stars are there of each easily visible magnitude? How many of the first magnitude, of the second, of the third, and so on to the smallest that have been measured? Even in this form we cannot answer the question in a way which is at the same time precise and satisfactory. One magnitude merges into another by insensible gradations, so that no two observers will agree as to where the line should be drawn between them. The difficulty is enhanced by the modern system—very necessary, it is true—of regarding magnitude as a continuously varying quantity and estimating it with all possible precision. In adjusting the new system to the old one, it may be assumed that an average star of any given magnitude on the old system would be designated by the corresponding number on the new system. For example, an average star of the fourth magnitude would be called 4.0; one of the fifth, 5.0, etc. Then the brightest stars, which formerly were called of the fourth magnitude, would now be, if the estimate were carried to hundredths, 3.50, while the faintest would be 4.50. What were formerly called stars of the fifth magnitude would range from 4.50 to 5.50, and so on. But we have meet with a difficulty when we come to the sixth magnitude. On the modern system, magnitude 6.0 represents the faintest star visible to the naked eye; but the stars formerly included in this class would, on the average, be somewhat brighter than this, because none could be catalogued except those so visible.

The most complete enumeration of the lucid stars by magnitudes has been made by Pickering ('Annals of the Harvard Observatory,' Vol. XIV). The stars were classified by half magnitudes, calling

			M.		M.
Mag.	2.0	all from	1.75	to	2.25
	2.5	" "	2.25	to	2.75
	etc.,				etc.

For the northern stars Pickering used the Harvard Photometry; for the southern, Gould's 'Uranometria Argentina.' A zone from the equator to 30° south declination is common to both; for this zone I use Gould. The number of each class in the entire sky, north and south of the celestial equator, is as follows:

	Northern Hemisphere. Pickering.	Southern Hemisphere. Gould.	Total.
1+	9	14	23
2.0	17	15	32
2.5	17	24	41
3.0	37	41	78
3.5	61	74	135
4.0	114	126	240
4.5	228	234	462
5.0	450	426	876
5.5	787	681	1,468
6.0	789	1,189	1,978
Sum.	2,509	2,824	5,333

It would seem from this that the number of lucid stars in the southern celestial hemisphere is 315 greater than in the northern. But this arises wholly from a seemingly greater number of stars of magnitude 6. In the zone 0° to 30° S., Pickering has 214 stars of this class fewer than Gould. Hence it is not likely that there is any really greater richness of the southern sky.

The total number of lucid stars is thus found to be 5,333. But it is not likely that stars of magnitudes 6.1 and 6.2 should be included in this class, though this is done in the above table. From a careful study and comparison of the same data from Pickering and Gould, Schiaparelli enumerated the stars to magnitude 6.0. He found:

North pole to 30° S.	3,113	stars.
30° S. to south pole	1,190	"
Total lucid stars	4,303	

For most purposes a classification by entire magnitudes is more instructive than one by half magnitudes. From the third magnitude downward we may assume that 40 per cent. of the stars of each half magnitude belong to the magnitude next above, and 60 per cent. to that next below. We thus find that of

		Total.
Mag. 0 and 1 there are	21 stars	21
Mag. 2 there are	52 stars	73
Mag. 3 there are	157 stars	230
Mag. 4 there are	506 stars	736
Mag. 5 there are	1,740 stars	2,476
Mag. 6 there are	5,171 stars	7,647

Here it is to be remarked that under magnitude 6 are included many other than the lucid stars, namely, all down to magnitude 6.4. The last column gives the entire number of stars down to each order of magnitude.

It will be remarked that the number of stars of each order is rather more than three times that of the order next higher. How far does this law extend? Argelander's 'Durchmusterung,' which is supposed to include all stars to magnitude 9.5, gives 315,039 stars for the northern hemisphere, from which it would be inferred that the whole sky contains 630,000 stars to the ninth magnitude. Comparing this with the number 7,647 of stars to the magnitude 6.5, we see that it is forty-fold, so that it would require a ratio of about 3.5 from each magnitude to the next lower. But it is now found that Argelander's list contains, in the greater part of the heavens, all the stars to the tenth magnitude.

On the other hand, Thome's Cordoba 'Durchmusterung' gives 340,380 stars between the parallels —22° and —42°. This is 0.14725 of the whole sky, so that, on Thome's scale of magnitude, there are about 2,311,000 stars to the tenth magnitude in the sky. This is more than three times the Argelander number to the ninth magnitude.

It would, therefore, seem that the ratio of number for each magnitude must exceed 3, even up to the tenth. If a ratio of only 3 extends four steps farther, the whole number of stars in the sky down to magnitude 14.5 inclusive must approach 200 millions. Until the international photographic chart of the sky is subjected to a detailed examination, it is impossible to make an estimation with any approach to certainty.

COLONIES AND THE MOTHER COUNTRY (III).

By JAMES COLLIER.

THE relations between a great state and its subject peoples will vary according to the status of these, as the relations between father and son differ according as the latter is self-supporting or still under tutelage. Roman provinces under the empire were classed as imperial when they were directly controlled by the Emperor, or senatorial when they were governed by the Senate and possessed a simulacrum of self-government. The dual status in this mother country of nearly the whole world foreshadows all subsequent relationships between a mother country and its dependencies. Spain and Portugal governed their colonies imperially, appointing all officers, immediately or through their representative mediately enacting all laws, and leaving almost as little freedom to their own countrymen as to the down-trodden indigenes. More humanely, indeed, but in spite of conceded French citizenship and theoretical equality, the French have ruled their scattered dependencies with as little of the reality of public life. The Dutch colonies are similarly controlled. The British Empire presents a variegated picture where every color is blended and every form of policy known among men is displayed. From it alone an Aristotle might delineate the metaphysics of government or a Spencer construct its physics. In Egypt and Crete, with practical possession, imperial England is vassal to the Sultan, and she now holds the conquered Soudan jointly with Egypt, but acknowledges no suzerainty. She is herself suzerain of the two South African Boer republics and regent of Zanzibar. In her magnificent dependency of India, 692 sovereignties and chiefships form a 'protected' girdle around her own possessions, or interlace or approach them. Between these beneficent despotisms and the free states of Australia, South Africa or North America there seems to be every possible variety of mingled absolutism and self-government. Certain territories are governed by chartered companies; one (Rhodesia) by a chartered company under the control of the Crown. Three native territories are governed by officers under the High Commissioner of South Africa; four others by the officers of Cape Colony. The status of Crown colonies administered more or less directly by the Imperial Government is almost as various. One colony may be dependent on another, as Natal was for years on Cape Colony. Others exhibit in an ascending scale the acquisition of the attributes of self-government. The governor rules at first alone despotically, then with an executive council, next with a nominated legislative council, further with the latter partly elected, and finally with it wholly elective. At these successive stages the colony is in a decreasing degree under the control of the Imperial Government, and a scale might be drawn showing groups of colonies indefinitely arrested at one or another of them. Only colonies destined for complete freedom victoriously pass through them all and emerge into full political manhood.

The duration of their infancy and youth is determined by internal and external circumstances: (1) When a colony is systematically founded and quickly peopled it may rapidly traverse the period of dependence, and (like New Zealand or South Australia) be granted responsible government in about fifteen years. (2) Convict colonies, like Tasmania and New South Wales, may have fifty or sixty years of pupilage. (3) A colony of retarded growth, like West Australia, may be nearly as long a minor. (4) Colonies that have long to struggle with an overwhelming mass of indigenes, like Cape Colony, may take half a century to ripen, and even then, like Natal, may retain traces of the earlier state. (5) When the mother country is herself despotically governed, as England was under the Stuarts, the Commonwealth and the early Hanoverians, colonies that possess every attribute qualifying them for freedom, like many of the North American colonies, may be forcibly retained in partial dependence. (6) The New England colonies, free from the start, were connected with Britain by a shadowy tie of nominal allegiance, tightened at times into real subjection. Lastly, a colony may revert, like Jamaica, after years of Parliamentary institutions, to the dependent position of a Crown colony.

So various and so intricate, so weak here, so strong there, and withal so marvelously compacted, is the network of relations forming the anatomy of the wonderful new type of social organism constituted by a mother country, its free and its subject colonies, its protected states and its dependencies.

The brain sometimes inhibits natural movements and enforces injurious actions, as a morbid conscience often prescribes irksome duties and forbids innocent pleasures. Fathers have misdirected the career of their sons, and the unwisdom of mothers (Lady Ashton, in 'The Bride of Lammermoor,' is a tragic, but far from a rare example) has destroyed the happiness of their daughters. So governments inevitably hinder and blunder, worry colonies by vexatious interferences or goad them into insurrection. For more than thirty years Bishop Fonseca, the president of the Council of the Indies, lay like an incubus on the Spanish colonies in South America. His main object seemed to be to throw impediments in the way of the great discoverers and rulers —Columbus and Cortez. When Cortez planned the conquest of Mexico he experienced protracted opposition from Fonseca, who "discouraged recruits, stopped supplies and sequestered the property" Cortez sent to Spain. The conqueror bitterly complained that he "had found it harder to contend against his own countrymen than against the Aztecs." The story of Spain's South American colonies is one of injustice, oppression and downright robbery. The natives naturally suffered most. They were condemned to forced labor in the mines under circumstances of extreme barbarity, in order that large sums of money might be sent annually to Spain. This insatiable demand neutralized all the efforts of the best-intentioned viceroys and rendered all attempts at good government nugatory. The Indians had further to submit to grinding oppression by the local officials and to the exactions and tyranny of the priests. The Spanish colonists had their own grievances. Articles of commerce were excluded, or had their prices heightened by the monopoly of the Cadiz merchants. They were oppressed by the military despotism of the government. The political development of the colonies was made impossible by the continued use of them for the purposes of the mother country. What Spain was for three centuries, that was she till the other day in her few remaining colonies. Lord Brassey writes of Cuba: "The casual visitor can not fail to be impressed with the evidences of inefficient administration. The fiscal policy is intensely exclusive. The taxation is heavy, and the government absolutely despotic. The police maintain a system of intolerable espionage. Every salaried servant of the local government is a Spaniard, who regards Cuba as a vassal state, over which Spain has unlimited rights, without reciprocal duties or obligations. The system has already severed all her noble settlements in South America from the mother country. In time it must involve the loss of Cuba."

If it were the case that the genesis and growth of the myriad buds formed round a prolific hydroid were accelerated by magnetic shoots (so to speak) from the parent zoöphyte, and 'persons' were thus differentiated, we should have a true analogue to a kind of action exercised by the mother country on its colonies. For it long supplies them with the greater part of their brain power, governing force, culture, science and experience of all sorts, and when these have done their work a new political, intellectual and moral center is created, which is henceforth self-subsistent; the colony has received a soul, a mind, a heart. First, the governor is usually sent out by the metropolis. Of six hundred and seventy-two rulers of South America, from its conquest to its independence, only eighteen were Americans. In French and Dutch colonies there are possibly no exceptions. Many of the charter and proprietary colonies of North America elected their own governors, and the insurrectionary governor of a Crown colony, New York, was popularly elected. The lieutenant-governors of the provinces of the Canadian Dominion are locally appointed. With these and one or two other exceptions, the governor may be considered as symbolizing (in so far as he has the capacity) the entire civilization of the mother country. He brings much or little to the colony he comes to govern. Sometimes, as in the case of Sir George Gray, he brings intellectual superiority, and he may thus stimulate its literary development, but that is rare. He oftener imparts an aroma of gentility that is much appreciated by a certain class. He may be of practical utility by applying the experience of a military engineer, as did Sir William Jervois. He may have had large colonial experience, like Sir Hercules Robinson, and use that to solve the intricate political problems of his colony. If he is a collector, like Sir George Gray, he may enrich it by bequests of libraries and museums. If he possesses literary gifts and has passed through an eventful time, he may enrich colonial history by dictating his biography, like one colonial governor, or writing his reminiscences, like so many. And lastly, after returning to the mother-land, he may continue to watch over the interests of the colony or colonies he ruled; he may become president or member of the Council of the Indies, like three viceroys of Peru, or Parliamentary under-secretary for the colonies, like Sir James Fergusson, or even his former colony's agent-general, like Sir W. Robinson. In Crown colonies the chief legal and administrative officials are imperial appointees, and are only superseded by local ministers when the colony is granted responsible government. In a unique case, that of Queensland, after a constitution had been conceded, the first governor took out with him the first premier; and he too was afterwards able to safeguard its interests as permanent under-secretary in London.

The Greek metropolis sometimes sent priests to its colonies, and bishops are long appointed by the mother church. During the three centuries of Peruvian dependence fully one in seven bishops—one hundred and five against seven hundred and six—were native Americans. Canada seems to have at length arrived at complete independence and appoints Canadians. In Australasia and South Africa the metropolitans and most of the suffragans are still nominated in England; a dean may be transferred from one colony to another as a bishop; or a small and poor diocese may elect one of its incumbents. Local jealousies and possibly the absence of a commanding spirit combine with the desire to have the best the home church can afford to give or the colonial church procure to dictate the extraneous selection. The stream of ecclesiastical culture flows likewise through the immigration or importation of ministers of all denominations. It means, among Catholics as among Protestants, the periodical addition to the spiritual wealth of the colonies of an amount of talent and high character which they would have been slow to acquire by natural growth. University or collegiate professors are for quite as long appointed by a committee of selection in the mother country. Such men—some of them brilliant, laborious, enthusiastic—are a real acquisition to communities immersed in material pursuits and cut off from the movement of science in Europe, and their position is deservedly high and well remunerated. Doctors, lawyers, artists, teachers, experts in many departments, place the colonies in the same position relatively to less-favored communities, as the sons of a squire relatively to the sons of an artisan. In this respect, as in most others, a colony follows the example of the mother country. The introduction of literature, the sciences and the arts into the mother-land was to a large extent at all stages in its history the work of aliens. It is so still; the names of Bunsen, Rosen, Max Müller, Goldstücker, Aufrecht, and a score of others, are proofs that men as well as things that are 'made in Germany' are still imported into England. To descend to the mechanical arts, "the ranks of skilled workmen in America were and are renewed from the more fertile soil of Europe"; even the workmen in the Portland stone-quarries are imported from England. The second mode in which foreign culture was introduced into the mother-land in common with all others—visits made abroad for discipleship or instruction—has all along been, and is now increasingly, maintained. Colonial students go to Europe to be trained in medicine and law. Experts go to become acquainted with advances in science and medicine, or with recent improvements in mechanical processes. The wealthier colonists who spend occasional seasons in Europe bring back new (or antiquated) social or political notions, and Americans who thus try to import into the United States an aristocratic style of living have to be ridiculed out of it. The third method by which an infusion of foreign civilization may pass into another community is by books, works of plastic art, music, tools, implements and instruments, and into this vast inheritance of the mother country the daughter colonies have entered. They participate in the advances made by other countries as well. The Canadian colonies owe only less to the United States than to England, and American railway cars, agricultural implements and household utensils are in use in Australasia. In New Zealand a French Masonic lodge has struck root.

The new colonial centers thus formed react on the father-land, as we may conceive the daughter buds to react on the parent hydroid. The discovery of the New World and the successive entrance of the five great maritime powers upon a long and fierce rivalry for its possession transformed the politics of Europe. Great wars were undertaken solely with this object. The political center of gravity was shifted from the Mediterranean to the Atlantic. New industrial interests were created. Insular and stagnant powers, isolated Continental powers, received a fresh lease of life, and, along with warlike Continental powers, were expanded to the measure of the globe. New sympathies were generated. Wider horizons were opened out. The heart and brain of all were in a manner enlarged. The policy of the mother country is even now being modified by its colonies. "The paramount object in legislating for colonies should be the welfare of the parent state," frankly avows the law officer of the Dutch East India Company at the Cape of Good Hope, in 1779. The Ashburton Treaty and the Oregon Agreement were entered into as if England and the United States were alone interested in their provisions. Treaties are now concluded in the interests of the colonies. Treaties are 'denounced' in order to allow them freedom to tax foreign commodities. They are represented by commissioners, on an equal footing with those of Britain, at conferences preparatory to the conclusion of treaties, and colonial conferences are summoned in order that the general views of the colonies may be ascertained.

There is a more direct reaction, resembling the adoption by an admiring father of the sentiments and opinions of a son who is rising in the world. The Greek cities that had planted colonies imitated the republican institutions of these and deposed their kings. "The American colonists," says Bancroft, "founded their institutions on popular freedom and 'set an example to the nations.' Already the . . . Anglo-Saxon emigrants were the hope of the world." The filial free colonies of Britain are exerting an influence on the domestic policy of the father-land. An aged colonial ruler used to console himself for exclusion from the English Parliament by cherishing the belief that ideas and measures of his had passed into the public life of England. Much of this is mere hallucination; some of it is reality. The testimony of a sagacious and experienced statesman on this subject is decisive:

"To the influence of the American Union must be added that of the British colonies. The success of popular self-government in these thriving communities is reacting on political opinion at home with a force that no statesman neglects, and that is every day increasing. There is even a danger that the influence may go too far. They are solving some of our problems, but not under our conditions, and not in presence of the same difficulties. Still, the effect of colonial prosperity—a prosperity alike of admirable achievement and boundless promise—is irresistible. It imparts a freedom, an elasticity, an expansiveness, to English political notions, and gives our people a confidence in free institutions and popular government, which they would never have drawn from the most eloquent assumptions of speculative system-mongers, nor from any other source whatever, save practical experience carefully observed and rationally interpreted."*

The New Zealand system of local government is a model which Great Britain, at one time famous in that line, has not been ashamed to imitate; the English county councils have been molded on those of her colony. From the same colony the mother country borrowed her First Offenders' act. The restriction of electors to the exercise of a single vote —unimportant excepting in principle in populous England, but impor-

* Morley, 'Studies in Literature,' pp. 126-7.

tant in young countries where property is widely held—was perseveringly proposed, and at length carried, by the aristocratic leader of the democratic party in New Zealand, whence it is spreading to the adjacent colonies; it has been for some years adopted by the British Liberals as an article in their programme, and it is also a plank in the European socialist platform. The general adhesion to an eight hours' day in the Australasian colonies is having an effect in England and is probably the measure to which Mr. Morley refers as likely to be dangerous; his opposition to it cost him his seat at Newcastle. The adoption of female suffrage in two of these colonies and the certainty of its adoption in others are habitually cited by the advocates of the cause in England as an argument for its adoption in England. The nationalization of the land has been a popular notion in these same colonies ever since Henry George's famous book was published, and the large extent of private lands bought back by the governments of New Zealand and Queensland has strengthened the hands of the land-nationalizers in Europe. The advanced government socialism of most of these colonies, made inevitable by the lack of private capital, and its apparent success, furnish socialists of the German type with weapons and encourage them to prophesy 'the dawn of a revolutionary epoch.'

The spiritual reaction of the colonies on the mother-land is much less considerable, yet is not nil. One or two instances stand out prominently. Jonathan Edwards is one of the giants of British as well as of American theology, and his treatise on the freedom of the will has counted for as much as Butler's Analogy in the development of English theological thought. Sam Slick has been the father or foster-father of the portentous overgrowth of humor by which the United States balances the devouring activity of its public and the overstrain of its private life, but he has been practically inoperative on the very different quality of English humor. From South Africa have come influences of a sterner sort. "Who could have foreseen," asks Mr. Stead, "that the new, and in many respects the most distinctive, note of the literature of the last decade of the nineteenth century would be sounded by a little chit of a girl reared in the solemn stillness of the Karoo, in the solitude of the African bush? The Cape has indeed done yeoman's service to the English-speaking world. To that pivot of the empire we owe our most pronounced types of the imperial man and the emancipated woman"—Cecil Rhodes and Olive Schreiner.

CAUSES OF DEGENERATION IN BLIND FISHES.

BY PROFESSOR CARL H. EIGENMANN,

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IT may now be profitable to take up the causes leading to the small degree of degeneration found in Chologaster, the degenerations of the eye in Amblyopsis, Typhlichthys and Troglichthys to a mere vestige, together with the total disappearance of some of the accessory structures of the eye, as the muscles.

In the outset of this consideration we must guard against the almost universal supposition that animals depending on their eyes for food are or have been colonizing caves, or that the blind forms are the results of catastrophes that have happened to eyed forms depending on their eyesight for their existence. This idea, so prevalent, vitiates nearly everything that has been written on the degeneration of the eyes of cave animals.

Another word of warning ought perhaps to be added. The process of degeneration found in the Amblyopsidæ need not necessarily be expected to be identical with the degeneration of the same organs in another group of animals, and, however much the conditions in one group may illuminate the conditions in another, cross-country conclusions must be guarded against.

The degeneration of organs ontogenetically and phylogenetically has received a variety of explanations:

1. The organ diminishes with disuse (ontogenetic degeneration)—Lamarck, Roux, Packard), and the effect of this disuse appears to some extent in the next generation (phylogenetic degeneration—Lamarck, Roux, Packard, Kohl).

2. Through a condition of panmixia the general average maintained by selection is reduced to the birth mean in one generation (ontogenetic—Romanes, Lankester, Lloyd Morgan, Weismann) to the greatest possible degeneration in succeeding generations (phylogenetic—Weismann), or but little below the birth average of the first generation (Weismann's later view, Romanes, Morgan, Lankester).

3. Through natural selection (reversed), the struggle of persons, the organ may be caused to degenerate either (A) by the migration of persons with highly developed eyes from the colony living in the dark (Lankester), or (B) through economy of weight and nutriment or liability to injury (phylogenetic purely—Darwin, Romanes).

4. Through the struggle of parts for room or for food an unused

organ in the individual may be crowded (ontogenetic—Roux). This may lead to the development of the used organ as against the disused through a compensation of growth (Goethe, Saint-Hilaire, Roux); this ontogenetic result becomes phylogenetic through transmission of the acquired character (Roux), or is in its very nature phyloblastic (Kohl).

5. Through the struggle between soma and germ to produce the maximum of efficiency of the former with the minimum expenditure to the latter (ontogenetic and phylogenetic—Lendenfeld).

6. Through germinal selection, the struggle of the representatives of organs in the germ (ontogenetic and phylogenetic—Weismann).

The idea of ontogenetic degeneration is intimately bound up with the idea of phylogenetic degeneration. Logically we ought to consider first the causes of individual degeneration, and then the processes or causes that led to the transmission of this. Practically it is impossible to do so, because many of the explanations are general. Only No. 4 of the above may be taken in the ontogenic sense purely, though it was certainly also meant to explain phylogenetic degeneration. In many of the explanations of particular cases of degeneration more than one of the above principles are invoked, though only one was meant to be used. In most cases, however, the discussions of degeneration have been in general terms, without direct bearing on any specific instance of degeneration in all its details. It must be evident that such discussions can only by accident lead to right results.

By the Lamarckian ontogenetic degeneration is considered the result of lack of use and consequent diminished blood supply. The results of the diminution caused by the lack of use during one generation are transmitted in some degree to the next generation, which thus starts at a lower level. A continuation of the same conditions leads finally to the great reduction and ultimate disappearance of an organ.

No one, so far as I am aware, has succeeded in accounting for the degeneration of the eye by means of this view. Packard's* explanations are evidently a mixture of Lamarckism and Darwinism.

Packard says: "When a number, few or many, of normal-seeing animals enter a totally dark cave or stream, some may become blind sooner than others," some having the eye slightly modified by disuse, while others may have in addition physical or functional defects, especially in the optic nerves and ganglia. "The result of the union of such individuals and adaptation to their Stygian life would be broods of young, some with vision unimpaired, others with a tendency to blindness, while in others there would be noticed the first steps in degeneration of nervous power and nervous tissue." Packard evidently had invertebrates in mind. He clearly admits the cessation of selection or

* *American Naturalist*, September, 1894, vol. xxviii, p. 727.

panmixia in that those born with defects may breed with the others. He supposes that the blind fauna may have arisen in but few or several generations, a supposition that may be applicable to invertebrates, but certainly is not to vertebrates. At first those becoming so modified that they can do without the use of their eyes would greatly preponderate over those 'congenitally blind.' "So all the while the process of adaptation was going on, the antennæ and other tactile organs increasing in length and in the delicacy of structures, while the eyes were meanwhile diminishing in strength of vision and their nervous force giving out, after a few generations—perhaps only two or three—the number of congenitally blind would increase, and eventually they would, in their turn, preponderate in numbers." Packard seems here to admit the principle of degeneration as the result of compensation of growth, the nervous force of the eye giving out with the increase of the tactile and olfactory organs. It is somewhat doubtful in what sense the term 'congenitally blind' is used, but it probably means born blind as the result of transmitted disuse, rather than blind as the result of fortuitous variation. The effects of disuse are thus supposed, through their transmission, to have given rise to generations of blind animals. The continued degeneration is not discussed.

Romanes maintained that the beginning of degeneration was due to cessation of selection, and continued degeneration to the reversal of selection and final failing of the power of heredity. Selection he supposed to be reversed because the organ no longer of use "is absorbing nutriment, causing weight, occupying space and so on, uselessly. Hence, even if it be not also a source of actual danger, economy of growth will determine a reversal of selection against an organ which is now not only useless, but deleterious." This process will continue until the organ becomes rudimentary and finally disappears.

Roux* attempted chiefly to explain degeneration in the individual. Degeneration is looked upon as the result of a struggle among the parts for (*a*) room and (*b*) food. Without doubting that both these principles are active agents in degeneration, it may be seriously doubted whether they are effective in the degeneration of the eyes in question. Certainly there can be no question of a struggle for room, for the position and room formerly occupied by the eye is now filled with fat, which can not have been operative against the eye. The presence of this large fat mass in the former location of the eye, the large reserve fat mass in the body, the uniformly good condition of the fish and the low vitality, which enables them to live for months without visible food, all argue against the possibility that the struggle for food between parts was an active agent in the degeneration of the eyes.

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* Gesammelte Abhandlungen, 1895.

Kohl* considers that "*Der Grund und direkter oder indirekter Anlass zum Eintreten der Entwickelungshemmung ist Lichtmangel.*" The method of operation of the lack of light he conceived to be as follows:

Other organs were developed to compensate for the disuse of the eye; and as the developmental force was used in the formation of these organs, each succeeding generation developed its eye less. The degeneration is thus explained as the result of a struggle of parts, although this term is nowhere used, acting through the principle of compensation. The same objections may be offered to this explanation of Kohl as to all his theoretical discussions—they are based on the assumption of conditions and processes that have no existence. The high development of 'compensating' organs is not primarily the result of the loss of the eye, but the high development of the former organs permitted the disuse and later degeneration of the latter. His whole process is a phylogenetic one, without a preceding ontogenetic one, though on this point he does not seem to be very clear himself, for on one page we are told that degeneration leads to retardation, and on another that degeneration is a consequence of retardation.

Ledenfeld† endeavors to apply Roux's *Kampf der Theile*, with reversed selection, to explain the conclusions reached by Kohl on the processes and causes of degeneration. The struggle is represented as taking place between the germ and soma, the former endeavoring to keep the latter at the lowest efficient point as weapon for the germ. If a series of individuals get into the dark the organs of vision are of no advantage and reversed selection will bring about their degeneration. The saving in ontogeny appears first as a retardation and then as a cessation of development.

Weismann‡ more recently accepts the view of Romanes, Morgan and Lankester on the inadequacy of panmixia to explain the whole phenomena of degeneration, and in his 'Germinal Selection' rejects the idea of reversed selection, and suggests a new explanation for what Romanes attributed to the failure of heredity and the Lamarckians to transmission of the effects of disuse. The struggle of the parts of Roux has been crowded by him back to the representatives of these parts in the germ.

"The phenomena observed in the stunting, or degeneration, of parts rendered useless . . . show distinctly that ordinary selection, which operates by the removal of entire persons—personal selection, as I prefer to call it—can not be the only cause of degeneration, for in most cases of degeneration it can not be assumed that slight individual vacillations in the size of the organ in question have possessed selective value. On the contrary, we see such retrogressions effected apparently

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* Rudimentäre Wirbelthieraugen, 1893. † Zoölogischer Centralblatt, 1896.

‡ The Monist, 1896, pp. 250-274.

in the shape of a continuous evolutionary process determined by internal causes, in the case of which there can be no question whatever of selection of persons or of a survival of the fittest—that is, of individuals with the smallest rudiments. The gradual diminution continuing for thousands and thousands of years and culminating in its final and absolute effacement" can only be accomplished by germinal selection. Germinal selection as applied to degeneration is the formal explanation of Romanes' failure of heredity through the struggle of parts for food. "Powerful determinants will absorb nutriment more rapidly than weaker determinants. The latter, accordingly, will grow more slowly and will produce weaker determinants than the former." If an organ is rendered useless, the size of this organ is no longer an element in personal selection. This alone would result in a slight degeneration. Minus variations are, however, supposed to rest "on the weaker determinants of the germ, such as absorb nutriment less powerfully than the rest. This will enable the stronger determinants to deprive them even of the full quantum of food corresponding to their weakened capacity of assimilation, and their descendants will be weakened still more. Inasmuch, now, as no weeding out of the weaker determinants of the hind leg [or eye] by personal selection takes place on our hypothesis, inevitably the average strength of this determinant must slowly but constantly diminish—that is, the hind leg [or eye] must grow smaller and smaller until it finally disappears altogether. . . . Panmixia is the indispensable precondition of the whole process; for, owing to the fact that persons with weak determinants are just as capable of life as those with strong, . . . solely by this means is a further weakening effected in the following generations."

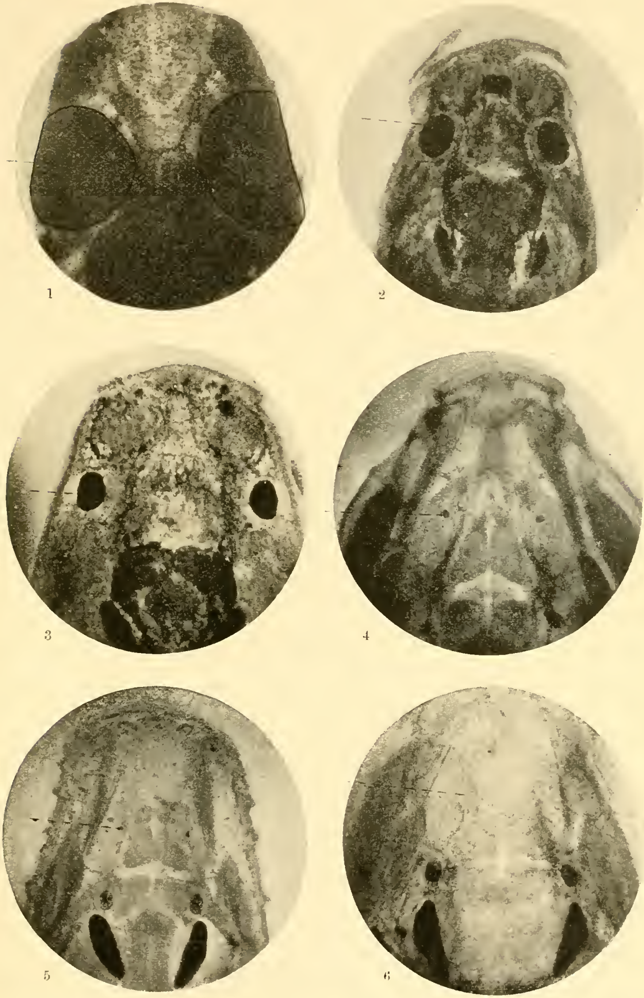
This theory presupposes the complex structure of the germ plasm formulated by Weismann and rejected by various persons for various reasons. But granting Weismann the necessary structure of the germ plasm, can germinal selection accomplish what is claimed for it? I think not. Granting that variations occur about a mean, would not all the effects claimed for minus variations be counteracted by positive variations? Eye determinants, which, on account of their strength, secure more than their fair share of food, and thereby produce eyes that are as far above the mean as the others are below, and leave descendent determinants that are still stronger than their ancestry would balance the effect produced by weak-eye determinants. It is evident that a large, really extravagant development of the eye in such a fish as Chologaster would not effect the removal of the individual by personal selection; still less so in Amblyopsis, which not only lives in comparative abundance, but has lived for twenty months in confinement without visible food, and in which the eye is minute. It seems that all the admitted objections to degeneration by panmixia apply with equal force to germinal selection. This, however, would be changed were the effect of disuse admitted to affect the determinants, and this it seems Weismann has unconsciously admitted. So far we have considered germinal selection in the abstract only. All its suppositions are found to be but a house of cards when the actual conditions of degeneration are considered. We find that degeneration is not a horizontal process affecting all the parts of an organ alike, as Weismann presupposes, not even a process in the reverse order of phyletic development, but the more vital, most worked parts degenerate first with disuse and panmixia; the passive structures remain longest. The rate of degeneration is proportional to the past activity of the parts, and the statement that "passively functioning parts—that is, parts which are not alterable during the individual life by function—by the same laws also degenerate when they become useless" finds no basis in fact, and is an example of the inexact utterances abundant in the discussion of degeneration on which it is entirely unsafe to build lofty theoretical structures. As one example of the unequal degeneration we need only call attention to the scleral cartilages and the rest of the eye of Troglichthys rosæ.

All are agreed that natural selection alone is insufficient to explain all, if any, of the processes of degeneration. All either consciously or not admit the principle of panmixia, and all are now agreed that this process alone can not produce extensive degeneration. All are agreed that the important point is degeneration beyond the point reached by panmixia, the establishment of the degenerating process, whatever it may be, in the germ, or, in other words, the breaking of the power of heredity. It is in the explanation of the latter that important differences of opinion exist.

Weismann attempts to explain the degeneration beyond the point which panmixia can reach by a process which not only is insufficient, even if all his premises are granted, to produce the desired result without the help of use transmission, but has as its result a horizontal degeneration which has no existence in fact.

Romanes supposed degeneration, beyond the point which may be reached by panmixia, to be the result of personal selection and the failure of the hereditary force. The former is not applicable to the species in question, and is denied by such an ardent Darwinist as Weismann to be applicable at all in accounting for degeneration. Moreover, the process as explained by Romanes would result in a horizontal degeneration which has no existence in fact. The second assumption, the failure of hereditary force, is not distinguishable, as Morgan has pointed out, from the effect of use transmission.

The struggle of parts in the organism has not affected the eye through the lack of room, since the space formerly occupied by the eye is now filled by fat and not by an actively functioning organ. It is not



FIGS. 1–6.—Photographs of the upper halves of the heads of specimens of nearly the same length under the same magnification, to show the gradual decrease of the eye. The dotted line leads to the eye in all cases.

FIG. 1.—*Zygonectes notatus.*
FIG. 2.—*Chologaster papilliferus.*
FIG. 3.—*Chologaster Agassizii.*
FIG. 4.—*Amblyopsis spelæus.*
FIG. 5.—*Troglichthys rosæ.*
FIG. 6.—*Typhlichthys subterraneus.*

affected by the struggle for food, for stored food occupies the former eye space. It could only be affected by the more active selection of specific parts of food by some actively functioning organ. It is possible that this has in fact affected the degeneration of the eye. The theory explains degeneration in the individual, and implies that the effect in the individual should be transmitted to the next generation. This second part seems but the explanation of the workings of the Lamarckian factor.

The Lamarckian view—that through disuse the organ is diminished during the life of the individual, in part, at least, on account of the diminution of the amount of blood going to a resting organ, and that this effect is transmitted to succeeding generations—not only would theoretically account for unlimited progressive degeneration, but is the only view so far examined that does not on the face of it present serious objections. Is this theory applicable in detail to the conditions found in the Amblyopsidæ? Before going further, objections may again be raised against the universal assumption that the cessation of use and the consequent panmixia was a sudden process. This assumes that the caves were peopled by a catastrophe. But it is absolutely certain that the caves were not so peopled, that the cessation of use was gradual, and the cessation of selection must also have been a gradual process. There must have been ever-widening bounds within which the variation of the eye would not subject the possessor to elimination.

Chologaster is in a stage of panmixia as far as the eye is concerned. It is true the eye is still functional, but that the fish can do without its use is evident by its general habit and by the fact that it sometimes lives in caves. The present conditions have apparently existed for countless generations—as long as the present habits have existed—and yet the eye still maintains a higher degree of structure than reverse selection, if operative, would lead us to expect, and a lower than the birth mean of fishes depending on their eyes, the condition that the state of panmixia alone would lead us to expect. There is a staying quality about the eye with the degeneration, and this can only be explained by the degree of use to which the eye is subjected.

The results in Chologaster are due to panmixia and the limited degree of use to which the eye is put. Chologaster Agassizii shows the rapid diminution with total disuse.

The difference in the conditions between Chologaster and Amblyopsis, Typhlichthys and Troglichthys, is that in the former the eyes are still in use, except when living in caves; in the latter they have not been in a position to be used for hundreds of generations. The transition between conditions of possible use and absolute disuse may have been rapid with each individual after permanently entering a cave. Panmixia, as regards the minute eye, continued. Reversed selection, for economy, can not have affected the eye for reasons already stated. The mere loss of the force of heredity, unless this was caused by disuse, or the process of germinal selection, can not have brought about the conditions, because some parts have been affected more than others.

Considering the parts most affected and the parts least affected, the degree of use is the only cause capable of explaining the conditions. Those parts most active during use are the ones reduced most—viz., the muscles, the retina, optic nerve and dioptric appliances, the lens and vitreous parts. Those organs occupying a more passive position, *e. g.*, the scleral cartilages, have been much less affected. The lens is one of the latest organs affected, not at all during use, possibly because during use it would continuously be in use. It disappears most rapidly

Fig. 7.—Head of a very young *Amblyopsis* before all the yolk is absorbed.

after the beginning of absolute disuse both ontogenetically and phylogenetically. All indications point to use and disuse as the effective agents in molding the eye. The process, however, does not give results with mathematical precision. In Typhlichthys subterraneus the pigmented layer is affected differently from that of Amblyopsis. The variable development of the eye muscles in different species would offer another objection if we did not know of the variable condition of these structures in different individuals. Chilton has objected to the application of the Lamarckian factor to explain degeneration, on account of the variable effects of degeneration in various invertebrates. But such differences in the reaction are still less explainable by any of the other theories.

THE EVOLUTION AND PRESENT STATUS OF THE AUTOMOBILE.

By WILLIAM BAXTER, Jr.

IN this closing year of a century which is marked by unparalleled advances in science and its applications to the industrial arts, we are very much inclined to take it for granted that none of the inventions that are regarded by us as indicative of the highest order of progressive tendency, could by any possibility have been thought of by our forefathers; and as the automobile is looked upon as an ultra-progressive idea, no one who has not investigated the subject would believe for a moment that its conception could antedate the present generation, much less the present century. The records, however,

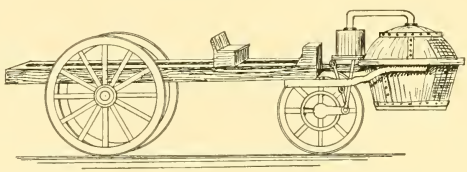


Fig. 1. Cugnot's Steam Gun Carriage, Made in 1763.

show that the subject engrossed the attention of inventive minds many hundreds of years ago. In fact, as far back as the beginning of the thirteenth century a Franciscan monk named Roger Bacon prophesied that the day would come when boats and carriages would be propelled by machinery.

The first authentic record of a self-propelled carriage dates back to the middle of the sixteenth century. The inventor was Johann Haustach, of Nuremburg. The device is described as a chariot propelled by the force of springs, and it is said that it attained a speed of two thousand paces per hour, about one mile and a quarter. Springs have been tried by many inventors since that time, but always without success from the simple fact that the amount of energy that can be stored in a spring is practically insignificant.

In 1763 a Frenchman by the name of Cugnot devised a vehicle that was propelled by steam, and a few years after the date of his first experiment, constructed for the French Government a gun carriage which is shown in Fig. 1. As will be seen, the design was of the tricycle type, and it was intended to mount the gun between the rear wheels. The boiler, which resembles a huge kettle, hung over the front end and was apparently devoid of a smoke stack. Motion was imparted to the front wheel by means of a ratchet. Although this

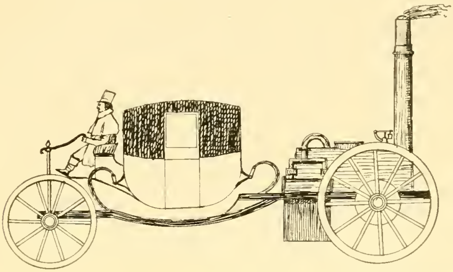


FIG. 2. SYMINGTON'S STEAM COACH, MADE IN 1784.

invention is very crude, it must be regarded as meritorious if we consider that it was made before the steam engine had been developed in a successful form for stationary purposes.

The next effort to solve the problem was made by W. Symington in the year 1784, the carriage devised by him being illustrated in Fig. 2. This coach, although pretentious in appearance, was crude

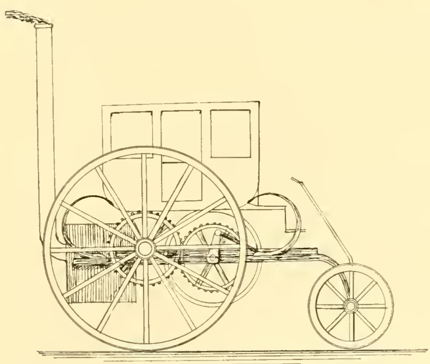


FIG. 3. TREVITHICK'S STEAM CARRIAGE, MADE IN 1803.

mechanically, but it actually ran. The service, however, was not what could be called satisfactory.

In 1803, Richard Trevithick brought out the carriage shown in Fig. 3, which could run, but was artistically a failure. Moreover, the machinery was such as would soon give out, even if well designed, on account of its exposed position.

Between 1805 and 1830, quite a number of steam vehicles were invented and put into practical operation. Fig. 4 shows a very elabo-

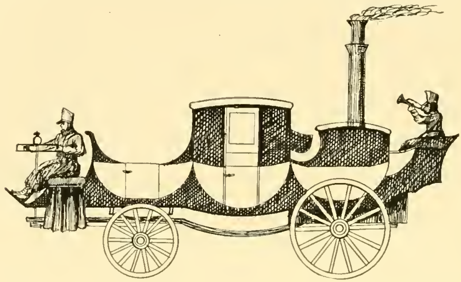


Fig. 4. Steam Coach, Made by James and Anderson, about 1810.

rate coach of this period, which was invented by W. H. James, and constructed with the assistance of Sir James Anderson, Bart. The machinery used in this design consisted of two powerful steam engines, one being connected with each one of the hind wheels in a manner similar to that employed in locomotives at the present time. The wheels were not fast upon the axle, hence they could revolve at different velocities in rounding curves. In this respect this invention embodied one of the features commonly used by automobiles of the latest design.

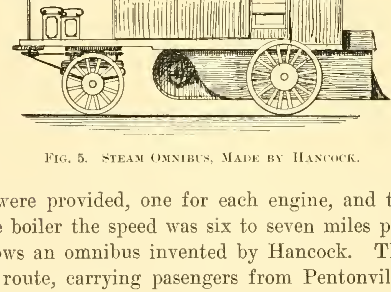


Fig. 5. Steam Omnibus, Made by Hancock.

Two boilers were provided, one for each engine, and the record says that with one boiler the speed was six to seven miles per hour.

Fig. 5 shows an omnibus invented by Hancock. This vehicle ran on a regular route, carrying pasengers from Pentonville to Finsbury

Square, London. Fig. 6 shows a carriage invented by Burstall and Hiel, which attracted a great deal of attention. It was probably the most complete and perfect mechanically of any invention that had been made up to that time.

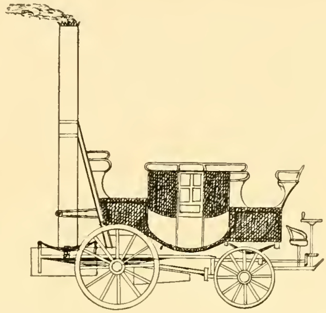


Fig. 6. Burstall and Hiel's Steam Carriage, Made Prior to 1825.

Fig. 7 shows a carriage invented by Squire and Maceroni, who had been for a long time in the service of Goldsworth Gurney, one of the most noted experimenters of his day in steam propulsion. A number of carriages were made by these workers, on designs similar to Fig. 7, and it is said that they ran at a high rate of speed, probably ten miles per hour.

Fig. 8 illustrates an invention that is interesting from the fact that

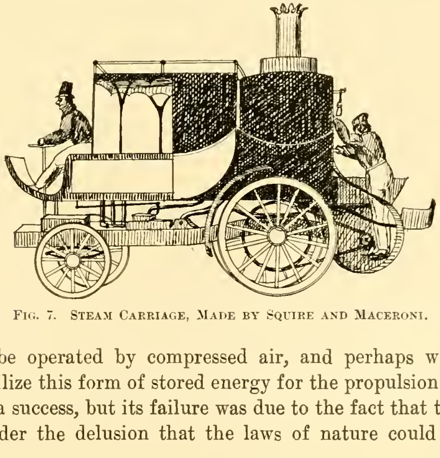


Fig. 7. Steam Carriage, Made by Squire and Maceroni.

it was to be operated by compressed air, and perhaps was the first effort to utilize this form of stored energy for the propulsion of vehicles. It was not a success, but its failure was due to the fact that the inventor labored under the delusion that the laws of nature could be circumvented by skillfully contrived mechanical devices so as to obtain something from nothing. The body of the carriage was used as a reservoir for the compressed air, and within the wheels were placed a number of pumps, the short bars projecting from the peripheries being the ends

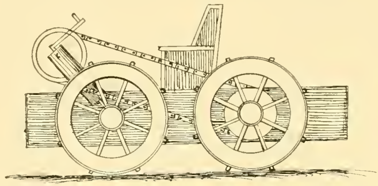


FIG. 8. COMPRESSED AIR WAGON, MADE ABOUT 1810.

of the plungers. The expectation was that as the wheels revolved, the plungers would be depressed, and thus air would be pumped into the reservoirs and this air would operate the engine that propelled the vehicle; hence the apparatus would supply its own power, and realize perpetual motion. If this attempt to controvert the laws of nature had not been relied upon, better results might have been obtained.

The highly ornamental coach shown in Fig. 9 was invented by Dr. Church about 1832. In addition to being ornamental, it was of massive construction and large capacity, being able to accommodate fifty passengers. Its operation is said to have been very satisfactory, a high rate of speed being attained and all grades on ordinary roads being easily mounted. The inventor swamped himself in endeavoring to compete with railroads.

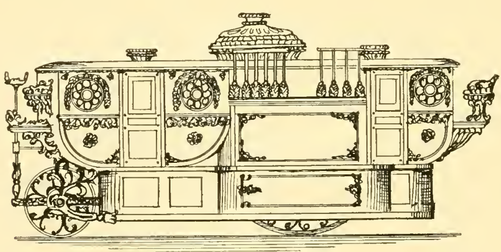


FIG. 9. SIDE VIEW OF DR. CHURCH'S STEAM COACH, MADE IN 1832.

Perhaps the most perfect of all the early automobiles was the one devised by Scott Russell, the celebrated designer of the Great Eastern. This carriage is shown in Fig. 10. It was operated successfully, and was able to mount the steepest hills and to attain a high rate of speed, but as coal was used for fuel and the engines were of large capacity, it is probable that the smoke, exhaust steam and noise of the machinery were decidedly objectionable features. A line of these coaches was put in commission in Glasgow in 1846, each one having a seating capacity of twenty-six, six inside and twenty on the top. After several months of successful operation, the line was withdrawn on account of the opposition of the authorities and of the general public.

These few examples of the early attempts to solve the problem of mechanical propulsion of vehicles are sufficient to show that the automobile is not entirely a creation of the progressive mind of the latter part of the nineteenth century, but that it engrossed the atten-

FIG. 9A. DR. CHURCH'S STEAM COACH ON THE ROAD.

tion of inventors more than one hundred and thirty years ago. The success attained by the workers in this field at different periods was directly in proportion to the degree to which the form of power used had been perfected at the time. The first inventors attained but slight success, owing to the fact that, in their time, the steam engine was in a crude form, but as the construction of the latter improved, so did that of the vehicles operated by it.

Before the days of steam, the power of wind mills was utilized to propel vehicles, and with such success that in the sixteenth and seventeenth centuries wind-propelled wagons or 'Charvolants,' as they were called, were very numerous upon the flat plains of the Netherlands.

From 1845 up to the early nineties, a period of nearly half a century, very little was done in the way of developing the automobile. From time to time inventors in various parts of the world devoted themselves to the subject, but they were generally looked upon as visionary cranks, and their work attracted little attention. During this period there was an almost universal prejudice against the use of any kind of mechanical power upon the streets or public highways, and it is even possible that if during these years any one had invented a horseless carriage, perfect in every way, he would have failed to obtain proper recognition. Prejudice against mechanically-propelled vehicles has gradually worn away, probably because of the introduction of cable and trolley cars, and at the present time the majority of people desire to see the substitution of mechanical for animal power. As a result of this change in public opinion, self-propelled vehicles are accepted as entirely satisfactory, which a few years ago would have been regarded

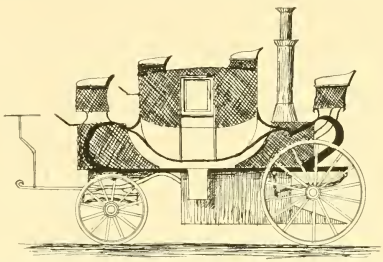


FIG. 10. SCOTT RUSSELL'S STEAM CARRIAGE, MADE IN 1845.

as failures. Notwithstanding this tolerant feeling, however, it is very doubtful whether the cumbersome coaches of the early part of the century would be received with favor at the present time when taste and requirements are entirely different. What is now desired is a light, fast-running and attractive vehicle, which could not be constructed along the lines followed by the inventors of former days. The automobile of to-day is a far more perfect device than its predecessors, although it can not be said to have reached a state of perfection. As motive power, steam, gasoline and electricity are used. Which of the three is the best, taking all things into consideration, it would be difficult to say, as each one has its defects as well as its advantages, and the evident superiority of each one in a certain direction is offset by deficiencies in other directions.

In every civilized country, where the mechanic arts are far enough advanced, automobiles are now being manufactured, but France is the country where modern development first began, and up to the present time it has maintained its leading position, although in quality of product, other nations, if not on a par with it, are certainly not very far behind.

The perfection to which the steam automobile has been developed

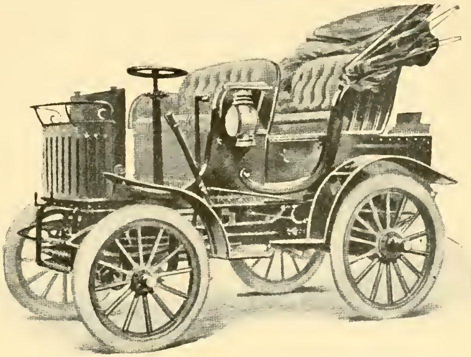


FIG. 11. SERPOLLET CARRIAGE, A MODERN STEAM AUTOMOBILE OF FRENCH DESIGN.

in these latter days is due mainly to the efforts of L. Serpollet, a distinguished French engineer. Other highly successful steam carriages are now manufactured in England and in this country, as well as in

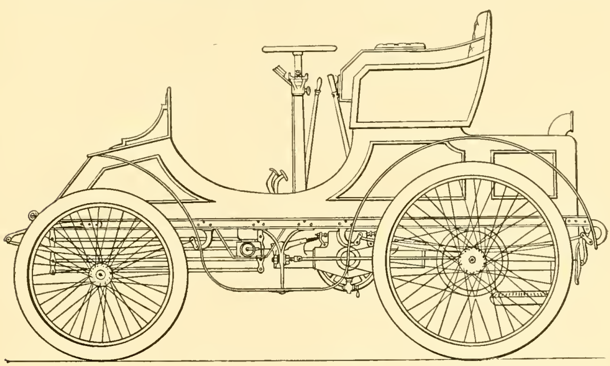


FIG. 12. SIDE VIEW OF SERPOLLET CARRIAGE, SHOWING LOCATION OF ENGINE, BOILER, CONDENSER, ETC.

several European nations, but Serpollet was the first to bring forth a successful fast-running and attractive vehicle, and the others have profited by his work.

One of the many designs of Serpollet carriages is shown in Fig. 11;

Fig. 12 shows more fully the arrangement and location of the machinery. The engine used in these vehicles is made with four cylinders of the single action type; that is, they take steam at one end only. By using this construction, while the number of cylinders is increased, the other parts are greatly simplified, as the piston rods, crossheads and guides can be dispensed with. In addition, the whole engine can be made very compact.

The boiler is of the flash type; that is, it carries no water ordinarily, but when the engine is in operation, a pump injects into the boiler at each stroke of the engine as much water as may be required to generate the steam necessary to propel the vehicle; the instant the water enters the boiler it is converted into steam. As the amount of steam is proportional to the amount of water, it can be seen that by regulating the water supply, the power of the engine and thereby the speed of the

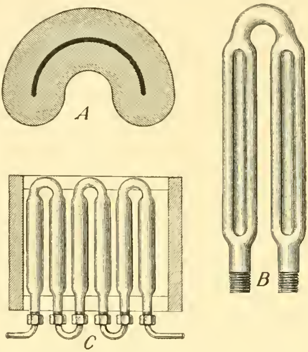


Fig. 13. Showing Details of the Boiler of the Serpollet Carriage.

carriage, can be controlled. This is the method actually employed to control the speed. In starting, a handle is moved which connects the engine, the boiler and the pump in the proper relation; and while under way the velocity is varied by the manipulation of a lever which controls the amount of water injected into the boiler. The fuel used is kerosene, which is vaporized and then fed into a properly constructed burner. The amount of oil supplied to the burner is regulated by the same lever that regulates the supply of water, so that both are increased or reduced in the proper proportion. The boiler is constructed of a number of steel tubes, which are about two and a half inches in diameter, and from three eighths to half an inch thick. These tubes are pressed into the form shown in Fig. 13, the dark line in the section marked A representing the interior space. A number of tubes collapsed in this form and bent into the shape B, are assembled as shown at C. The number of tubes depends upon the capacity of the boiler. As the tubes are very thick, they can, without any danger of bursting, be heated to so high a temperature that the water injected into them is at once turned into steam.

In Fig. 12 it will be seen that the engine is located under the body of the carriage between the two axles, and that motion is imparted to the hind wheels by means of chains and sprocket wheels. The boiler is located at the back of the vehicle, the lower part projecting some distance below the rear axle. A small smoke stack at the rear of the body allows the gases of combustion to escape. Between the front wheels, a compact condenser is located, and into this the steam from the engine is exhausted. The condenser serves two purposes:

FIG. 14. AN AMERICAN STEAM CARRIAGE OF 1900.

it recovers a portion of the water that would otherwise escape into the air, and thus increases the distance the carriage can run without a new supply, and at the same time it lessens the noise produced by the exhaust, and also the volume of steam escaping into the atmosphere, which in cold or rainy weather becomes plainly visible.

Although we have been rather slow in this country in taking up the automobile, inventors and manufacturers are now working at a pace that will soon make up for lost time. We already have a number of designs of steam carriages whose operation is highly creditable. Fig. 14 illustrates one of these. The design of the engine, boiler and other mechanism can be well understood from Fig. 15, in which a portion of the body is removed to expose the internal parts.

The boiler is a very compact form of the upright type, such as is used in fire engines. It is about fourteen inches in diameter and twenty inches high. To increase its strength, it is surrounded with two layers of piano wire. The engine is of the locomotive type, consisting of two

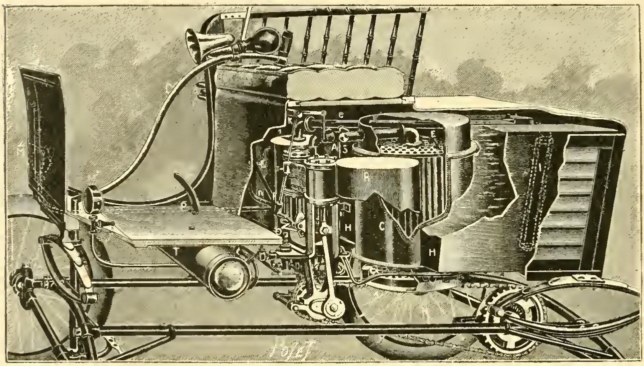


FIG. 15. SECTIONAL VIEW OF FIG. 14, SHOWING LOCATION OF ENGINE, BOILER AND OTHER DETAILS.

cylinders, the pistons of which are connected with cranks on the end of the shaft, these cranks being set at right angles, so as to prevent catching the engine on the dead center. The direction of rotation is reversed by means of the ordinary link motion. The fuel used is

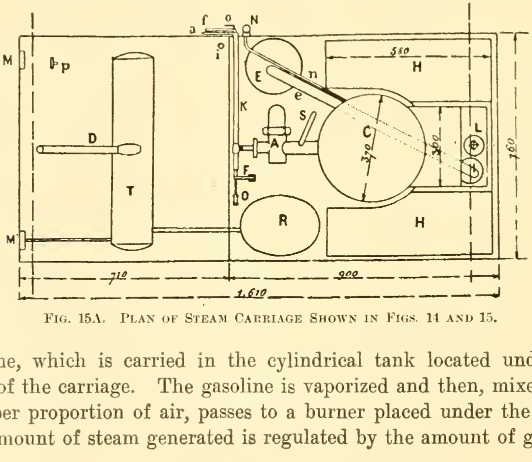


FIG. 15A. PLAN OF STEAM CARRIAGE SHOWN IN FIGS. 14 AND 15.

gasoline, which is carried in the cylindrical tank located under the front of the carriage. The gasoline is vaporized and then, mixed with a proper proportion of air, passes to a burner placed under the boiler. The amount of steam generated is regulated by the amount of gasoline supplied to the burner, and this supply in turn is regulated by the pressure of the steam, so that the action is entirely automatic. The cylinder H is a reservoir of compressed air, connected with tank I, so that the gasoline is under pressure, and therefore is forced through the pipe to the burner under the boiler. Between the burner and the tank there is a valve controlled by the steam pressure, being opened when the pressure is low and closed when it is high. When the pressure reaches a certain point the valve is closed entirely, so that even if the carriage is running very slowly, it is not possible to run the pressure above the fixed limit. The exhaust passes from the engine cylinders

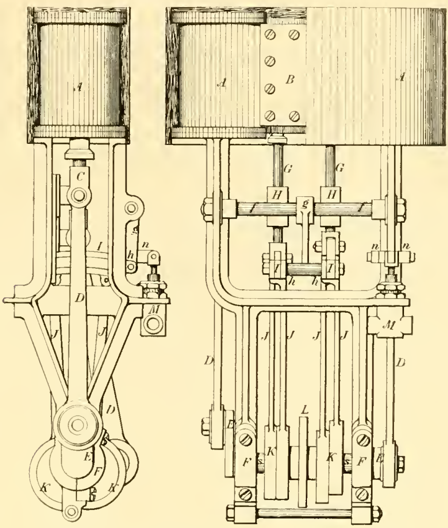


FIG. 16. ENGINE OF CARRIAGE SHOWN IN FIG. 14.

into a muffler, from which it escapes into the pipe K. This pipe projects downward into an opening through the center of the water tank, and the draught produced thereby draws the gases of combustion through from the top of the boiler to the under side of the carriage body, where they escape into the atmosphere.

Directly in front of the exhaust muffler is seen the water gauge, which is in such a position as to be outside of the carriage body, as shown in Fig. 14. A mirror is placed at the front of the vehicle, and by looking into this the water gauge can be seen. Fig. 14 also shows clearly the position of the operating levers at the side of the carriage.

The actual construction of the engine is better shown in Fig. 16, in which A A are the cylinders, B is the steam chest and G G are the valve rods. The piston rods connect with the crossheads C. The connecting rods D transmit motion from the latter to the cranks E, and thus rotate the shaft S. The link motions, by means of which the direction of rotation is reversed, are at I I, and are operated by the lever G, which is mounted upon the shaft F F. This shaft is directly connected with the starting lever. The boiler feed pump is located at M. The motion of the engine is transmitted to the rear axle of the carriage by means of a chain that runs over the sprocket wheel L located between the eccentrics K K. In Fig. 15, this wheel is located at D, and the chain F connects it with the axle sprocket E.

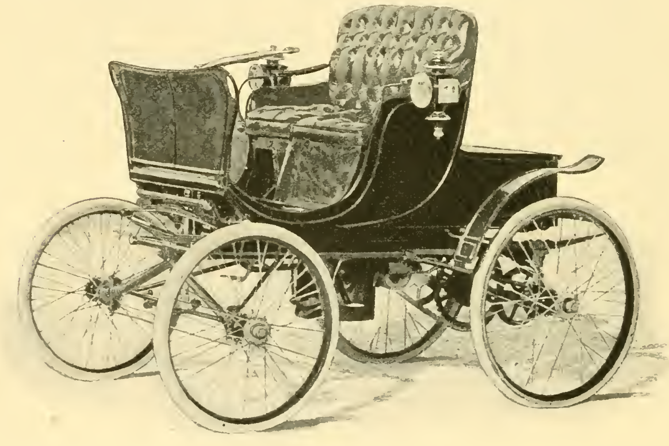


FIG. 17. AMERICAN STEAM AUTOMOBILE OF 1900.

Fig. 17 shows another American steam carriage. In this vehicle the running gear is a complete truck, upon which the carriage body is supported. The appearance of the truck with the body removed is shown in Fig. 18. The boiler is of the tubular type and the double cylinder engine is secured to its side. In this particular the construction differs from that of the previously described carriage, for in that the engine is attached to the cross-framing of the body of the vehicle. Although the general appearance of the mechanism of these two carriages is very similar, there are many differences in the details of their construction. In both, vertical tubular boilers are used, and the steam is generated by the use of gasoline, which is burned in the vaporized state in specially constructed burners. The engine in both cases is of the vertical double cylinder type, and motion is transmitted to the hind axle by means of sprocket wheels and a chain; but here the similarity ends; the minor details, which it is not necessary to refer to in this connection, are with few exceptions very different.

A careful examination of Figs. 11, 14 and 17 will show that from an artistic point of view these examples of steam carriages are satisfactory. In regard to their operation it can be said that they have sufficient power to run up the steepest grades encountered on ordinary roads at a fair rate of speed, while on level ground their velocity is more than enough to satisfy the average rider. The danger of explosion is so remote that it need not be considered. The Serpollet

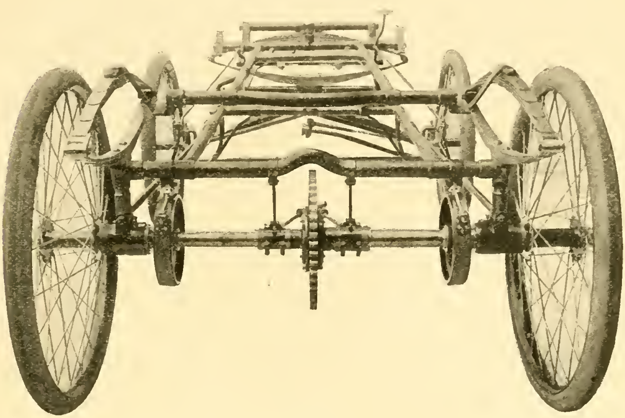


FIG 18

boiler is practically inexplosive, while those used in the American vehicles are so constructed that they can withstand a pressure far greater than any they can be subjected to in practice. It might be expected that the motion of the machinery would produce an unpleasant vibration, but on account of the lightness of the moving parts and careful balancing, this effect is much reduced. The use of gasoline as fuel, in connection with automatic burners, eliminates the smoke and ashes incident to the use of coal, and in addition reduces the labor of handling the vehicle, as no attention need be given to the mechanism other than to see that the water in the boiler is maintained at the proper level. In the case of the Serpollet carriages, not even this point need be looked after, as the feed of the boiler is perfectly automatic.

SCIENTIFIC RESULTS OF THE NORWEGIAN POLAR EXPEDITION, 1893-1896.*

BY GENERAL A. W. GREELY, U. S. ARMY.

FEW Arctic expeditions have done so much to increase the world's knowledge as to the physical condition of large areas of the north polar zone as has that of the *Fram*, initiated and commanded by Dr. Fridtjof Nansen.

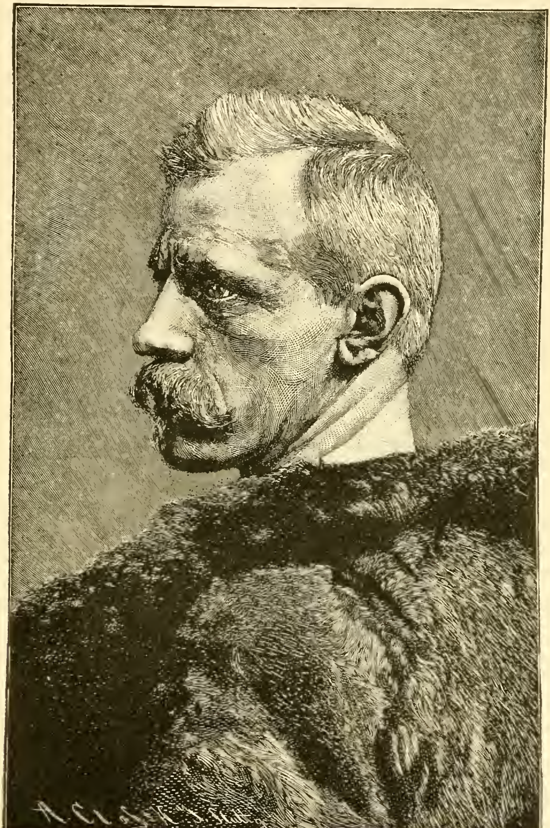
The expedition was unique in many respects. The *Fram* was a departure from the accepted models of Arctic ships; the route followed was one unindorsed by any Arctic authority. The ship was destined to drift unprecedented distances, beset by the enormous ice-pack of the Arctic ocean. The commander himself was not only to attain the highest north, but was to make a most hazardous journey, which was to have a successful and unexpected issue partly through the aid of another polar expedition whose location and existence were unknown to the expeditionary forces of the *Fram*. Electricity made the Arctic ship a glow of light, a phonograph brought well-known voices to cheer their hours of leisure. Indeed, every device that was deemed of value was utilized.

The extent of the Arctic ocean traversed by the *Fram* is indicated by the simple fact that she passed over 120 degrees of longitude above the eightieth parallel of north latitude, a distance of one-third around the world on that parallel.

Nansen and Johansen, in an attempt to reach the Pole, left the *Fram* March 14, 1895, in about 84° N., 100 E., but after an uneventful journey with dogs, they were obliged to turn back on April 7, 1895, in latitude 86° 14′ N. They aimed to reach Spitzbergen and after months of weary effort and varying fortunes, these two hardy men landed on the east coast of the Franz Josef archipelago. Coming winter forbade further progress, so they constructed a hut and subsisted on land and sea game that was fortunately abundant. In the spring of 1896, turning southward, they attempted to reach by the kyak the east coast of Spitzbergen, hoping to be picked up by Norwegian whalers who frequent those waters. Fortunately for them, they met in April, 1896, Jackson, the commander of the Jackson-Harmsworth expedition, near Cape Flora.

Meanwhile the *Fram*, continuing its westerly drift, in which it

*The Norwegian North Polar Expedition. 1893-1896. Scientific Results edited by Fridtjof Nansen. Vol. I. Longmans, Green & Co. N. Y., 1900. 1-16, 3 pl. 1-147, 3 pl 1-26, 2 pl. 1-53 pl. 1-137, 36 pl passed the most northerly point reached by Parry in boats in 1827, emerged from the ice-floe of the Arctic ocean in the late summer of 1896 and reached Norway on August 20, about ten days later than Nansen's own arrival with the English expedition from Franz Josef



DR. FRIDTJOF NANSEN.

Land. The *Fram* returned with its frame uninjured and its expeditionary force in health, after having covered in its voyage across the unknown Polar sea an enormous area, estimated at fifty thousand square miles.

The most important discovery was the oceanic depth of the Arctic Sea, where for hundreds of miles this unknown ocean disclosed a depth of over two miles. Naturally the absence of land limited the phases of the scientific work of the expeditionary force, which devoted itself to recording the phenomena of the air and the sea.

Nansen in his separate journey utilized his brief opportunities in Franz Josef Land so successfully that his contributions to the geology of that region are of no small importance.

The world has looked forward with a degree of impatience to the publication of the scientific results of this expedition, and now is favored with the first volume, a beautiful quarto of some 479 pages, with 46 fine plates. It consists of a series of memoirs on the building of the ship, on the birds of the air, on the crustacean forms of sea life and a geological study of the southern part of the archipelago of Franz Josef Land. It is a striking tribute to English-speaking scientists that the work will appear in English text only. Although printed in Christiana, such has been the vigilance of the editors that typographical errors are comparatively few.

The account by Colin Archer of the construction of the *Fram* is not without interest, in view of the fact that this vessel was built on novel lines calculated to cause the ice to meet a sloping surface, so that, pressing down under the bilge, it would cause the vessel to rise and thus insure its immunity from destruction.

Archer says: "In order to utilize this principle, it was decided to depart entirely from the usual deep-bilged form of section and to adopt a shape which would afford the ice no point of attack normal to the ship's side, but would, as the horizontal pressure increased, force the attacking floes to divide under the ship's bottom, lifting her as described above. . . . Plane or concave surfaces were avoided as much as possible by giving her round and full lines. This, while increasing the power to resist pressure from outside, also had the advantage of making it easy for the ice to glide along the bottom in any direction."

As great length is an element of weakness, the *Fram's* length was cut down as much as possible, with a tendency to make its form circular or oval. Various expedients were adopted to reduce the dead weight of the ship by a judicious arrangement of materials. While economizing weight, the cargo-carrying capacity of the ship could not be too much reduced, and the great strength of the ship must be preserved. Inasmuch as the broadside of the ship, both structurally and from its shape, is its weakest part, it was necessary to adopt extraordinary measures to strengthen it. This was done largely by adding stays of yellow pine placed nearly at right angles to the ship's sides, and securely fastened with wooden knees. These were supplemented with upright stanchions tied by iron straps.

While experienced whalers strongly advocated the square rig, Archer decided to ignore their advice and rigged the *Fram* as a fore-and-aft three-masted schooner, which style of rig proved, under the circumstances, to be most suitable. The slight increase in leakage is believed by Archer to be due in part to the drawing of the oakum out of the seams and in part to the expansion and contraction of the timbers. While the *Fram* was not subjected to such tremendous ice convulsions as have been many other Arctic ships, yet her experiences were very severe and may be considered to prove that the design and system of construction adopted were the most efficient possible.

THE FRAM.

The most extensive, if not the most important, of the treatises that form this volume, relate to regions and investigations with which the voyage of the *Fram* were only incidentally connected. Reference is had to the papers on the geological formations of Cape Flora, Franz Josef Land, by Professors Nansen, Pompeckj and Nathorst. Dr. Nansen most cordially acknowledges his great indebtedness to Mr. Jackson and Dr. Reginald Koettlitz, respectively the leader and geologist of the Jackson-Harmsworth expedition to Franz Josef Land, 1894-1896. The latter of these gentlemen, in a spirit of broad scientific generosity, accorded

Dr. Nansen full and equal access to his discoveries, covering three years' work on Northbrook Island, among fossils and geological conditions of special interest.

MAP SHOWING REGIONS TRAVERSED.

Nansen confines himself to a brief geological sketch of Cape Flora and its neighborhood; Pompeckj treats fully the Jurassic fauna, while Nathorst briefly discusses the fossil plants.

Nansen says: "Through Jackson's kindness and Koettlitz's valuable assistance, I was enabled to make a collection of fossils and rocks from the Jurassic deposits of this locality."

"(Koettlitz) took me to places where, before my arrival, he had already found fossils, or had observed anything of importance. Had it not been for him I should certainly not have been able to do what little I did during the few days at my disposal. I agree with Koettlitz on all essential points, and have nothing new of importance to add to what he has already said."

As Nansen elsewhere remarks, the memoirs of Pompeckj and Nathorst supplement the papers of Koettlitz, Newton and Teall, which appeared in the Quarterly Journal of the Geological Society, 1897, pp. 477-519, and 1898, pp. 620-651.

Pompeckj describes fully the various fossils, illustrates them with wealth of detail, discusses their stratigraphical relations, and outlines the paleographical history of Franz Josef Land.

Of the twenty-six species collected by Nansen no less than seventeen are new as compared with the Jackson-Harmsworth collection, which contains five species lacking to Nansen. There are representatives of single species only of echinoderms, vermes and gastropods, the scarcity of the last named being generally characteristic of the Jurassic fauna of the arctic regions, whether in Siberia, Greenland, or Arctic America. On the other hand, at Cape Flora the cephalopods and the lamellibranchs predominate very largely. This fact makes most notable the absence of the lamellibranch genus *Aucella,* with all other forms that are especially characteristic of the higher Jura.

The following new species have been determined by Pompeckj: *Pseudomonotis Jacksoni,* an ornamented shell of a remarkably large Aviculid form. *Macrocephalites Koettlitzi,* a shell with a very narrow umbilicus and almost completely encircling whorls. *Cadoceras Nanseni,* an ammonite showing a flat disc-like growth, with moderately thick whorls of which cross-sections are nearly elliptical. Another ammonite may possibly be a variety of *C. Nanseni,* but Pompeckj considers that it is a separate species owing to its wider umbilicus, less pronounced involution and somewhat asymmetrical lobe-line.

Pompeckj's outline of the paleontographical history of Franz Josef Land is worthy of careful consideration by all interested in this department of science, although many may differ from some of the conclusions reached by him. Commenting on the stratigraphical studies of Prof. E. T. Newton, Pompeckj states that his own investigations compel him to differ materially from the inferences drawn and theories advanced by that scientist.

Pompeckj says: "The occurrence of these three genera of Ammonites proves that the marine fauna of Cape Flora contain representatives of the Callovian. More recent marine horizons have certainly not been formed at Cape Flora, as far as I can judge from the collection of fossils before me. . . . . The Oxfordian and all the more recent Jurassic horizons do not occur as marine deposits at Cape Flora."

He finds species pertaining to the Lower Bajocian, Lower, Middle and Upper Callovian horizons. It is most interesting to note that only one other part of the arctic regions, Prince Patrick Island, Parry Archipelago, has produced fossils, described by Haughton as Lias, that are certainly older than the Callovian. It is, however, recognized as possible that Lundgreen's fossils from East Greenland may form another exception.

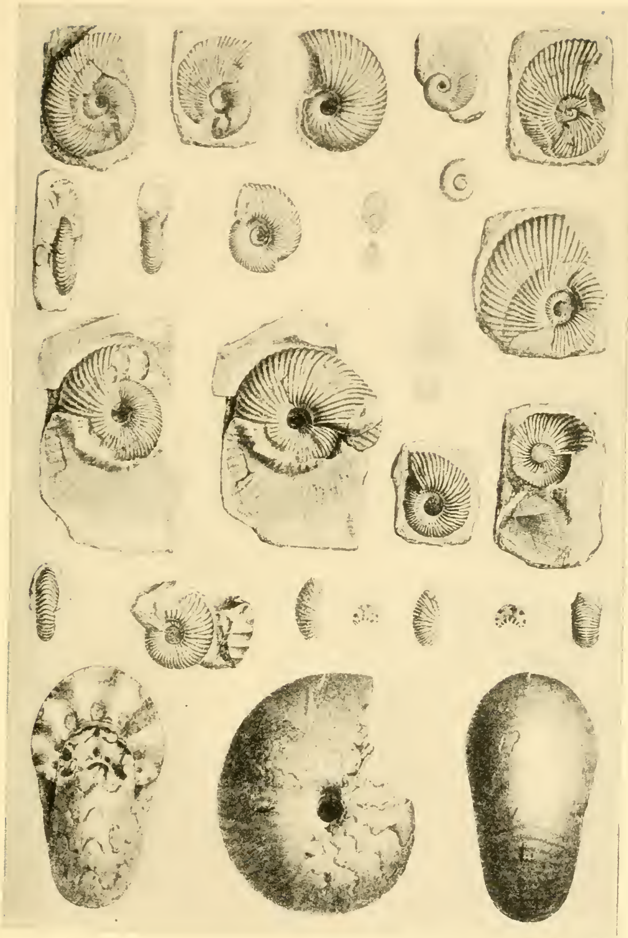
Pompeckj points out that while the Bajocian fauna of Cape Flora is without analogy in the arctic regions, it nevertheless presents distinct affinities to the Central European Jura, and especially resembles the Russian Callovian.

Moreover, this Jurrassic collection from Cape Flora is of special importance in outlining the geographic distribution of that system. Pompeckj adds: "Hence the existence of a Bajocian sea in the north of the Eurasian Jura continent is proved beyond all doubt. . . . As early as the Bajocian period, there existed a Shetland Straits, which separated the Eurasian continent, existing through the Lias period until the end of the Bathonian, from the nearctic Jura continent."

The comments relative to the transition of Nova Zembla, Spitzbergen, Franz Josef Land, and possibly Alaska, from land to sea and sea to land, are of marked interest, indicating as they do that large areas of polar regions were exposed in the mesozoic period to repeated and very considerable oscillations of the sea level.

The more interesting of the Jurassic fossils, found at Cape Flora, are shown in the accompanying illustration. *Cadocera Nanseni* (n. sp.), 1, 2, 3, 5, 6. *Cadoceras*, sp. ex. aff. *Cad. Nanseni* (n. sp.), 4. *Cadoceras Tchefkini*, d'Orb, 7. *Cadoceras*, sp. indet., 8. *Quenstedoceras vertumnum*, Sintzow, 9. *Cadoceras Frearsi*, d'Orb, 10. *Macrocephalites*, 11. *Macrocephalites Koettlitzi*, n. sp., 12.

The collections of fossil plants, made by Nansen in Franz Josef Land through the courtesy of the Jackson-Harmsworth expedition, are of scientific value as indicating the fossil Jurassic flora of Franz Josef Land as compared with that of Spitzbergen. These collections fill in a not inconsiderable gap in the Arctic regions, and Nathorst's investigations serve to confirm the opinions and statements made by Professor Heer, whose five volumes of Flora Fossilis Arctica constitute a monumental work. As is well known, research has established the fact that at one time Spitzbergen was covered with a luxuriant miocene vegetation—cypresses, birches, sequoiæ, oaks and planes. It moreover appears that this growth was coincident with the period when Spitzbergen, Green-



JURASSIC FOSSILS FOUND AT CAPE FLORA.

land, Franz Josef Land and Nova Zembla experienced a continental climate.

As fossil collections accumulate, one appreciates more and more the masterly manner in which Heer summed up the results of polar exploration as regards Arctic vegetable paleontology. He was the first to present to the world a clear idea of the vegetation of the Cretaceous land, scarcely known to science until elucidated by him. It developed that in Heer's time, among the fossil plants found in Spitzbergen alone were 7 ginkos, 8 pines, a short bamboo, 7 poplars, 3 maples and a fossil strawberry.

Dr. Nansen was fortunate in securing the co-operation of Prof. A. G. Nathorst in the examination of the fossil plants collected in Franz Josef Land, as he has devoted much time to the flora, present and past, of various portions of the Arctic regions, especially Spitzbergen and King Charles Land. Nathorst had the advantage of the notes of Newton, J. H. Steele and R. Curtis on the fossils of Franz Josef Land, published in the Quarterly Journal of Geological Science, London, vols. 53-54, 1897-1898.

Most unfortunately, the fossils were very fragmentary, the leaves in themselves small and often indistinguishable in color from the rock, so that their examination was made almost entirely under the magnifying lens. While the organic substance of the plants was sometimes still to be seen in a soft, brownish variety of rock, yet the harder yellowish varieties offered only impressions, or cavities, their organic substance having entirely disappeared. In cross fractures there were sometimes cavities which were complete transverse sections of coniferous leaves.

There were twenty-nine species, of which the entire number are coniferous except one fungus, one fern, two palms and one uncertain.

Nathorst says: "The plant-bearing strata of Franz Josef Land, which are yet known to us, all belong, with the exception of those from Cook's Rock and Cape Stephen, the age of which is still uncertain, to the upper Jurassic, or the transition beds to the cretaceous, while as yet no tertiary strata have been discovered."

In geological age, while the Franz Josef flora resembles most the previously known Jurassic floras of Siberia and Spitzbergen, yet Nathorst considers the geological age different, and naturally places it between the two, it being evidently younger than that of Siberia.

It is interesting to note that Doctor Koettlitz found in an isolated basalt nunatak (rock or hill protruding from a glacier) fossil plants similar to those found by himself and Nansen on the north side of Cape Flora. These nunatak plants, which Koettlitz believed to be *in situ*, are identified by Nathorst as Upper Jurassic, and came from an elevation variously estimated as from six hundred to seven hundred and fifty feet above the sea.

Nansen agrees with Koettlitz in believing that tree-trunks found by them, charred into charcoal or partly silicified, chiefly belonged to conifers growing on the soil over which basalt flows were discharged during the Upper Jurassic or Lower Cretaceous age, and that they have been charred by a flowing mass of lava that overwhelmed them.

These fossil plants tell the story of tremendous physical changes which have produced very important modifications in climatic conditions in the Arctic regions. The changes in the types of vegetable life are apparently as extensive in high as in low latitudes. The lower cretaceous flora is almost tropical, as is shown by the predominating forms of this vegetation. Carboniferous formations obtain extensively in the Arctic regions, as they occur in the Parry Archipelago, Spitzbergen and in Siberia. During the carboniferous age there was a great extent of land near the North Pole closely resembling that of the temperate latitude of the same period, as is shown by the small number of fossil plants that are peculiar to the Arctic regions. In the tertiary period miocene flora flourished in Spitzbergen, where even the lime, the juniper and poplars have been found near latitude 79 N. Then also throve sequoias, which closely resemble trees growing in the southern part of the United States. The miocene flora gives evidence of a very great contrast between the climatic conditions at that epoch between Europe and the Arctic regions.

The cretaceous flora throws important light on the changes of climate in the Arctic regions, and, as has been pointed out, the tropical forms predominate in the vegetation of the Lower Cretaceous flora. Heer's prediction that the plants found on the west coast of Spitzbergen would also be found on the East Greenland coast has been fully verified. Miocene plants have been found from Spitzbergen westward through Iceland and Greenland to Banks Land and in the Parry Archipelago, and it is interesting to note that more than one fourth of the Arctic plants are common to the miocene of Europe; in Greenland and on McKenzie the percentage is nearly one half.

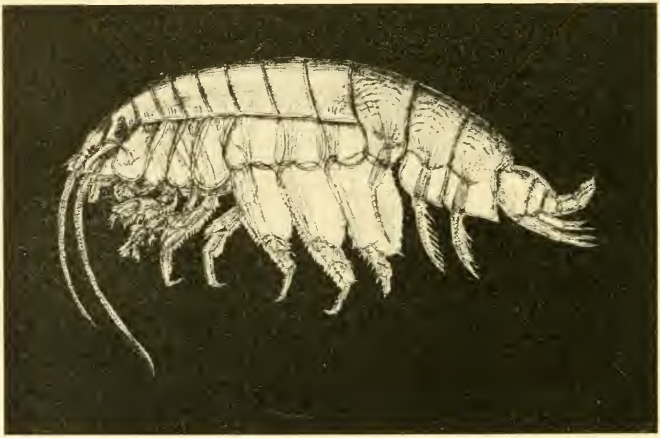
In all probability, the paper which is of the highest popular interest is the account of the birds by Robert Collet and Dr. Nansen. The full notes regarding Arctic birds testify fully to the fact that the observers had in view the principal points of ornithological importance. These comprise not only a mere record of the presence or absence of certain species, but also additional observations regarding them in their Arctic habitat.

Certainly the reproach can not be brought against the expedition of the *Fram*, which has obtained in the case of many Arctic expeditions, that it has added nothing to ornithological Arctic data.

The account of the birds, prepared by Mr. Robert Collet, has been compiled from the various journals of the expeditionary force, supplemented by verbal comments of Nansen. The memoir contains such specific data as enable students to determine not only the general character of the avifauna as one moves northward in the Siberian ocean, but also the arrival and departure of the migrants and the presence of stragglers. Among the birds of special interest which were observed are the gray plover, the gray phalarope, the sabine gull and the cuneate or Ross's gull.

One of the greatest authorities on Arctic birds, Prof. Alfred Newton, of the University of Cambridge, has well said that in consideration of the avifauna of any country its peculiarities can be determined only by dismissing accidental stragglers from the discussion. In elucidating the great question of geographical distribution, one must confine himself to either the birds that breed therein, or to those species which regularly frequent it for a considerable portion of the year.

Considering the enormous area covered by the *Fram* expedition and its great diversity of physical conditions of sea and land, it was impossible to treat under a single heading the birds observed.



PSEUDALIBROTUS NANSENI, G. O. SARS.

Mr. Collet has, therefore, been wise in dividing his notes into four sections, covering the Asiatic coast, the Siberian ocean, the sledge journey to Franz Josef Land, and the Arctic Ocean to the north of Franz Josef Land and Spitzbergen. But for this division, confusion would have resulted from combining birds of regions so widely extended in longitude and latitude.

The notes show conclusively what might have been anticipated, that the avifauna of the Siberian Sea, and especially that portion of the Arctic Ocean to the north of Franz Josef Land and Spitzbergen, is strictly limited.

Including the species observed during the entire voyage, there are only thirty-three recorded. Only twenty-one species pertain to the Arctic Ocean, whether as regular migrants or stragglers, after excluding the twelve species which were observed near the Asiatic coast. The presence on the shores of the Siberian Sea of some of these twelve, however, is of ornithological interest. There may be specially mentioned the gray goose *(Anser segetum)*, long-tailed duck *(Harelda glacialis)*, silver gull *(Larus argentatus)*, snowy owl *(Nyctea scandiaca)*, gray plover *(Squatarola helvetica)* and the red-necked phalarope *(Phalaropus hyperboreous)*.

Confining ourselves to birds observed to the north of 81° 30, attention is called to the abundant avifauna of the western as compared with the eastern hemisphere. In Kennedy Channel, Grinnell Land, there have been recorded no less than thirty-two species against twenty-one noted by the *Fram* in this voyage, including those seen in Franz Josef Land. This is not surprising, however, when it is considered that the drift of the *Fram* was across a deep ocean of large extent, which is covered perpetually by an unbroken ice-pack, unrelieved by any view of land until the north coast of Spitzbergen was seen.

Omitting the birds observed in Franz Josef Land, the paucity of species frequenting the great western Arctic Ocean is even more apparent. The striking dissimilarity of the four regions traversed by the *Fram* is plainly evident from the bird-life recorded. While there were observed nine species in the Siberian Sea, fifteen in the Franz Josef Archipelago, eighteen in the Arctic Ocean and twenty-three on the Asiatic coast, yet only five were common to all four regions, viz.: the dovekie, the glaucous gull, the ivory gull, the kittiwake and the snow-bird.

The Siberian Sea presented a most limited avifauna, as in addition to the five common species, there were recorded in the first summer in the ice only the little auk, the fulmar, the roseate gull and a small skua. The entire absence of land or shore birds that frequent Arctic islands, omitting a single straggling snow-bird, indicates clearly that the Siberian Sea extends far northward unbroken by any land area.

The eighteen species of birds that were found in the Arctic Ocean, far to the north, naturally demand special comment. The six following species are doubtless stragglers: the ringed plover *(Aegialitis hiaticula)*, 82° 59′ N., the most northerly shore-bird of Spitzbergen, Nordenskiold having observed it on Seven islands, 80° 45′ N.; the eider duck *(Somateria mollissima)*, 82° 55′ N., near Spitzbergen; the arctic tern *(Sterna macrura)*, 84° 32′ N.; the puffin *(Fratercula arctica glacialis)*, 83° 11′ N., near Spitzbergen; the black-backed gull (*(Larus marinus)*, 84° 35′ N. 75° E., and the Sabine gull *(Xema Sabini)*, 83° N., near Spitzbergen.

Of other species, the roseate gull *(Rhodostethia rosea)*. 84° 41′ N., disappeared as the *Fram* drifted west from the longitude of Franz

Josef Land, to be replaced as Spitzbergen was neared by a wader *(Crymophilus fulicarius)*, 83° 01′ N.; forked-tailed skuas *(Stercorarius pomatorhinus)*, 82° 57′ N., and Bruennich's guillemot *(Uria lomvia)*, 83° 11′ N. The glaucous gull *(Larus glaucus)*, 84° 48′ N., and long-tailed skua *(Stercorarius longicaudus)*, 84° 47′ N., although seen both summers, were quite infrequent. These data indicate absence of land at any near distance to the north, and disclose the interesting fact that only the six following species, including the snow-bird who is more probably a straggler, can be classed as regular summer migrants to the

RHODOSTETHIA ROSEA (MAGG), 1824. YOUNG IN FIRST PLUMAGE.

vast ice-fields which cover the Arctic Ocean to the north of Spitzbergen and Franz Josef Land.

The little auk *(Alle alle)*, 84° 48′ N., was visible almost daily near the 83d parallel in great numbers during the summer season, wherever there were numerous water channels near the *Fram*. Of 40 birds killed at one time, only ten were females.

The dovekie *(Cepphus mandti)*, 84° 32′ N., with the little auk, was the most numerous of all birds in very high latitudes, and nearly

150 were shot for the table. Out of 40 specimens only 14 were males. The dovekie came early, May 13, 1896.

The ivory gull *(Pagophila eburnea)* is also present the entire summer. It was the first visitor in 1895, when on May 14 it was seen in 84° 38′ N., and what is of special interest, was flying from the north-northeast.

The snow bunting *(Plectrophenax nivalis)*, although a land-bird, was seen both summers at somewhat infrequent intervals, as far as 84° 45′ N. They fed on refuse near the ships, but were also seen near water-holes, and appeared to be feeding on crustaceans. Two of three specimens were males. The first specimen in 1895 visited the *Fram* on May 22 in 84° 40′ N., and then flew towards the north. In 1896 it appeared on April 25, the first bird of the year, in 84° 17′ N.

The kittiwake *(Rissa tridactyla)* was much less numerous than the ivory gull. It was seen in 82° 54′ N. They fed, as a rule, on crustaceans, although in one bird were found parts of a *Gadus saida* about 70 mm. in length. A *Gadus* about 120 mm. in length was observed on July 16, 1895, in 84° 42′ N., the most northerly point at which any fish has been found.

The fulmar *(Fulmarus glacialis)* came early in 1895, on May 13, and in 1896 on May 22. This bold, voracious bird fed on crustaceans usually, and owing to its villainous smell was utilized principally as food for dogs. The last bird of 1895, a fulmar, was seen on September 14, when the *Fram* was in 85° 05′ N., 79° E. This is the most northern latitude in which any bird has ever been observed.

The fulmars and ivory gulls were very bold and noisy, the latter being specially objectionable. Ivory gulls were seen at the winter hut in Franz Josef Land until October, when all water had long been frozen over, and appeared again as early as March 12, 1896.

The first roseate gulls were young birds observed August 3, 1894, in 81° 05′ N., 120° E., about 500 kilometres from the nearest land. A long and interesting description is given of these gulls in various stages. One of the beautiful plates, which is imperfectly reproduced, shows the plumage of a very young gull about a month old. Their food consists exclusively of small fish and crustaceans, of the latter the *Hymenodora glacialis* predominating. Large numbers of these beautiful gulls were seen in 1895 to the northeast of Franz Josef Land, which points to their breeding in that locality. One was seen by Nansen on July 11, 1895, in 82° 08′ N., flying from the northeast.

The very full memoir on *Crustacea* is by Dr. G. O. Sars, well known as one of the editorial committee of the scientific work of the Norwegian North Atlantic Expedition. As the greater number of marine vertebrate animals collected by the Norwegian North Polar Expedition belong to the *Crustacea,* this memoir covers the greater part of the marine collection.

The *Copepoda* are predominant, especially those belonging to the *Calanoid* group, having been taken at nearly every haul along the whole route of the *Fram.* The zoölogical equipment of the *Fram* was based unfortunately on the supposition that the Siberian basin was shallow, so that the enormous oceanic depths which were found were only inadequately explored by an extemporized sounding apparatus.

While the results of the dredging operations indicate that there was very little animal life at the bottom of the ocean, on the other hand, it appears that the entire surface of the sea, which consisted usually of small temporary openings in the ice-pack, was covered with abundant life throughout the entire year even to the most northern latitudes.

Including surface and deep-sea specimens, there were taken on October 12, 1895, no less than eleven species in latitude 85° 13′ N., longitude 79° E. On June 28, 1895, in 84° 32′ N., 76° E., there were taken from the surface by tow net in a large water-channel fourteen species. This indicates abundant marine life in the sea immediately near the North Pole.

The pelagic animals, therefore, were not found at the sea surface alone, but were also drawn from considerable depths. Many specimens were obtained from strata at least 250 metres below the surface, and in a number of instances from depths ranging between 500 and 1,000 metres. It is to be added that the imperfect development of the visual organs of the peculiar amphipod, *Cyclocaris Guilelmi,* Chevreux, points to abyssal habits, as similar conditions do in the cases of other pelagic animals.

In general pelagic fauna in the Polar Sea resembles that of the northern Atlantic basin, the greater number of species being common to both. While several heretofore unknown forms collected by this expedition may be peculiar to the polar basin, yet it is not improbable that these forms also occur in the North Atlantic. This appears probable, since the western part of the *Fram's* route lies on the border of the two basins, where the fauna does not differ essentially from that in the eastern part.

While the pelagic fauna of the Polar Sea, even in the lowest depths, resembles that of the Atlantic basin, the great salinity of its water clearly indicates that it comes from the North Atlantic, and it is therefore more than probable that the migration of pelagic animals to the North Polar Sea is also from the west.

Indeed, Doctor Sars is of the opinion that the greater part of the pelagic life of the north-polar basin comes by the underlying easterly current from the North Atlantic. On the other hand, it is evident that the westerly-flowing surface current of the Siberian Sea is of vital importance as a means of supplying nourishment to the marine animals of the western Arctic Ocean. This food supply, microscopic algæ chiefly *Diatomeae*, while very abundant on the surface of the Siberian Sea, diminishes gradually towards the west. "Indeed," says Sars, "without such a constant conveyance of nourishing matter, there could be no such rich animal life in the Polar Sea."

A very remarkable fact was the presence of certain pelagic *Copepoda*, which hitherto had only been observed in southern waters, and a *Calanoid* of the genus *Hemicalanus* Claus, previously known only from the Mediterranean and tropical parts of the Atlantic and Pacific oceans. Two species of the genus *Oncoea*, which accord perfectly with species in the Bay of Naples, were found in great abundance north of the New Siberian Islands. Another copepod, of the genus *Lubbockia* Claus, heretofore only known in the Mediterranean and tropical oceans, was found in the same locality, with which was a small perfectly hyaline copepod of the very remarkable genus *Mormonilla*, of which heretofore only two species have been recorded, both in the tropical Pacific and south of the equator.

Perhaps the most remarkable forms are those mentioned by Doctor Sars, when he says: "The very close and apparently genetic relationship between the two polar species of the amphipodous genus *Pseudalibrotos* and those occurring in the Caspian Sea, is another remarkable instance which seems fully to corroborate the correctness of the assumption of geologists as to a direct connexion in olden times between this isolated basin and the North Polar Sea."

Both species, taken near 85° N., are regarded as the primitive types from which the Caspian forms are descended. The more remarkable of the Arctic forms, *P. Nanseni*, is reproduced on page 430.

To conclude, this volume is a most valuable contribution to the scientific literature of the Arctic regions. It has but one marked objection, its publication in such beautiful form and high price as necessarily places this series beyond the means of many scientific students.

DISCUSSION AND CORRESPONDENCE.

*LEGISLATION AGAINST MEDICAL DISCOVERY.**

Dear Sir: I observe that a new bill on the subject of vivisection has been introduced into the Senate, Bill No. 34. This bill is a slight improvement on its predecessor, but it is still very objectionable. I beg leave to state very briefly the objection to all such legislation.

1. To interfere with or retard the progress of medical discovery is an inhuman thing. Within fifteen years medical research has made rapid progress, almost exclusively through the use of the lower animals, and what such research has done for the diagnosis and treatment of diphtheria it can probably do in time for tuberculosis, erysipelis, cerebro-spinal meningitis and cancer, to name only four horrible scourges of mankind which are known to be of germ origin.

2. The human race makes use of animals without the smallest compunctions as articles of food and as laborers. It kills them, confines them, gelds them and interferes in all manner of ways with their natural lives. The liberty we take with the animal creation in using utterly insignificant numbers of them for scientific researches is infinitesimal compared with the other liberties we take with animals, and it is that use of animals from which the human race has most to hope.

3. The few medical investigators can not, probably, be supervised or inspected or controlled by any of the ordinary processes of Government supervision. Neither can they properly be licensed, because there is no competent supervising or licensing body. The Government may properly license a plumber, because it can provide the proper examination boards for plumbers; it can properly license young men to practice medicine, because it can provide the proper examination boards for that profession, and these boards can testify to the fitness of candidates; but the Government cannot provide any board of officials competent to testify to the fitness of the medical investigator.

4. The advocates of anti-vivisection laws consider themselves more humane and merciful than the opponents of such laws. To my thinking these unthinking advocates are really cruel to their own race. How many cats or guinea pigs would you or I sacrifice to save the life of our child or to win a chance of saving the life of our child? The diphtheria-antitoxin has already saved the lives of many thousands of human beings, yet it is produced through a moderate amount of inconvenience and suffering inflicted on horses and through the sacrifice of a moderate number of guinea pigs. Who are the merciful people—the few physicians who superintend the making of the antitoxin and make sure of its quality, or the people who cry out against the infliction of any suffering on animals on behalf of mankind?

It is, of course, possible to legislate against an improper use of vivisection. For instance, it should not be allowed in secondary schools or before college classes for purposes of demonstration only; but any attempt to interfere with the necessary processes of medical investigation is, in my judgment, in the highest degree inexpedient, and is fundamentally inhuman.

Yours very truly,

C. W. Eliot.

Hon. James McMillan.

*An open letter from President Eliot of Harvard University to the Chairman of the Senate Committee on the District of Columbia.

THE HIGHER EDUCATION FOR COLORED YOUTH.

Prof. Shaler's article in the June number of the Popular Science Monthly was in many ways sensible and timely, but it seems to the writer that in common with many other people he is misleading in his remarks about higher education for the negro. One would think from the great outcry against the higher education for young people of the colored race, that scarcely any other kind of education was being given them. On all sides we hear the familiar refrain: "The higher education for the negro has been a failure." Now success is a relative term. If a mere handful of colored college graduates, in a few years, ought to have settled the race problem, and induced their white fellow-citizens to treat these graduates and all members of their race fairly, then it has been a failure. But if the higher education should simply give added power of mind, enlarge the mental grasp and capacity for usefulness, lift up, socially, morally, religiously and financially, not only its disciples, but also thousands who have been induced to look upward by the force of their example, then the higher education for colored youth has been a tremendous success. Is not the latter the fair test? Of course the higher education of the few has not eliminated crime. It has not done that for the white race. The writer is a colored man and a college graduate. He can not see that the higher education has any different effect on the colored youth from what it has on the white. If there be any difference it is this: It raises the colored youth from a lower social level, as a rule, and places him on a social plane, relatively, among his own people, higher than it does in the case of the white youth. The higher training, therefore, should be more valuable to the colored youth.

In a recent address before a graduating class at Howard University, the Hon. W. T. Harris, Commissioner of Education, submitted statistics which showed that the proportionate number of secondary and higher students to the whole number of children attending school in the United States had increased from 2.22 per cent in 1879 to 5.01 per cent in 1897, nearly two and a half times; while the proportion of colored students in secondary schools and colleges had increased very little indeed, from 1 per cent to only 1.16 per cent. But the story is not yet half told. According to the report of the Commissioner of Education, 1897-98, Vol. 2, page 2,097, the total number of students taking the higher education in the United States, as a whole, was 144,477, being 1,980 to each million of the total population. The same report, page 2,480, gives the total number of colored students pursuing collegiate courses in these much discussed colored colleges as 2,492. This is only 310 to the million of colored population, whereas the whole of the United States, as shown above, had 1,980 to the million, nearly six and a half times as many in proportion to population. This does not look as if the entire colored population were rapidly stampeding to the higher education, or as if the labor supply in the Southern States were falling off from this cause.

This is an age of higher education for the masses. The increase in the number of students taking the secondary and higher education in the United States during the last ten years has been phenomenal—unprecedented. Is the person of color so much superior to the white that he does not need so much educational training? I think not. In view of the history and present condition of this race, there is an obvious necessity for a large number of educated and trained teachers, ministers, physicians, lawyers and pharmacists; and in view of the fact that this race has only one fifth of its quota pursuing studies above the elementary grades, what fair mind will not say that there is great need of more of the secondary and higher education for colored youth, instead of less of it?

According to the report above cited, 161 academies and colleges for colored youth in the United States reported. The total number enrolled was 42,328, of which 2,492 were reported in collegiate grades, 13,669 in secondary grades and 26,167 in elementary grades. Even in these colored colleges less than 6 per cent of the students are pursuing collegiate courses. Of these, perhaps not more than 2 per cent are pursuing a college course equal to that offered at Howard. Nearly two thirds of the total enrollment in these colored colleges are receiving elementary instruction in the three R's. Classified by courses of study, 1,711—217 in a million—were taking the classical course; 1,200—150 in a million—the scientific; 4,449—555 to the million—the normal course in preparation for teaching; 1,285—160 in a million—professional courses; 9,724 the English course, and 244 the business course. In each of these courses the colored race has only about one fifth or one sixth of its quota. Is there anything in these figures to alarm the nation?

About one third of the total number of students in these 161 colored schools and colleges are taking industrial training. When we consider the great demand for educated colored ministers, teachers and physicians, and the quick reward for ability in these lines, on the one hand, and the exclusiveness of some trade-unions in shutting out colored workmen, on the other, the wonder is that one third of the total number of colored youth in these schools have chosen the industrial course. For it is by no means certain that they will be allowed to work at their trades after they have learned them.

The number of colored students who have had even a smattering of the higher education has been shown to be ridiculously small, and the total number of colored graduates with the college degree proper does not at the most liberal estimate exceed one thousand. Many of them are dead. Of the number now living, almost every one can be located in some useful and uplifting employment as ministers, teachers, physicians, lawyers, business men, or as wives presiding over happy, prosperous, cultured homes which white persons seldom enter except on business. Our critics seem to know nothing of these homes, which, as a rule, are owned by their occupants. For the most part these homes are scattered throughout the South, and are centers of culture and refinement that elevate the moral and social status of the entire community.

To deprive the youth of the colored race of the higher education is to deprive them of all the nobler incentives to study, to sacrifice, to struggle to get an education. Every thoughtful person knows that these incentives are necessary for the white race; they are equally necessary for the colored race. Neither the white youth nor the colored, in large numbers, will toil and struggle and apply himself to get an education, unless he sees that education brings power and a better living to its possessors.

The colored race, like every other part of our population, needs all kinds of education. It is a sheer fallacy and a grievous wrong to them to hold *all* of them down to the rudiments of an education, with industrial training. All can not profit by the industrial training any more than all can profit by the higher training. There is no conflict between the advocates of industrial training and the higher education. Both are right. Both are good in their respective spheres. At any rate, it is not necessary to disparage the magnificent achievements of colored persons who have received the higher training to make an argument in favor of training *all* of them in the manual trades, or to justify their elimination from politics.

ANDREW F. HILGER,

Washington, D. C.

SCIENTIFIC LITERATURE.

GEOLOGY.

In accordance with the general results of Mr. G. K. Gilbert's investigation of recent earth movements in the Great Lakes region—that the whole district is being lifted on one side or depressed on the other, so that its plane is bodily canted toward the south-southwest, and that the rate of change is such that the two ends of a line one hundred miles long, running in a south-southwest direction, are relatively displaced four tenths of a foot in one hundred years—certain general consequences ensue. The waters of each lake are gradually rising on the southern and western shores, or falling on the northern and eastern shores, or both. This change is not directly abvious, because masked by temporary changes due to inequalities of rainfall and evaporation and various other causes, but it affects the mean height of the lake surface. In Lake Ontario the water is advancing on all shores, the rate at any place being proportional to its distance from the isobase through the outlet. At Hamilton and Port Dalhousie it amounts to six inches in a century. The water also advances on all shores of Lake Erie, most rapidly at Toledo and Sandusky, where the change is eight or nine inches a century. All about Lake Huron the water is falling, most rapidly at the north and northeast; at Mackinac the rate is six inches, and at the mouth of French River ten inches a century. On Lake Superior the isobase of the outlet cuts the shore at the international boundary; the water is advancing on the American shore, and sinking on the Canadian. At Duluth the advance is six inches, and at Huron Bay the recession is five inches a century. The shores of Lake Michigan are divided by the Port Huron isobase. North of Oconto and Manistee the water is falling; south of these places it is rising, the rate at Milwaukee being five or six inches a century, and at Chicago nine or ten inches. Eventually, unless a dam is erected to prevent it, Lake Michigan will again overflow to the Illinois River, its discharge occupying the channel carved by the outlet of a Pleistocene glacial lake. The summit in that channel is now about eight feet above the mean level of the lake, and the time before it will be overtopped may be computed. For the mean lake stage such discharge will begin in about one thousand years, and after fifteen hundred years there will be no interruption. In about two thousand years the Illinois River and the Niagara will carry equal portions of the surplus water of the Great Lakes. In twenty-five hundred years the discharge of the Niagara will be intermittent, failing at low stages of the lake, and in thirty-five hundred years there will be no Niagara. The basin of Lake Erie will then be tributary to Lake Huron, the current being reversed in the Detroit and St. Clair channels.

GEOGRAPHY.

Relating to the Royal Geographical Society the story of his exploration of the Bolivian Andes, Sir Martin Conway spoke of his journey by way of the Arequipa Railroad, Peru, to Lake Titicaca. That remarkable sheet of water is fourteen times the size of the Lake of Geneva and twelve thousand feet above the sea, and might be regarded as the remnant of a far greater inland sea, now shrunk away. Driving from Chililaya, he reached the snowy mountain called the Cordillera Real—the backbone of Bolivia—which he had come especially to visit, and in the region of which he spent four months. To the east the mountains fell very rapidly to a low hill country and the fertile valleys that send their waters to the river Beni. On the other side lay a high plateau, at a uniform altitude of from twelve thousand to thirteen thousand feet, from which the tops of low rocky hills here and there emerged. This plateau had obviously been at one time submerged; evidence was plentiful that in ancient times the glaciers enveloped a large part of the slopes that led down to it from the main Cordilleras and reached down many miles farther than now. In the immense pile of *débris* left by the glaciers deep valleys were afterward cut by the action of water, and into these valleys the glaciers of a second period of advance protruded their snouts, depositing moraines that could still be traced *in situ* as much as four or five miles below the present limit of the ice. Contrary to the apparently general impression that the peaks of the Cordilleras were volcanic, the author had not been able to find any trace of volcanic action along the axis of the range. The Cordillera Real had been elevated by a great earth movement, and the heart of the range consisted of granites, schists and similar rocks. The whole range might be described as highly mineralized. Gold was found at several points, but the chief auriferous valleys were those on the east side of the range. Just below the snowy mass of Cacaaca on the west was a really enormous vein of tin; and antimony, cobalt and platinum have been found in different parts. The great copper deposits were not in this range, but farther west. The flora of the high regions of the Cordillera Real was apparently sparse, but is probably more abundant in the rainy season. Bird life was more prolific and birds were numerous, at suitable places, up to an altitude of seventeen thousand feet above the sea.

ZOOLOGY.

THE most recent elementary text-book in zoölogy is from the press of The Macmillan Co. Professor and Mrs. Charles B. Davenport are the joint authors. It is recognized now-a-days that what the general high school or elementary student in zoölogy needs is not professional training in that subject, but rather an opportunity to view the field so that he may have as wide an acquaintance as may be of the forms of animals and of their doings. This he needs that he may have an interest in the things of nature and that he may be a more intelligent member of society in the things pertaining to his welfare as affected by animals. The book is therefore an attempt to restore the old natural history in a newer garb. The text is divided into twenty-one chapters. The first of these deals with 'The Grasshopper and its Allies,' followed by others upon the butterfly, beetle, fly, spider, etc., similarly treated. Each chapter has one or two 'keys'—that is, arrangements whereby the families of animals may be determined. The book is richly illustrated by means of half-tone and line reproduction; a number of photographs are from life, and one of these is a flash-light photograph of a slug and an earthworm crawling upon a pavement at night! Outlines for simple laboratory work and a list of books dealing with the classification and habits of American animals are to be found in an appendix. Many good things might be said of this contribution to zoölogical text-books. This ought to be said, that it will be a book which will be of value to any person who, while upon his holiday trip, wishes to learn about the animals he may come across.

ORNITHOLOGY.

MR. CHAPMAN is equally at home with camera or pen. In 'Bird Studies with a Camera, with Introductory Chapters on the Outfit and Methods of the Bird Photographer,' he gives us some of his many experiences from Central Park to the swamps of Florida and the bare rocks of the Gulf of St. Lawrence. The first two chapters are devoted to a brief discussion of the outfit and methods of the bird photographer, and these any one thinking of taking up this branch of art will do well to read carefully. Mr. Chapman considers that a 4x5 plate is the size best adapted for general purposes, and notes that while a lens with short focus may serve for photographing nests and eggs, for the birds themselves a rapid lens with focus of fourteen to eighteen inches should be used. The rest of the book is for the general reader, and contains many facts of interest concerning the haunts, habits, and home life of a number of birds from the well-known sparrow to the unfamiliar pelican, the accounts of the Bird Rock and Pelican Island being the most interesting. Some of the illustrations are a little disappointing, and emphasize the difficulties of photographing wild birds, but there is ample compensation for these in the excellence of others, particularly those devoted to Percé, Bonaventure and Bird Rock. This is equally true of birds and scenery, the views of Percé Rock being the finest that have fallen under our notice. Mr. Chapman's estimate of the feathered population of Great Bird Rock, which he puts at 4,000, is by far the smallest yet made, and probably has the soundest basis, and shows a sad diminution from the hosts of fifty years ago.

'Bird Homes,' by A. Radclyffe Dugmore, seems well adapted for its stated purpose of stimulating the love of birds, helping the ordinary unscientific person to get some closer glimpses of them, and aiding in the study of their wonderfully adapted nests and beautiful eggs. Furthermore, it will probably create a strong desire in the reader to become a photographer of birds and their nests. To further these aims we have a first part containing half-a-dozen chapters devoted among other things to birds' nests and eggs, photographing nests and young birds and the approximate dates when birds begin to nest, this being adapted to the vicinity of New York.

Following this is the bulk of the volume, containing brief descriptions of the birds, their nests, nesting places and eggs, and here the author has confessedly borrowed from Bendire, Davie and other well-known authorities, although one might wish that Mr. Dugmore had introduced more of his own observations, since those given incidentally in the first part are very interesting; where he indulges in theory he is less successful. In place of the usual method of studying the nest from the bird, we have that of studying the bird from the nest, and for this purpose the nests are grouped in classes, a chapter being devoted to each class; thus we have nests open, on the ground in open fields, marshes and generally open country; open nests in trees; nests in bridges, buildings, walls, etc. By this plan any one finding a nest can, with a little care and observation, identify the bird that made it. The illustrations, largely of nests and eggs, are a noteworthy feature of the book, although the three-color process which succeeded so admirably in Dr. Holland's *Butterfly Book*, is here as equally distinct a failure, the least bad of the colored plates being that showing the nest of the yellow-breasted chat, the worst that of the nest of the Baltimore oriole. Those in black and white, however, merit the highest praise, and this includes the smaller cuts introduced as decorative features in the first portion of the book. It would seem difficult in a half-tone to improve on the plate of young crested flycatchers for clearness of detail, while among others that deserve special mention for artistic effect is the wood thrush on nest, and the nests of the chestnut-sided, yellow, blue-winged and worm-eating warblers. The general 'get-up' of the book is excellent, and the printing of the plates separately permits the use of a dead-faced paper for the text, which is pleasant to the eye.

THE PROGRESS OF SCIENCE.

We are able to publish in the present issue of the Monthly the address given by Mr. G. K. Gilbert as retiring president of the American Association for the Advancement of Science. The problem that he discusses is one of the most pressing for scientific workers, while at the same time it is of interest to everyone, and the address is at once an important contribution to the subject and an exposition that all can understand. The mathematical physicists find that as an abode fitted for life the earth can not be allowed a history indefinitely long—not longer perhaps than 20,000,000 years—while the geologists with equally strong arguments claim a much greater antiquity. The biologists are also concerned, owing to the time taken up by the processes of evolution, and their facts and interests range them with the geologists rather than with the physicists. The man not versed in science would also prefer to assign a long history to the earth, for while he may be ready to let the 'dead past bury its dead,' he looks forward even to the distant future, and the shorter the past history of the earth the less the time it will continue to be habitable. We have thus a question in the solution of which all the sciences are concerned, and one possessing a dramatic interest that appeals to everyone. The unity of science is well illustrated by such a problem. It was the subject of the address of the retiring president of the Association, a geologist; it might be taken as the subject for the address of the newly elected president, a biologist and student of the processes of evolution; and it is one to which the president of the meeting, a mathematical physicist, has given special attention.

Dr. Robert Simpson Woodward, who presided over the New York meeting of the Association, is professor of mechanics and mathematical physics and dean of the Faculty of Pure Science in Columbia University. He was born at Rochester, Oakland County, Michigan, July 21, 1849, and spent his early life on a farm with the exception of about two years of experience in mercantile and manufacturing pursuits. He was prepared for college at the Rochester Academy, entered the University of Michigan in 1868, and was graduated in 1872 with the degree of C. E. Twenty years later the same institution conferred upon him the degree of Ph. D. While yet an undergraduate he entered the U. S. Lake Survey, and immediately after graduation he was appointed assistant engineer in that service. He was employed in the astronomical and geodetic work of the Lake Survey until its completion in 1882. He then accepted the position of assistant astronomer to the U. S. Transit of Venus Commission and accompanied the expedition of Prof. Asaph Hall, U. S. N., to San Antonio, Tex., to observe the transit of December, 1882. He remained with the Transit of Venus Commission until 1884, when he resigned in order to take the position of astronomer in the U. S. Geological Survey. After four years of service in this bureau he resigned to accept the position of assistant in the U. S. Coast and Geodetic Survey. This he held until 1893, when he retired from the public service and accepted the call of Columbia University to the chair of mechanics. In 1895, and again in 1900, he was elected to the deanship of the graduate faculty of pure science in that institution. Professor Woodward has published many papers on subjects in astronomy, geodesy, mathematics and mechanics. He edited, and contributed several chapters to the final report of the U. S. Lake Survey, a volume of about one thousand quarto pages devoted chiefly to a discussion of the geodetic work of the Survey done during the forty years of its existence. He is the author of several of the Bulletins of the U. S. Geological Survey, and of a memoir on the Iced Bar and Long Tape Base Apparatus of the U. S. Coast and Geodetic Survey. These forms of apparatus, devised and perfected by him, involve many novel features and secure a much higher precision at a much smaller cost than apparatus previously used. He prepared for the Smithsonian Institution a volume entitled 'Geographical Tables,' being a manual for astronomers, geographers, engineers and cartographers, published in 1894. Several of his most important mathematical papers relate to geophysics, especially those bearing on the secular cooling and cubical contraction of the earth, on the form and position of the sea surface, and on the profoundly difficult problem presented by the recently discovered phenomenon of the variation of terrestrial latitudes. Although most of his publications are necessarily of a highly technical character, his semi-popular addresses and reviews have been widely read and appreciated. Professor Woodward was an associate editor of the 'Annals of Mathematics' from 1889 to 1899 and has been an associate editor of 'Science' since 1894. He has taken an active part in the work of the scientific societies with which he is connected, and in addition to the official positions he holds in the American Association for the Advancement of Science, he has been honored by election to the presidency of the American Mathematical Society and to the presidency of the New York Academy of Sciences. Professor Woodward represents the highest type of the man of science. Eminent for his original contributions to science, a teacher of great intellectual and moral influence, an administrator with unfailing tact and unerring judgment, he confers an honor on the Association which has elected him to its highest office.

President Low welcomed the American Association to New York and to Columbia University in an address which recounted the increased recognition given to science by the city since the Association met there thirteen years ago and the great progress of science itself. He concluded with the following words: "I am especially glad to welcome you because you are an Association for the *Advancement* of Science. That, after all, is what ought to make you feel at home in the atmosphere of this university; for a university that does not assist the advancement of science has hardly a right to call itself by that great name. I heard Phillips Brooks say, in a sermon that I heard him preach in Boston when this Association met there twenty years ago, that you can get no idea of eternity, by adding century to century or by piling æon upon æon; but that, if you will remember how little you knew when you sat at your mother's knee to learn the alphabet, and how with every acquisition of knowledge which has marked the intervening years you have come to feel, not how much more you know, but how much more there is to be known, all can get some idea of how long eternity can be, because all can understand that there never can be time enough to enable any one to learn all that there is to know. There is so much to be known, that even the great advances of the last generation do not make us feel that everything is discovered, but they appeal to new aspirations and awaken renewed energy in order to make fresh discoveries in a region that teems with so much that is worthy of knowledge. I congratulate you upon your success, and I bid you welcome to Columbia."

In the course of his reply, the president of the Association, Professor Woodward, said: "But surprising and gratifying as have been the achievements of science in our day, their most important indication to us is that there is indefinite room for improvement and advancement. While we have witnessed the establishment of the two widest generalizations of science, the doctrine of energy and the doctrine of evolution, we have also witnessed the accumulation of an appalling aggregate of unrelated facts. The proper interpretation of these must lead to simplification and unification, and thence on to additional generalizations. An almost inevitable result of the rapid developments of the past three decades especially is that much that goes by the name of science is quite unscientific. The elementary teaching and the popular exposition of science have fallen, unluckily, into the keeping largely of those who can not rise above the level of a purely literary view of phenomena. Many of the bare facts of science are so far stranger than fiction that the general public has become somewhat overcredulous, and untrained minds fall an easy prey to the tricks of the magazine romancer or to the schemes of the perpetual motion promoter. Along with the growth of real science there has gone on also a growth of pseudo-science. It is so much easier to accept sensational than to interpret sound scientific literature, so much easier to acquire the form than it is to possess the substance of thought that the deluded enthusiast and the designing charlatan are not infrequently mistaken by the expectant public for true men of science. There is, therefore, plenty of work before us; and while our principal business is the direct advancement of science, an important, though less agreeable duty, at times, is the elimination of error and the exposure of fraud."

The meeting of the Association in New York was of more than usual importance. Not only did the nine sections of the Association hold their daily sessions, but there were also fifteen special scientific societies meeting simultaneously at Columbia University. Men of science came together from all parts of the country to present the results of the year's research, to gain profit and pleasure from association with other workers, and to return to their homes with increased knowledge and renewed interest. It is obviously impossible to give here an account of the hundreds of scientific papers presented, or even to report upon the general proceedings of the Association. Two of the more important actions may, however, be mentioned. It was decided to send 'Science,' our weekly journal of general science, to all members of the Association without charge, and a section devoted to physiology and experimental medicine was established. It was thought that the receipt of a journal such as 'Science' would increase the membership of the Association and lead to a greater interest in its work, as even those who are unable to attend the meetings will hereafter have a definite return for membership. The Association will be greatly strengthened by giving recognition to the great group of sciences—physiology, experimental psychology, anatomy, embryology, histology, morphology, pathology, bacteriology and their applications—which have developed with such remarkable activity within the past few years.

It is not possible to report on the scientific work of the meeting in part owing to its magnitude—the papers would fill the volumes of this journal for several years to come. It is also true that each paper taken singly is likely to be of interest only to the special student. Specialization in science is absolutely necessary for its advance, but the terminology required for exactness and economy makes the work in each department scarcely intelligible to those not immediately concerned, while the great detail necessary in careful research seems almost trivial until we realize that it is upon such special work that the general principles and the applications of science depend. We all know that our ways of thought and habits of life are chiefly based on the results of modern science. This has not been the result of a sudden revelation, but of a continual growth, scarcely perceptible until viewed from a distance. The importance of current political events is magnified by the common interest they excite, whereas in art, literature and science time is required before things can be seen in their right perspective. We can, however, take the reports of the three committees of the Association to which small grants were made for research and use these as examples of the scientific work described at the meeting. These committees were on 'Anthropometry,' on 'The Quantitative Study of Variation' and on 'The Cave Fauna of North America.'

The committee on anthropometry is undertaking to make measurements of the physical and mental traits of members of the Association, and to encourage such work elsewhere. At the present time there exists but little exact knowledge of how people differ from each other and of the causes and results of such differences. Much has been written regarding men of genius, criminals and other classes, but without an adequate foundation of fact. The members of a scientific society are a fairly homogeneous class, regarding whose heredity, education and achievements correct information can be secured. The measurements made at the New York meeting, determining such traits as size of head, strength, eyesight, quickness of perception, memory, etc., will supply the standard type for scientific men and their variations from this type. When other classes of the community have been measured, comparisons can be made and we shall know whether scientific men are more variable than others, have larger heads, better memory and the like. Work of this character has been carried on at Columbia University for some years. The freshmen, both the men of Columbia College and the women of Barnard College, are measured and tested with care, equal attention being paid to mental and physical traits. Then the measurements are repeated at the end of the senior year. Anthropometric work has also been done in Great Britain under the auspices of Dr. Galton and Professor Pearson, and we may perhaps hope that the time will come when we shall have as exact knowledge about human differences as we now have about different kinds of butterflies.

Although geologists and botanists have defined hundreds of thousands of species, they have not as a matter of fact until very recently attempted to secure exact measurements of differences, and the committee of the Association on 'The Quantitative Study of Variation,' of which Prof. Chas. B. Davenport is the recorder, aims to encourage such work. It is now over forty years since the facts and arguments presented in Darwin's 'Origin of Species' paved the way for general acceptance of the doctrine of evolution. But the objection is hardly less valid to-day than it was then that the evidence for evolution is almost wholly indirect. Over and over again naturalists have been challenged to cite one case where a species in nature has changed within historic times and repeatedly they have taken refuge in the plea that the historic period is too short for a noticeable change to have taken place. This plea can be accepted, however, only so long as we have no exact way of measuring race change. When we can express quantitatively the condition of a community to-day, we may hope to be able to say whether any change has occurred after five, ten, or a hundred years. The committee of the Association has especially concerned itself with a piece of work which may be considered typical. In the headwaters of the Tennessee River there lives a univalor mollusc which is found nowhere else in the world and which belongs to a family of molluscs that was early separated from its marine cogeners as a fluviatile species. This genus, Io, varies greatly in different parts of the Tennessee basin. In some places it is smooth; in others, spiny; in others, long drawn out. Under a grant of the Association, Mr. C. C. Adams, of Bloomington, Ill., visited this region; travelled down one of the tributaries in a boat, collecting samples from every community of Ios; and went by train up a second river collecting at every stopping place. The results of this trip were, in a word, that in passing from the mouth to the headwaters of the two parallel tributaries the shells vary in parallel fashion and show a uniform, continuous change from the spiny, elongated condition characteristic of the mouths of the rivers to the smooth, more globose condition characteristic of the headwaters. The additional grant by the Association of one hundred dollars will assist Mr. Adams in making further quantitative studies on variation in the genus Io.

Hardly any fact has excited more interest among evolutionists than the blindness of cave animals; and various theories have been advanced to explain the fact. It is known that the blind condition is due to a degeneration of formerly fuctional eyes. The difficulty has been to understand what advantage is gained by losing the eyes even in a locality where eyes are of no use. It has been affirmed that 'Nature is economical' and will not expend energy in building an unnecessary organ. Weismann has suggested that the only reason why we have eyes at all is because Natural Selection is constantly weeding out poor eyes. Withdraw the necessity for good eyes, and poor eyes and good eyes will have an equal chance of surviving. According to a third theory, the functional activity of any organ is essential to its maintenance. Just as the unused arm withers so the unused eye degenerates. Of course all these theories assume that the ancestors of the blind species—for instance, of the blind fishes—had originally no inherent tendency to blindness or degeneration of the eyes. This assumption has, however, been recently combatted by Professor Eigenmann, who has shown that although many kinds of fish are accidentally swept into caves, only one kind has become blind; of this kind the nearest allies which live in open streams shun the light, live in crevices and under stones, and have less perfect eyes than other fishes. Some of the allies of such light-shunning fishes have made their way into caves, and have there worked out their tendency to a reduction of eyes. That has been the history of eyeless fishes. To continue the researches of Professor Eigenmann, so auspiciously begun, the Association last year granted one hundred dollars to a committee on the cave vertebrates of North America. With the aid of the grant Dr. Eigenmann has during the past year penetrated into numerous caves and obtained much additional material for his researches.

The American Association will meet next year at Denver, beginning on August 26th. The newly elected officers are:

President.

Prof. Charles Sedgwick Minot, Harvard Medical School.

Vice-Presidents.

Mathematics and Astronomy: Prof. James McMahon, Cornell University.

Physics: Prof. D. D. Brace, University of Nebraska.

Chemistry: Prof. John H. Long, Northwestern University.

Mechanical Science and Engineering: Prof. H. S. Jacoby, Cornell University.

Geology and Geography: Prof. C. R. Van Hise, University of Wisconsin.

Zoölogy: President D. S. Jordan, Leland Stanford Jr. University.

Botany: B. T. Galloway, U. S. Department of Agriculture, Washington, D. C.

Anthropology: J. W. Fewkes, Bureau of Ethnology, Washington, D. C.

Economic Science and Statistics;

John Hyde, Department of Agriculture, Washington, D. C.

Permanent Secretary.

L. O. Howard, U. S. Department of Agriculture, Washington, D. C.

General Secretary.

Prof. William Hallock, Columbia University, New York.

Secretary of the Council.

D. T. McDougal, New York Botanical Gardens.

Secretaries of the Sections.

Mathematics and Astronomy: Prof. H. C. Lord, Ohio State University.

Physics: J. O. Reed, University of Michigan.

Chemistry: Prof. W. McPherson, Ohio State University.

Mechanical Science and Engineering: William H. Jacques, Boston, Mass.

Geology and Geography: Dr. R. A. F. Penrose, Pierce, Ariz.

Zoölogy: Prof. H. B. Ward, University of Nebraska.

Botany: A. S. Hitchcock, Manhattan, Kan.

Anthropology: G. G. McCurdy, Yale University.

Economic Science and Statistics: Miss C. A. Benneson, Cambridge, Mass.

Treasurer.

Prof. R. S. Woodward, Columbia University.

The National Educational Association, which held its annual session at Charleston during the week beginning on July 9th, is the leading representative of the many educational associations of the country. Its membership includes the ablest teachers of education in colleges and the most successful school superintendents and teachers. Its meetings give occasion for discussions of matters of educational theory and practice in many ways comparable to the discussions in scientific societies. The program of the present meeting shows that like the scientific associations, the National Educational Association has become differentiated into a number of practically isolated sections with differing interests. There are separate departments of Kindergarten Education, Manual Training, Child Study, Normal Schools, Libraries, etc. The Department of Superintendence now has a special meeting at a different time and place. There are also general sessions, and these have not become mere formal business meetings. The leading topic for discussion this year seems to have been the proposed National University at Washington. The most obviously important service which the Association has rendered to educational endeavor has been its elaboration (through efficient committees) and publication of reports on Secondary Education, Elementary Education, Rural Schools and College Entrance Requirements. These reports represent if not demonstrable facts, at least the well-considered opinion of competent judges and they have had a highly beneficial influence. Dr. J. M. Green, of Newark, will preside over next year's meeting. The decision in regard to the place has been left to the executive committee, the claims of Detroit, Cincinnati and Tacoma having been especially urged.

The opening of a summer school at Columbia University and the attendance at Harvard University of a large proportion of all the school teachers of Cuba are important steps towards increasing the usefulness of our institutions for higher education. The grounds, buildings and equipment of Columbia University have cost in the neighborhood of $10,000,000, and to let these lie idle and rusting for nearly one-third of the year is evidently wasteful. But it is not only a question of the most economical administration of these trust funds that is at issue. The teachers of the country, perhaps 500,000 in number, have had just enough education to profit particularly by attendance at a university. They are engaged at their work during three-fourths of the year, but their summers can be spent in no more pleasant and useful way than by attending a university summer school. It would be good business policy for school boards to send their teachers to the summer schools, except that the benefit might not be reaped locally, as each teacher would soon deserve a better position than he now has. It is, however, not only for teachers that university sessions during the summer are needed. The long vacation is largely a tradition from the time when boys were most usefully occupied on the farm during the summer. It is doubtful whether students now come back to college in the autumn in an improved physical or moral condition. They might spend their time to advantage, but are not likely to do so at the ordinary summer resort. It is admitted by everyone that young men are too old when they leave college and the professional schools. Reforms are needed in various directions, but an obvious one is not to take four years for three years' work. Though university professors, who for the general good need freedom from routine teaching for other work, should be allowed leave of absence for a part of the year, it does not follow that they should all be away at the same time. It seems probable that the example set by the University of Chicago, which holds four sessions extending through the year, will be followed by all our universities.

The third International Conference on a Catalogue of Scientific Literature was held in London on June 12th and 13th. It will be remembered by those who are interested in the organization of science that a conference on this subject was called by the Royal Society in 1896 at which it was proposed to undertake by international coöperation a catalogue of contributions to science. Certain details were arranged and others were left to a committee of the Royal Society. Under the auspices of this committee schedules of classification were drawn up and estimates of the cost secured. A second conference was held in 1898, and after various changes in the plans for the catalogue it was at the recent Conference definitely decided to proceed with its publication. It is estimated that the cost will be covered by the sale of three hundred sets, and different governments or national agencies have made themselves responsible for a certain number of sets, Germany and Great Britain for example, subscribing for forty-five sets, each costing £17. The Catalogue will be published in seventeen volumes devoted to as many sciences, and will be both an author's and a subject index. The collection of material is to commence from January 1, 1901. While all scientific men welcome improvements in cataloguing scientific literature, the arrangements proposed by the Royal Society and by the different conferences have met with some criticism. The serious mistake has been made of entirely ignoring the catalogues and bibliographies already existing for most of the sciences, and it is not certain that the elaborate and expensive machinery proposed will be as useful as some plan would have been for unifying the existing agencies. Still in the end there must be some international and uniform method for cataloguing scientific literature, and it is to be hoped that our Government will do its share toward supporting the present undertaking.

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THE MODERN OCCULT.

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IF that imaginary individual so convenient for literary illustration, a visitor from Mars, were to alight upon our planet at the present time, and if his intellectual interests induced him to take a survey of mundane views of what is "in heaven above, or on the earth beneath or in the waters under the earth," of terrestrial opinions in regard to the great problems of mind and matter, of government and society, of life and death—our Martian observer might conceivably report that a limited portion of mankind were guided by views that were the outcome of accumulated toil, and generations of studious devotion, representing a slow and tortuous, but progressive growth through error and superstition, and at the cost of persecution and bloodshed; that they maintained institutions of learning where the fruits of such thought could be imparted and the seeds cultivated to bear still more richly, but that outside of this respectable yet influential minority there were endless upholders of utterly unlike notions and of widely diverging beliefs, clamoring like the builders of the tower of Babel in diverse tongues.

It is well at least occasionally to remember that our conceptions of science and of truth, of the nature of logic and of evidence, are not so universally held as we unreflectingly assume or as we hopefully wish. Almost every one of the fundamental and indisputable tenets of science is regarded as hopelessly in error by some ardent would-be reformer. One Hampden declares that the earth is a motionless plane with the North Pole as the center; one Carpenter gives a hundred remarkable reasons why the earth is not round, with a challenge to the scientists of America to disprove them; one Symmes regarded the earth as hollow and habitable within, with openings at the poles which he offered to explore for the consideration of the "patronage of this and the new worlds"; while Symmes, Jr., explains how the interior is lighted, and that it probably forms the home of the lost tribes of Israel; and one Teed announces on equally conclusive evidence that the earth is a "stationary concave cell . . . with people, Sun, Moon, Planets and Stars on the inside," the whole constituting an "alchemico-organic structure, a Gigantic Electro-Magnetic Battery." If we were to pass from opinions regarding the shape of the earth to the many other and complex problems that appeal to human interests, it would be equally easy to collect 'ideas' comparable to these in value, evidence and eccentricity. With the conspicuously pathological outgrowth of brain-functioning—although its representatives in the literature of my topic are neither few nor far between—I shall not specifically deal; and yet the general abuse of logic, the helpless flounderings in the mire of delusive analogy, the baseless assumptions, which characterize insane or 'crank' productions, are readily found in modern occult literature.

The occult consists of a mixed aggregate of movements and doctrines, which may be the expressions of kindred interests and dispositions but present no essential community of content. Such members of this cluster of beliefs as in our day and generation have attained a considerable adherence or still retain it from former generations constitute the modern occult. The prominent characteristic of the occult is its marked divergence in trend and belief from the recognized standards and achievements of human thought. This divergence is one of attitude and logic and general perspective. It is a divergence of intellectual temperament that distorts the normal reactions to science and evidence and to the general significance and values of the factors of our complicated natures and our equally complicated environment. At least it is this in extreme and pronounced forms; and shades from it through an irregular variety of tints to a vague and often unconscious susceptibility for the unusual and eccentric, combined with an instability of conviction regarding established beliefs that is more often the expression of the weakness of ignorance than of the courage of independence. Occult doctrines are also likely to involve and to proceed upon mysticism and superstition; and their theme centers about such problems as the nature of mental action, the conception of life and death, the effect of cosmic conditions upon human events and endowment, the delineation of character, the nature and treatment of disease, or indeed about any of the larger or smaller realms of knowledge that combine with a strong human and possibly a practical interest, a considerable complexity of basal principles and general relations.

In surveying the more notable instances of the modern occult, it is well while bearing in mind the particular form of occultism or mysticism, or it may be merely of superstition and error, which one or another of the occult movements exhibits, to emphasize the importance of the intellectual motive or temperament that inclines to the occult. It is important to inquire not only what is believed, but what is the nature of the evidence that induces belief, what attracts and then makes converts, what the influences by which the belief spreads. Two classes of motives or interests are conspicuous; the one prominently intellectual or theoretical, the other moderately or grossly practical. Movements in which the former interest dominates contain elements that command respect even when they do not engage sympathy; they frequently appeal, though it may be unwisely, to worthy impulses and lofty aspirations. Amongst the movements presenting prominent practical aspects are to be found instances of the most irreverent and pernicious, as well as of the most vulgar, ignorant and fraudulent schemes which have been devised to mislead the human mind. Most occult movements, however, are of a mixed character, and in their career the speculative and the practical change in importance at different times or in different lands, or at the hands of variously minded leaders. Few escape and some seem especially designed for the partisanship of that class who are seeking whom they may devour; and stimulated by the greed for gain or the love for notoriety, set their snares for the eternally gullible. Fortunately, it must be added that the interest in the occult is under the sway of the law of fashion, and many a mental garment which is donned in spite of the protest of reason and propriety, is quietly laid aside when the dictum of the hour pronounces it unbecoming.

Historically considered, the occult points back to distant epochs and foreign civilizations; to ages when the facts of nature were but weakly grasped, when belief was largely dominated by the authority of tradition, when even the ablest minds fostered or assented to superstition, when the social conditions of life were inimical to independent thought and the mass of men were cut off from intellectual growth of even the most elementary kind. Pseudo-science flourished in the absence of true knowledge, and imaginative insight and unfounded belief held the office intended for inductive reason. Ignorance inevitably led to error and false views to false practices. In a sympathetic environment of this kind the occultist flourished and displayed the impressive insignia of exclusive wisdom. His attitude was that of one seeking to solve an enigma, to find the key to a strange puzzle; his search was for some mystic charm, some talismanic formula, some magical procedure, which shall dispel the mist that hides the face of nature and expose her secrets to his ecstatic gaze. By one all-encompassing, masterful effort the correct solution was to be discovered or revealed; and at once and for all, ignorance would give place to true knowledge, science and nature become as an open book, doubt and despair be replaced by the serenity of perfect wisdom. As our ordinary senses and faculties are obviously insufficient to accomplish such ends, supernatural powers must be appealed to, a transcendental sphere of spiritual activity must be cultivated capable of perceiving through the hidden symbolism of apparent phenomena, the underlying relations of cosmic structure and final purposes. Long periods of training and devotion, seclusion from the world, contemplation of inner mysteries, lead the initiate through the various stages of adeptship up to the final plane of communion with the infinite and the comprehension of truth in all things. This form of occultism reaches its fullest and purest expression in Oriental wisdom-religions. These vie in interest to the historian with the mythology and philosophy of Greece and Rome; and we of the Occident feel free to profit by their ethical and philosophical content, and to cherish the impulses which gave them life. But when such views are forcibly transplanted to our age and clime, when they are decked in garments so unlike their original vestments, particularly when they are associated with dubious practices and come into violent conflict with the truth that has accumulated since they first had birth, their aspect is profoundly altered and they come within the circle of the modern occult.

Of this character is Theosophy, an occult movement brought into recent prominence by the works and personality of Mme. Blavatsky. The story of the checkered career of that remarkable woman is fairly accessible. Born in Russia in 1831 as Helen Petrovna, daughter of Colonel Hahn, of the Russian army, she was married at the age of seventeen to an elderly gentleman, M. Blavatsky. She is described in girlhood as a person of passionate temper and wilful and erratic disposition. She separated or escaped from her husband after a few months of married life and entered upon an extended period of travel and adventure, in which 'psychic' experiences and the search for unusual persons and beliefs were prominent. She absorbed Hindu wisdom from the adepts of India; she sat at the feet of a thaumaturgist at Cairo; she journeyed to Canada to meet the medicine man of the Red Indians, and to New Orleans to observe the practices of Voodoo among the negroes. It is difficult to know what to believe in the accounts prepared by her enthusiastic followers. Violations of physical laws were constantly occurring in her presence, and "sporadic outbreaks of rappings and feats of impulsive pots, pans, beds and chairs insisted on making themselves notorious." In 1873 she came to New York and sat in 'spiritualistic' circles, assuming an assent to their theories, but claiming to see through and beyond the manifestations the operations of her theosophic guides in astral projection. At one of these séances she met Colonel Olcott and assisted him in the foundation of the Theosophical Society in New York in October, 1875. Mme. Blavatsky directed the thought of this society to the doctrines of Indian occultism, and reported the appearance in New York of a Hindu Mahatma, who left a turban behind him as evidence of his astral visit. Later Mme. Blavatsky and Colonel Olcott (who remained her staunch supporter, but whom she referred to in private as a 'psychologized baby') went to India and at Adyar established a shrine from which were mysteriously issued answers to letters placed within its recesses, from which inaccessible facts were revealed and a variety of interesting marvels performed. Discords arose within her household and led to the publication by M. and Mme. Coulomb, her confederates, of letters illuminating the tricks of the trade by which the miracles had been produced. Mme. Blavatsky pronounced the letters to be forgeries, but they were sufficiently momentous to bring Mr. Hodgson to India to investigate for the Society for Psychical Research. He was able to deprive many of the miracles of their mystery, to show how the 'shrine' from which the Mahatma's messages emanated was accessible to Mme. Blavatsky by the aid of sliding panels and secret drawers, to show that these messages were in style, spelling and handwriting the counterpart of Mme. Blavatsky's, to show that many of the phenomena were the result of planned collusion and that others were created by the limitless credulity and the imaginative exaggeration of the witnesses—'domestic imbeciles,' as madame confidentially called them. The report of the society convicted 'the Priestess of Isis' of "a long continued combination with other persons to produce by ordinary means a series of apparent marvels for the support of the Theosophic movement"; and concludes with these words: "For our own part, we regard her neither as the mouthpiece of hidden seers nor as a mere vulgar adventuress; we think that she has achieved a title to permanent remembrance as one of the most accomplished, ingenious and interesting impostors in history." Mme. Blavatsky died in 1891, and her ashes were divided between Adyar, London and New York.

The Theosophic movement continues, though with abated vigor, owing partly to the above-mentioned disclosures, but probably more to the increasing propagandism of other cults, to the lack of a leader of Mme. Blavatsky's genius, or to the inevitable ebb and flow of such interests. Mme. Blavatsky continued to expound Theosophy after the exposures, and Mrs. Besant, Mr. Sinnett and others were ready to take up the work at her death. However, miracles are no longer performed, and no immediately practical ends are proclaimed. Individual development and evolution, mystic discourses on adeptship and Karma and Maya and Nirvana, communion with the higher ends of life, the cultivation of an esoteric psychic insight, form the goal of present endeavor. The Mahatmas are giving "intellectual instructions, enormously more interesting than even the exhibition of their abnormal powers." . . .

The modern Theosophist seeks to appeal to men and women of philosophical inclinations, for whom an element of mysticism has its charm, and who are intellectually at unrest with the conceptions underlying modern science and modern life. Such persons are quite likely to be well-educated, refined and sincere. We may believe them intellectually misguided; we may recognize the fraud to which their leader resorted to glorify her creed, but we must equally recognize the absence of many pernicious tendencies in their teachings which characterize other and more practical occult movements.

Spiritualism, another member of the modern occult family, presents a combination of features rather difficult to portray; but its public career of half a century has probably rendered its tenets and practices fairly familiar. For, like other movements, it presents both doctrines and manifestations, and, like other movements, it achieved its popularity through its manifestations and emphasized the doctrines to maintain the interest and solidarity of its numerous converts. Deliberate fraud has been repeatedly demonstrated in a large number of alleged 'spiritualistic' manifestations; in many more the very nature of the phenomena and of the conditions under which they appear is so strongly suggestive of trickery as to render any other hypothesis of their origin improbable and unnecessary. Unconscious deception, exaggerated and distorted reports, defective and misleading observation have been demonstrated to be most potent reagents, whereby alleged miracles are made to throw off their mystifying envelopings and to leave a simple deposit of intelligible and often commonplace fact. That the methods of this or that medium have not been brought within the range of such explanation may be admitted, but the admission carries with it no bias in favor of the spiritualistic hypothesis. It may be urged, however, that where there is much smoke there is apt to be some fire; yet there is little prospect of discovering the nature of the fire until the smoke has been completely cleared away. Perhaps it has been snatched from heaven by a materialized Prometheus; perhaps it may prove to be the trick of a *ridiculus mus* gnawing at a match. However, the main point to be insisted upon with regard to such manifestations is that their interpretation and their explanation demand technical knowledge and training, or at least special adaptability to such pursuits. "The problem cannot be solved and settled by amateurs, nor by 'common sense' that

> Delivers brawling judgments all day long,
> On all things unashamed."

Spiritualism represents a systematization of popular beliefs and superstitions, modified by echoes of religious and philosophical doctrines; and is thus not wholly occult. Its main purpose was to establish the reality of communication wth departed spirits; the means which at first spontaneously presented themselves and later were devised for this purpose were in large measure not original. The rappings are in accord with the traditional folk-lore behavior of ghosts, though their transformation into a signal code may have been due to the originality of the Fox children; the planchette has its analogies in Chinese and European modes of divination; clairvoyance was incorporated from the phenomena of artificial somnambulism, as practiced by the successors of Mesmer; the 'sensitive' or 'medium' suggests the same origin as well as the popular belief in the gift of supernatural powers to favored individuals; others of the phenomena such as 'levitation' and 'cabinet performances' have counterparts in Oriental magic; 'slate-writing,' 'form materializations,' 'spirit-messages' and 'spirit photographs' are, in the main, modern contributions. These various phenomena as ordinarily presented breed the typical atmosphere of the séance chamber, which resists precise analysis, but in which it is easy to detect morbid credulity, blind prepossession and emotional contagion; while the dependence of the phenomena on the character of the medium offers strong temptation alike to shrewdness, eccentricity and dishonesty. On the side of his teachings the spiritualist is likewise not strikingly original. The relations of his beliefs to those that grew about the revelations of Swedenborg, to the speculations of the German 'pneumatologists' and to other philosophical doctrines, though perhaps not intimate, are yet traceable and interesting; and in another view the 'spiritualist' is as old as man himself and finds his antecedents in the necromancer of Chaldea, or in the Shaman of Siberia, or the Angekok of Greenland, or the spirit-doctor of the Karens. The modern mediums are simply repeating with new costumes and improved scenic effects the mystic drama of primitive man.

Spiritualism thus appeals to a deep-seated craving in human nature, that of assurance of personal immortality and of communion with the departed. Just so long as a portion of mankind will accept material evidence of such a belief, and will even countenance the irreverence, the triviality and the vulgarity surrounding the manifestations, just so long as these persons will misjudge their own powers of detecting how the alleged supernatural appearances were really produced and remain unimpressed by the principles upon which alone a consistent explanation is possible, just so long will spiritualism and kindred delusions flourish.

As to the present-day status of this cult it is not easy to speak positively. Its clientèle has apparently greatly diminished; it still numbers amongst its adherents men and women of culture and education and many more who cannot be said to possess these qualities. There seems to be a considerable class of persons who believe that natural laws are insufficient to account for their personal experiences and those of others, and who temporarily or permanently incline to a spiritualistic hypothesis in preference to any other. Spiritualists of this intellectual temper can, however, form but a small portion of those who are enrolled under its creed. If one may judge by the tone and contents of current spiritualistic literature, the rank and file to which Spiritualism appeals present an unintellectual occult company, credulously accepting what they wish to believe, utterly regardless of the intrinsic significance of evidence or hypothesis, vibrating from one extreme or absurdity to another, and blindly following a blinder or more fanatic leader or a self-interested charlatan. While for the most extravagant and unreasonable expressions of Spiritualism one would probably turn to the literature of a few decades ago, yet the symptoms presented by the Spiritualism of to-day are unmistakably of the same character, and form a complex as characteristic as the symptom-complex of hysteria or epilepsy, and which, *faute de mieux*, may be termed occult. It is a type of occultism of a particularly pernicious character because of its power to lead a parasitic life upon the established growths of religious beliefs and interests, and at the same time to administer to the needs of an unfortunate but widely prevalent passion for special signs and omens and the interpretation of personal experiences. It is a weak though comprehensible nature that becomes bewildered in the presence of a few experiences that seem homeless among the generous provisions of modern science, and runs off panic-stricken to find shelter in a system that satisfies a narrow personal craving at the sacrifice of broadly established principles, nurtured and grown strong in the hardy and beneficent atmosphere of science. It is a weaker and an ignorant nature that is attracted to the cruder forms of such beliefs, be it by the impulsive yielding to emotional susceptibility, by the contagion of an unfortunate mental environment, or by the absence of the steadying power of religious faith or of logical vigor or of confidence in the knowledge of others. Spiritualism finds converts in both camps and assembles them under the flag of the occult.*

*To prevent misunderstanding it is well to repeat that I am speaking of the general average of thorough-going spiritualists. The fact that a few mediums have engaged the attention of scientifically minded investigators has no bearing on the motives which lead most persons to make a professional call on a medium, or to join a circle. The further fact that these investigators have at times found themselves baffled by the medium's performances, and that a few of them have announced their readiness to accept the spiritualistic hypothesis is of importance in some aspects, but does not determine the general trend of the spiritualistic movement in the direction in which it is considered in the present discussion. It may also prevent misunderstanding of other parts of my presentation to continue this footnote by adding that I desire to distinguish sharply between the occult and what has unwisely been termed Psychical Research—unwisely because such research is either truly psychological and requires no differentiation from other allied and legitimate research, or it is something other than psychological which is inaptly expressed by calling it 'psychical.' I admit and emphasize that the majority of such research is the result of a scientific motive and is far removed from the occult. I therefore shall say nothing of Psychical Research and regret that it is necessary even to deny its possible inclusion in the occult. Such inclusion is, however, suggested by much that is talked of

The wane in the popularity of Spiritualism may be due in part to frequent exposures, in part to the passing of the occult interest to pastures new, and in part to other and less accessible causes. Such interest may again become dominant by the success or innovations of some original medium or by the appearance of some unforeseen circumstances; at present there is a disposition to take up 'spiritual healing' and 'spiritual readings of the future' rather than mere assurances from the dead, and thus to emulate the practical success of more recently established rivals. The history of Spiritualism, by its importance and its extravagance of doctrine and practice, forms an essential and an instructive chapter in the history of belief; and there is no difficulty in tracing the imprints of its footsteps on the sands of the occult.

The impress of ancient and mediæval lore upon latter-day occultism is conspicuous in the survivals of Alchemy and Astrology. Phrenology represents a more recent pseudo-science, but one sufficiently obsolete to be considered under the same head, as may also Palmistry, which has relations both to an ancient form of divination and to a more modern development after the manner of Physiognomy. The common characteristic of these is their devotion to a practical end. Alchemy occupies a somewhat distinct position. The original alchemists sought the secret of converting the baser metals into gold, in itself a sufficiently alluring and human occupation. There is no reason why such a problem should assume an occult aspect, except the sufficient one that ordinary procedures have not proved capable to effect the desired end. It is a proverbial fault of ambitious inexperience to attack valiantly large problems with endless confidence and sweeping aspiration. It is well enough in shaping your ideas to hitch your wagon to a star; yet the temporary utility of horses need not be overlooked; but shooting arrows at the stars is apt to prove an idle pastime. If we are willing to forget for the moment that the same development of logic and experiment that makes possible the mental and material equipment of

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and written under the name of Psychic Research, and there can be no doubt that the interest of many members of Psychic Research Societies and of readers of their publications, is essentially of an occult nature. Whatever in these publications seems to favor mystery and to substantiate supernormal powers is readily absorbed, and its bearings fancifully interpreted and exaggerated; the more critical and successfully explanatory papers meet with a less extended and less sensational reception. Unless most wisely directed, Psychic Research is likely, by not letting the right hand know what the left hand is doing, to foster the undesirable propensities of human nature as rapidly as it antagonizes them. Like indiscriminate alms-giving it has the possibilities of affording relief and of making paupers at the same time. While I regard the acceptance of telepathy as an established phenomenon, as absolutely unwarranted and most unfortunate, and while I feel a keen personal regret that men whose ability and opinions I estimate highly have announced their belief in a spiritualistic explanation of their personal experiences with a particular medium, yet my personal regret and my logical disapproval of these conclusions have obviously no bearing upon the general questions under discussion. The scientific investigation of the same phenomena which have formed the subject matter of occult beliefs, is radically different in motive, method and result from the truly occult.

the modern chemist makes impossible his consideration of the alchemist's search, we may note how far the inherent constitution of the elements, to say nothing of their possible transmutation, has eluded his most ultimate analysis. How immeasurably farther it was removed from the grasp of the alchemist can hardly be expressed. But this is a scientific and not an occult view of the matter; it was not by progressive training in marksmanship that the occultist hoped to send his arrows to the stars. His was a mystic search for the magical transmutation, the elixir of life or the philosopher's stone. One might suppose that once the world has agreed that these ends are past finding out, the alchemist, like the maker of stone arrow-heads, would have found his occupation gone and have left no successor. His modern representative, however, is an interesting and by no means extinct species. He seems to flourish in France, but may be found in Germany, in England and in this country. He is rarely a pure alchemist (although so recently as 1854 one of them offered to manufacture gold for the French mint), but represents the pure type of occultist. He calls himself a Rosicrucian; he establishes a university of the higher studies and becomes a Professor of Hermetic Philosophy. His thought is mystic, and symbolism has an endless fascination for him. The mystic significance of numbers, extravagant analogies of correspondence, the traditional hidden meanings of the Kabbalah fairly intoxicate him; and verbose accounts of momentous relations and of unintelligible discoveries run riot in his writings. His science is not a mere Chemistry, but a Hyper-Chemistry; his transmutations are not merely material but spiritual. Like all followers of an esoteric belief, he must stand apart from his fellow-men; he must cultivate the higher 'psychic' powers so that eventually he may be able by the mere action of his will to cause the atoms to group themselves into gold.

The modern alchemist is, however, a general occultist; he may be also an astrologer or a magnetist or a theosophist. But he is foremost an ardent enthusiast for exclusive and unusual lore—not the common and superficial possessions of misguided democratic science. He goes through the forms of study, remains superior to the baser practical ends of life, and finds his reward in the self-satisfaction of exclusive wisdom. In Paris, at least, he forms part of a rather respectable salon, speaking socially, or a 'company of educated charlatans,' speaking scientifically. His class does not constitute a large proportion of modern occultists, but they present a prominent form of its intellectual temperament. "There are also people," says Mr. Lang, "who so dislike our detention in the prison house of old unvarying laws that their bias is in favor of anything which may tend to prove that science in her contemporary mood is not infallible. As the Frenchman did not care what sort of a scheme he invested money in, provided that it annoys the English, so many persons do not care what they invest belief in, provided that it irritates men of science." Of such is the kingdom of alchemists and their brethren.

Astrology, phrenology, physiognomy and palmistry have in common a search for knowledge whereby to regulate the affairs of life, to foretell the future, to comprehend one's destiny and capabilities. They aim to secure success or at least to be forearmed against failure by being forewarned. This is a natural, a practical, and in no essential way, an occult desire. It becomes occult, or better, superstitious, when it is satisfied by appeals to relations and influences which do not exist, and by false interpretation of what may be admitted as measurably and vaguely true and about equally important. When not engaged in their usual occupation of building most startling superstructures on the weakest foundations, practical occultists are like Dr. Holmes' katydid, "saying an undisputed thing in such a solemn way." They will not hearken to the experience of the ages that success cannot be secured nor character read by discovering their mystic stigmata; they will not learn from physiology and psychology that the mental capabilities, the moral and emotional endowment of an individual are not stamped on his body so that they may be revealed by half an hour's use of the calipers and tape-measure; they will not listen when science and common sense unite in teaching that the knowledge of mental powers is not such as may be applied by rule of thumb to individual cases, but that like much other valuable knowledge, it proceeds by the exercise of sound judgment, and must as a rule rest content with suggestive generalizations and imperfectly established correlations. An educated man with wholesome interests and a vigorous logical sense can consider a possible science of character and the means of aiding its advance without danger and with some profit. But this meat is sheer poison to those who are usually attracted to such speculations, while it offers to the unscrupulous charlatan a most convenient net to spread for the unwary. In so far as these occult mariners, the astrologists and phrenologists and *id genus omne* are sincere, and in so far represent superstition rather than commercial fraud, they simply ignore through obstinacy or ignorance the light-houses and charts and the other aids to modern navigation, and persist in steering their craft by an occult compass. In some cases they are professedly setting out, not for any harbor marked on terrestrial maps, but their expedition is for the golden fleece or for the apples of the Hesperides; and with loud-voiced advertisements of their skill as pilots, they proceed to form stock companies for the promotion of the enterprise and to sell the shares to credulous speculators.

It would be a profitless task to review the alleged data of astrology or phrenology or palmistry except for the illustrations which they readily yield of the nature of the conceptions and the logic which command a certain popular interest and acceptance. The interest in these notions, is, as Mr. Lang argues about ghosts and rappings and bogles, in how they come to be believed rather than in how much or how little they chance to be true. In examining the professed evidence for the facts and laws and principles (*sit venia verbis*) that pervade astrology or phrenology or palmistry or dream-interpretation, or beliefs of that ilk, we find the flimsiest kind of texture that will hardly bear examination and holds together only so long as it is kept secluded from the light of day. Far-fetched analogy, baseless assertion, the uncritical assimilation of popular superstitions, a great deal of prophecy after the event —it is wonderful how clearly the astrologer finds the indications of Napoleon's career in his horoscope, or the phrenologist reads them in the Napoleonic cranial protuberances—much fanciful elaboration of detail, ringing the variations on a sufficiently complex and non-demonstrable proposition, cultivating a convenient vagueness of expression together with an apologetic skill in providing for and explaining exceptions, the courage to ignore failure and the shrewdness to profit by coincidences and half-assimilated smatterings of science; and with it all an insensibility to the moral and intellectual demands of the logical decalogue, and you have the skeleton which clothed with one flesh becomes astrology, and with another phrenology and with another palmistry or solar biology or descriptive mentality or what not. Such pseudo-sciences thrive upon that widespread and intense craving for practical guidance of our individual affairs, which is not satisfied with judicious applications of general principles, with due consideration of the probabilities and uncertainties of human life, but demands an impossible and precise revelation. Not all that passes for, and in a way is, knowledge, is or is likely soon to become scientific; and when a peasant parades in an academic gown the result is likely to be a caricature.

To achieve fortune, to judge well and command one's fellow-men, to foretell and control the future, to be wise in worldly lore, are natural objects of human desire; but still another is essential to happiness. Whether we attempt to procure these good fortunes by going early to bed and early to rise, or by more occult procedures, we wish to be healthy as well as wealthy and wise. The maintenance of health and the perpetuity of youth were not absent from the mediæval occultist's search, and formed an essential part of the benefits to be conferred by the elixir of life and the philosopher's stone. A series of superstitions and extravagant systems are conspicuous in the antecedents and the bye-paths of the history of medicine, and are related to it much as astrology is to astronomy or alchemy to chemistry; and because medicine in part remains, and to previous generations was conspicuously an empirical art rather than a science, it offers great opportunity for practical error and misapplied partial knowledge. It is not necessary to go back to early civilizations or to primitive peoples, among whom the medicine-man and the priest were one and alike appealing to occult powers, nor to early theories of disease which beheld in insanity the obsession of demons and resorted to exorcism to cast them out; it is not necessary to consider the various personages who acquired notoriety as healers by laying on of hands or by appeal to faith, or who like Mesmer introduced the system of Animal Magnetism, or like some of his followers, sought directions for healing from the clairvoyant dicta of somnambules; it is not necessary to ransack folk-lore superstitions and popular remedies for the treatment of disease; for the modern forms of 'irregular' healing offer sufficient illustrations of occult methods of escaping the ills that flesh is heir to.

The existence of a special term for a medical impostor is doubtless the result of the prevalence of the class thus named, but quackery and occult medicine though mutually overlapping, can by no means be held accountable for one another's failings. Many forms of quackery proceed on the basis of superstitions or fanciful or exaggerated notions containing occult elements, but for the present purpose it is wise to limit attention to those in which this occult factor is distinctive; for medical quackery in its larger relations is neither modern nor occult. Occult healing takes its distinctive character from the theory underlying the practice rather than from the nature of the practice. It is not so much what is done as why it is done or pretended to be done or not done, that determines its occult character. A factor of prominence in modern occult healing is indeed one that in other forms characterized many of its predecessors and was rarely wholly absent from the connection between the procedure and the result; this is the mental factor, which may be called upon to give character to a theory of disease, or be utilized consciously or unconsciously as a curative principle. It is not implied that 'mental medicine' is necessarily and intrinsically occult, but only that the general trend of modern occult notions regarding disease may be best portrayed in certain typical forms of 'psychic' healing. The legitimate recognition of the importance of mental conditions in health and disease is one of the results of the union of modern psychology and modern medicine. An exaggerated and extravagant as well as pretentious and illogical over-statement and misstatement of this principle may properly be considered as occult.

Among such systems there is one which by its momentary prominence overshadows all others, and for this reason as well as for its more explicit or rather extended statement of principles, must be accorded special attention. I need hardly say that I refer to that egregious misnomer, Christian Science. This system is said to have been discovered by or revealed to Mrs. Mary Baker Glover Eddy in 1866. Several of its most distinctive positions (without their religious setting) are to be found in the writings and were used in the practice of Mr. or Dr. P. P. Quimby (1802-1866), whom Mrs. Eddy professionally consulted shortly before she began her own propagandum. On its theoretical side the system presents a series of quasi-metaphysical principles, and also a professed interpretation of the Scriptures; on its practical side it offers a means of curing or avoiding disease and includes under disease also what is more generally described as sin and misfortune. With Christian Science as a religious movement I shall not directly deal; I wish, however, to point out that this assumption of a religious aspect finds a parallel in Spiritualism and Theosophy and doubtless forms one of the most potent reasons for the success of these occult movements. It would be a most dangerous principle to admit that the treatment of disease and the right to ignore hygiene can become the perquisite of any religious faith. It would be equally unwarranted to permit the principles which are responsible for such beliefs to take shelter behind the ramparts of religious tolerance; for the essential principles of Christian Science do not constitute a form of Christianity any more than they constitute a science; but in so far as they do not altogether elude description, pertain to the domain over which medicine, physiology and psychology hold sway. As David Harum, in speaking of his church-going habits, characteristically explains, "the one I stay away from when I don't go's the Prespyteriun," so the doctrines which Christian Science 'stays away from' are those over which recognized departments of academic learning have the authority to decide.

Mrs. Eddy's magnum opus serving at once as the text-book of the 'science' and as a revised version of the Scriptures—Science and Health, with Key to the Scriptures—has been circulated to the extent of one hundred and seventy thousand copies. I shall not give an account of this book nor subject its more tangible tenets to a logical review; I must be content to recommend its pages as suggestive reading for the student of the occult and to set forth in the credentials of quotation marks some of the dicta concerning disease. Yet it may be due to the author of this system to begin by citing what are declared to be its fundamental tenets, even if their connection with what is built upon them is far from evident.

"The fundamental propositions of Christian Science are summarized in the four following, to me *self-evident* propositions. Even if read backward, these propositions will be found to agree in statement and proof:

1. God is All in all.
2. God is good. Good is Mind.
3. God, Spirit, being all, nothing is matter.

4. Life, God, omnipotent Good, deny death, evil, sin, disease—Disease, sin, evil, death, deny Good, omnipotent God, Life."

"What is termed disease does not exist." "Matter has no being." "All is mind." "Matter is but the subjective state of what is here termed *mortal mind.*" "All disease is the result of education, and can carry its ill-effects no farther than mortal mind maps out the way." "The fear of dissevered bodily members, or a belief in such a possibility, is reflected on the body, in the shape of headache, fractured bones, dislocated joints, and so on, as directly as shame is seen rising to the cheek. This human error about physical wounds and colics is part and parcel of the delusion that matter can feel and see, having sensation and substance." "Insanity implies belief in a diseased brain, while physical ailments (so-called) arise from belief that some other portions of the body are deranged. . . . A bunion would produce insanity as perceptible as that produced by congestion of the brain, were it not that mortal mind calls the bunion an unconscious portion of the body. Reverse this belief and the results would be different." "We weep because others weep, we yawn because they yawn, and we have small-pox because others have it; but mortal mind, not matter, contains and carries the infection." "A Christian Scientist never gives medicine, never recommends hygiene, never manipulates." "Anatomy, Physiology, Treatises on Health, sustained by what is termed material law, are the husbandmen of sickness and disease." "You can even educate a healthy horse so far in physiology that he will take cold without his blanket." "If exposure to a draught of air while in a state of perspiration is followed by chills, dry cough, influenza, congestive symptoms in the lungs, or hints of inflammatory rheumatism, your Mind-remedy is safe and sure. If you are a Christian Scientist, such symptoms will not follow from the exposure; but if you believe in laws of matter and their fatal effects when transgressed, you are not fit to conduct your own case or to destroy the bad effects of belief. When the fear subsides and the conviction abides that you have broken no law, neither rheumatism, consumption nor any other disease will ever result from exposure to the weather." "Destroy fear and you end the fever." "To prevent disease or cure it mentally let spirit destroy the dream of sense. If you wish to heal by argument, find the type of the ailment, get its name and array your mental plea against the physical. Argue with the patient (mentally, not audibly) that he has no disease, and conform the argument to the evidence. Mentally insist that health is the everlasting fact, and sickness the temporal falsity. Then realize the presence of health and the corporeal senses will respond, so be it." "My publications alone heal more sickness than an unconscientious student can begin to reach." "The quotient when numbers have been divided by a fixd rule, are not more unquestionable than the scientific tests I have made of the effects of truth upon the sick." "I am never mistaken in my scientific diagnosis of disease." "Outside of Christian Science all is vague and hypothetical, the opposite of Truth." "Outside Christian Science all is error."

Surely this is a remarkable product of mortal mind! It would perhaps be an interesting *tour de force,* though hardly so entertaining as 'Alice in Wonderland,' to construct a universe on the assertions and hypotheses which Christian Science presents; but it would have less resemblance to the world we know than has Alice's Wonderland. For any person for whom logic and evidence are something more real than ghosts or myths, the feat must always be relegated to the airy realm of the imagination and must not be brought in contact with earthly realities. And yet the extravagance of Mrs. Eddy's book, its superb disdain of vulgar fact, its transcendental self-confidence, its solemn assumption that reiteration and variation of assertion somehow spontaneously generate proof or self-evidence, its shrewd assimilation of a theological flavor, its occasional successes in producing a presentable travesty of scientific truth—all these distinctions may be found in many a dust-covered volume, that represents the intensity of conviction of some equally enthusiastic and equally inspired occultist, but one less successful in securing a chorus to echo his refrain.

I cannot dismiss 'Eddyism' without illustrating the peculiar structures under which, in an effort to be consistent, it is forced to take shelter. Since disease is always of purely mental origin, it follows that disease and its symptoms cannot ensue without the conscious coöperation of the patient; since "Christian Science divests material drugs of their imaginary power," it follows that the labels on the bottles that stand on the druggist's shelves are correspondingly meaningless. And it becomes an interesting problem to inquire how the consensus of mortal mind came about that associates one set of symptoms with prussic acid, and another with alcohol, and another with quinine. Inhaling oxygen or common air would prepare one for the surgeon's knife, and prussic acid or alcohol have no more effect than water, if only a congress of nations would pronounce the former to be anæsthetic and promulgate a decree that the latter shall be harmless. Christian Science does not flinch from this position. "If a dose of poison is swallowed through mistake and the patient dies, even though physician and patient are expecting favorable results, does belief, you ask, cause this death? Even so, and as directly as if the poison had been intentionally taken. In such cases a few persons believe the potion swallowed by the patient to be harmless; but the vast majority of mankind, though they know nothing of this particular case and this special person, believe the arsenic, the strychnine, or whatever the drug used, to be poisonous, for it has been set down as a poison by mortal mind. The consequence is that the result is controlled by the majority of opinions outside, not by the infinitesimal minority of opinions in the sick chamber." But why should the opinions of οἱ πολλοὶ be of influence in such a case, and the enlightened minorities be sufficient to effect the marvellous cures in all the other cases? Christian Scientists do not take cold in draughts in spite of the contrary opinions or illusions of misguided majorities. The logical Christian Scientist need not eat, "for the truth is food does not affect the life of man," and should not renounce his faith by adding, "but it would be foolish to venture beyond our present understanding, foolish to stop eating, until we gain more goodness and a clearer comprehension of the living God." And if he is a mental physician he must be a mental surgeon, too, and not plead that, "Until the advancing age admits the efficacy and supremacy of mind, it is better to leave the adjustment of broken bones and dislocations to the fingers of surgeons." But it is unprofitable to consider the weakness of any occult system in its encounters with actual science and actual fact. It is simply as a real and prominent menace to rationality that these doctrines naturally attract consideration. As illustrations of present-day occult beliefs we are naturally tempted to inquire what measure of (perverted) truth they may contain; but the more worthy question is, How do such perversions come to find so large a company of 'supporting listeners'? For to any one who can read and be convinced by the sequence of words of this system, ordinary logic has no power, and to him the world of reality brings no message. No form of the modern occult antagonizes the foundations of science so brusquely as this one. The possibility of science rests on the thorough and absolute distinction between the subjective and the objective. In what measure a man loses the power to draw this distinction clearly and as other men do, in that measure he becomes irrational and insane. The objective exists; and no amount of thinking it away, or thinking it differently, will change it. That is what is understood by ultimate scientific truth; something that will endure unmodified by passing ways of viewing it, open to every one's verification who can come equipped with the proper means to verify—a permanent objective to be ascertained by careful logical inquiry, not to be determined by subjective opinion. Logic is the language of science; Christian Science and what sane men call science can never communicate because they do not speak the same language.

It would be unfortunate if in emphasizing the popular preëminence of Christian Science, one were to overlook the significance of the many other forms of 'drugless healing' which bid for public favor by appeal to ignorance and to occult and superstitious instincts. Some are allied to Christian Science and like it assimilate their cult to a religious movement; others are unmistakably the attempts of charlatans to lure the credulous by noisy advertisements of newly discovered and scientifically indorsed systems of 'psychic force,' or some personal 'ism.' For many purposes it would be unjust to group together such various systems, which in the nature of things must include sinner and saint, the misguided sincere, the half-believers who think 'there may be something in it,' or 'that it is worth a trial,' along with scheming quacks and adepts in commercial fraud. They illustrate the many and various roads traveled in the search for health by pilgrims who are dissatisfied with the highways over which medical science goes its steady, though it may be, uncertain gait. Among them there is both plausible exaggeration and ignorant perversion and dishonest libel of the relations that bind together body and mind. Among the several schisms from the Mother Church of Christian Science there is one that claims to be the 'rational phase of the mental healing doctrine,' that acknowledges the reality of disease and the incurability of serious organic disorders and resents any connection with the "half-fanatical personality worship [of Mrs. Eddy] as quite as foreign to its tenets as would be the views of the 'Free Religious Association' to the 'Pope of Rome.' 'Divine Healing' exhibits its success in one notable instance, in the establishment of a school and college, a bank, a land and investment association, a printing and publishing office and sundry Divine Healing Homes; and this prosperity is now to be extended by the foundation of a city or colony of converts who shall be united by the common bond of faith in divine healing as transmitted in the personal power of their leader. The official organ of this movement announces that the personification of their faith "makes her religion a business and conducts herself upon sound business principles." With emphatic protest on the part of each that he alone holds the key to salvation, and that his system is quite original and unlike any other, comes the procession of Metaphysical Healer and Mind-Curist and Viticulturist and Magnetic Healer and Astrological Health Guide and Phrenopathist and Medical Clairvoyant and Psychic Scientist and Mesmerist and Occultist. Some use or abuse the manipulations of Hypnotism; others claim the power to concentrate the magnetism of the air and to excite the vital fluids by arousing the proper mental vibrations, or by some equally lucid and demonstrable procedure; some advertise magnetic cups and positive and negative powders and absent treatment by outputs of 'psychic force' and countless other imposing devices. In truth, they form a motley crew, and with their 'Colleges of Fine Forces' and 'Psychic Research Companies,' offering diplomas and degrees for a three weeks' course of study or the reading of a book, represent the slums of the occult. An account of their methods is likely to be of as much interest to the student of fraud as to the student of opinion.

There can be no doubt that many of these systems have been stimulated into life or into renewed vigor by the success of 'Christian Science'; this is particularly noticeable in the introduction of absent treatment as a plank in their diverse platforms. This ingenious method of restoring the health of their patients and their own exchequers appealed to all the band of healing occultists from Spiritualist to Vibrationist, as easily adaptable to their several systems. In much the same way Mesmer, more than a hundred years ago, administered to the practice which had exhausted the capacity of his personal attention by magnetizing trees and selling magnetized water. The absent treatment represents the occult 'extension movement'; and unencumbered by the hampering restrictions of physical forces, superior even to wireless telegraphy, carries its influence into the remotest homes. From ocean to ocean and from North to South these absent healers set apart some hour of the day when they mentally convey their healing word to the scattered members of their flock. On the payment of a small fee you are made acquainted with the 'soul-communion time-table' for your longitude and may know when to meet the healing vibrations as they pass by. Others disdain any such temporal details and assure a cure merely on payment of the fee; the healer will know sympathetically when and how to transmit the curative impulses. Poverty and bad habits as well as disease readily succumb to the magic of the absent treatment. Here is the hysterical edict of one of them: 'Join the Success Circle.' . . . "The Centre of that Circle is my omnipotent WORD. Daily I speak it. Its vibrations radiate more and more powerfully day by day. . . . As the sun sends out vibrations . . . so my WORD radiates Success to 10,000 lives as easily as to one."

It is impossible to appreciate fully the extravagances of these occult healers unless one makes a sufficient sacrifice of time and patience to read over a considerable sample of the periodical publications with which American occultism is abundantly provided. And when one has accomplished this task he is still at sea to account for the readers and believers who support these various systems so undreamt of in our philosophy. It would really seem that there is no combination of ideas too absurd to fail entirely of a following. Carlyle without special provocation concluded that there were about forty million persons in England, mostly fools; what would have been his comment in the face of this vast array of human folly! If it be urged in rejoinder that beneath all this rubbish heap a true jewel lies buried, that the wonderful cures and the practical success of these various systems indicate their dependence upon an essential and valuable factor in the cure of disease and the formation of habits, it is possible with reservation to assent and with emphasis to demur. Such success, in so far as it is rightly reported, exemplifies the truly remarkable function of the mental factor in the control of normal as of disordered physiological functions. This truth has been recognized and utilized in unobtrusive ways for many generations, and within recent years has received substantial elaboration from carefully conducted experiments and observations. Specifically the therapeutic action of suggestion, both in its more usual forms and as hypnotic suggestion, has shown to what unexpected extent such action may proceed in susceptible individuals. The well-informed and capable physician requires no instruction on this point; his medical education furnishes him with the means of determining the symptoms of true organic disorder, of functional derangement and of the modifications of these under the more or less unconscious interference of an unfortunate nervous system. It is quite as human for the physician as for other mortals to err, and there is doubtless as wide a range among them as among other pursuits, of ability, tact and insight. 'But when all is said and done' the fundamental fact remains that the utilization of the mental factor in the alleviation of disease will be best administered by those who are specifically trained in the knowledge of bodily and mental symptoms of disease. Such application of an established scientific principle may prove to be a jewel of worth in the hands of him who knows how to cut and set it. The difference between truth and error, between science and superstition, between what is beneficent to mankind and what is pernicious, frequently lies in the interpretation and the spirit as much as or more than in the fact. The utilization of mental influences in health and disease becomes the one or the other according to the wisdom and the truth and the insight into the real relations of things that guide its application. As far removed as chemistry from alchemy, as astronomy from astrology, as the doctrine of the localization of function in the brain from phrenology, as 'animal magnetism' from hypnotic suggestion, are the crude and perverse notions of Christian Scientist or Metaphysical Healer removed from the rational application of the influence of the mind over the body.

The growth and development of the occult forms an interesting problem in the psychology of belief. The motives that induce the will to believe in the several doctrines that have been passed in review are certainly not more easy to detect and to describe than would be the case in reference to the many other general problems—philosophical, scientific, religious, social, political or educational—on which the right to an opinion seems to be regarded as an inalienable heritage of humanity or at least of democracy. Professor James tells us that often "our faith is faith in some one else's faith, and in the greatest matters this is most the case." Certainly the waves of popularity of one cult and another reflect the potent influence of contagion in the formation of opinion and the direction of conduct. When we look upon the popular delusions of the past through the achromatic glasses which historical remoteness from present conditions enables us to adjust to our eyes, we marvel that humanity could have been so grossly misled, that obvious relations and fallacies could have been so stupidly overlooked, that worthless and prejudiced evidence could have been accepted as sound and significant. But the opinions to which we incline are all colored o'er with the deep tinge of emotional reality, which is the living expression of our interest in them or our inclination toward them. What they require is a more vigorous infusion of the pale cast of thought; for the problem of the occult and the temptations to belief which it holds out are such as can be met only by a vigorous and critical application of a scientific logic. As logical acumen predominates over superficial plausibility, as belief comes to be formed and evidence estimated according to its intrinsic value rather than according to its emotional acceptability, the propagandum of the occult will meet with greater resistance and aversion.

The fixation of belief proceeds under the influence of both general and special forces; the formation of a belief is at once a personal and a social reaction—a reaction to the evidence which recorded and personal experience presents and to the beliefs current in our environment, and this reaction is further modified by the temperament of the reagent. And although individual beliefs, however complex, are neither matters of chance nor are their causes altogether past finding out, yet some of their contributing factors are so vague and so inaccessible that they are most profitably considered as particular results of more or less clearly discerned general principles; and in many respects there is more valid interest in the general principles than in the particular results. It is interesting and it may be profitable to investigate why this area is wooded with oak and that with maple, but it is somewhat idle to speculate why this particular tree happens to be a maple rather than an oak, even if it chances to stand on our property, and to have an interest to us beyond all other trees. It is this false concentration of the attention to the personal and individual result that is responsible for much unwarranted belief in the occult. It is likely that no single influence is more potent in this direction than this unfortunate over-interest in one's own personality and the consequent demand for a precise explanation of one's individual experiences. This habit seems to me a positive vice, and I am glad to find support in Professor James: "The chronic belief of mankind that events may happen for the sake of their personal significance is an abomination." Carried over to the field of subjective experiences, this habit sees in coincidences peculiarly significant omens and portents, not definitely and superstitiously, it may be, but sufficiently to obscure the consideration of the experience in any other than a personal light. The victim of this habit will remain logically unfit to survive the struggle against the occult. Only when the general problem is recognized as more significant for the guidance of belief than the attempted explicit personal explanations will these problems stand out in their true relations. It is interesting to note that the partaking of mince-pie at evening may induce bad dreams, but it is hardly profitable to speculate deeply why my dream took the form of a leering demon with the impolite habit of squatting on my chest. The stuff that dreams are made of is not susceptible of that type of analysis. The most generous allowance must be made for coincidences and irrelevancies, and it must be constantly remembered that the obscure phenomena of psychology, and, indeed, the phenomena of more thoroughly established and intrinsically more definite sciences, cannot be expected to pass the test of detailed and concrete combinations of circumstances. In other classes of knowledge the temptation to demand such explicit explanations of observations and experiences is not so strong because of the absence of an equally strong personal interest; but that clearly does not affect the logical status of the problem. The reply to this argument I can readily anticipate; and I confess that my admiration of Hamlet is somewhat dulled by reason of that ill-advised remark to Horatio about there being more things in heaven and earth than are dreamt of in our philosophies. The occultist always seizes upon that citation to refute the scientist. He prints it as his motto on his books and journals, and regards it as a slow poison that will in time effect the destruction of the rabble of scientists and reveal the truth of his own Psycho-Harmonic Science or Heliocentric Astrology. It is one thing to be open-minded and to realize the incompleteness of scientific knowledge and to appreciate how often what was ignored by one generation has become the science of the next; and it is a very different thing to be impressed with coincidences and dreams and premonitions, and to regard them as giving the keynote to the conceptions of nature and reality, and to look upon science as a misdirected effort. Such differences of attitude depend frequently upon a difference of temperament as well as upon intellectual discernment; the man or the woman who flies to the things not dreamt of in our philosophy quite commonly does not understand the things which our philosophy very creditably accounts for. The two types of mind are different, and (I am again citing Professor James) "the scientific-academic mind and the feminine-mystical mind shy from each other's facts just as they fly from each other's temper and spirit."

Certain special influences combine with these fundamental differences of attitude to favor the spread of belief in the occult; and of these the character of the beliefs as of the believers furnish some evidence. At various stages of the discussion I have referred to the deceptive nature of the argument by analogy; to the dominating sympathy with a conclusion and the resulting assimilation and overestimation of apparent evidence in its favor; to the frequent failure to understand that the formation of valid opinion and the interpretation of evidence in any field of inquiry require somewhat of expert training and special aptitude, obviously so in technical matters, but only moderately less so in matters misleadingly regarded as general; to bias and superstition, to the weakness that bends easily to the influences of contagion, to unfortunate educational limitations and perversions and, not the least, to a defective grounding in the nature of scientific fact and proof. The mystery attaching to the behavior of the magnet led Mesmer to call his curative influence 'animal magnetism'—a conception that still prevails among latter-day occultists. The principle of sympathetic vibration, in obedience to which a tuning-fork takes up the vibrations of another in unison with it, is violently transferred to imaginary brain vibrations and to still more imaginary telepathic currents. The X-ray and wireless telegraphy are certain to be utilized in corroboration of unproven modes of mental action, and will be regarded as the key to clairvoyance and rapport, just as well-known electrical phenomena have given rise to the notions of positive and negative temperaments and mediumistic polar attraction and repulsion. All this results from the absurd application of analogies; for analogies even when appropriate are little more than suggestive or at least corroborative of relations or conceptions which owe their main support to other and more sturdy evidence. Analogy under careful supervision may make a useful apprentice, but endless havoc results when the servant plays the part of the master.

No better illustrations could be desired of the effects of mental prepossession and the resulting distortion of evidence and of logical insight, than those afforded by Spiritualism and Christian Science. In both these movements the assimilation of a religious trend has been of inestimable importance to their dissemination. Surely it is not merely or mainly the evidences obtainable in the séance chamber, nor the irresistible accumulation of cures by argument and thought-healings, that account for the organized gatherings of Spiritualists and the costly temples and thriving congregations of Christ Scientist. It is the presentation of a practical doctrine of immortality and of the spiritual nature of disease in conjunction with an accepted religious system, that is responsible for these vast results. The 'Key to the Scriptures' has immeasurably reinforced the 'Science and Health,' and brought believers to a new form of Christianity who never would have been converted to a new system of medicine presented on purely intellectual grounds. Rationality is doubtless a characteristic tendency of humanity, but logicality is an acquired possession and one by no means firmly established in the race at large. So long as we are reproved by the discipline of nature and that rather promptly, we tend to act in accordance with the established relations of things; and that is rationality. But the more remote connections between antecedent and consequent and the development of habits of thought which shall lead to reliable conclusions in complex situations; and again, the ability to distinguish between the plausibile and the true, the firmness to support principle in the face of paradox and seeming non-conformity, to think clearly and consistently in the absence of the practical reproof of nature—that is logicality. It is only as the result of a prolonged and conscientious training aided by an extensive experience and a knowledge of the historical experience of the race, that the inherent rational tendencies develop into established logical habits and principles of belief. For many this development remains stunted or arrested; and they continue as children of a larger growth, leaning much on others, rarely venturing abroad alone and wisely confining their excursions to familiar ground. When they unfortunately become possessed with the desire to travel, their lack of appreciation of the sights which their journeys bring before them gives to their reports the same degree of reliability and value as attaches to the much ridiculed comments of the philistine *nouveaux riches*.

For these sufficient reasons it is Utopian to look forward to the day when the occult shall have disappeared, and the lion and the lamb shall feed and grow strong on the same nourishment. Doubtless new forms and phases of the occult will arise to take the place of the old as their popularity declines; and the world will be the more interesting and more characteristically a human dwelling-place for containing all sorts and conditions of minds. None the less it is the plain duty and privilege of each generation to utilize every opportunity to dispel error and superstition, and to oppose the dissemination of irrational beliefs. It is particularly the obligation of the torch-bearers of science to illuminate the path of progress and to transmit the light to their successors with undiminished power and brilliancy; this flame must burn both as a beacon-light to guide the wayfarer along the highways of advance and as a warning against the will-of-the-wisps that shine seductively in the bye-ways. The safest and most efficient antidote to the spread of the pernicious tendencies inherent in the occult lies in the cultivation of a wholesome and whole-souled interest in the genuine and profitable problems of nature and of life, and in the cultivation with it of a steadfast adherence to common sense and to a true logical perspective of the significance and value of things. These qualities, fortunately for our forefathers, are not the prerogative of the modern; and, fortunately for posterity, are likely to remain characteristic of the scientific and antagonistic to the occult.

BIRDS AS FLYING MACHINES.

BY FREDERICK A LUCAS.

FROM the day of Solomon onward the way of a bird in the air has been a subject of general interest, and the attention given to the problem of aerial navigation of late years has caused the flight of birds to be carefully studied in the hope that it might throw some light on the subject. There have been many conceptions, not to say misconceptions, regarding the flight of birds; it has been assumed that their muscles exerted a power quite beyond that of other animals, that the air sacs of some birds and the hollow bones of others gave them a degree of lightness quite unattainable by the use of ordinary materials, while some have even gone so far as to suggest the presence of some mysterious power, something like Stockton's negative gravity, whereby birds could set at naught the law of gravitation and rise at will like a balloon. The strength of a bird's muscles, of some birds' muscles at least, is not to be underrated; a hawk will plant its talons in a bird of nearly its own size and weight and bear the victim bodily away, and an osprey will carry a fish for a long distance. But a tiger has been known to fell a bullock with a single blow of the paw, to carry a man as a cat would carry a rat and to drag an Indian buffalo heavier than himself. On the other hand, some of the petrels, birds which can pass a day or so on the wing with ease, cannot rise from the water after a hearty meal, and the humming-bird, unsurpassed in aerial evolutions, may be trapped in a spider's web. This shows no great power, and long ago Marey found that the pulling force of a hawk's great breast muscle, applied through the humerus, amounted to 1,298 grams per square centimeter, something like seven pounds to the square inch; not a very heavy pull. So it seems fair to assume that while the power exerted by a bird is great, it is very far from marvelous, probably far less in proportion to size than the engine of Maxim's great aeroplane, or the naphtha motor of Professor Langley, which weighs less than ten pounds per horse power. We may get a fair idea of what this means by remembering that a bald eagle weighs from nine to fifteen pounds and that he exerts but a small fraction of a horse power.

Turning to the question of the part played by the air sacs it may be said that their value is not proved; some of the fastest birds get along without them, while birds of the most labored flight are sometimes well provided. In birds like the gannet and brown pelican the air sacs and cellular tissue about the body undoubtedly serve as buffers to break the shock of a headlong plunge into the water from a height of a hundred to a hundred and fifty feet. Or, again, they equalize the internal and external pressure when a soaring bird drops suddenly from a great height, or still more often aid in oxygenating the blood.

The hollow bones of birds are frequently cited as beautiful instances of providential mechanics in building the strongest and largest possible limb with the least expenditure of material, and this is largely true. And yet birds like ducks, which cleave the air with the speed of an express train, have the long bones filled with marrow or saturated with fat, while the lumbering hornbill that fairly hurtles over the tree tops has one of the most completely pneumatic skeletons imaginable, permeated with air to the very toe tips; and the ungainly pelican is nearly as well off. Still it is but fair to say that the frigate bird and turkey buzzards, creatures which are most at ease when on the wing, have extremely light and hollow bones, but comparing one bird with another the paramount importance of a pneumatic skeleton to a bird is not as evident as that of a pneumatic tire to a bicycle.

While it may not be easy to disprove Herr Gätke's assertion that birds sustain themselves in the air by the exercise of some power beyond our own, it is pretty safe to assume that they do not, and it would seem that the burden of proof should lie with those who take the affirmative side of the question.

If we have nothing to learn from birds in the way of building an engine that shall exert great power for its size and weight we may still have something to gain in the matter of speed, although here the popular idea is apt to be exaggerated. We often read that ducks fly at the rate of a mile a minute, or that the swallow has a speed of two hundred miles an hour, but it is very difficult to lay hands upon any facts that will sustain these assertions.

So, too, homing pigeons are frequently stated to have travelled for long distances at the rate of sixty miles an hour, but some of the published records show that one hundred and twenty miles in two hours and a quarter is unusually fast traveling, and this is at the rate of only nine-tenths of a mile per minute, a speed not unusual for express trains. However, it may be said that actual observations show that ducks do travel from forty to fifty miles an hour, and any sportsman will readily believe that under some conditions they attain a velocity of a mile and a quarter a minute, although a confession of faith is not a demonstration of an assured fact.

So far the lesson taught by the bird is that a machine of low power may attain a very considerable speed and it remains to be seen if there is anything to be learned concerning methods of flight. Broadly speaking, there are two, possibly three, distinct modes of flight, by repeated strokes of the wings and by soaring or sailing, although we find every intermediate stage between the two, or combinations of flapping and sailing, and as a matter of fact no bird can entirely dispense with strokes of the wing.

The humming-bird represents the perfection of one method, the frigate bird of the other, and in his own line each is unrivaled. These two modes of flight are associated with equally distinct modifications of structure, and just as we have every intermediate state of flight between flapping and soaring so the two structural extremes are merged into one another. The humming-bird flies as the Irishman played the fiddle, by main strength, the frigate bird relies on his skill in taking advantage of every varying current of air, and the skeleton of the one indicates great muscular power while that of the other shows its absence. No other bird has such proportionately great muscles as the humming-bird, the keel of the sternum or breast bone from which these muscles arise runs from one end of the body to the other while at the same time it projects downward like the keel of a modern racing yacht. These muscles drive at the rate of several hundred strokes a minute a pair of small, rigid wings, the outermost bones of which are very long while the innermost are very short, a feature calculated to give the greatest amount of motion at the tip of the wing with the least movement of the bones of the upper arm, to which the driving muscles are attached. Another peculiar feature is that the outermost feathers, the flight feathers or primaries, are long and strong, while the innermost, those attached to the forearm, are few and weak; so far as flight is concerned the bird could dispense with these secondaries and not feel their loss. Finally the heart, which we may look upon as the boiler that supplies steam for this machinery, is large and powerful, as is necessary for such a high-pressure engine as the little humming-bird. It is hardly to him that we would look for aid in constructing a flying machine, the expenditure of force is too great for the results attained, the space required for boiler and engine leaves no room for carrying freight.

As just intimated the frigate bird is exactly the reverse of his tiny relative; the body is a mere appendage to a pair of wings, while the breast muscles are so small as to show at a glance that of all flying creatures the frigate bird is the one which has most successfully solved the problem of the conservation of energy and can obtain the greatest amount of power with the least expenditure of muscle.

There is also a great difference between the hummer and the frigate bird, or between flapping and sailing birds generally, in the complexity of what may be termed the muscles of adjustment, the little muscles that run from the shoulder to the elbow and forearm and, among other duties, are concerned in keeping free from wrinkles that portion of the wing which lies between the shoulder and the wrist, forming a triangular flap with the base forming the front edge of the wing and the apex lying in the elbow joint.

The wing of the frigate bird, too, is quite the opposite of that of the hummer, for it is the inner portion of the wing, the upper arm and forearm, which is elongated, and instead of the six feeble secondaries of the humming-bird there are no less than twenty-four; instead of a short, stiff, rounded wing we have one that is long, flexible and pointed. Instead of a wing driven at the rate of several hundred strokes a minute there is a wing that may be held outstretched and apparently motionless for minutes at a time, the muscles of the frigate bird being almost as constantly in repose as those of the other are perpetually in motion.

If the frigate bird represents the highest type of soaring flight two more familiar birds, the turkey buzzard and albatross, are not far behind, and these represent two methods of sailing flight and two distinct modifications in the type of wings. The albatross is continually on the move, ever quartering the water as a well-trained setter does the ground, and yet with all this movement rarely mounting higher than fifty feet above the water and never wheeling in great circles in mid-air. This bird has that type of wing which best fulfills the conditions necessary for an aeroplane, being long and narrow, so that while a fully grown albatross may spread from ten to twelve feet from tip to tip, this wing is not more than nine inches wide. This spread of wing, like that of the frigate bird, is gained by the elongation of the inner bones of the wing and by increasing the number of secondaries, there being about forty of these feathers in the wing of the albatross.

The turkey buzzard is emphatically a high flyer, wheeling slowly about, half a mile or a mile above the earth, while his cousin, the condor, so Humboldt tells us, has been seen above the summit of Chimborazo. If any bird knows how to utilize every breath of wind to the utmost that bird is the albatross, and it is equally a delight and a marvel to see this bird apparently setting at naught all natural laws as he sails with outstretched pinions almost into the eye of the wind or hangs just off the lee quarter of a ship reeling off ten or twelve knots an hour. In this last trick, however, the gull is almost equally expert, evidently making use of the draft from the sails as well as of the eddies caused by the passage of the vessel.

It has long been evident that if man is to navigate the air it must be done after the method of the albatross rather than that of the humming-bird, by the aeroplane and not by any device to imitate the strokes of a bird's wings, for not only do the largest birds and those of the longest flight for the most part sail or soar, but it is apparent that the limit of size in a vibrating wing must soon be reached, since in a strong wind with its varying eddies it would be quite out of the question to manipulate such a piece of mechanism.

But in spite of the fact that sailing flight calls for the exercise of comparatively little muscular power, the structure of the skeleton suggests that the wing of a soaring or sailing bird needs a particularly strong point of support, for birds which sail or soar have the bones which sustain the direct pull of the wing strengthened or braced as other birds do not. The shoulder joint of a bird is formed by the shoulder blade and coracoid, this last being the bone which is attached to the breast bone and on which comes the direct pull of the wing, and in front of the coracoids, running downwards towards the sternum, is the wishbone or furcula, corresponding to our collar bones or clavicles. It is evident that the greater the length of the coracoid the less able would it be to resist the strain brought upon it, and it is also evident that the simultaneous downward stroke of the wings must have a tendency to force the coracoids inwards, or towards one another. Obviously the greater the strain the greater the need of strengthening or bracing the coracoid to resist it, and there are in the shoulder girdle of a bird various devices looking towards this end. In some birds, the albatross, for example, the coracoid is short and stout, while in others extra bracing is obtained from the wishbone.

In the humming-bird the wishbone is light and weak and so short that it does not come near the sternum; the pigeon, a bird of powerful flight, is little better off, for the wishbone is so long and slender that it does little or nothing towards strengthening the shoulder joint, and in both these birds which fly by rapid wing strokes the entire pull of the wing is taken by the coracoid. In the frigate bird, on the contrary, the wishbone is not only strong, but it rests upon and is firmly soldered to the breastbone, while at its upper end it fuses with the coracoid, thus making the firmest possible support to the wing. The cranes, which soar well, also have the wishbone united with sternum, and in the albatrosses and petrels the wishbone touches the breastbone and is so curved forward as to gain strength in this way while, as previously noted, the strength of the coracoid is increased by its shortness. The turkey buzzard and birds of prey, some of which both soar and flap, have the wishbone strengthened by having more material added to make the furcula thick and strong while at the same time it is shaped like a wide U instead of a V.

Either there is more force exerted in sailing than is at first sight apparent or else extra strength is called for in making sudden turns, or when it becomes necessary, as it does more or less frequently, to take a sudden wing stroke. As wings are levers of the third order the longer the wing the more force is required to move it and more strength is needed at the fulcrum or shoulder joint, and since sailing birds have long wings the need of strength is evident.

Neither birds nor any creatures that live or have lived afford us any criterion as to the limit of size that must be placed on an aeroplane. The largest of whales is weak and insignificant beside an ocean liner, and the condor and albatross, with their spread of ten or twelve feet and weight of ten to twenty pounds, tell us nothing of what may be the possibilities of size and weight.

Among the various problems confronting the would-be navigator of the air is that of at times making headway against a medium moving at the rate of ten, twenty, or thirty miles an hour, sometimes even more, a difficulty that neither locomotive nor steamer is called upon to meet. True, an aeroplane would, to use a technical term, probably lie within two and one-half points of the wind and could thus advantageously beat to windward, but any deviation from a straight course means loss of time, and nowadays time is everything.

The mode of propulsion may be, undoubtedly will be, as entirely different from a wing as the propeller is unlike the tail of a fish, and as the study of fish has thrown little or no light on the problems of the proper form or best motor for a ship, it is doubtful if the study of birds will do more for the aerodrome. Nor does it seem likely that a study of the bird will suggest any new devices in the way of joints, braces, or rudders, for what must be discouraging to those engaged in solving the problems of flight is the utter inadequacy of the bird's wing, from a mechanical standpoint, for the work it is called upon to do, for in all its articulations there is a freedom of movement, an amount of play that would be inadmissible in any machine. The shoulder, elbow and wrist joints are but loose affairs, depending for their efficiency on the pull of the muscles; subtract the element of life from the wing of a bird and it becomes at once limp and useless. And herein is the key to the bird's success as a flying machine; it has *life*, and while the wing may reveal certain principles of balancing, it cannot teach us all the art, for it is done instinctively. The bird has back of it untold ages of experience and its actions during flight demand no thought; the muscles respond instinctively to each change in the pressure and direction of the wind, and the bird need take no thought as to how it shall fly.

Mr. Chanute has taken the greatest step yet made towards overcoming the difficulty of responding to changes in the velocity of the fickle air, but whether or not it will be possible to construct apparatus that will not only adjust itself to changes in the force of the wind, but to eddies and changes in direction as well, remains to be seen, the more that it must act not on planes six feet in length, but on surfaces infinitely larger. The proper method of constructing the wings of an aeroplane so as to insure stability and utilize the power of the wind to the best advantage, and some hints as to balancing and steering are the main assistance that we seem likely to gain from a study of the structure and flight of birds.

ELECTRIC AUTOMOBILES.

BY WM. BAXTER, JR.

AS electricity has been so successful in the street railway, where it has superseded all other forms of motive power, it might naturally be supposed that it would do equally well in the automobile; but when the difference in the conditions is taken into consideration it will be found that such a conclusion is not justified. In the street railway systems the cars run continuously over the same route, and on that account the electric current required to operate the motors can be conveyed to them from a central power station by means of wires. With the automobile the case is very different; the vehicle has no fixed course, but is required to go everywhere, and the current must be supplied from a source carried by it. If primary batteries could be made so as to furnish electric currents at a low cost, then the electric carriage would be in the same position as those operated by steam or gasoline, and it could go wherever the proper chemicals to renew the battery could be obtained. But as there are no such primary batteries, the only way in which the current can be supplied is by the use of storage batteries, and these cannot give out any more energy than is put into them, and in practice cannot give quite as much. Thus if the capacity of the battery is sufficient to run the vehicle forty miles when this distance has been traversed the propelling power will be exhausted, and the batteries will have to be recharged before the carriage can go any further. If the recharging could be done in a few minutes, the storage battery would be as good as a primary battery that would generate electricity economically; but as it requires three or more hours, the electrical vehicle cannot be used for long runs, unless the user is willing to make long stops each time the battery has to be recharged. Even then an electric vehicle could not go everywhere, for it would be compelled to follow routes along which facilities for recharging the batteries could be found. From this fact it can be seen that the electric automobile carriage cannot cover the same field as the steam or the gasoline (in the present state of electrical development). Within the limits to which it is applicable, however, it can perform its work in the most satisfactory manner, and, in fact, no possible objection can be raised against it. Its operation is noiseless and vibration of the vehicle is impossible. There is no heat to inconvenience the passengers, no disagreeable smell, no escaping steam. Any desired speed can be obtained, although, of course, a heavy delivery wagon cannot be used also as a racer. The power can be made sufficient to propel any desired load up any grade, including grades far steeper than any to be encountered on streets or highways.

The only point in which the electric vehicle suffers in comparison with the others is in the weight. The capacity of a storage battery is proportional to its weight, and if it is made light, the power derived from it will be small or the time during which it is furnished will be short. To furnish one horse power for one hour requires about one hundred pounds of battery, so that if the average consumption of energy is at the rate of two horse power, one thousand pounds of bat-

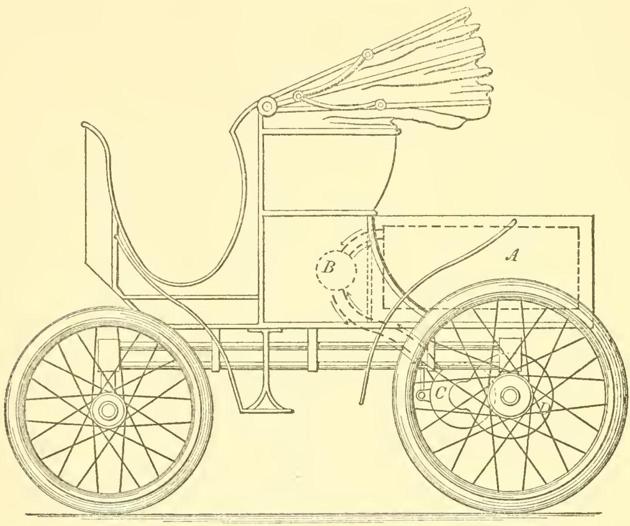

Fig. 1. General Arrangement of an Electric Carriage.

tery will keep the vehicle in motion for five hours. The weight of batteries used in automobiles ranges from four or five hundred to about two thousand pounds, and the distance traversed without recharging varies from twenty-five to ninety miles, so that the radius of action of electric vehicles can be said to vary from about twelve to forty-five miles from the charging station.

The general arrangement of an electric carriage can be understood from Fig. 1. The rectangle shown in broken lines at *A* represents the storage battery. The circle *B* under the seat represents the controlling switch. The motor is at *C* and imparts motion to the axle or wheels through the gearing contained in the casing *D*. When the carriage is stopped the controller B is turned into such a position that all electrical connections between the battery and the motor C are broken. To start the vehicle the controller B is turned so as to make the necessary electrical connections between the battery A and the motor C, and then the electric current passes from the battery through the controlling switch to the motor, and thence back to the controller and the battery. The heavy broken lines indicate the path of the current and the arrows show the direction. The velocity of the motor and the speed of the carriage are varied by varying the strength of the current, and this is effected by the movement of the controlling switch B. There are many ways in which the movement of this switch can vary the strength of the current, but an explanation of any one of them would be dry and rather technical; hence it is sufficient to say that whatever the arrangement of the connections of the controller with the other parts of the system, their relation is such that by the movement of the switch handle the speed of the motor is changed from zero to the maximum velocity.

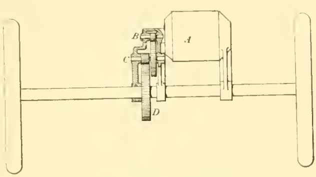

FIG. 2. DOUBLE REDUCTION.

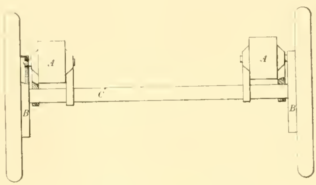

FIG. 3. SINGLE REDUCTION.

In the majority of American vehicles the motion of the motor is transmitted to the wheels by means of spur gearing. In some cases a single motor is used, in others two; and in one or two designs that have come to public notice, four motors are employed, one for each wheel of the carriage. Fig. 2 illustrates what is commonly called a double reduction gear for single motor equipment. The outline A represents the motor, B being the shaft. Upon this shaft is mounted a small pinion which meshes into a larger wheel on the intermediate shaft C. This shaft carries a pinion which meshes into the wheel D mounted upon the axle of the vehicle.

Fig. 3 illustrates a single reduction double motor equipment, the motors being located at AA. In this arrangement the pinion on the end of the motor shaft meshes directly into a large gear secured to the carriage wheel, thus dispensing with the intermediate shaft C of the previous figure. The single reduction gear is the more simple in construction, but the motors run at a lower velocity, and on that account must be larger for the same capacity. With the double motor construction each wheel is driven independently and the axle *C*, in Fig. 3, remains stationary, as in any ordinary vehicle; but in a single motor equipment, arranged as in Fig. 2, the wheels are fastened to the axle and the latter rotates. When a carriage runs round a short curve the outer wheels will revolve faster than the inner ones, if free to move independently, as in Fig. 3. If they are rigidly attached to the axle, as in Fig. 2, one or the other will have to slide over the ground, and this is decidedly objectionable with rubber tires. To prevent this slipping of the wheels in rounding curves, the axles, in designs following the construction of Fig. 2, are made in two parts, and the gear *D* is arranged so as to drive the two halves, imparting to each one the proper velocity. Gear wheels of this kind are called compensating gears; they are made in many designs, but the most common form is that illustrated in Fig. 4. In this drawing *A* is the gear *D* of Fig. 2, and *BB*

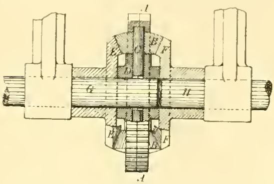

FIG. 4. COMPENSATING GEARS.

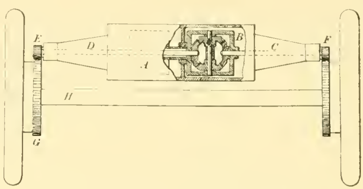

FIG. 5. SINGLE MOTOR EQUIPMENTS.

are bevel gears which are mounted upon studs *C*, which are virtually the spokes of wheel *AA*. Large bevel gears *E* and *F* are placed on either side of *A E*, being secured to *G*, which is one-half of the axle, and *F* and *H*, which is the other half. If the carriage is running in a straight line, the two parts of the axle *G* and *H* will revolve at the same velocity and the gears *BB* will not revolve around the studs *C*, but in rounding a curve one of the halves of the axle will revolve faster than the other and then the gears *B* will rotate round the studs *C*. The compensating gear is not a feature peculiar to electric vehicles; it is used on all kinds of automobiles when the construction is such as to require it.

If a compensating gear is placed upon the axle the latter, instead of supporting its end of the vehicle, will itself have to be supported, for as it is cut in two at the center, it has no supporting strength. By placing the compensating gear on another shaft this difficulty can be overcome. Fig. 5 shows the construction used by the Columbia Company in its single motor equipment. In this arrangement the motor casing is made of sufficient length to reach from one side of the vehicle to the other. The armature and field magnets of the motor, which are the parts that develop the power, are located at *A* and the compensating gear is placed at B. The motor armature is mounted upon a hollow shaft, which is connected with the compensating gear. The shafts D

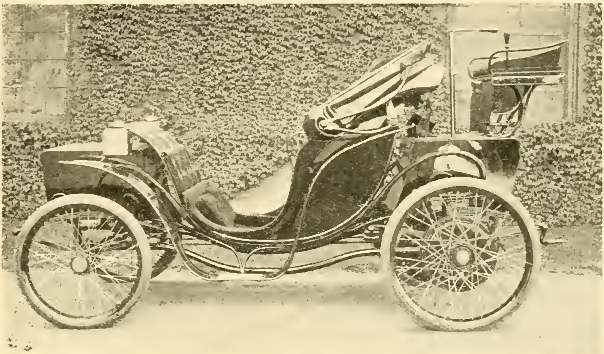

FIG. 6. A COLUMBIA VICTORIA.

and C, upon which are mounted the pinions E and F, are turned by the side wheels of the compensating gear, and therefore will run at such velocities as the motion of the carriage wheels may require.

Fig. 6 shows a Columbia victoria provided with a single motor equip-

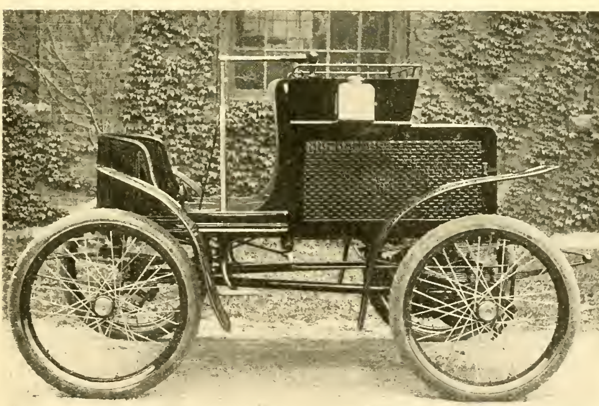

FIG. 7. COLUMBIA VEHICLE WITH DOUBLE MOTOR EQUIPMENT.

ment arranged in accordance with the diagram, Fig. 5. Fig 7 shows another Columbia vehicle in which a double motor equipment is employed. The position of the motor, with reference to the carriage wheel, in the single motor design, is shown in Fig. 8. The gear attached to the carriage wheel is used also as a brake wheel, a friction band being located so as to bear against the periphery, while the pinion on the end of the motor shaft meshes into teeth on the inner side of the rim. This single motor design is also used in the omnibus made by the Columbia Company, a number of which are now in regular service on Fifth avenue, New York. These omnibuses, which are illustrated in Fig. 9, seat eight passengers, and are able to carry as many as are willing to crowd into them. One feature of the electric motor

Fig. 8. Position of Motor in the Single Motor Design.

which fits it admirably for automobile service is the fact that for a short time it can put forth an effort far greater than its normal capacity, and it can do this at all times, without any special preparation. Owing to this feature it is practically impossible to stall the vehicle. If the wheels run into a rut or sink into a mud hole, the motor will be able to turn them around, and if they do not slip the carriage will be moved ahead.

The management of the vehicle is exceedingly simple and entirely free from care, the driver having nothing to tax his mind but the steering lever and the handle of the controlling switch. As the moving parts all have a rotatory motion and are perfectly balanced, there is no possibility of vibration, and there is an entire absence of heat or disagreeable odors.

Any one who has observed the action of a two-horse team will have noticed that, unless the pavement is very smooth, the tongue continually swings from side to side, and occasionally with a considerable amount of violence. It will be evident from this fact that if the front axle of an automobile were the same as that of a horse vehicle, the driver would have an unpleasant task, to say the least, in holding the steering lever in position, and should one of the wheels drop into a rut, the handle would be jerked violently out of his hand and the vehicle would sheer off to one side, possibly with serious results. To avoid this difficulty the front wheels of horseless carriages are arranged so as to swing round on a center close to the hub, if not actually within it. The most common construction is illustrated in Fig. 10, the first being a

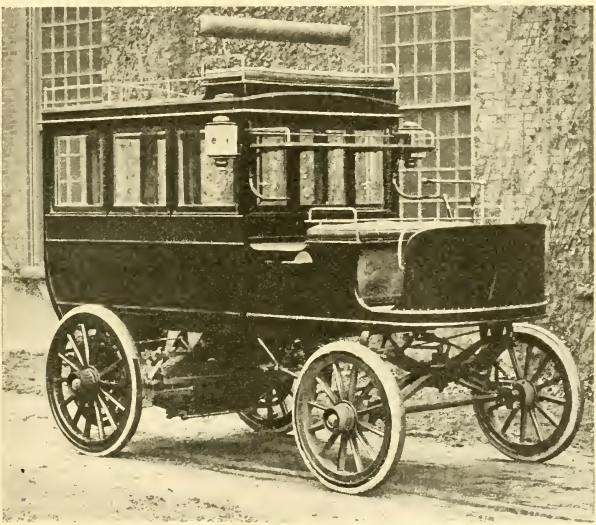

Fig. 9. A Columbia Omnibus.

view of the axle and wheels as seen from the front, and the second a view from above. On the left-hand side of Fig. 10, *A* is the axle proper, and *BB* are the portions upon which the wheels are placed. The central part *A* is held rigidly to the body of the vehicle or to the truck which carries it, and the ends *BB* are swung round the studs *PP* in a manner more clearly indicated on the right-hand side. Here the levers *CC* are shown, and these extend from the side of *BB*. The right-angle lever *E* is connected with the steering lever *G* by means of rod *F*, hence, when *G* is moved, rod *D* moves, and thus levers *CC* are rotated round the studs *PP*, and in that way the supporting studs *BB* which carry the wheels are turned. As the studs *PP* are not exactly in line with the plane passing through the center of the rim of the wheel, there is a slight tendency to jerk the steering handle round when

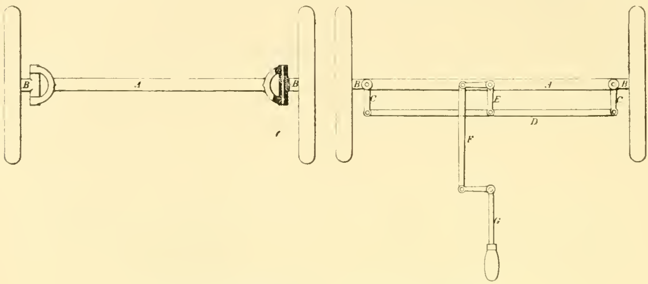

FIG. 10. ARRANGEMENT OF AXLES AND WHEELS.

a wheel drops into a hole in the pavement, but the leverage of *B* being very short, this tendency is so small as to be hardly noticeable.

Fig. 10 illustrates the general principle upon which the front axle is designed, but the construction of the swivel joints *P* is far more elaborate, as can be seen from Fig. 11, which illustrates the actual design employed in the vehicles just described. Looking at Fig 9, it will be noticed that the front axle consists of two bars, one of which runs

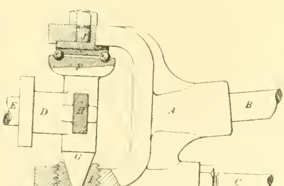

FIG. 11. FRONT AXLE.

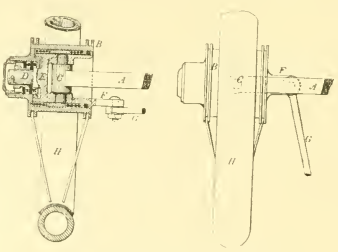

FIG. 12. FRONT AXLE WHEELS.

in a straight line from side to side, while the other is curved with the convex side upward. In Fig. 11 *B* is the end of the upper curved rod and *C* is the lower straight one. These two rods are secured into the casting *A*, which holds the part *D* upon which the wheel is carried, *D* being the part *B* at the left side of Fig. 10. The end *E* which is broken off in the drawing extends through the hub of the wheel and is provided with ball bearings so as to run without friction. The upper end *F*, of *D*, is arranged so as to be held by a ball bearing, as shown, against the end of *J*. By means of an adjusting screw *I* at the lower end, the parts are brought into proper position with reference to each other. The shaded portion *H* is the lever *C* at the right side of Fig. 10.

The left-hand end of Fig. 12 shows a design for front axle wheels which is one of the many modifications of the general arrangement just described. In this construction the wheel swings round the stud *C*, which is placed within the hub, and in a line, or nearly so, with the center of the rim. The rod *A* is the axle and *F* is the lever extending from the inner part of the wheel hub by means of which the steering is effected. The left-hand side of Fig. 12 is a view as seen from the front and the right-hand side shows the device as seen from above. In this last drawing it will be observed that as the lever *F* is attached to the inner portion of the wheel hub, if it is moved to one side or the other of axle *A*, by pulling or pushing on rod *G*, the wheel will be swung round. The advantage of designs of this type is that there is no strain whatever brought to bear upon the steering handle, and the

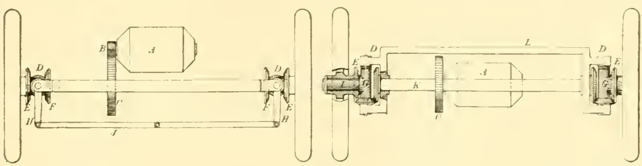

Fig. 13. Constructions Showing Power Applied to Front Wheels.

objection is that the wheel hub is made much larger and the whole construction is somewhat more complicated.

The arrangement of the front axle, so as to swing the wheels round a center close to the hub or within it, as described in the foregoing paragraphs, is used on all types of automobiles and is not a distinguishing feature of the electric carriage. In some of the lighter vehicles the front wheels are held in forks of a design substantially the same as that of the front wheel of the ordinary bicycle, the tops of the forks being connected with each other by means of a rod, as in the lower part of Fig. 10, so as to obtain simultaneous movement of the two wheels by the movement of a single steering handle.

In the majority of electric vehicles the power is applied to the rear axle, but some are made with the motors geared to the front axle. In a few of these designs the wheels and axle are made the same as in an ordinary carriage, so as to swing round a pivot or king bolt located at the center of the axle and reinforced by a fifth wheel. When this construction is used the steering gear is made so as to hold the axle in position more firmly than in the other designs; but even with this assistance the driver has a harder task than with the independently swinging wheels. The advantage derived from swinging the whole axle is that the carriage can be turned round in a very small space, and on that account the construction is well adapted to cabs.

Several arrangements have been devised by means of which the power can be applied to the front wheels, while these may at the same time swing round independent centers. One of these constructions is illustrated in Fig. 13, the first drawing presenting the appearance when seen from above, the second being a view from the front. In the first diagram the motor is shown at *A*, and by means of pinion *B* and gear *C*, motion is transmitted to the axle, which is shown more clearly in the right-hand figure. On the ends of the axle are bevel gears *FF*,

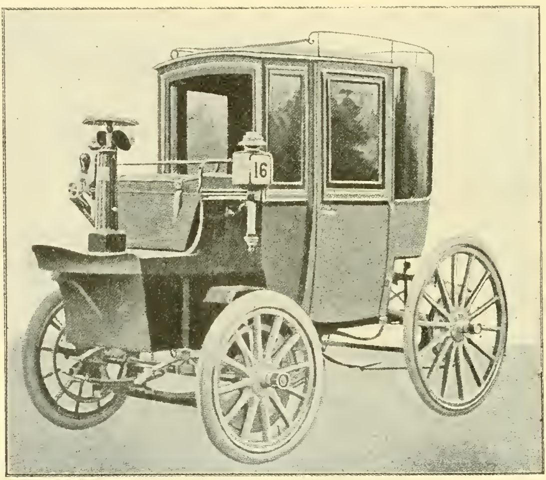

Fig. 14. Krieger Coupé.

and these mesh into other bevel gears which revolve round the vertical studs *D*. Through this train of gearing the bevel wheels *E* are driven, and these are attached to the hubs of the carriage wheels. From the first diagram of Fig. 13 it can be seen at once that the gears *EE* can swing round *D* in either direction without in any way interfering with the transmission of motion from gears *FF*. The levers *HH* are secured to the sleeves *GG* which swing round the studs *DD*, hence, by connecting these with the rod *J* and moving the latter to one side or the other by means of the steering handle, the wheels are turned in any direction desired.

While this construction renders the carriage as easy to steer as those in which the motors are connected with the rear axle, it sacrifices the advantage derived from applying the power to the front wheels, namely, the ability to turn round in a small space.

Another design for driving the front wheels which allows them to swing round independent pivots, is shown in Fig. 14, which is a coupé made by Krieger in France. The power is supplied by two motors, one being mounted on each swivel point. The construction can be understood by considering that in the lower part of Fig. 13 the motor would be secured to a suitable support at the end of the frame *L*, being held in such a position that the shaft would replace pivot *D* and a pinion mounted thereon would gear into wheel *E*. What the advantage of this construction may be, the writer is not able to point out; it certainly

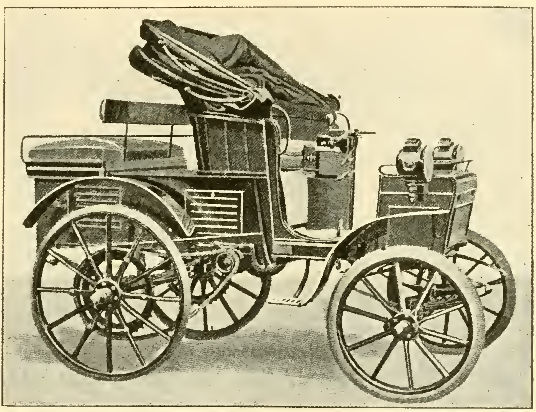

FIG. 15. JENATZY DOG-PHAETON.

shows, however, that there are many ways in which the object sought may be acomplished.

American manufacturers of electric vehicles, at least the great majority of them, resort to spur-gearing to transmit the motion of the motor to the driving wheels, but with the French designers the chain and sprocket appears to be in great favor. Fig. 15 shows a Jenatzy vehicle (French), in which the chain is used. This construction would not be received with favor by Americans, who as a rule desire to have the mechanical part of the apparatus hidden from view as much as possible. In the Jenatzy vehicle two chain gears are used, one on each side of the body, and from the engineering point of view this is the most desirable arrangement, as with it the driving wheels are independently operated and a compensating gear need not be placed upon the axle. The American designer, however, would in most cases be controlled more by the artistic appearance and would use a single chain which would be placed under the body of the carriage, and thus as much out of sight as possible.

Fig. 16 shows an English design of electric dog cart. The mechanism consists of a single motor which is connected with the axle by means of spur gearing, this being so arranged that several different speeds can be obtained for the vehicle with the same velocity for the motor. To obtain variable speeds by means of gearing it is necessary to introduce a considerable amount of complication, and in this country the opinion

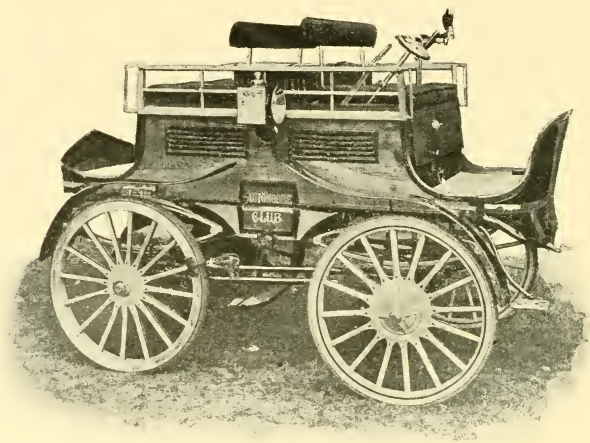

FIG. 16. THE ELECTRIC MOTIVE POWER COMPANY'S DOG CART.

of most designers appears to be that the gain effected thereby is not sufficient to compensate for the increased complication, and differential speed gearing is not often used.

A comparison of Figs 14 and 16 with 6 and 9 will clearly show that in so far as artistic effect is concerned, our manufacturers of electric vehicles have little to learn from Europeans, although the industry here is much younger than abroad. As to the operative merits, all that can be said is that the American carriages run so well and possess such endurance that it is probable that they are not second to any in these respects.

THE HUMAN BODY AS AN ENGINE.

BY PROFESSOR E. B. ROSA.

THERE is no more interesting subject for scientific investigation than the structure and operation, the anatomy and physiology of the human body. That it is an amazingly complex and delicate mechanism, performing a multitude of functions in a wonderfully perfect manner, is, of course, an old story. That in the assimilation of its nourishment and in the growth and repair of its tissue the body obeys the laws of chemistry has long been understood. But that the body obeys in everything the fundamental law of physics, namely, the law of the conservation of energy, has not been so generally recognized. For some years the writer was engaged in some investigations upon this subject.[1] The development of the complex apparatus and unique methods of the research required years of patient labor and study. One of the features of the apparatus was an air-tight chamber, in which a man, as the subject of the experiment, could be confined for any desired period, eating, sleeping, working and living while under minute observation. The experiments usually continued four or five days, but were sometimes prolonged to eight or ten days, and the observations were made and recorded day and night continuously for the entire period.

The atmosphere within the chamber was maintained sufficiently pure to make a prolonged sojourn within its walls entirely comfortable. A current of fresh air, displacing as it entered an equal quantity of air which contained the products of respiration, was maintained continuously. The respired air was analyzed and measured, and the products of respiration from lungs and skin accurately determined. The ventilating air current was maintained by a pair of measuring air pumps, driven by an electric motor. The air was dried, both before entering and after leaving the chamber by freezing out its moisture. This was done by passing it through a refrigerator where its temperature was reduced far below the freezing point. The refrigerator was operated by an ammonia machine, driven by an electric motor. The quantity of air was automatically recorded by the pumps.

The chamber was so constructed and fitted with electrical and other devices as to afford the means of measuring the quantity of heat which the subject of the experiment gave off from his body. And in order to keep the temperature of the room constant this heat was absorbed and carried away by a stream of cold water, the latter flowing through a

[1] The work was done at Wesleyan University, in collaboration with Prof. W. O. Atwater, under the patronage of the University and the U. S. Department of Agriculture.

series of copper pipes within the chamber, and coming out considerably warmer than it entered. So delicate were the regulating devices that the temperature could be maintained constant, hour after hour, to within one or two hundredths of a degree. In some cases the man under investigation worked regularly eight hours a day, the work done being measured by apparatus designed for the purpose.

Food and drink were passed into the chamber three times a day through an air-tight trap. Both were accurately weighed, their temperature recorded and samples reserved for chemical analysis. Solid and liquid excreta were likewise weighed and analyzed. The observations, analyses and computations of a single experiment thus involved a vast amount of labor and expense, which was only justified by the importance of the question under investigation. In order to be able to understand just what this question is, let us see what is meant by the conservation of matter and energy in the physical world.

The impossibility of creating or destroying matter is very generally recognized. Its forms or properties may be altered, chemical and physical changes may be effected, it may, indeed, vanish from sight, but its quantity remains unchanged. Thus ice may turn to water and water to invisible steam, but the total quantity or mass of the substance remains constant; and if by refrigeration the steam be brought to the condition of ice again, there will be precisely the same amount as before. These are physical changes and are easily effected. We simply apply heat to melt the ice and then more heat to vaporize the water. Conversely, withdrawing heat will condense the vapor to water, when a further subtraction of heat will change the water into ice.

Again, wood disappears when burned and seems to be destroyed. And yet we know that the weight of the resulting smoke and ashes is exactly equal to that of the wood. The matter has been changed in form and composition, but its mass cannot be altered. It is not so easy to bring the smoke and ashes into combination again and so restore the matter to its original form as in the case of ice and steam. But this is done by nature. Ashes go to the soil, smoke into the atmosphere. The forces of nature bring these elements together again in plant and tree, and so it comes about that the materials resulting from the burning of wood again become wood, and over and over again the cycle is repeated as time rolls on. Many other examples might be cited to show what is meant by the indestructibility of matter, or the conservation of matter; but these will suffice to show that the one essential fact is that the matter or stuff of a body cannot be destroyed.

Although matter is protean and its transformations limitless, there are certain changes which cannot be made. Iron cannot be turned into silver, nor silver into gold, nor oxygen into nitrogen. There appear to be indeed about seventy or eighty distinct kinds of matter, and so far as we know one cannot be converted into another. They may be united in countless combinations, but each is itself not only indestructible but unchangeable. Why this is so is an interesting subject of speculation. We do not positively know.

That energy is also something which cannot be created or destroyed is not so generally recognized. Transformations of energy from one form to another are constantly occurring before our very eyes; and yet we seldom stop to think what the conservation of energy means in any given case. Energy itself is often defined as that which has the capacity for doing work, and work is done when force or resistance is overcome. A hod carrier does work when, overcoming the force of gravity upon his body and his hod of brick, he climbs to the top of a ladder; and the work done is a measure of the energy expended. Energy stored up in his body has been transferred to the brick in their elevated position, and if they are allowed to fall to the ground their energy is turned into heat, developed by their impact upon the ground. Again, work is done by a windmill in pumping water up into an elevated reservoir, and the so-called 'potential' energy which the water possesses in its elevated position has all been transferred to the water from the wind which drove the mill. If the water be allowed to flow down to the ground again through a water motor the latter could drive machinery and so do work; and the work it could do plus the heat produced by friction would exactly equal the work done in pumping the water up to its elevated position. Thus is the energy conserved, and not destroyed. More or less of it is dissipated by friction, and lost, so far as useful effect may go. But it all remains in existence, somewhere.

Again, coal is burned under the boiler of a steam engine. Heat is produced, steam is generated, the engine does work. The coal possessed a store of energy, potentially. That is, the coal had the capacity of uniting with the oxygen of the air and setting free a store of energy. This energy, potential or latent in the coal, becomes kinetic and evident in the heat of the boiler and the work of the engine. Moreover, the work done by the engine added to the heat given off by the boiler and engine is exactly equal to the total store of energy possessed by the coal. And if from a store of energy, either in the body of a man or horse, or in a pile of wood or coal, a certain portion is expended in doing work, the amount remaining is exactly the difference between that expended and the original amount. In short, energy can be measured, stored up and expended, just as truly as merchandise or money.

Thus the conservation of energy means that energy cannot be created or destroyed; but it may be transferred from one body to another or transformed from one form to another. Heat may be converted into work and work into heat. The chemical energy of a zinc rod may be expended to generate an electric current, and the latter passing through a coil of wire or the filament of a lamp gives up its energy to produce heat and light. The last form of this energy is equal in quantity to the first.

Niagara represents a vast store of energy. Millions of tons of water falling 160 feet could do a vast amount of mechanical work if properly applied through water wheels. More than 50,000 horse power of useful work is actually derived from Niagara's waters, but this is only a small fraction of the total. The energy is, however, given up in falling, even though no useful work is done. In fact, the water is slightly heated by the impact, and the amount of heat produced is exactly equivalent to the mechanical energy lost by the water.

A cannon ball receives a large amount of kinetic energy from the exploded powder as it leaves the muzzle of a great gun. If it be suddenly stopped by a rigid target its mechanical or mass energy is at once converted into heat; that is, into the vibratory motion of the molecules. Ball and target are highly heated. Indeed, lead bullets are often melted by the heat of impact. Meteors flying through space come into our atmosphere and their speed is checked by its resistance. Part or all of their kinetic energy is thus converted into heat. Both air and meteor are heated; heated to so high a temperature that the meteor becomes brilliantly luminous, and we call it a shooting star. The idea of heat due to frictional resistance is common enough. The *exact equivalence* between the mechanical energy lost and the heat produced is the thing to be especially noticed here.

Let us now take as a final example a locomotive engine. It takes on a store of fuel and water and, directed by its engineer, sets out for a day's duty. The coal to be burned possesses a definite amount of energy. Let us say every pound has one unit of energy, and suppose 5,000 pounds of coal are taken. What becomes of these 5,000 units of energy, appearing as heat when the coal is burned?

1. A large amount of heat is required to keep the boiler and engine hot, due to the loss of heat to the atmosphere. The engine cylinders, as well as fire box and boiler, must be kept very hot; other parts of the engine become more or less heated. All parts therefore continually give off heat, and a large part of the heat produced by the burning coal is thus expended.

2. A second portion is expended in doing work. If our locomotive hauls a 500-ton train up a one-per cent. grade for 100 miles it would be doing 2,640,000 foot-tons of work in addition to that required to overcome the friction of the rails and the resistance of the atmosphere. This would require nearly 500 units of energy which would come from the heat of the coal. The work is done through the agency of steam, but the energy of the steam comes from the burning coal. A small amount of work is also done in pumping water from the tank on the

tender into the boiler and in pumping air into the reservoir for the use of the air brakes. This may be called the internal work of the engine. A second portion of the heat is therefore expended in internal and external work.

3. The steam after expanding in the cylinders of the engine escapes into the atmosphere. Although it has been cooled somewhat by expansion, it is still hot, and carries a large amount of heat away with it. Moreover, the smoke and hot air which pass out through the smokestack carry away a large quantity of heat. Hot ashes likewise carry away heat. Hence a third portion of heat is lost through smoke and steam and ashes. And this is the largest portion of the total quantity of heat generated by the burning coal.

When coal is burned, oxygen of the air unites chemically with the carbon and hydrogen of the coal to form carbonic acid, or carbon dioxid, as it is technically called, and water vapor. The incombustible mineral matter of the coal remains as ashes. Hence smeke contains carbonic acid gas and water vapor in addition to fine particles of unburned coal carried away in the draft of air.

When the grade is steep a great deal of work must be done by the locomotive, much steam is required, and the quantity of fuel burned is large in proportion. When the road is level fuel burns less rapidly, and when the train stops, still more slowly. At night the locomotive rests, fires are banked and combustion is very slow. This process so briefly and incompletely sketched, is more interesting as one examines it closer, and a locomotive seems almost living when one considers minutely its wonderful performance.

But interesting and instructive though the operation of the locomotive may be, it is not for its own sake that I have mentioned it. It is rather in order to point out a remarkable parallel between its operation and that of a human body. A parallel, indeed, between the operation of a complex inanimate engine of iron and steel, and a still more complex living engine of flesh and bone and blood; both obeying the law of the conservation of energy, as well as the other laws of physics and chemistry.

Consider now a human body as a living engine. That man is more than matter is, of course, conceded. But we here regard only the animal body, guided by the brain as its engineer. The day begins, as with the locomotive, by taking a store of fuel and water, namely, food and drink. Food is not, however, burned in the body in a confined receptacle, like coal in the fire box of an engine, but is digested, assimilated and distributed through the body by means of the circulating blood. And while some of it goes to repair bodily waste, becoming tissue, other portions are oxidized or burned to produce heat. Nondigestible parts of the food pass away from the body as refuse, like ashes from the fire box of the engine. That the body fat and muscular tissue are also burned, producing heat, is literally true. A hibernating animal keeps his body warm all winter by burning up his autumnal store of body fat. Even a well-fed body is constantly wearing away, or burning away, and hence requires constant repair. Thus we see two distinct functions for food, which should be carefully distinguished.

In the first place, as already indicated, food repairs waste and builds up the body. It makes blood, bone and muscular tissue. Herein we see a departure from the parallel with the steam engine. A locomotive is a machine which runs in a way determined by its builder. But it cannot grow nor repair wear and tear. It requires a whole machine shop plus skilful mechanics to do that. The body, on the other hand, not only runs like a complex mechanism when supplied with energy, but also builds itself up and repairs waste. We express this by saying that it possesses vital force or life, but in just what vital force consists is a matter of speculation and controversy. The raw material which is employed in this work of repairing and building up is found in the food. But not all food can be so utilized. Only those materials which contain nitrogen, the so-called proteids, as lean meat, the casein of milk and gluten of wheat, can be made use of in this most important work of growth and repair.

In the second place, food is the fuel of the body and is just as truly burned as is coal in a furnace. Moreover, the quantity of heat which a piece of meat or a slice of bread yields when burned in the body is just the same as if it had been burned in a stove. Complete combustion yields a definite amount of heat wherever and whatever may be the place and manner of burning. Any kind of food may serve as fuel for the body, but those which consist mainly of sugar, starch and fat, which contain no nitrogen and so cannot build up the body, are used chiefly as fuel. These fuel foods form the bulk of our daily ration, comparatively little being required for purposes of growth and repair.

We are hearing a good deal recently about alcohol as a food. When it is remembered that alcohol contains no nitrogen it will be seen that it cannot serve the first function of food, namely, the purpose of growth and repair. It can, however, serve as fuel food, for when taken into the body in small quantities it is assimilated and burned up, producing the same amount of heat as if burned in a lamp. In sickness this may be beneficial, at times when the body cannot assimilate other foods. But the injurious effects of alcohol upon the digestive and nervous systems are so important and far-reaching that its value as a fuel food sinks into insignificance in comparison.

The process of combustion or burning in the fire box of our locomotive consists, as has been said, in oxygen of the air uniting with the carbon and hydrogen of the coal, forming carbonic acid and water, and setting free a definite quantity of heat for every pound of fuel so burned. So, in exactly the same way, oxygen, which has been taken up by the blood from the air in the lungs, unites with carbon and hydrogen in the tissues of the body and forms carbonic acid and water, yielding precisely the same amount of heat as though the combustion had occurred in a furnace. This idea of food, that it is literally fuel, is a very suggestive one. And as fuels differ in the quantity of ash contained and the amount of heat produced, so food materials differ in the quantity of undigestible residue and in their heat-producing power.

Remembering the analogy of the steam engine, let us now inquire what becomes of the energy supplied to the body in the fuel foods eaten, and which is turned into heat by this process of combustion constantly going on.

1. A large amount of heat is constantly being expended in keeping the body warm. Like the locomotive, the body is warmer than the surrounding air, and is constantly losing heat to the atmosphere. Unlike the locomotive, however, the body has a nearly uniform temperature throughout, namely, 98 degrees Fahr. The delicate regulation of temperature which is automatically maintained in the animal body is one of the wonders of physiology.

2. A second portion of energy is required to do the mechanical work of the body. When a locomotive hauls a loaded train up grade, or steams up grade alone, it is doing work in proportion to the total weight and the height to which it is carried. So when a man walks up hill or climbs a ladder he is lifting his body against the force of gravity, and hence doing work. If his weight be 200 pounds he is doing twice as much work as though he weighed only 100 pounds. If a man weighing 150 pounds climbs Bunker Hill Monument (220 feet), 33,000 foot-pounds of work will then be done; and if he succeeds in making the ascent in one minute, he would be doing work at the rate of one full horse power for that minute. If he climbs a mountain two miles high in three hours and twelve minutes he would be doing work in so lifting his body at the rate of one quarter of a horse power. This is, of course, a faster rate of work than an average man could maintain. In all the functions of daily life the body is necessarily doing some mechanical work. Even dressing and eating require a certain expenditure of energy, and in ordinary business and manual labor the amount of mechanical work done is considerable. Moreover, a large amount of work is done by the heart in pumping the blood through the circulatory system, and by the chest in respiration. This, then, the internal and external work done, as in the locomotive, represents the second portion of energy derived from the food eaten.

3. The warm air, carbonic acid gas and water vapor passing away from the lungs in respiration carry with them a large amount of heat.

This corresponds to the loss of heat in the locomotive through the smoke passing out the smokestack, and in both cases the loss is greater when work is being done and less during inaction. The refuse products of the body (as the ashes of the locomotive) also carry away heat. This is the third portion of heat and is a large one.

Work is done in the locomotive by the expanding steam in the cylinders of the engine. The steam is cooled as it expands. Hence heat disappears when work is done; that is, is converted into mechanical energy, and a steam engine is hence called a heat engine; an engine for converting heat into work, according to the law of the conservation of energy. As the pistons are pushed to and fro by the tremendous pressure of the expanding steam, the reciprocating motion is communicated to the great drivers of the engine by strong arms of steel. But how is work done in the body? That is a question of prime importance and of surpassing interest. When muscle contracts and force is exerted, as when the body is lifted or an oar is pulled, muscular tissue (or material stored in muscular tissue) is oxidized; that is, burned, and heat is produced; yet not as much heat appears as would have appeared on the combustion of the same amount of body material if no work had been done. Apparently, then, heat has been converted into work. But we cannot trace the process with the same clearness as in the cylinder of a steam engine. Whether the potential energy of the body material is directly converted into work, or whether combustion first produces heat and a part of this heat is then converted into work, we do not know. In other words, we do not know whether the animal body as a machine for doing mechanical work is a heat engine or some other kind of engine. This is a fundamental question, as well as a very difficult one, and to a student of thermodynamics and physiology it prompts all sorts of speculation.

When one tries to picture to himself how the potential energy of food or body tissue can be directly converted into mechanical work, he is apt to turn to the other alternative and imagine that in some way the body is a heat engine. For we know that heat results from the oxidation of tissue, and we also know how heat can be converted into mechanical work. But we are at once confronted with a difficulty. One of the fundamental laws of thermodynamics requires that when heat is converted into work there shall be a difference of temperature between the source of heat and the place to which the heated material employed passes after doing the work. In other words, in a heat engine, whatever the mechanism, there must be a fall of temperature, which is greater as the relative amount of work, or efficiency, is greater. In the human body the efficiency perhaps surpasses that of the best steam engines; hence there should be a fall of temperature comparable with that between the boiler and condenser of a steam engine. This may be 100 degrees or more, and we do not know of any such difference of temperature in the body. Indeed, we know, on the contrary, that the temperature of the body is remarkably uniform, as already stated. It is possible, however, that there are molecular differences of large amount. In other words, if we could make an ultra-microscopic survey of temperature in a muscle during contraction, there might be found places of high temperature where combustion was occurring, and all the requirements of a heat engine of molecular dimensions fulfilled. But this is a matter of speculation. The process may yet be found to be electrical, or something else quite different from that of a steam engine.

We thus find between the animal body and a locomotive engine a striking parallel. In many particulars the chemical and physical processes going on in the latter are found also in the former. In both, the fundamental law of the conservation of energy is strictly observed. Nevertheless, the animal body considered simply as a machine is far more complex in its structure and operation than the engine, and far more of mystery envelops its working. Much remains for the chemist and physicist and physiologist to reveal, and no more fascinating field of research exists.

CHAPTERS ON THE STARS.

By Professor SIMON NEWCOMB, U. S. N.

THE SPECTRA OF THE STARS.

THE principles on which spectrum analysis rests can be stated so concisely that I shall set them forth for the special use of such readers as may not be entirely familiar with the subject. Every one knows that when the rays of the sun pass through a triangular prism of glass or other transparent substance they are unequally refracted, and thus separated into rays of different colors. These colors are not distinct, but each runs into the other by insensible gradations, from deep red through orange, yellow, green and blue to a faint violet.

This result is due to the fact that the light of the sun is composed of rays of an infinite number of wave-lengths, or, as we might express it, of an infinite number of shades of color, since to every wave-length corresponds a definite shade. Such a spreading out of elementary colors in the form of a visible sheet is called a spectrum. By the spectrum of an incandescent object is meant the spectrum formed by the light emitted by the object when passed through a refracting prism, or otherwise separated into its elementary colors. The interest and value which attach to the study of spectra arise from the fact that different bodies give different kinds of spectra, according to their constitution, their temperature and the substances of which they are composed. In this manner it is possible, by a study of the spectrum of a body, to reach certain inferences respecting its constitution.

In order that such a study should lead to a definite conclusion, we must recall that to each special shade of color corresponds a definite position in the spectrum. That is to say, there is a special kind of light having a certain wave-length and therefore a certain shade which will be refracted through a certain fixed angle, and will therefore fall into a definite position in the spectrum. This position is, for every possible kind of light, expressed by a number indicating its wave-length.

If we form a spectrum with the light emitted by an ordinary incandescent body, a gaslight for example, we shall find the series of colors to be unbroken from one end of the spectrum to the other. That is to say, there will be light in every part of the spectrum. Such a spectrum is said to be continuous. But if we form the spectrum by means of sunlight, we shall find the spectrum to be crossed by a great number of more or less dark lines. This shows that in the spectrum of the sun light of certain definite wave-lengths is wholly or partly wanting. This fact has been observed for more than a century, but its true significance was not seen until a comparatively recent time.

If, instead of using the light of the sun, we form a spectrum with the light emitted by an incandescent gas, say hydrogen made luminous by the electric spark, we shall find that the spectrum consists only of a limited number of separate bright lines, of various colors. This shows that such a gas, instead of emitting light of all wave-lengths, as an incandescent solid body does, principally emits light of certain definite wave-lengths.

It is also found that if we pass the light of a luminous solid through a sufficiently large mass of gas, cooler than the body, the spectrum, instead of being entirely continuous, will be crossed with dark lines like that of the sun. This shows that light of certain wave-lengths is absorbed by the gas. A comparison of these dark lines with the bright lines emitted by an incandescent gas led Kirchhoff to the discovery of the following fundamental principle:

Every gas, when cold, absorbs the same rays of light which it emits when incandescent.

An immediate inference from this law is that the dark lines seen in the spectrum of the sun are caused by the passage of the light through gases either existing on the sun or forming the atmosphere of the earth. A second inference is that we can determine what these gases are by comparing the position of the dark lines with that of the bright lines produced by different gases when they are made incandescent. Hence arose the possibility of spectrum analysis, a method which has been applied with such success to the study of the heavenly bodies.

So far as the general constitution of bodies is concerned, the canons of spectrum analysis are these:

Firstly, when a spectrum is formed of distinct bright lines, the light which forms it is emitted by a transparent mass of glowing gas.

Secondly, when a spectrum is entirely continuous the light emanates from an incandescent solid, from a body composed of solid particles, which may be ever so small, or from a mass of incandescent gas so large and dense as not to be transparent through and through.

Thirdly, when the spectrum is continuous, except that it is crossed by fine dark lines, the body emitting the light is surrounded by a gas cooler than itself. The chemical constitution of this gas can be determined by the position of the lines.

Fourthly, if, as is frequently the case, a spectrum is composed of an irregular row of bright and shaded portions, the body is a compound one, partly gaseous and partly solid.

It will be seen from the preceding statement that, in reality, a mass of gas so large as not to be transparent cannot be distinguished from a solid. It is therefore not strictly correct to say, as is sometimes done, that an incandescent gas always gives a spectrum of bright lines. It will give such a spectrum only when it is transparent through and through.*

A gaseous mass, so large as to be opaque, would, if it were of the same temperature inside and out, give a continuous spectrum, without any dark lines. But the laws of temperature in such a mass show that it will be cooler at the surface than in the interior. This cooler envelope will absorb the rays emanating from the interior as in the case when the latter is solid. We conclude, therefore, that the fact that the great majority of stars show a spectrum like that of the sun, namely, a continuous one crossed by dark lines, does not throw any light on the question whether the matter composing the body of the star is in a solid, liquid or gaseous state. The fact is that the most plausible theories of the constitution of the sun lead to the conclusion that its interior mass is really gaseous. Only the photosphere may be to a greater or less extent solid or liquid. The dark lines that we see in the solar spectrum are produced by the absorption of a comparatively thin and cool layer of gas resting upon the photosphere. Analogy as well as the general similarity of the spectra lead us to believe that the constitution of most of the stars is similar to that of the sun.

CLASSIFICATION OF STELLAR SPECTRA.

When the spectra of thousands of stars were recorded for study, such a variety was found that some system of classification was necessary. The commencement of such a system was made by Secchi in 1863. It was based on the observed relation between the color of a star and the general character of its spectrum.

Arranging the stars in a regular series, from blue in tint through white to red, it was found that the number and character of the spectral lines varied in a corresponding way. The blue stars, like Sirius, Vega and α Aquilæ, though they had the F lines strong, as well as the two violet lines H, had otherwise only extremely fine lines. On the other hand, the red stars, like α Orionis and α Scorpii, show spectra with several broad bands. Secchi was thus led to recognize three types of spectra, as follows:

The first type is that of the white or slightly blue stars, like Sirius, Vega, Altair, Rigel, etc. The typical spectrum of these stars shows all seven spectral colors, interrupted by four strong, dark lines, one in the

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* As this principle is not universally understood, it may be well to remark that it results immediately from Kirchoff's law of the proportionality between the radiating and absorbing powers of all bodies for light of each separate wave-length. When a body, even if gaseous in form, is of such great size and density that light of no color can pass entirely through it, then the consequent absorption by the body of light of all colors shows that throughout the region where the absorption occurs there must be an emission of light of these same colors. Thus light from all parts of the spectrum will be emitted by the entire mass.

FIG. 1. SPECTRUM OF SIRIUS.

FIG. 2. SPECTRA OF α AURIGÆ AND SUN.

FIG. 3. SPECTRA OF α BOOTIS AND β GEMINORUM.

red, one in the bluish green, and the two others in the violet. All four of these lines belong to hydrogen. Their marked peculiarity is their breadth, which tends to show that the absorbing layer is of considerable thickness or is subjected to a great pressure. Besides these broad rays, fine metallic rays are found in the brighter stars of this type. Secchi considers that this is the most numerous type of all, half the stars which he studied belonging to it.

The second type is that of the somewhat yellow stars, like Capella, Pollux, Arcturus, Procyon, etc. The most striking feature of the spectrum of these stars is its resemblance to that of our sun. Like the latter, it is crossed by very fine and close black rays. It would seem that the more the star inclines toward red, the broader these rays become and the easier it is to distinguish them. We give a figure showing the remarkable agreement between the spectrum of Capella, which may be taken as an example of the type, and that of the sun.

The spectra of the third type, belonging mostly to the red stars, are composed of a double system of nebulous bands and dark lines. The latter are fundamentally the same as in the second type, the broad nebulous bands being an addition to the spectrum. α Herculis may be taken as an example of this type.

It is to be remarked that, in these progressive types, the brilliancy

Fig. 7. Spectrum with both Bright and Dark Lines.

of the more refrangible end of the spectrum continually diminishes relatively to that of the red end. To this is due the gradations of color in the stars.

To these three types Secchi subsequently added a fourth, given by comparatively few stars of a deep red color. The spectra of this class consist principally of three bright bands, which are separated by dark intervals. The brightest is in the green; a very faint one is in the blue; the third is in the yellow and red, and is divided up into a number of others.

To these types a fifth was subsequently added by Wolf and Rayet, of the Paris Observatory. The spectra of this class show a singular mixture of bright lines and dark bands, as if three different spectra were combined, one continuous, one an absorption spectrum, and one an emission spectrum from glowing gas. Less than a hundred stars of this type have been discovered. A very remarkable peculiarity, which we

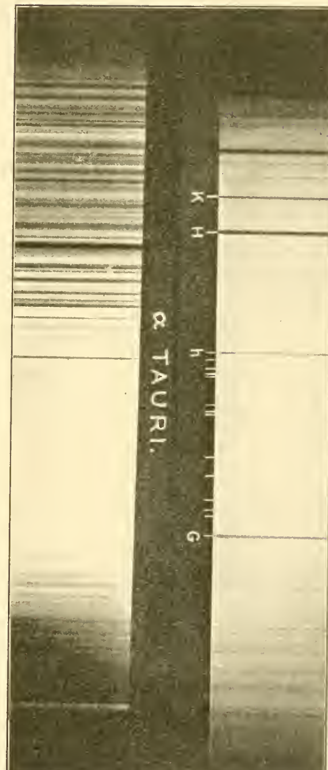

FIG. 4. SPECTRA OF α CYGNI AND α TAURI.

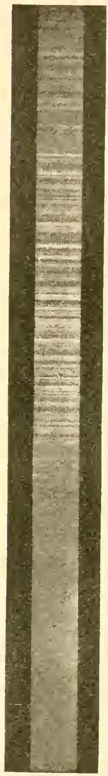

FIG. 5. SPECTRUM OF α ORIONIS.

FIG. 6. SPECTRUM OF γ CASSIOPEIÆ.

shall discuss hereafter, is that they are nearly all situated very near the central line of the Milky Way.

Vogel proposed a modification of Secchi's classification, by subdividing each of his three types into two or three others, and including the Wolf-Rayet stars under the second type. His definitions are as follows:

Type I is distinguished by the intensity of the light in the more refrangible end of the spectrum, the blue and violet. The type may be divided into three subdivisions, designated *a*, *b* and *c*:

In I*a* the metallic lines are very faint, while the hydrogen lines are distinguished by their breadth and strength.

In I*b* the hydrogen lines are wanting.

In I*c* the lines of hydrogen and helium both show as bright lines. Stars showing this spectrum are now known as helium stars.

According to Vogel, the spectra of type II are distinguished by having the metallic lines well-marked and the more refrangible end of the spectrum much fainter than in the case of type I. He recognizes two subdivisions:

In II*a* the metallic lines are very numerous, especially in the yellow and green. The hydrogen lines are strong, but not so striking as in I*a*.

In II*b* are found dark lines, bright lines and faint bands. In this subdivision he includes the Wolf-Rayet stars, more generally classified as of the fifth type.

The distinguishing mark of the third type is that, besides dark lines, there are numerous dark bands in all parts of the spectrum, and the more refrangible end of the latter is almost wanting. There are two subdivisions of this type:

In III*a* the broad bands nearest the violet end are sharp, dark and well-defined, while those near the red end are ill-defined and faint. In III*b* the bands near the red end are sharp and well-defined; those toward the violet faint and ill-defined. The character of the bands is therefore the reverse of that in subdivision *a*.

This classification of Vogel is still generally followed in Germany and elsewhere. It is found, however, that there are star spectra of types intermediate to all these defined. Moreover, in each type the individual differences are so considerable that there is no well-defined limit to the number of classes that may be recognized. At the Harvard Observatory a classification quite different from that of Vogel has been used, but it is too detailed for presentation here. The stars of type II are frequently termed Capellan stars, or Solar stars. Certain stars of type I are termed Orion stars, owing to the number of stars of the type found in that constellation. The stars which show the lines of helium are known as helium stars. We mention these designations because they frequently occur in literature. It would, however, be outside the object of the present work to describe all these classifications in detail. We therefore confine ourselves to a few illustrations of spectra of the familiar types described by Secchi and Vogel.

There are many star spectra which cannot be included in any of the classes we have described. Up to the present time these are generally described as stars of peculiar spectra.

As the present chapter is confined to the more general side of the subject, we shall not attempt any description of special spectra. These, especially the peculiar spectra of the nebulæ, of new stars, of variable stars, etc., will be referred to, so far as necessary, in the chapters relating to those objects.

The most interesting conclusion drawn from observations with the spectroscope is that the stars are composed, in the main, of elements similar to those found in our sun. As the latter contains most of the elements found on the earth and few or none not found there, we may say that earth and stars seem to be all made out of like matter. It is, however, not yet easy to say that no elements unknown on the earth exist in the heavens. It would scarcely be safe to assume that, because the line of some terrestrial substance is found in the spectrum of a star, it is produced by that substance. It is quite possible that an unknown substance might show a line in appreciably the same position as that of some substance known to us. The evidence becomes conclusive only in the case of those elements of which the spectral lines are so numerous that when they all coincide with lines given by a star, there can be no doubt of the identity.

PROPER MOTIONS OF THE STARS.

We may assume that the stars are all in motion. It is true that only a comparatively small number of stars have been actually seen to be in motion; but as some motion exists in nearly every case where observations would permit of its being determined, we may assume the rule to be universal. Moreover, if a star were at rest at one time it would be set in motion by the attraction of other stars.

Statements of the motion from different points of view illustrate in a striking way the vast distance of the stars and the power of modern telescopic research. If Hipparchus or Ptolemy should rise from their sleep of 2,000 years—nay, if the earliest priests of Babylon should come to life again and view the heavens, they would not perceive any change to have taken place in the relative positions of the stars. The general configurations of the constellations would be exactly that to which they were accustomed. Had they been very exact observers they might notice a slight difference in the position of Arcturus; but as a general rule the unchangeability would have been manifest.

In dealing with the subject, the astronomer commonly expresses the motion in angular measurement as so many seconds per year or per century. The keenest eye would not, without telescopic aid, be able to distinguish between two stars whose apparent distance is less than $2'$ or $120''$ of arc. The pair of stars known as (ϵ) Lyræ are $3'$ apart; yet, to ordinary vision they appear simply as a single star. To appreciate what $1''$ of arc means we must conceive that the distance between these two stars is divided by 200. Yet this minute space is easily distinguished and accurately measured by the aid of a telescope of ordinary power.

On the other hand, if we measure the motions by terrestrial standards they are swift indeed. Arcturus has been moving ever since the time of Job at the rate of probably more than 200 miles per second—possibly 300 miles. Generally, however, the motion is much smaller, ranging from an imperceptible quantity up to 5, 10 or 20 miles a second. Slow as the angular motion is, our telescopic power is such that the motion in the course of a very few years (with Arcturus the motion in a few days) can be detected. As accurate determinations of positions of the stars have been made only during a century and a half, no motions can be positively determined except those which would become evident to telescopic vision in that period. Only about 3,000 stars have been accurately observed so long as this. In the large majority of cases the interval of observation is so short or the motion so slow that nothing can be asserted respecting the law of the motion.

The great mass of stars seem to move only a few seconds per century, but there are some whose motions are exceptionally rapid. The general rule is that the brighter stars have the largest proper motions. This is what we should expect, because in the general average they are nearer to us, and therefore their motion will subtend the greatest angle to the eye. But this rule is only one of majorities. As a matter of fact, the stars of largest proper motion happen to be low in the scale of magnitude. It happens thus because the number of stars of smaller magnitudes is so much greater than that of the brighter ones that the very small proportion of large proper motions which they offer over-balances those of the brighter stars.

The discovery of the star of greatest known proper motion was made by Kapteyn, of Groningen, in 1897, coöperating with Gill and Innes, of the Cape Observatory. While examining the photographs of the stars made at this institution, Kapteyn was surprised to notice the impression of a star of the eighth magnitude which at first could not be found in any catalogue. But on comparing different star lists and different photographs it soon became evident that the star had been previously seen or photographed, but always in slightly varying positions. An examination of the observed positions at various times showed that the star had a more rapid proper motion than any other yet known. Yet, great though this motion is, it would require nearly 150,000 years for the star to make a complete circuit of the heavens if it moved round the sun uniformly at its present rate.

The fact that the stars move suggests a very natural analogy to the solar system. In the latter a number of planets revolve round the sun as their center, each planet continually describing the same orbit, while the various planets have different velocities. Around several of the planets revolve one or more satellites. Were civilized men ephemeral, observing the planets and satellites only for a few minutes, these bodies would be described as having proper motions of their own, as we find the stars to have. May it not then be that the stars also form a system; that each star is moving in a fixed orbit performing a revolution around some far-distant center in a period which may be hundreds of thousands or hundreds of millions of years? May it not be that there are systems of stars in which each star revolves around a center of its own while all these systems are in revolution around a single center?

This thought has been entertained by more than one contemplative astronomer. Lambert's magnificent conception of system upon system will be described hereafter. Mädler thought that he had obtained evidence of the revolution of the stars around Alcyone, the brightest of the Pleiades, as a center. But, as the proper motions of the stars are more carefully studied and their motion and direction more exactly ascertained, it becomes very clear that when considered on a large scale these conceptions are never realized in the actual universe as a whole. But there are isolated cases of systems of stars which are shown to be in some way connected by their having a common proper motion. We shall mention some of the more notable cases.

The Pleiades are found to move together with such exactness that up to the present time no difference in their proper motions has been detected. This is true not only of the six stars which we readily see with the naked eye, but of a much larger number of fainter ones made known by the telescope. It is an interesting fact, however, that a few stars apparently within the group do not partake of this motion, from which it may be inferred that they do not belong to the system. But there must be some motion among themselves, else the stars would ultimately fall together by their mutual attraction. The amount and nature of this motion cannot, however, be ascertained except by centuries of observation.

Another example of the same sort is seen in five out of the seven stars of Ursæ Major, or The Dipper. The stars are those lettered β, γ, δ, ε and ϑ. All five have a proper motion in R. A. of nearly $8''$ per century, while in declination the movements are sometimes positive and sometimes negative: that is to say, some of the stars are apparently lessening their distance from the pole, while others are increasing it. But when we project the motions on a map we find that the actual direction is very nearly the same for all five stars, and the reason why some move slightly to the north and others slightly to the south is due to the divergence of the circles of right ascension. It is worthy of remark that the community of motion is also shown by spectroscopic observations of the radial motions described below.

The five stars in question are all of the second magnitude except δ, which is of the third. It is a curious fact that no fainter stars than these five have been found to belong to the system.

From a study of these motions Höffler has concluded that the five stars lie nearly in the same plane and have an equal motion in one and the same direction. From this hypothesis he has attempted to make a determination of their relative and actual distances. The result reached in this way cannot yet, however, be regarded as conclusive.

There are three stars in Cassiopeia, β, η and μ, each having a large proper motion in so nearly the same direction that it is difficult to avoid at least a suspicion of some relation between them. The angular motions are, however, so far from equal that we cannot regard the relation as established.

In the constellation Taurus, between Aldebaran and the Pleiades, most of the stars which have been accurately determined seem to have a common motion. But these motions are not yet so well ascertained that we can base anything definite upon them. They show a phenomenon which Proctor very aptly designated as star-drift.

The systems we have just described comprise stars situated so far apart that, but for their common motion, we should not have suspected any relation between them. The community of origin which their connection indicates is of great interest and importance, but the question belongs to a later chapter.

MOTIONS IN THE LINE OF SIGHT, OR RADIAL MOTIONS.

No achievement of modern science is more remarkable than the measurement of the velocity with which stars are moving to or from us. This is effected by means of the spectroscope through a comparison of the position of the spectral lines produced by the absorption of any substance in the atmosphere of the star with the corresponding lines produced by the same substance on the earth. The principle on which the method depends may be illustrated by the analogous case of sound. It is a familiar fact that if we stand alongside a railway while a locomotive is passing us at full speed, and at the same time blowing a whistle, the pitch of the note which we hear from the whistle is higher as the engine is approaching than after it passes. The reason is that the pitch of a sound depends upon the number of sound beats per second.

Now, we may consider the waves which form light when they strike our apparatus as beats in the ethereal medium which follow each other with extraordinary rapidity, millions of millions in a second, moving forward with a definite velocity of more than 186,000 miles a second. Each spectral line produced by a chemical element shows that that element, when incandescent, beats the ether a certain number of times in a second. These beats are transmitted as waves. Since the velocity is the same whether the number of beats per second is less or greater, it follows that, if the body is in motion in the direction in which it emits the light, the beats will be closer together than if it is at rest; if moving away they will be further apart. The fundamental fact on which this result depends is that the velocity of the light-beat through the ether is independent of the motion of the body causing the beat. To show

the result, let A be a luminous body at rest; let the seven dots to the right of A be the crests of seven waves or beats, the first of which, at the end of a certain time, has reached X. The wave-length will then be one seventh the distance A X. Now, suppose A in motion toward X with such speed that, when the first beat has reached X, A has reached the point B. Then the seven beats made by A while the first beat is traveling from A to X, and A traveling from A to B, will be crowded into the space B X, so that each wave will be one seventh shorter than before. In other words, the wave-lengths of the light emitted by any substance will be less or greater than their normal length, according to the motion of the substance in the direction in which its light is transmitted, or in the opposite direction.

The position of a ray in the spectrum depends solely on the wave-length of the light. It follows that the rays produced by any substance will be displaced toward the blue or red end of the spectrum, according as the body emitting or absorbing the rays is moving towards or from us. This method of determining the motions of stars to or from us, or their velocity in the line of sight from us to the star, was first put into practice by Mr.—now Sir William—Huggins, of London. The method has since been perfected by photographing the spectrum of a star, or other heavenly body, side by side with that of a terrestrial substance, rendered incandescent in the tube of a telescope. The rays of this substance pass through the same spectroscope as those from the star, so that, if the wave-lengths of the lines produced by the substance were the same as those found in the star spectrum, the two lines would correspond in position. The minute difference found on the photographic plate is the measure of the velocity of the star in the line of sight.

It will be seen that the conclusion depends on the hypothesis that the position of any ray produced by a substance is affected by no cause but the motion of the substance. How and when this hypothesis may fail is a very important question. It is found, for example, that the position of a spectral ray may be altered by compressing the gas emitting or absorbing the ray, and it may be inquired whether the results for motion in the line of sight may not be vitiated by the absorbing atmosphere of the star being under heavy pressure, thus displacing the absorption line.

To this it may be replied that, in any case, the outer layers of the atmosphere, through which the light must last pass, are not under pressure. How far inner portions may produce an absorption spectrum we cannot discuss at present, but it does not seem likely that serious errors are thus introduced in many cases.

These measures require apparatus and manipulation of extraordinary delicacy, in order to avoid every possible source of error. The displacement of the lines produced by motion is in fact so minute that great skill is required to make it evident, unless in exceptional cases. The Mills spectrograph of the Lick Observatory in the hands of Professor Campbell has, notwithstanding these difficulties, yielded results of extraordinary precision. Quite a number of investigators at some leading observatories of Europe and America are pursuing the work of determining these motions. The determinations have almost necessarily been limited to the brighter stars, because, owing to the light of the star being spread over so broad a space in the spectrum, instead of being concentrated on a point, a far longer exposure is necessary to photograph the spectrum of a star than to photograph the star itself. The larger the telescope the fainter the star whose spectrum can be photographed. Vogel, of Potsdam, who has made the most systematic sets of these measures that have yet appeared, included few stars fainter than the second magnitude. With the largest telescopes the spectro of stars down to about the fifth magnitude may be photographed; beyond this it is extremely difficult to go. The limit will probably be reached by the spectrograph of the Yerkes Observatory, which is now being put into operation by Professors Hale and Frost.

THE MOTION OF THE SUN.

When a star is found to be seemingly in motion, as described in the last section, we may ascribe the phenomenon to a motion either of the star itself or of the observer. In fact no motion can be determined or defined except by reference to some body supposed to be at rest. In the case of any one star, we may equally well suppose the star to be at rest and the observer in motion, or the contrary. Or we may suppose both to have such motions that the difference of the two shall represent the apparent movement of the star. Hence our actual result in the case of each separate star is a relation between the motion of the star and the motion of the sun.

I say the motion of the sun and not of the earth, because although the observer is actually on the earth, yet the latter never leaves the neighborhood of the sun, and, as a matter of fact, the ultimate result in the long run must be a motion relative to the sun itself as if we made our observations from that body. The question then arises whether there is any criterion for determining how much of the apparent motion of any given star should be attributed to the star itself and how much to a motion of the sun in the opposite direction.

If we should find that the stars, in consequence of their proper motions, all appeared to move in the same direction, we would naturally assume that they were at rest and the sun in motion. A conclusion of this sort was first reached by Herschel, who observed that among the stars having notable proper motions there was a general tendency to move from the direction of the constellation Hercules, which is in the northern hemisphere, towards the opposite constellation Argo, in the southern hemisphere.

Acting on this suggestion, subsequent astronomers have adopted the practice of considering the general average of all the stars, or a position which we may regard as their common center of gravity, to be at rest, and then determining the motion of the sun with respect to this center. Here we encounter the difficulty that we cannot make any absolute determination of the position of any such center. The latter will vary according to what particular stars we are able to include in our estimate. What we can do is to take all the stars which appear to have a proper motion, and determine the general direction of that motion. This gives us a certain point in the heavens toward which the solar system is traveling, and which is now called the *solar apex*, or the apex of the solar way.

The apparent motion of the stars due to this motion of the solar system is now called their *parallactic motion*, to distinguish it from the actual motion of the star itself.

The interest which attaches to the determination of the solar apex has led a great number of investigators to attempt it. Owing to the rather indefinite character of the material of investigation, the uncertainty of the proper motions, and the additions constantly made to the number of stars which are available for the purpose in view, different investigators have reached different results. Until quite recently, the general conclusionn was that the solar apex was situated somewhere in the constellation Hercules. But the general trend of recent research has been to place it in or near the adjoining constellation Lyra. This change has arisen mainly from including a larger number of stars, whose motions were determined with greater accuracy.

Former investigators based their conclusions entirely on stars having considerable proper motions, these being, in general, the nearer to us. The fact is, however, that it is better to include stars having a small proper motion, because the advantage of their great number more than counterbalances the disadvantage of their distance.

The conclusions reached by some recent investigators of the position of the solar apex will now be given. We call A the right ascension of the apex; D its declination.

Prof. Lewis Boss, from 273 stars of large proper motion found

$$A = 283°.3;\ D = 44°.1.$$

If he excluded the motions of 26 stars which exceeded 40″ per century the result was

$$A = 288°.7;\ D = 51°.5.$$

A comparison of these numbers shows how much the result depends on the special stars selected. By leaving out 26 stars the apex is changed by 5° in R. A., and 7° in declination.

It is to be remarked that the stars used by Boss are all contained in a belt four degrees wide, extending from 1° to 5° north of the equator.

Dr. Oscar Stumpe, of Berlin, made a list of 996 stars having proper motions between 16″ and 128″ per century. He divided them into three groups, the first including those between 16″ and 32″; the second between 32″ and 64″; the third between 64″ and 128″. The number of stars in each group and the position of the apex derived from them are as follows:

Gr. I, 551 stars;	A = 287°.4;	D = ×45°.0
II, 339	282°.2	43°.5
III, 106	280°.2	33°.5

Porter, of Cincinnati, made a determination from a yet larger list of stars with results of the same general character.

These determinations have the advantage that the stars are scattered over the entire heavens, the southern as well as the northern ones. The difference of more than 10° between the position derived from stars with the largest proper motions, and from the other stars, is remarkable.

The present writer, in a determination of the precessional motion, incidentally determined the solar motion from 2,527 stars contained in Bradley's Catalogue which had small proper motions, and from about 600 more having larger proper motions. Of the latter the declinations only were used. The results were:

From small motions:	A = 274°.2;	D = ×31°.2
From large motions:	276°.9	31°.4

From all these results it would seem that the most likely apex of the solar motion is toward the point in

Right Ascension, 280°
Declination, 38° north.

This point is situated in the constellation Lyra, about 2° from the first magnitude star Vega. The uncertainty of the result is more than this difference, four or five degrees at least. We may therefore state the conclusion in this form:

The apex of the solar motion is in the general direction of the constellation Lyra, and probably very near the star Vega, the brightest of that constellation.

It must be admitted that the wide difference between the position of the apex from large and from small proper motions, as found by Porter, Boss and Stumpe, require explanation. Since the apparent motions of the stars are less the greater their distance, these results, if accepted as real, would lead to the conclusion that the position of the solar apex derived from stars near to us was much further south than when derived from more distant stars. This again would indicate that our sun is one of a cluster or group of stars, having, in the general average, a different proper motion from the more distant stars. But this conclusion is not to be accepted as real until the subject has been more exhaustively investigated. The result may depend on the selection of the stars; and there is, as yet, no general agreement among investigators as to the best way of making the determination.

The next question which arises is that of the velocity of the solar motion. The data for this determination are more meagre and doubtful than those for the direction of the motion. The most obvious and direct method is to determine the parallactic motion of the stars of known parallax. Regarding any star 90° from the apex of the solar motion as in a state of absolute rest, we have the obvious rule that the quotient of its parallactic motion during any period, say a century, divided by its parallax, gives the solar motion during that period, in units of the earth's distance from the sun. In fact, by a motion of the sun through one such unit, the star would have an apparent motion in the opposite direction equal to its annual parallax. If the star were not 90° from the apex we can easily reduce its observed parallactic motion by dividing it by the sign of its actual distance from the apex.

Since every star has, presumably, a proper motion of its own, we can draw no conclusion from the apparent motion of any one star, owing to the impossibility of distinguishing its actual from its parallactic motion. We should, therefore, base our conclusion on the mean result from a great number of stars, whose average position or center of mass we might assume to be at rest. Here we meet the difficulty that there are only about 60 stars whose parallaxes can be said to be determined; and one-half of these are too near the apex, or have too small a parallax, to permit of any conclusion being drawn from them.

A second method is based on the spectroscopic measures of the motion of stars in the line of sight, or the line from the earth to the star. A star at rest in the direction of the solar apex would be apparently moving toward us with a velocity equal to that of the solar motion. Assuming the center of mass of all the stars observed to be at rest, we should get the solar motion from the mean of all.

Thus far, however, there are only about 50 stars whose motions in the line of sight have been used for the determination, so that the data are yet more meagre than in the case of the proper motions. From them, however, using a statistical method Kapteyn has derived results which seem to show that the actual velocity of the solar system through space is about 16 kilometres, or 10 statute miles, per second.

THE PSYCHOLOGY OF RED. (II.)

BY HAVELOCK ELLIS.

The facts and considerations we have passed in review fairly indicate the physiological and psychological preëminence of red among the colors of the spectrum to which we are sensitive. What is the cause of that preëminence?

It seems to me that two orders of causes have coöperated to produce this predominant influence, one physical and depending on the special effects of the long-waved portion of the spectrum on living matter, the other psychological and resulting from the special environmental influences to which man, and to some extent even the higher animals generally, have been subjected. It is possible that these two influences blend together and cannot at any point be disentangled; it is possible that acquired aptitude may be inherited or that what seem to be acquired aptitudes are really perpetuated congenital variations; but on the whole the two influences are so distinct that we may deal with them separately.

On the physical side the influence of the red rays, although there is much evidence showing that it may be traced throughout the whole of organic nature, is certainly most strongly and convincingly exhibited on plants. The characteristic greenness of vegetation alone bears witness to this fact. The red rays are life to the chlorophyll-bearing plant, the violet rays are death. A meadow, it has been justly said, is a vast field of tongues of fire greedily licking up the red rays and vomiting forth the poisonous bile of blue and yellow. An experiment of Flammarion's has beautifully shown the widely different reaction of plants to the red and violet rays. At the climatological station at Juvisy he constructed four greenhouses—one of ordinary transparent glass, another of red glass, another of green, the fourth of dark blue. The glass was monochromatic, as carefully tested by the spectroscope, and dark blue was used instead of violet because it was impossible to obtain a perfect violet glass. These were all placed under uniform meteorological and other conditions, and from certain plants such as the sensitive plant, previously sown on the same day in the same soil, eight of each kind were selected, all measuring 27 millimetres, and placed by two and two in the four greenhouses on the 4th of July. On the 15th of August there were notable differences in height, color and sensitiveness, and these differences continued to become marked; photographs of the plants on the 4th of October showed that while those under blue glass had made no progress, those under red glass had attained extraordinary development, red light acting like a manure. While those under blue glass became insensitive, under red glass the sensitive plants had become excessively sensitive to the least breath. They also flowered, those under transparent glass being vigorous and showing buds, but not flowering. The foliage under red glass was very light, under blue darkest. Similar but less marked effects were found in the case of geraniums, strawberries, etc. The strawberries under blue glass were no more advanced in October than in May; though not growing old their life was little more than a sleep. It appears, however, that the stimulating influence of red light fails to influence favorably the ripening of fruit. Zacharewiez, professor of agriculture at Vaucluse, has found that red, or rather orange, produces the greatest amount of vegetation, while as regards fruit, the finest and earliest was grown under clear glass, violet glass, indeed, causing the amount of fruit to increase but at the expense of the quality.

Moreover, the lowest as well as the highest plants participated in this response to the red rays, and in even a more marked degree, for they perish altogether under the influence of the violet rays. Marshall Ward and others have shown that the blue, violet and ultra-violet rays, but no others, are deleterious to bacteria. Finsen has successfully made use of this fact in the treatment of bacterial skin diseases. Reynolds Green has shown that while the ultra-violet rays have a destructive influence on diastase, the red rays have a powerfully stimulating effect, increasing diastase and converting zymogen into diastase.

While the influence of the red rays on the plant is thus so enormous and easily demonstrated, the physical effects of red on animals seem to be even opposite in character, although results of experiments are somewhat contradictory. Béclard found that the larvæ of the flesh fly raised under violet glass were three fourths larger than those raised under green glass; the order was violet, blue, red, yellow, white, green. In the case of tadpoles, Yung found that violet or blue was especially favorable to the growth of frogs; he also found that fish hatch most rapidly under violet light. Thus the influence that is practically death to plants is that most favorable to life in animals. Both effects, however, as Davenport truly remarks in his 'Experimental Morphology,' when summing up the results of investigations, are due to the same chemical metabolic changes, but while plants succumb to the influence of the violet rays, animals, being more highly organized, are able to take advantage of them and flourish.

At the same time the influence of violet rays on animal tissue is by no means invariably beneficial; they are often too powerful a stimulant. That the violet rays have an influence on the human skin which in the first place, at all events, is destructive and harmful in a high degree, is now clearly established by the observations and experiments of Charcot, Unna, Hammer, Bowles and others, while Finsen has made an important advance in the treatment of disease based on this fact. The conditions called 'sun-burn,' 'snow-burn,' 'snow-blindness,' for instance, which may affect even travelers on snow-fields and Arctic explorers, are now known to be wholly due to the violet and not to the red rays. Unna's device of wearing a yellow veil, and Bowles's plan of painting the skin brown, thus shutting off the violet rays, suffice to prevent sunburn. The same effect is also obtained by nature, which under the stress of sunlight, and largely through the irritation of the violet rays themselves, weaves a pigmentary veil of yellow and brown on the skin, which thus protects from the further injurious influence of the violet rays and renders the sunlight a source of less alloyed joy and health.

That the presence of the red rays, or at all events the exclusion of the violet, is of great benefit in many skin diseases seems to be now beyond doubt. This has been shown by Finsen in his treatment of smallpox in red rooms; it appears that it was also known in the Middle Ages as well as in Japan, Tonquin and Roumania, red bed-covers, curtains or carpets being used to obtain the effect. Under the treatment by red light not only is the skin enabled to heal healthfully without scarring, but the whole course of the disease is beneficially affected and abbreviated, the fever is diminished and also the risk of complications. Another physician has discovered that a similar beneficial effect is produced by red light in measles. A child with a severe attack of measles was put into a room with red blinds and a photographic lamp. The rash speedily disappeared and the fever subsided, the child complaining only of the absence of light; the blinds were consequently removed, and the fever, rash and prostration returned, to disappear again when the blinds were resumed.

Whether red light, or the exclusion of violet, exerts a beneficial influence on the hæmoglobin of the blood and on metabolism generally has not been distinctly proved, but it seems to me to be indicated by such experiments as those of Marti published a few years ago in the *Atti dei Lincei.* This investigator found that while feeble irritation of the skin promotes the formation of blood corpuscles, strong irritation diminishes the blood corpuscles and also the hæmoglobin; at the same time he found that darkness also diminishes the number of red corpuscles, while continued exposure to intense light (even at night the electric light, which, however, is rich in violet rays) favors increased formation of red corpuscles, and in some degree of hæmoglobin. Finsen has shown that inflammation of the skin caused by chemical or violet light leads to contraction of the red corpuscles.

This brings us to the consideration of the influence of the red rays on the nervous system. From time to time experiments have been made as to the influence of various colored lights, chiefly on the insane, as first suggested by Father Secchi in 1895. Even yet, however, the specific mental influences of the various colors are not quite clear. It has been found by some that the red rays are far more soothing and comfortable, less irritating, than the total rays of uncolored light, and Garbini found that angry infants were soothed by the light through red glass, only slightly by that through green and not at all by other colored light. On the other hand, it is stated that a well-known dry plate manufacturer at Lyons was obliged to substitute green-colored glass in the windows of his large room for the usual red because the work people sang and gesticulated all day and the men made love to the women, while under the influence of green glass (which also allows yellow rays to pass) they became quiet and silent and seemed less fatigued when they left off work. We need not attach much value to these statements, but in this connection it is interesting to refer to the results obtained some years ago by Féré and recorded in his 'Sensation et Mouvement.' Experimenting on normal subjects as well as on nervous subjects, who were found more sensitive, with colored light passed through glass or sheets of gelatine, he found notable differences in muscular power, measured by the dynamometer, and in the circulation as measured by plethysmographic tracings of the forearm under the influence of different colors. He found in this manner with one subject whose normal muscular power was represented by 23 that blue light increased his power to 24, green to 28, yellow to 30, orange to 35 and red to 42. The dynamogenic powers of the different colors were thus found to rank in the spectral order, red representing the climax of energy, or, as Féré puts it, "the intensity of the visual sensation varies as the vibrations." Féré found that colors need not be perceived in order to show their influence, thus proving the purely physical nature of that influence, for in a subject who was unable to see colors with one eye, the color stimulus had the same dynamogenic effect whether applied to the seeing or the defective eye. Increase of volume of blood in the limbs, measured by the plethysmograph, so far as we can rely on Féré's experiments, ran parallel with the influence on muscular power, culminating with red, so that no metaphor is involved, Féré remarks, when we speak of red as a 'warm' color. On the insane the results attained by the use of colored glass do not seem to be quite coherent. Some of the earlier observers described the beneficial effects of blue glass in soothing maniacs. Pritchard Davies, however, was not able to find that red light had any beneficial effect, though on some cases blue had, while Roffegean found that, in the case of a somber and taciturn maniac who could rarely be persuaded to eat, three hours in a red-lighted room produced a markedly beneficial effect, and a man with delusions of persecution became quite rational and was even in a condition to be sent home after a few days in the same room. He also found that a violent maniac wearing a strait jacket, after a few hours in a room with blue glass windows became quite calm and gave no further trouble. Osburne has found, after many years' experience, that in the absence of structural disease violet light (for from three to six hours) is most useful in the treatment of excitement, sleeplessness and acute mania; red he has found of some benefit, though to a much less degree in such cases (it must be remarked that violet light as usually applied is not free from red), while he has not found any color with which he has tried experiments (red, orange or violet) of benefit in melancholia. The significance of these facts is not altogether clear; the influence, as Pritchard Davies concluded, seems to be largely moral, though it may be that the colors of long wave-length are tonic and those of short wave-length sedative.

So far I have been chiefly concerned to point out that the immense emotional impressiveness of red has a basis in physical laws, being by no means altogether a matter of environmental associations. It is true that the two groups of influences overlap, and that we can not always distinguish them. We can not be sure that the greater sensitiveness to the red rays may not have been emphasized in the organism, not necessarily as the result of inherited acquirement, but probably as the perpetuation of a variation of sensibility, found beneficial in an environment where red was liable to be especially associated with objects that were to be avoided as terrible or sought as useful. In this way the physical and environmental factors would run in a circle.

We have to bear this consideration in mind when we take into account the susceptibilities of animals, especially of the higher animals, to red. The color sense, it is well known, is widely diffused among animals; indeed this fact has been brought forward, especially by Pouchet, to prove that there can have been no color evolution in man; this it can scarcely be said to show, since evolution does not run in a straight line, and it is quite conceivable and even probable that the ancestors of man were less dependent than many lower animals, for the means of living, on a highly developed color sense. Thus a color sense that among some creatures is so highly developed as to include even the ultra-violet rays, was among our own ape-like ancestors either never developed or partially lost.

Graber, in his important investigation into the color sense of animals, showed that of fifty animals studied by him forty showed strong color preferences in their places of abode. In general he found, without being able to explain the fact, that animals which prefer the dark are red lovers, those which prefer the light are blue lovers. The common worm, with head and tail cut off, still preferred red to blue nearly as much as when uninjured. (This would seem to indicate the same kind of susceptibility to unaccustomed violet rays which we have already encountered in the phenomenon of sun-burn.) The triton and cochineal, with eyes removed and heads covered with wax, still had delicate sense for color and brightness. The flea infesting the dog had a finer color sense than the bee, while nearly all the animals Graber investigated were more or less sensitive to the ultra-red rays.

Among insects it scarcely appears, nor should we expect that there would be any peculiarly marked predilection or aversion for red. Cockerell and F. W. Anderson, from observations in various parts of the United States, believe that yellow (*i. e.*, the brightest color) is the most attractive to insects, and the former doubts whether insects can distinguish red from yellow. Among the higher animals, and even among fishes and birds, there is not only a color sense, but a highly emotionalized color sense, and red appears to be usually the color that arouses the emotion. There is a proverb, 'Women and mackerel are caught by red,' and perch is also said to be caught by red bait. Sparrows appear to be repelled by red; the case is reported of a hen sparrow, kept in captivity for ten years, which though otherwise a fearless bird 'would on seeing scarlet show painful signs of distress and faint away.' The lady who records this observation has noted the same repugnance to red, though in a less marked degree, in other sparrows, one of which showed a predilection for blue objects, and she remarks that when feeding outdoor sparrows from the window they flew away when she wore a red jacket, while a blue jacket inspired them with confidence; other birds, she found, except a cockatoo, were unaffected by colors. Red, it is well known, is very obnoxious to turkey cocks, while the fury aroused in various quadrupeds by red was known at a very early period; Seneca referred to it in the case of the bull, the most familiar example; it is seen in buffaloes, sometimes in horses, and also, it is said, in the hippopotamus.

The phenomena of color aversion and color predilection among insects may possibly be in some degree a matter of physical sensibility, varying according to the creature's tissues, habitat and needs, but as we approach the vertebrates and especially the mammals there can be little doubt that it is mainly a matter of environment and association; in other words, that it is accounted for by the color of food, the color of blood and the color of the chief secondary sexual characters.

Let us, however, confine ourselves to man, and consider what are the chief colored objects that are of most vital concern to the human and most closely allied species.

One of the earliest groups of such objects—some would say the most important group in this connection—is that of ripe fruits. Certainly among the frugivorous apes and among many races of primitive man, the color of fruits must be a powerful factor in developing a sensibility for red rays, and in associating such sensibility with emotional satisfaction. The color of fruits is most generally red, orange or purple, and since purple is largely made up of red, it is clear that the influence of fruits will almost exclusively bear on the rays of long wave-length. We may reasonably suppose that the search for fruits acted as an important factor in the development of a special sensibility for red.

A later factor in the predilection for the red, orange and yellow rays, though scarcely a factor in their discrimination, lies in the fact that these are the colors of fire. Flame, apart from its beauty, on which certain poets, Shelley especially, have often insisted, is a source of massive physical satisfaction. Even under the conditions of civilization we are often acutely sensitive to this fact, while under the conditions of primitive life, in imperfect shelters, caves or tents, where no other source of artificial light and heat is known, the satisfaction is immensely greater. At the same time fire is associated with food, it is a protection from wild beasts and the accompaniment of the festival. It may even take on a sacred and symbolic character, and the Roman goddess Vesta was, as Ovid said, simply 'living flame.'

While fruit or fire would tend to make the emotional tone of red pleasant, another very powerful factor in its emotional influences, though this time as much by causing terror as pleasure, is the fact that it is the color of blood. That 'the blood is the life' is a belief instinctively stamped even on the emotions of animals, and it has not died even in civilized man, for the sight of blood produces on many persons a sickening and terrifying sensation which is only overcome by habit and experience or by a very strong effort of will. It is not surprising that in some parts of the world, and even in our own Indo-European group of languages, the name for red is 'blood-color.'

It is evident, however, that at a very early period of primitive culture the blood had ceased to be merely a source of terror, or even of the joy of battle. We find everywhere that blood is blended into complex ritual customs, and thus associated with complex emotional states. Among the ancient Arabians blood was smeared on the body on various occasions, and in modern Arabia blood is still so used. Everywhere, even in the folk-lore of modern Europe, we find that blood is a medicine, as it is also among the primitive aborigines of Australia, so carefully investigated by Baldwin Spencer and Gillen. Among these latter primitive people we meet with a phenomenon of very great significance. We find, that is, that blood is the earliest pigment. There can be little doubt that the earliest paint used by man—no doubt by man when in a much more primitive condition than even the Australians—was blood. In the initiation rites of the Arunta tribes, as described by Spencer and Gillen, the chief performer is elaborately decorated with patterns in eagle-hawk down stuck to his body with blood drawn from some member of the tribe. It was estimated that one man alone, on one of these occasions, allowed five half-pints to be taken from him during a single day; at the same time the blood is not regarded as sufficient pigment and the down is also colored red and yellow with ochre. Red ochre, Spencer and Gillen remark, is frequently a substitute for blood or is used with it. Blood is a medicine, and when any one is ill he is first rubbed over with red ochre, it being obvious to the primitive mind that the ochre will share the remedial properties of blood; in the same way ceremonial objects may sometimes be rubbed over with ochre instead of blood. They associate this red ochre especially with women's blood; and it is said that once some women after long walking were so exhausted that hemorrhage came on and this gave rise to deposits of red ochre. Other red ochre pits, also, they attribute to blood which flowed from women. It appears also that the blood with which sacred implements used in the ritual ceremonies of these Central Australians were smeared must be drawn from women.

Far from Australia, among the hill tribes of the Central Indian hills, we find the same blood ritual and the same tendency to substitute pigments for blood. Among some of the Bengal tribes, says Crooke, blood is drawn from the husband's little finger, mixed with betel and eaten by the bride. A further stage is seen among the allied Kurmis who mix the blood with lac dye. Lastly come the rites, common to all these tribes, in which the bridegroom, often in secrecy, covered by a sheet, rubs vermilion on the parting of the girl's hair, while the women relations smear their toes with lac dye. It is a sacramental rite, and after the husband's death the widow solemnly washes off the red from her hair, or flings the little box in which she keeps the coloring matter into running water.

Some of the foregoing facts, both in Australia and India, suggest the transition to another factor in the emotional potency possessed by red. Red is not only the color of fire and of war and of ritual pigment; it is the color of love. This is certainly an ancient and powerful factor in the emotional attitude towards red. Secondary sexual characters, even among birds, are often red; many fishes, also, at the epoch of the oviposit show a red tint on the orifice of the sexual apparatus; patches of red, sometimes very brilliant, but only appearing when the animal is mature, are perhaps the commonest adornments of monkeys. In man the color of the hair and beard, the most conspicuous of the secondary sexual characters, is most usually brown, or some other variety of red. The lips are crimson, the mucous membrane generally a dark red; the scarlet of the blush, among all fair races, whatever other sources it may have, is always regarded as especially the ensign of love. The rose is the flower of love, as the pale lily is of virtue. This association is quite inapt, and many people who are sensitive in such matters feel that the lily and many white flowers are far more symbolical of rapture and voluptuousness than the rose. It is, however, the color and not the scent or other qualities that has exerted decisive influence on the choice of the symbol. In the Teutonic symbolism of fourteenth century Europe red was the color of love, as also, with yellow, it was the favorite color for garments. In more modern times this last tendency has survived. Sardou decides, it is reported, the color of the dresses to be worn in his plays, on the ground that if he did not the actresses would all wear red to attract attention to themselves, as once occurred at the Odéon. Eighteen hundred years earlier, Clement of Alexandria had written: "Would it were possible to abolish purple in dress, so as not to turn the eyes of the spectators on the faces of those that wear it!" He proceeds to lament that women make all their garments of purple (the classic purple was really a red) in order to inflame lust—those 'stupid and luxurious purples' which have caused Tyre and Sidon and the Lacedæmonian Sea to be so much in demand for their purple fishes. Similar phenomena are noted on the other side of the world. Thus the Japanese, as the Rev. Walter Weston informs us, have a proverb: 'Love flies with a red petticoat.' Married women are not there supposed to wear red petticoats, for they are too attractive, and a married woman should be attractive only to her husband. The æsthetic Japanese may be thought to be specially sensitive to color, but in Africa also, in Loango, as Pechuel-Loesche mentions, pregnant women are forbidden to wear red, and it would doubtless be possible to find many similar indications of this feeling in other parts of the world.

We have now passed in review all the influences which, by force of their powerful attraction or repulsion, have during countless ages impressed on man, and often on his ancestors, the strong and poignant emotions which accompany the sensation of the most vividly and persistently seen of all colors. We find evidence of the reality of the influences we have traced—especially those of fire, blood and love—in Christian ecclesiastical symbolism, according to which red variously signifies ardent love, burning zeal, energy, courage, cruelty and bloodthirstiness. To the antagonism and complexity of these influences we must doubtless attribute the disturbing nature of the emotion aroused by the group of red sensations and the fluctuations in the predilection felt towards it. It is at once the most attractive and the most repulsive of colors. To enjoy it we must use it economically. The vision of poppies on a background of golden corn, the glint of roses embowered in green leaves, the sudden flash of a scarlet flower on a southern woman's dark hair—it is in such visions as these that red gives us its emotional thrill altogether untouched by pain. If the 'multitudinous seas' were indeed 'incarnadined' for us in 'one red,' if the sky were scarlet, or all vegetation crimson, the horror of the world would be painful to contemplate for nervous systems moulded to our vision of nature. Our eyes have developed in a world where the green and blue rays meet us at every step, and where we have in consequence been almost as dulled to them as we are to the weight of the atmosphere that presses in on us on every side. It is under the clouded skies of northern lands that blue is counted the loveliest of colors; it is in the desert that green becomes supremely beautiful and sacred.

THE EXPENDITURE OF THE WORKING CLASSES*.

BY HENRY HIGGS.

THE prime concern of the economist and of the statistician is the condition of the people. Other matters which engage their attention—particular problems, questions of history, discussions of method, developments of theory—all derive their ultimate importance from their bearing upon this central subject. The statistician measures the changing phenomena of the production, distribution and consumption of wealth, which to a large extent reflect and determine the material condition of the people. The economist analyzes the motives of these phenomena, and endeavors to trace the connection between cause and effect. He is unable to push his analysis far without a firm mastery of the theory of value, the perfecting of which has been the chief stride made by economic science in the nineteenth century. When we read the 'Wealth of Nations' we are forced to admit that in sheer sagacity Adam Smith is unsurpassed by any of his successors. It is only when we come to his imperfect and unconnected views upon value that we feel the power of increased knowledge. J. S. Mill supposed in 1848 that the last word had been said on the theory of value. In his third book he writes: "In a state of society in which the industrial system is entirely founded on purchase and sale . . . the question of value is fundamental. Almost every speculation respecting the economical interests of a society thus constituted implies some theory of value; the smallest error on this subject infects with corresponding error all our other conclusions, and anything vague or misty in our conception of it creates confusion and uncertainty in everything else." And he adds: "Happily, there is nothing in the laws of value which remains for the present or any future writer to clear up; the theory of the subject is complete."

We know now that he was wrong. Thanks in the main to economists still alive, and especially to the mathematical economists, we have at length a theory of value so formally exact that, whatever may be added to it in the future, time can take nothing from it; while it is sufficiently flexible to lend itself as well to a *régime* of monopoly as to one of competition. Yet our confidence in this instrument of analysis is far from inspiring us with the assurance which has done so much to discredit economics by provoking its professors to dogmatize upon

* Address by the President to the Economic Science and Statistics Section at the Dover meeting of the British Association for the Advancement of Science.

problems with the whole facts of which they were imperfectly acquainted. Given certain conditions of supply and certain conditions of demand, the economist should have no doubt as to the resulting determination of value; but he is more than ever alert to make sure that he has all the material factors of the case before him; that he understands the facts and their mutual relation before he ventures to pronounce an opinion upon any mixed question. He must have the facts before he can analyze them. A small array of syllogisms, which, as Bacon says, "master the assent and not the subject," are not an adequate equipment for him. He sees more and more the need for careful and industrious investigation, and prominent among the subjects which await his trained observation are the condition of the people and the related subject of the consumption of wealth. Training is, indeed, indispensable. Every social question has its purely economic elements for the skilled economist to unravel, and when this part of his task has been achieved, he is at an advantage in approaching the other parts of it, while his habit of mind helps him to know what to look out for and what to expect.

It is a curious paradox that, busying ourselves as we do with the condition of the people, we are lamentably lacking in precision in our knowledge of the economic life and state of the British people in the present day. Political economy has, however, followed the lines of development of political power. At one time it was, as the Germans say, cameralistic—an affair of the council chamber, a question of the power and resources of the king. Taking a wider but still restricted view of society, it became capitalistic, identifying the economic interests of the community to a too great extent with those of the capitalist class. It has at length become frankly democratic, looking consciously and directly to the prosperity of the people at large.

Thus, then, we have at once a more accurate theory, a livelier sense of caution as to its limitations in practice, and the widest possible field of study. So far as most of us are concerned, we might as well spend our time in verifying the ready reckoner as in tracing and retracing the lines of pure theory. These tools are made for use. Economic science is likely to make the most satisfactory progress if we watch the social forces that surround us, detecting the operation of economic law in all its manifestations, and in observing, coördinating and recording the facts of economic life. It is not enough, to borrow the language of the biologist (part of which he himself borrowed from the old economist), to talk of the struggle for existence, the survival of the fittest and of evolution. We want, above all, his spirit and his method—the careful, minute, systematic observation of life as affected by environment, heredity and habit. Different problems are brought to the front by different circumstances and appeal to different minds; but at all times and to all economists the condition of the people is of chief interest, and the consumption of wealth is so closely connected with it that it might seem superfluous to plead for its study. Yet some such plea is necessary. The arts of production improve apace. The victories of science are rapidly utilized by manufacturers anxious to make a fortune. Even here the descriptive study of the subject is hampered by the trade secrets involved in many processes, and by a feeling that production may safely be left to the unresting intelligence of captains of industry, so that the onlooker is chiefly concerned in this branch of the subject with solicitude for the health and safety of the workmen employed. The departments of distribution and exchange appeal especially to the pride of intellect. The delicate theorems of value in all their branches—wages, rent, interest, profits, the problems of taxation, the alluring study of currency, the mechanism of banking and exchange—have attracted the greatest share of the economist's attention. On the practical side of distribution the growth of trade unions, the spread of education, the improved standard of living, have increased the bargaining power of the working classes and combined with other causes to effect a gratifying improvement in the distribution of wealth, so that they receive a growing share of the growing national dividend. The practical and the speculative aspects alike of the consumption of wealth have received less consideration. Nobody sees his way to a fortune through the spread of more knowledge of domestic economy in workmen's homes; and the scientific observer has curbed his curiosity before what might seem an inquisitorial investigation into the question, what becomes of wages? Economists long ago discovered the necessity of distinguishing between money wages and real wages. It is now necessary for us to distinguish between real wages and utilities—not to stop at the fact that so many shillings a week *might* procure such and such necessaries, comforts, or luxuries, but to ascertain how they *are* expended. From the first we can deduce what the economic condition of the people might be; from the second we shall know what it is. And when we know what it is we shall see more clearly what with more wisdom it might become. Wealth, after all, is a means to an end. It is not enough to maximize wealth; we must strive to maximize utilities. And we can no more judge of the condition of a people from its receipts alone, than we can judge of the financial condition of a nation from a mere statement of its revenues.

The condition of the people has, of course, improved, and is improving. Public hygiene has made great progress, and houses are better and more sanitary, though for this and other reasons rents have risen. Wages are higher. Commodities are cheaper. Coöperation and the better organization of retail business, giving no credit, have saved some of the profits of middlemen for the benefit of the consumer, while authority fights without ceasing against frauds in weights and measures, and adulteration. Free libraries, museums, picture galleries, parks, public gardens and promenades have multiplied, and it is almost sufficient to observe that no one seems to be too poor to command the use of a bicycle. But with all this progress it is to be feared that house-keeping is no better understood than it was two centuries ago—perhaps not even so well. In the interval it has become enormously simplified. The complete housewife is no longer a brewer, a baker, a dyer, a tailor and a host of other specialists rolled into one. But among the working classes the advent of the factory system has increased the employment of women and girls away from home to such an extent that many of them now marry with a minimum of domestic experience, and are with the best intentions the innocent agents of inefficiency and waste, even in this simplified household.

If we were suddenly swallowed up by the ocean, it appears probable that the foreign student would find it easier to describe from existing documents the life and home of the British craftsman in the middle ages than of his descendant of to-day. In part, no doubt, our fiscal system, with its few taxes upon articles of food and its light pressure on the working classes, is responsible for this neglect. During the Napoleonic war Pitt sent for Arthur Young to ask him what were the ordinary and necessary expenses of a workman's family, and the question would again become one of practical politics if any large addition were required in the proceeds of indirect taxation. Taxation has the one advantage of providing us with statistics. We know tolerably well the facts in the mass about the consumption of tea and coffee, dried fruits and tobacco, and of alcohol, while the income tax (aided in the near future by returns of the death duties) may give us some idea of the stratification of the wealthier classes. But the details of consumption are still obscure. It has already been suggested that some restraint may arise from the sentiment that individuals are likely to resent what they may regard as a prying into their affairs. But when we travel abroad we are curious to notice, and do notice without giving offence, the dress, the habits and the food of peasants and workmen; and it is difficult to resist the conclusion that we are less observant at home because these common and trivial details appear to us unworthy of attention. In his 'Principles of Economics' Professor Marshall says: "Perhaps £100,000,000 annually are spent, even by the working classes, and £400,000,000 by the rest of the population of England, in ways that do little or nothing towards making life nobler or truly happier." And, again, speaking before the Royal Statistical Society in 1893: "Something like the whole imperial revenue, say 100 millions a year, might be saved if a sufficient number of able women went about the country and induced the other women to manage their households as they did themselves." These figures show, at any rate, the possibilities of greatness in the economic progress which may result from attention to the humblest details of domestic life.

Economics, like other sciences, lies under a great debt of obligation to French pioneers. The physiocrats, or *économistes*, of the eighteenth century, were the first school of writers to make it worthy of the name of a science. In Cournot, France gave us a giant of originality in pure theory. In Comte, we have a philosopher fruitful in suggestion to the narrower economist. In Le Play, we have a writer as yet little known in England, but to whom recognition and respect are gradually coming for his early perception of the importance of ascertaining the facts of consumption, and it is to Le Play's 'family budgets,' the receipts and expenses of workmen's families, that I desire especially to call attention. I have given elsewhere an account of his life and work.* Broadly speaking, he sets himself by the comparative study of workmen's families in different countries of Europe to arrive at the causes of well-being and of misery among the laboring classes. The subject was too large to lead him in many directions to very precise conclusions. We are reminded in reading him of an incident at a dinner of the Political Economy Club in 1876, when Mr. Robert Lowe propounded the question: "What are the more important results which have followed from the publication of the 'Wealth of Nations' just one hundred years ago?" Some of the most enthusiastic admirers of Adam Smith were present, Mr. Gladstone and M. Léon Say among the number; and Mr. Lowe trenchantly declared that it all came to this: "The causes of wealth are two, industry and thrift; the causes of poverty are two, idleness and waste." It was left to Mr. W. E. Forster to make the rugged remark: "You don't want to go to Adam Smith for that—you can get that out of the Proverbs of Solomon." And Le Play's conclusions frequently go still further back, to the Decalogue. There are, however, many observations, suggestive and original, upon the material facts, the economic life, of the families he brought under review. And we are now concerned rather with his method than with his conclusions. Given half a dozen Le Plays applying their minds to the study of the consumption of wealth among the working classes of England, we might expect soon to see a greater advance in comfort, a greater rise in the standard of life, than improved arts of production alone are likely to yield in a generation. Certain English writers had, indeed, prepared family budgets before Le Play arose. But their method was usually incomplete except for the specific purpose they had before them. David Davies and Sir F. Eden were chiefly concerned with the poor law, Arthur Young and Cobbett with agricultural poli-

* *Harvard Quarterly Journal of Economics*, vol. iv., 1890; *Journal of Royal Statistical Society*, March, 1893; Palgrave's *Dictionary of Political Economy, s. v.* Le Play, 1896.

tics, Dudley Baxter and Leone Levi with taxation. Le Play may fairly be called the father of the scientific family budget. His studies of four English families* are the most complete economic pictures of English popular life to be found in literature. With the aid of some local authority he chose what was thought a fairly typical family, and then, frankly explaining his scientific object and securing confidence, he set himself to study it. Nothing of economic interest is too unimportant for him to record. A minute inventory and valuation of clothes, furniture and household goods; a detailed account, item by item, of income from all sources and of expenditure upon all objects for a year, with the quantities and prices of foods, &c.; a description of the family, member by member, their past history, their environment, how they came to be where they are and to earn their living as they do; their resources in the present, their provision for the future; their meals, hygiene and recreations; their social, moral, political and religious observances—nothing escapes him. And the whole is organized, classified, fitted into a framework identical for all cases, with the painstaking and methodical industry of the naturalist. Contrasted with this the realism of novelists, the occasional excursions of journalists, the observations of professed economists, are pitiably incomplete. As early as 1857 Le Play found one ardent admirer in England, Mr. W. L. Sargant, whose "Economy of the Laboring Classes," avowedly inspired by Le Play, is a valuable and interesting piece of work. Since then, however, with the magnificent exception of Mr. Charles Booth, little has been done to throw light upon the mode of life of the wage-earners of England. The Board of Trade heralded the formation of its Labor Department by issuing a blue book—unhappily without sequel—entitled "Returns of Expenditure by Working Men," in 1889, and the Economic Club has published a useful collection of studies in 'Family Budgets,' 1896. But we shall probably still depend very much upon foreign observers for fuller knowledge of the subject. M. René Lavollée, an adherent who may almost be called a colleague of Le Play, has devoted to England a whole volume of his important work 'Les Classes Ouvrières en Europe: études sur leur situation matérielle et morale.'† M. Urbain Guérin, another member of the Société d'Economie Sociale, founded by Le Play to carry on his work, has recently added a study of a tanner's family in Nottingham to Le Play's gallery of portraits; and some of the young members of the Musée Social and the Ecole Libre des Sciences Politiques have come among us animated with the same scientific curiosity. A vivid (and, so far as Newcastle is concerned, a trustworthy) sketch by a German miner, "How the English Workman Lives," just translated into English, is our

*_Les Ouvriers Europeens_, Paris, folio, 1855.

†Paris, 1896, tom. iii., 656 pp., large 8vo.

latest debt to foreign observers. It may be hoped that the British Association, largely attended as it is by persons who would shrink from more ambitious scientific labors, will furnish some workers ready to do their country the very real service of recording such facts as they can collect about the economic habits of our own people, and so helping us to know ourselves.

Consider, for a moment, the consumption of food. To the ordinary English workman life would seem unendurable without white wheaten bread. Other forms of bread he knows there are, but he has unreasoning prejudices against wholemeal bread—the food of workhouses and prisons—and against rye bread or other kinds of bread, the food of foreigners. But in many parts of Europe the working classes have no bread. Cereals of some sort, prepared in some way, they of course employ. Wheat, oats, rye, barley, maize, buckwheat, even chestnuts, are used indifferently in different places, and rice and potatoes are among the substitutes. What is the relative value of these as food-stuffs, and what is the best mode of preparing them? The reasons which induced men in the middle ages to consume the cereals of their own neighborhood have been so much weakened by the cheapening of transport and the international specialization of industries, that the conservatism of food habits is brought into strong relief when we find neighboring peoples abandoning, first in town and then in country, marked distinctions of national costumes, but clinging everywhere to national differences of food. We are perhaps on the eve of considerable changes here. Two years ago an American economist told me in Boston that fruit had been the great ally of the workmen in a recent severe strike. There had been an exceptionally large crop of bananas, which were sold at one cent apiece, and the strikers had sustained themselves and their families almost entirely upon bananas at a trifling cost—very greatly below their usual expense for food. Returning to London I found bananas on sale in the streets for a halfpenny. No doubt they were consumed here in addition to, and not in substitution for, ordinary food; but they illustrate the fact that the foods of other latitudes are no longer the sole luxury of the rich, but are brought within the reach of all classes, and that our popular food habits need no longer be made to conform to the narrow range of former days, but may be put upon a wider rational basis. The vegetarians, largely dependent upon other countries, have recognized this. The chemist and the physiologist might give us great assistance in these matters. Most of the calculations which I have seen as to the constituents of foods, their heat-giving and nutritive properties, appear to ignore the greater or less facility with which the different foods are assimilated. It is surprising that rice, in some respects the most economical of all grains, needing no milling, easily cooked and easily digested, is not more largely consumed by the poorer families in this country.

The effect upon our food habits of the introduction of railways and the supply of comparatively cheap fuel to every household is almost incalculable. But for this the consumption of tea, perhaps even of potatoes where there is no peat, would be very small. The preference of the French for liquid, and of the English for solid, food, has been attributed to the greater relative facilities which the French once enjoyed for making a fire, though the persistence (if not the origin) of our popular habits in this respect probably lies rather in the fact that a Frenchwoman's cookery makes greater demands upon her time and attention. One result of this preference is that the essential juices of meat preserved by the French in soups and ragouts are with us to a large extent absolutely wasted. Owners of small house properties complain that, however well trapped their sinks may be, the pipes are constantly choked, and that the mysterious mischief is almost invariably cured by liberal doses of boiling water, which melt the solidified fats cast away in a state of solution. The number of persons who died of starvation in the administrative county of London in 1898, or whose death was accelerated by privation, amounted to 48; and we shall be pretty safe in estimating the total number in the United Kingdom at something less than 500. The common and inevitable reflection is that they might have been easily relieved from the superfluities of the rich; but it is true also that their sufficient sustenance was destroyed many times over through the ignorance of the poor. It would be difficult to find an English cookery book which a workman's wife would not reject as too fanciful and ambitious to be practical. A little French treatise, 'La parfaite Cuisinière, ou l'Art d'utiliser les Restes,' strikes in its title, at any rate, the keynote of the popular domestic economy of which we stand much in need in England. Housekeeping, even the humblest, is a skilled business. To know what to buy, how to use it and how to utilize waste does not come by the light of nature. If more knowledge and more imagination were devoted to the teaching of cookery in our board schools, the family meal might be made more varied, more appetizing, more attractive and more economical, leaving a larger margin for the comforts, culture and recreations which help to develop the best social qualities. A happy family is a family of good citizens. It would be discourteous to another section of this Association to quote without reserve the *mot* of Brillat-Savarin: "He who discovers a new dish does more for the happiness of mankind than he who discovers a new planet." We must stipulate that the new dish effects an improvement in the economy of the working classes.

Take, again, the consumption of coal. Mr. Sargant says, "It is impossible to say how much of the superiority of English health and longevity is owing to the use of open fireplaces"; probably a considerable part is owing to it. We all know how close and stifling is the atmosphere of a room heated by a stove, and how much more difficult it is to keep a room perfectly ventilated in summer than it is in winter, when the fire is constantly changing the air. It may be true that three fourths of the heat of our fireplaces passes up the chimney and is lost to us; but we gain far more advantage by the fresh air constantly introduced into the room. Now, with improved grates and improved fireplaces we may retain all the advantages of the open fire without so great a waste either of the substance of the consumer or of the national stock of coal; and attention is already being devoted to this fact in middle-class households, but some time must yet elapse before the advantage is reaped by the working classes. At a former meeting of this Association Mr. Edward Atkinson exhibited a portable oven or cooking-stove, which was a marvel of simplicity and economy. He has described it at length in his 'Science of Nutrition,' 1892. He argues that the attempts to combine cooking with the warming of a room or house are absurdly wasteful; that almost the whole of the fuel used in cooking is wasted; and that nine tenths of the time devoted to watching the process of cooking is wasted; and he estimates the waste of food from bad cooking in the United States at $1,000,000,000 a year. I have not, however, heard of his oven being at all extensively used.

Upon the thorny subject of dress it is perilous to venture; but it is impossible to be in the neighborhood of a London park on a Sunday afternoon without feeling that the efforts of domestic servants to follow the rapidly changing vagaries of fashion are carried to a pernicious degree of waste. The blouse of the French workman and the bare head of the Parisian factory-girl or flower-girl are infinitely more pleasing than the soiled and frowsy woolens or the dowdy hats of their English fellows, nor does the difference of climate afford an adequate explanation of the difference of habit. We must perhaps admit a greater dislike in England to any external indication of a difference in wealth by a costume different in kind. M. Lavollée, after referring to the low price of the ready-made suits which the English factories "fling by the million on the markets of the world, including their own," adds: "This extraordinary cheapness is, however, not always without inconvenience to the consumer. If the clothes he buys cost little, they are not lasting, and their renewal becomes in the long run very burdensome. This renewal is, too, the more frequent in that the wife of the English workman is in general far from skillful in sewing and mending. Whether she lacks inclination, or the necessary training, or whether the fatigues of a too frequent maternity make her *rôle* as a housewife too difficult for her to support, the woman of the people is generally, on the other side of the Channel, a rather poor cook, an indifferent needle-woman and a still more indifferent hand at repairs." As a consequence, he says, the English workman has often no alternative but to wear his garments in holes or to replace them by others. Given an equal income, there is probably no doubt that a French working-class family will be better fed and better clad than a corresponding English family dealing in the same market, and will lay up a larger stock of the household goods, and especially linen, which are the pride of the French peasant.

The waste resulting from the immoderate use of alcohol and from the widespread habit of betting, serious as it is, need not detain me, as I wish to confine myself more particularly to waste which can hardly be called intentional. It is not suggested that every man should confine his expenditure to what is strictly necessary to maintain his social position. The great German writer on finance, Professor Wagner, is accustomed to say that "parsimony is not a principle." It is sometimes, indeed, a bad policy and a wasteful policy; and life would be a very dull business if its monotony were not relieved by amusement and variety, even at the occasional expense of thrift. Le Play refers to tobacco as "the most economical of all recreations." How else, he asks, could the Hartz miner "give himself an agreeable sensation" a thousand times in a year at so low a cost as 10 francs? But nobody would wish to see a free man using his tobacco like the Russian prisoners described to me by Prince Krapotkin, as chewing it, drying and smoking it, and finally snuffing the ashes! Nor should we desire to eradicate from society the impulses of hospitality, and even of a certain measure of display. An austere and selfish avarice, if generally diffused, may strike at the very existence of a nation.

Another respect in which French example may be profitable to us is the municipal management of funerals (*pompes funèbres*). Many a struggling family of the working classes has been seriously crippled by launching out into exaggerated expenses at the death of one of its members, and especially of a bread-winner. The French system, while preserving the highest respect for the dead, has some respect for the living, who are frequently unable and unwilling at a time of bereavement to resist any suggestion for expensive display, which seems to them a last token of affection as well as a proof of self-respect.

As regards housing the English cottage or artisan's house is regarded on the Continent rather as a model for imitation than as a subject for criticism; but the pressure of population upon space in our large cities, joined with a love of life in the town, may possibly prove too strong for the individualist's desire for a house to himself. If we should be driven to what Mrs. Leonard Courtney has proposed to call Associated Homes, the *famillistère* founded by M. Godin at Guise, and rooted in the idea of Fourier's *phalanstère* will show us what has already been achieved in this direction. Dissociated from industrial enterprise it might easily become popular in England. Some of its collective economies are certainly deserving of imitation, and the experience not only of the Continent, but also of America, may soon bring us face to face with the question whether the preparation of dinners, in large towns, should not—at least for the working classes—be left to the outside specialist like the old-home industries of baking and brewing. An excellent example of scientific observation is 'Les Maisons types,' by M. de Foville, the well-known master of the French Mint. He describes in detail the various forms of huts, cottages and houses scattered over France in such a fashion that it is said the traveler in a railway train may tell, by reading the book, through what part of the country he is passing; and he gives the reasons, founded upon history or local circumstances, for the peculiarities in architecture to be observed. The book is a useful warning against rash generalizations as to the best type of house for a working man.

A well-informed writer shows, in a recent article in the 'Times,' that not less than about fifty million gallons of water a day might be saved in London, "without withdrawing a drop from any legitimate purpose, public or private, including the watering of plants." He says: "The detection of waste is carried out by means of meters placed on the mains, which record automatically the quantity of water passing hour by hour throughout the day and night. The whole area served by a given water supply is mapped out into small districts, each of which is controlled by one of these detective meters. The chart traced by the apparatus shows precisely how much water is used in each of the twenty-four hours. It records in a graphic form and with singular fidelity the daily life of the people. It shows when they get up in the morning, when they go to bed at night, when they wash the tea-things, the children and the clothes; it shows in a suburban district when the head of the household comes from the city and starts watering his flowers; it shows when the watering-cart goes round; but, above all, it shows when the water is running away to waste, and how much."

I quote this not to multiply examples of the waste of wealth, but to illustrate the insight which a few figures, such as those recorded by this meter, give us into the lives of the people. How much more does the account-book, a detective meter of every economic action, give us an animated photograph of the family life. Nothing is so calculated to stimulate social sympathy or to suggest questions for consideration. Like a doctor's notes of his patients the facts are not for publication in any form which will reveal the identity of the subject; but when we have enough of them they will be of the highest scientific value. We have at present too few to offer any useful generalizations. All that can be done is to serve as a finger-post to point the road along which there is work to be done.

If nothing has been said about the waste and extravagance of the wealthier classes, it is because economy is with them of less moment. They suffer little or no privation from extravagance, and derive less advantage from checking it than those to whom every little is a help. And so far as much of this waste is concerned, they sin against the light. It is one thing to point out a more excellent way to the unwary, another to preach to those who, seeing the better, follow the worse.

But the expenditure of the working classes is also, from a scientific point of view, vastly more important. Their expenses are more uniform, less disturbed by fantasy, or hospitality, or expensive travel, and will give us more insight into the hitherto inscrutable laws of demand. The time is far removed when any reduction in the cost of living could be successfully made the pretext for a reduction in the rate of wages. The Committee on the Aged Deserving Poor recommends under certain conditions pensions varying with the 'cost of living in the locality.' The same factor, we are told, enters into the adjustment of postmen's wages as between town and town. How are we to know the comparative cost of living without these details of expenditure? How else can we measure with any exactness the progress of civilization itself? How else can we discover the cohesive force of the family in holding together the structure of society, the mutual succor of young and old, the strong and the infirm or sick, the well-to-do and the victim of accident or ill-luck? To what department soever of economic life we turn our eyes we find live men and women, born into families, living in families, their social happiness and efficiency largely dependent on their family lives, and when we consider how greatly our knowledge and insight into society will be increased by a more intimate acquaintance with the economics of the family, we may well cherish the highest hopes for the future progress of our science. The theory of this subject, at any rate, is not 'complete.' It has not even been begun.

Upon certain aspects of the spending or using of wealth as opposed to the getting of wealth, like the expenditure of central and local governments, it would hardly be proper for me to enlarge. The first is subject to the watchful control of the tax-payer, of Parliament, and of a highly trained civil service; the second to the jealous criticism of the rate-payer and his representative. But there is some social expenditure, like the scandalous multiplication of advertisements (which by a refinement of cruelty gives us no rest night or day), which is wicked to a degree. In all these matters of the consumption of wealth, individually and collectively, we are as yet, it must be again repeated, too ignorant of the facts. An unimaginative people as we are, we are fortunately fond enough of travel to have suggestions constantly forced upon us by the different experiences and habits of foreign countries. And we are happy in a neighbor like France, with her literary and social charms and graces, her scientific lucidity and inventiveness, and the contrasts of her social genius to inspire comparisons, and in many respects to set us examples. I have singled out one of her many writers for attention, precisely because of this quality of suggestiveness. Other investigators have, of course, attacked the subject. In Belgium and Switzerland, Germany, Italy and Austria, and the United States, governments and individuals have recently undertaken the preparation of family budgets; but in many respects Le Play's monographs are the first and greatest of all. They yield excellent material, upon which science, in its various branches, has yet to do work which will benefit mankind in general; and promises especially to benefit the people of this country. The cosmopolitan attitude of the older economists was largely due to their centering their attention upon the problems of exchange. To them the globe was peopled by men like ourselves, producing the fruits of the earth, anxious to exchange them to the greatest mutual advantage, but hindered from doing so by the perversity of national governments. The facts of consumption, at any rate, are local. They are often determined by geology, geography, climate and occupation; and, however fully we may admit the economic solidarity of the world, and the advantage which one part of it derives from the prosperity of another, yet we may be easily forgiven for thinking that our first duty lies to our own brethren; that our natural work is that which lies at our own doors; that, as the old proverb says, 'the skin is nearer than the shirt.' And we may fairly be excused if we attempt to make our contribution to the welfare of the human family through the improvement of the consumption of wealth and the condition of the people in our own land.

THE CONQUEST OF THE TROPICS.

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THE most beautiful and the most fruitful portions of the earth are at the present time in the possession of partially civilized, or barbarous and savage races, to the exclusion of the more enlightened Caucasian. Shall he ever remain unable to possess and occupy tropical lands to the exclusion of dark-skinned and inferior races? Will the time never come when he can rear a family of strong and vigorous children, of pure blood, under the equatorial sun? Is it true that the white man removing to the Tropics necessarily deteriorates?

The almost universal belief is that these questions must be answered in the affirmative. That, owing to the great heat, and to evil influences operating through the air, the water and the soil, it will always be impossible for white people to live in hot countries permanently, and, at the same time, to retain the physical vigor of temperate latitudes, and to rear healthy children. But these persons do not take into account certain recent great discoveries in the domain of science, medicine and hygiene. In the light of these discoveries, it is not wise to say that the white man will never conquer the Tropics.

White races have, in the past, reached a high degree of civilization in hot countries. Egypt, where the first civilization arose, is a land of tropical heat. The valley of the Euphrates, where arose the civilization of Babylon, and much of Persia, are both tropical or sub-tropical in temperature. The people of Egypt, Babylon and Persia were white. It would seem that to originate a civilization is more difficult than to maintain it.

Many countries, now most salubrious, were once considered very unhealthful. Health conditions were so bad in England, after the withdrawal of the Romans, that for nearly a thousand years there was absolutely no increase in the population, and the most dismal accounts of the reign of disease have come down to our times. What was true in England, was in great part true of all of Europe throughout the Dark Ages. Scurvy, rheumatism, fevers and plagues held high carnival in recurring epidemics every few years. If we can believe the reports, it was fully as dangerous then to dwell in the most favorable portion of Europe as it is now in the most dreaded tropical regions.

New England was at first thought to be a very unhealthful land. The early settlers in Massachusetts wrote to their friends in England imploring shipments of ale and beer, because the water was 'wholly unfit to drink.' What held concerning New England was doubtless maintained about every other portion of the Continent settled by the English, and, in some cases, these views prevailed until recent times.

It is well known that our ancestors thought it would never be possible for white people, or, indeed, for any people, to live on the treeless prairies of the great West. The earliest settlers always occupied the wooded belts, and only seventy years ago the prairies, which now sustain millions of happy and healthy whites, were looked upon probably in much the same way as we regard the plains of the Amazon, of the Orinoco, or even the Sahara of Africa.

Many persons yet living can recall the terrible struggles with disease which the first settlers passed through in Ohio, Indiana, Illinois, Missouri, and even in salubrious California. The early settlers in these States were doubtless as sallow, as cadaverous looking, and with as little prospect of leaving vigorous descendants as the present white inhabitants in Cuba, Porto Rico or the Philippines. The reputations of Florida, Louisiana and Texas were no better.

Adults can live without deterioration in the Tropics. This has been proven by English and Dutch officers in India, Ceylon, Java, Sumatra and elsewhere. In the West Indies are men from the United States and from all the countries of Europe, who have been in the islands twenty, thirty, forty, and in some cases even fifty, years, who are to-day the picture of good health, active and vigorous in their work. The same is true in all parts of the tropical world. Adults can live in good health there.

Children born in the Tropics, if educated in temperate latitudes, can return to the Tropics, and this can continue indefinitely in the same families without deterioration. This has been found true in India, Java, the Sandwich Islands and in the West Indies.

It has been assumed, heretofore, that the bracing climate of the north-lands has produced vigorous constitutions in the children sent from the Tropics. That this was of some value will not be denied, but it is insisted that of greater value is the education in the higher ideals of the temperate latitudes. In the Tropics, ideas of morality, of sanitation, of correct living, are very crude. A child born and reared in the midst of low ideals unconsciously absorbs them, and assimilates readily with the population around him. The Spanish idea that everyone born in a tropical colony is necessarily a 'degenerate' is practically true, if he is also reared among 'degenerates.' The custom which exists in these colonies of giving each child born a 'degenerate' native child as a companion and playfellow, only makes more sure the outcome. Isolated families exist in Cuba and Porto Rico, where, high ideals having been maintained and inculcated in the children, we now find vigorous descendants to the third and fourth generations. There are many such families in Porto Rico, and the same is true in the Sandwich Islands.

It is here maintained that it is the letting go, little by little, the correct views of living, which causes the white race to deteriorate, and not the climate. The necessities of life are fewer and easier to obtain in hot countries than in cold ones; and this makes it easy for men to become indolent, to lose ambition and to sink to a low level of living and thinking.

The Tropics, contrary to the usual view, are healthful regions. Malaria exists in hot countries, but so it does in temperate ones. Typhoid fever and contagious diseases are no worse than in cold climes. Smallpox is regarded as a mild disease. Scarlet fever is said not to exist at all. Where filth is allowed to accumulate disease prevails, but in lands well drained and free from decaying matter and filth, there is, under ordinary care, no more to be feared from disease than in the most favored portions of the earth. At present, in hot countries the people pay little attention to sanitation. As a rule, they are unutterably dirty. They live in their own filth, and seem to enjoy it. The germs of disease from one body are promptly taken into another before they have time to die, or are cultivated in filth deposits until the whole community is affected.

The Tropics, in themselves, are no more and no less healthful than temperate regions. But the people in cold countries have some respect for sanitation, while those in hot countries have very little or no respect for decent cleanliness. This is the whole explanation of this matter. People who have the latrine in the kitchen and uncleaned for a century, who sleep in rooms into which a breath of fresh air cannot enter; who seldom wash their bodies; who use rum and tobacco instead of food; who permit children to cohabit promiscuously, can scarcely hope to escape disease, if any prevails in their neighborhood. Such conditions are the rule with the masses in hot countries.

Those who become 'acclimatized' will be able to live in hot countries. It is doubtful whether or not there is any actual condition known as 'acclimatization,' although if the term means becoming accustomed to filth, and to certain germs which live in filth, there may be something in the term.

Instead of a bodily change, the individual gradually becomes educated to his new environment. He learns what to eat and drink, what to wear and where to sleep, when and how much to work, to come in out of the shower and to change his wet clothes, to avoid the midday sun and the damp air of the night. When a man new to the Tropics has learned these things, he is 'acclimatized.' Some learn them at once; others are years in learning, and meanwhile suffer from sickness and distress.

New conditions must be met in every country new to the pioneer, whether the country is in temperate or hot latitudes. In opening up a new country to settlement, it is the severe labors, the exposure, the meagre diet, the anxiety, the general hard conditions of life, which undermine the general system and make the body an almost unresisting victim to the germs of malaria and other diseases. It is not the climate in new countries, but the hard conditions of life, which kill the settlers.

So, in the recent war with Spain, bad conditions in the northern camps, uncleanliness of person due to lack of water, over-exertion in practice marches, sleeping on the ground, change of food, overcrowding in tents preventing restful sleep, unsanitary conditions on transports, caused the men to be landed in the Tropics in an extremely bad condition of body. Landing in the rainy season, opening the earth to form trenches for defence and about their tents, sleeping upon the damp ground, with a deficient and unbalanced ration, with no change of clothes for nearly three months, it is no wonder that many became sick. But the sickness was not due to the climate at all. It was due to the hard conditions in the home camps, and to hard conditions during the campaigns in the islands.

It is said that the heat, the rains and the insects of the Tropics are certainly unbearable by a white person from the temperate latitudes. But these things are magnified by the distance from which they are viewed. So far as the tropical lands recently acquired by the United States are concerned, they are not elements to be dreaded.

These lands are all Oceanic Islands. Surrounded by immense areas of water, they have an unvarying, or slightly varying, temperature. They are warm the whole year round, while never hot. In all these Islands the midday temperature is about 80° Fahrenheit. At night it falls to 75° or even to 70°; in the mountains still lower, depending upon the elevation.

But this heat is moderated by sea breezes. Except for about an hour in the morning, there is a breeze the whole day long, which tempers the heat. Sunstroke is unknown. No bad conditions arising from the heat have been seen in Porto Rico. The nights are always so cool that refreshing sleep may be obtained, and the effect of the sun is tempered by clouds, which shade the earth nearly all summer.

All the islands have mountains which may be reached in a few hours, where the climate of the temperate latitudes may be enjoyed by those desiring the change.

The tropical rains are no serious drawback. They fall at a fixed time each day, usually from two to four o'clock in the afternoon. They are much like heavy June showers in the States, unaccompanied by thunder and lightning. The ground soon dries off, and the rain has occasioned no inconvenience of consequence to anyone. The absence of thunder and lightning is remarkable. This is certainly true in Porto Rico.

The hurricanes and other great wind storms are probably no more frequent nor more destructive than are cyclones in the States. In Porto Rico there is a belief that a single severe hurricane occurs about once in each hundred years.

Insects are strangely few. The mosquito is grown in the cisterns, and is abundant in the towns. It is practically absent in the country. The flea is found only in the towns, where it is a sort of domestic animal. A little attention to cleanliness would diminish the numbers. The bedbug has not been seen in a year in Porto Rico, though there is no reason why it should not be here. Centipedes, spiders and tarantulas are so scarce that the natives expect about fifty centavos for each large specimen which they catch. Indeed, instead of an abundance of insects, these islands are remarkable for the small number of species and individuals indigenous to them.

Recent inventions and discoveries have made the conquest of the Tropics by the Caucasian race possible. There have been great discoveries made in chemistry, biology, bacteriology and medicine within recent years. Chemical discoveries have produced new and powerful remedies. Biology and bacteriology have brought to light numerous microscopic forms of life, traced their life histories, and shown that beyond a doubt, many, if not all, of the diseases designated communicable (contagious and infectious) are due to living beings called 'germs.' The experimental physician has discovered, in some cases, remedies which will destroy these germs after they have been introduced into the body, while the sanitarian has made vast studies in demonstrating how they may be destroyed before entering the body. Thus, sterilized food, water and clothing never convey diseases. Cities which are kept clean and have pure water supplies have little fear of epidemic diseases. The draining of lowlands, the thorough cultivation of the soil, the paving of streets and the use of quinine cause malaria to retreat from its old haunts.

Biologists have shown that a tick conveys the Texas cattle fever; the tsetse fly in Africa spreads the 'fly disease' among the cattle in that continent. The house-fly spread typhoid fever among our soldiers last summer, and there is good reason for believing that the mosquito is in large part the disseminator of malaria. Consumption, dysentery, the Asiatic plague, leprosy, typhoid fever, are all germ diseases. Knowing the causes of these diseases, the life history of the germs, and the remedies to apply, it is hoped that in a very few years the biologist, the bacteriologist, the sanitarian, all working together, will make tropical diseases to be no more dreaded than are the diseases of temperate regions. As warm countries become better known, physicians will certainly become more skillful to treat the diseases peculiar to them.

Rapid transportation and rapid communication between the tropic and temperate regions will rob the former of many terrors. When a person can communicate with his family every few days, or by telegraph in a few hours, and when he knows he can reach his old home readily, one element which disturbed former pioneers is removed.

Rapid transportation and the discovery of the process of canning fruits, vegetables and meats, together with the process of manufacturing ice, and of cold storage methods, make it possible for a person in a hot country to enjoy the foods to which he was accustomed in his old home. This will be a great help until he has learned to use native products.

Education and good laws will remove from the Tropics many undesirable features which now repel people from the North. It has been already remarked that the people in these islands have no knowledge of sanitation, and live in utter disregard of all the well-known rules of hygiene. Some of the most striking examples of this are the living in their own excretions, sleeping in air-tight compartments, the lack of a variety of food, working long hours in the hot sun with an empty stomach, using rum, tobacco and coffee in place of food, the utter lack of any restraint of the sexual instinct by either men or women of the lower classes and by the men of all classes, producing a well-nigh universal corruption of blood.

These unsanitary and unhygienic conditions have dwarfed the tropical dwellers in body and in mind. These things cannot be laid to the climate. They are due to ignorance. The same condition would produce similar results in Pennsylvania or Connecticut, and such results were seen a generation ago in New Mexico, California and elsewhere.

The laws under which these people have been living have been monstrously bad. Marriage has in some cases been actually discouraged; there was little opportunity and little inducement to accumulate property. There were few schools, and they were of poor quality. The different races, white, Indian and African, have fully commingled, and the result the world knows is bad. The strongest arguments against the mixing of the Caucasian and the African are to be found in the West India Islands. The mixed races will be much harder to deal with than pure bloods of any race.

The climate in Cuba and Porto Rico—and the same is claimed for the Philippines—is equal to any in the States south of the Carolinas. With the masses educated and with wholesome laws, these islands will all become garden spots, and will ultimately be occupied by pure-blooded Anglo-Saxons, the present inhabitants disappearing before the stronger and purer-blooded race.

DISCUSSION AND CORRESPONDENCE.

POETRY AND SCIENCE.

In spite of the occasional croak of prophets of evil, poetry is not in danger of being crowded out of the hearts of men by the materialism of science. It is true that just now there are no poets of surpassing genius with whom the reading public is popularly acquainted. It is true that the development of our material civilization through the surprisingly rapid advance of scientific discovery is a thing which engages attention to a very great degree. It is true that the necessity of dealing continually with practical, matter-of-fact details, whether of the office, or the factory, or the laboratory, is not in itself distinctly poetical. It is true that planning practical uses for the Röntgen rays or liquid air is not essentially stimulating to a love for poetry, but this is only one aspect of the case.

A great deal of the appeal of poetry comes through what it suggests of the unknown and mysterious, suggestions, not of the strange and the fanciful, but of the beautiful, hints of a something beyond the beauty to which our eyes have yet come, a beauty to which, perhaps, for all our longing, they may never come. A man for whom the problems of existence have ceased to be problems, a man whose theology is a settled thing, who believes certain things definitely and rests with assured ease in his belief, a man for whom the vague anticipations of a world of doubt as yet beyond his ken "make no purple in the distance," such a man can neither have appreciation for a wide range of poetry, nor will he write verse that can take any serious place as poetry for modern readers. The poetry of a primitive people, dealing with primitive emotions, finds in more elementary things, like the boy in Wordsworth's "Intimations of Immortality," hints and suggestions of a "something that is gone," "the glory and the freshness of a dream." These emotions become our emotions sympathetically, and not because they are quite the normal feelings for the mature reader of poetry to-day. The things that were a wonder to the Greek of Homer's time have ceased to be a wonder to us, and if a poet would excite the same feelings in us he must employ other means. Science, in giving us absolute knowledge in regard to many things which not so long ago were full of strangeness for us, has taken out of them the olden poetry and the trees have nymphs that direct their growth no longer, the streams that were once dæmon-haunted are now merely water courses, and the other spirits of the earth and air have gone far away into the world's forgetfulness. But while we have been pushing out into the unknown and annexing portions of it to the region of the known, we have been merely enlarging the boundary, not obliterating it. More than this man never can do. Always beyond the farthest vision of his telescope and microscope will lie the unknowable, growing smaller, perhaps, but seeming larger as it gives up some of its secret places for the inhabiting of the dwellers in the known. And this is the significant thing, that, as our knowledge grows, our sense of what lies beyond that knowledge finds an increasing number of things that may excite wonder. Every new scientific discovery, at least in certain departments of science, simply acts as an index finger pointing the way to related phenomena not yet understood. And so it will be ever. The most learned man that the schools, and the fields and the sky aided by the finest instruments human skill can devise, can produce, will only find himself awed by the vast darkness of the unknown into which his eyes cannot pierce.

There is another phase of the question that must not pass unnoticed. As the region of the unknown widens it offers more objects of interest and may thereby more fully absorb attention. When reality is sufficiently rich in experience we do not care to indulge in dreams. When the present satisfies us and answers all our needs we are less inclined to look forward to the future, whether that glows before us with the hues of promise or darkens with the threat of coming storm. But the fullest life may weary at times and wish, for the mere rest of change, to go outside of itself and find in the strangeness of something new and not yet known a relaxation and recreation for the tired hand and brain. And so the strenuousness of modern life with its ceaseless outreaching for new pleasures and new truths will be ready always for the soothing restfulness of a poetry that gives the form of beauty to things just beyond the wonderland of the known.

But how to make poetry of these things is the perplexing problem. Truth, whether of the world of fact or of the world of imagination reaching out into the spiritual realm, is not poetry until in some fashion it is made beautiful in its appeal to our sensibilities. A hundred years ago the things that were fitting subjects for poetic treatment were much more elementary and as emotional stimulus they reached consciousness in a much more immediate and direct fashion than the themes that are fitted for poetry now. The poet who would achieve distinct success in the higher walks of poetry to-day must be master of an art surpassing that of all but a few of his brethren of the craft who have gone before him. The world of the known is so large, comparatively, now, and the individual is so far removed from the boundaries of the unknown, save, perhaps, at one point, that more art is required to induce him to travel the longer distance out of the world of cold fact into the borderland of strangeness where suggestions of new truth and new beauty may come to quicken aspirations.

It is true that there are themes that were new a thousand years ago and will be new a thousand years hence, but a poet to achieve distinct success must strike a note not only individual, but one closely attuned to the thought and feeling of his time. Milton we know rather as a voice of Puritan England than as a poetic genius. We call Wordsworth a great poet and are conscious as we do so, that he deserves the distinction rather because he interpreted to men a new phase of thought and feeling, than because he knew how to make his verse wholly pure poetry rather than bald prose. Even poets of such spiritual elevation as Shelley and Coleridge caught the feeling and the tone of their time, and the revolutionary spirit and the love of nature that was molding Wordsworth finds a distinct voice in them as well. Even Burns, isolated as he was, is not altogether an anomaly, and no one need be told that Byron was in an extreme degree the voice of the reactionary spirit of post-revolutionary Europe. William Morris, retelling old legends of Greek and Saxon, none the less informed his verse with the humanitarian and æsthetic spirit of modern life, and applied his sense of the beautiful to the problems of nineteenth century existence. Swinburne, too, is democratic and in his vision the world moves on to new glories even though the old be not wholly faded from the earth.

Robert Browning is first and fundamentally a painter of character, a student of the more subtle moods that dominate the individual, and toward this the reader of English fiction would hardly fail to see that the development of literature has steadily been advancing for two centuries. Even Mrs. Browning through the somewhat morbid and mawkish sentimentality and the overstrained art of "Aurora Leigh," in the vague and uncertain way of a woman whose contact with reality was necessarily slight, catches at the problems of nineteenth century feeling. Tennyson, as all men know, gave us poetry that was inwrought of the latest word of science, the last aspiration of religious hope, the newest sure conclusion in the field of social endeavor for the betterment of man.

And Tennyson in "In Memoriam," as Browning in "Paracelsus" and Lowell in "The Cathedral," has taught us that abstract truth may be made into poetry and that of the loftiest and most vitalizing kind. And to such poetry the world is ready to give a willing ear, though it will not be satisfied with the mere tricking out in rhyme and meter of scientific truth. The difficulty for the poet to-day is not merely that of new knowledge, but that of a science advancing so rapidly that the poet, whose art is meditative, can hardly avail himself of its latest revelations before their significance has vanished in the light of some new and revolutionary discovery announced from some investigator's laboratory. This is so new a thing that literary conditions have not yet been adjusted to it, as we may fairly hope that they will be some time in the not distant future.

A thing, almost if not quite, as distinctive of our time as the progress of scientific discovery is the growth of the democratic spirit. This latter has been a thing of common observation for over a century, and about that long ago Wordsworth and Shelley, Burns and Byron voiced with glowing enthusiasm the new revolutionary gospel. Since then it has been the theme of other pens and has become a matter of commonplace, and yet, though it has not lost interest because of the fulfilment of the hopes of man, it is not now a vital force in literature of the better class. The reason for this is, perhaps, not far to seek. In the domain of politics the advance in thought and feeling from a hundred years ago is a matter of no great moment. The poet who would voice for the world a message of brotherhood, thrilled with the spirit of a new humanity, inevitably finds himself harking back; he is compelled to repeat the sentiments of Mrs. Browning's perfervid Italian poems, or Whittier's simple songs, or Shelley's vague theorizing: he ceases to be individual. Under present conditions, strenuously vocal as the world is with the voices of those trying to be heard, failure to be distinctly and positively individual is failure to gain attention.

And it is significant that we are approaching the solution of social problems in the scientific way. The development of a better state of society is to come about, as we now realize, through the operation of natural laws, and not by the sensational process of awakening in the hearts of men a flashing enthusiasm for new forms of government.

Benjamin Kidd's 'Social Evolution' indicates quite clearly the new point of view from which all problems of society are to be considered, and perhaps, not less remarkable for a like significance is Henry Drummond's 'Ascent of Man.' As the laboratory gives up its secrets, as the mysteries of biology and processes of growth in the organic world become less mysterious, we are approaching nearer and nearer to a knowledge of the laws that are concerned in all growth, whether of the star fish or of the modern state. Assuming that man is the most vitally concerned in the organization of society here in this present world, and with the problem of another world, whether real or imaginary, whether a perfect state, or state of growth as that of earth, one cannot escape the reflection that both these problems have become in a measure problems of science, rather than problems of intuition or authority or emotional susceptibility.

And when science has come so close to all the inmost convictions and aspirations of man, there must follow a poetry of science, fuller, richer, more vitalizing and more enduring than any that has gone before it. It will appeal to a nobler and loftier sense of beauty, a finer and more perfect conception of truth. It will clothe its utterances in an imagery as much more varied as the knowledge of to-day is fuller than that of yesterday. It will be artistic beyond the dreams of other days, and its art will be something more than that of mere intuition. It will glow with color, but no crudeness of taste will guide the artist's brush, and the intelligent, æsthetic sense of a broadly cultured people will find inspiration in it, as once heroes did in the songs of the bards of old.

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ANTIQUITY OF THE CHEWING GUM HABIT.

IN the letter of Columbus on the discovery of America, facsimile edition, 1892, of the four Latin editions belonging to the Lenox Library, the following occurs in the translation (page 11): "Finally, that I may compress in few words the brief account of our departure and quick return, and the gain, I promise this, that if I am supported by our most invincible sovereigns with a little of their help, as much gold can be supplied as they will need, indeed, as much of spices, of cotton, of chewing gum (which is only found in Chios), also as much of aloeswood, and as many slaves for the navy as their majesties will wish to demand."

The date of this letter is March 14, 1493,—over four hundred years ago. It will be seen by the above that the chewing gum habit is by no means a modern or recent one, and doubtless antedates Columbus' letter by many years.

The reference to Chios, an island in the Grecian Archipelago, is presumably for the purpose of indicating the character of the 'gum.' The Chios 'gum' of the ancients has been described as an earth of a compact character, probably argillaceous, and had the reputation of possessing medicinal qualities. Its consistency and appearance may have been such as to have led to its being popularly called 'gum.'

That the chewing of gum, or some other article or waxy substance suitable for chewing, was in vogue at the time, there can be no doubt, and that the discovery of such a substance would be regarded as an important acquisition is implied by its being specially mentioned and promised by Columbus.

Years ago, more than half a century, shoemakers' wax, so-called, Burgundy pitch and crude spruce-gum were chewed to a considerable extent, as the writer clearly remembers.

Betel chewing, the leaves and the nut mixed in certain proportions *with lime*, as practiced in Asiatic countries, naturally occurs to the mind in connection with the foregoing, as well as occasional instances of chewing slate pencils and lime mortar, an interesting case of the latter having been brought to my notice several years since by a well-known physician of Newark, N. J. But these are rather exceptional and individual cases, therefore not to be regarded as general or popular habits. From the *chewing* of earthy substances to the *eating* of the same, would appear to be but a natural step. The latter habit, so far as facts are available, is of comparatively infrequent occurrence and restricted to a much smaller number of persons. Beds of white infusorial earth, resembling magnesia in appearance, known as *Bergmehl*, occur in Lapland and Finland. This is, or has been used in seasons of scarcity, mixed with flour made of some kind of grain or ground birch-bark, and *clay-eating* probably, to a greater or less extent, still continues to be a habit in North Carolina as in the past. The effect of this habit, as any intelligent person would suppose, is decidedly injurious to the individual that pursues it. In several cases that have come under my observation the results are exhibited in sallowness of complexion, lack-lustre eyes, distension of the abdomen caused by engorgement or clogging of the liver, and other intestinal derangement, listlessness and general debility.

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SCIENTIFIC LITERATURE.

A GRAMMAR OF SCIENCE.

THE increasing specialization of the sciences and the consequent occupation with the details and technical manipulations of a specialty render it possible for many a student to secure the equipment needed for his immediate activity, with but little appreciation of the general principles that give direction and solidarity to his science, or of the more general and fundamental conceptions which the various sciences and the spirit and progress of science as a whole have in common. The student runs the danger of gaining a certain familiarity with the vocabulary and the usage of the language of science, but of ignoring its grammar. One of the purposes met by Prof. Karl Pearson's 'The Grammar of Science' is to give the serious student an opportunity to acquaint himself with these underlying conceptions—cause and effect and probability, space and time, motion and matter and the composition of the physical and organic worlds. It discusses with him and for him the nature of the knowing process, and demonstrates how the sciences stand—not for a literal copy of reality, but represent a special abstraction and construction on the basis of experience, which serve the purposes of intelligibility and logical system. A law of nature is not an objective reality, but "a *résumé* in mental shorthand, which replaces for us a lengthy description of the sequences of our sense-impressions. Law in the scientific sense . . . owes its existence to the creative power of his [man's] intellect." Science is thus not the mere reflection of perceptual experience, but is dependent for its advance quite as much upon the formation of appropriate conceptions by the exercise of insight and a keen logical analysis and synthesis. Hence, the importance of the imagination as a requisite for scientific discovery, which leads Professor Pearson to regard Darwin and Faraday as superior in this quality to the best of the poets and novelists. Not only the content of the sciences but the spirit and the means that guide its advance form part of the grammar of science. The nature of the scientific method, the appreciation that the scope of science is really coincident with the scope of verifiable knowledge; that science represents a mode of approach and of inquiry, and that the scientist or the scientifically-minded individual is characterized by a definite logical attitude, by a manner of entering into relation with his surroundings and of dealing with reality; that science discountenances attempted short-cuts and inspired revelations, or guesses of the riddles of existence; that it avoids metaphysic and impractical speculation; that it justifies its existence and the energies which are expended on its behalf by the mental training it provides in education, by its illumination of the problems of life and society, by the practical benefits it confers in the various fields of human activity, as well as by the gratification it yields to some of the most permanent and most worthy of our intellectual and æsthetic impulses —these and other propositions are ably and interestingly presented and constitute an essential portion of this very stimulating and clarifying volume. The success of the work is attested by the appearance of this second edition; the chief addition consists of a discussion of the quantitative method as applied to biological phenomena, which the readers of others of the author's works will recognize as one of his favorite subjects of investigation.

THE TEACHING OF ELEMENTARY MATHEMATICS.

THE book with the above title, by David Eugene Smith, principal of the

State Normal School, at Brockport, N. Y., contains much of value, presented in a very readable and attractive manner. The subjects treated are arithmetic, algebra and geometry. About half the book is devoted to the first. The author sketches the history of the teaching of arithmetic from the earliest times, gives a critical examination of the different systems which have been tried and aims to discover the correct general principles upon which the instruction should proceed. He notices the tendency of many of our schools to follow too closely the Grube method, or a modification of it. The chapter on the present teaching of arithmetic is full of valuable suggestions. Algebra and geometry are treated in the same way. Much useless lumber is cleared away, and the whole discussion is marked by strong common-sense, an element not always present in discussions of this kind. The extreme differentiation in the teaching of these three branches which prevails in so many schools is condemned. It is urged that the blending of algebraic method and notation with the higher parts of arithmetic, and the early introduction of the inductive study of geometric form, both contribute to the substantial progress and development of the student. Valuable references are given to other writings for fuller discussions on special topics. These references cover works in English, French, German and Italian.

GEOLOGY.

PROFESSOR SUESS's great work, 'Das Antlitz der Erde,' has been translated into French with emendations and annotations, and thus becomes accessible to an enlarged number of readers. No strictly geological publication since the time of the first appearance of Sir Charles Lyell's 'Principles of Geology' has brought together so many data concerning the nature of the altitude of the continents in relation to sea level. Geologists have generally assumed that it is the land which rises or sinks when a change of level takes place in relation to the sea. Professor Suess attacks this view and endeavors to show that the ocean has and has had its great movements, now keeping up its waters in the equatorial district, now accumulating about the poles and transgressing the low lands of its borders. An exhaustive review of the geological structure of the known parts of the earth, particularly complete with regard to the borders of the oceans and the the Mediterranean, is presented as a basis for discussing the evidence of such changes as the sinking in modern geological times of lands or islands in what is now the North Atlantic. By the sinking of the ocean floor, it is held that the sea level is lowered around the earth, thus giving rise to emerged lands. Parts of these plateaus have in turn sunk, and so the earth has experienced varied and often sudden changes of the relations of land and sea. The work is entertainingly written, despite the laborious compilation of geological details, which is made evident in its numerous chapters. The geological explanation of the Noachian Deluge is perhaps one of the most interesting sections of the work. Aside from the theory which the work sets forth, it affords the best general survey of the earth's surface which is at present available in any language. It has been supplied with numerous recent references by M. de Margerie and his able assistants in the work of translation.

A YEARBOOK OF BIOLOGY.

L'Année Biologique for 1897.—Every year the number of biological workers increases, the number of repositories of researches is multiplied and the difficulties of keeping informed of the results obtained in even a restricted department of science are enhanced. Hence, new bibliographical works are ever welcome, especially if they give not only titles but abstracts. *L'Année Biologique* does not only this, but more, for its abstracts are likewise critical reviews indicating the true place in the science of the results given in any paper. It goes still further, in that it summarizes the advance made during the year in each subject, and the contents of the volume are rendered still more accessible by a thorough author-genus subject index. Everything seems to be done that is possible to make the results of general biological studies available. Occasionally figures are reproduced and comprehensive, synoptic articles on the recent advances in one subject are printed. In the present volume there is a report on senile degenerescence, by Elie Metchnikov; on the urinary tubules in vertebrates, with seventeen figures, by P. Vignon; and on the conditions of existence in and the bionomic divisions of fresh waters by G. Prouvot. The reviews are all signed by the authors, the critical remarks being bracketed. Many of the reviews have the dignity of distinct contributions to science, as where a half-page abstract is followed by a two-page discussion. The reviewers, or 'collaborators,' are drawn from various countries, America, Austria, Belgium, England, Russia and Scotland being represented in addition to France. This periodical may be commended in the strongest terms to biologists and to others interested in the results of biology. It is surprising that the work is still so little known in this country. Scientific men have a right to take pride in the unremunerative efforts of the chief editor, Professor Delage, to make accessible the literature of the science of general biology in order to facilitate its advancement.

ASTROPHYSICS.

The 'Atlas of Representative Stellar Spectra, together with a Discussion of the Evolutional Order of the Stars,' by Sir Wm. Huggins, K. C. B., and Lady Huggins (Wesley & Son), is not only a sumptuous and beautifully illustrated volume, but is also of great scientific value. Sir Wm. Huggins belongs to that group of men in England who, unconnected with any university, devote themselves to research for the pure love of truth. His distinguished services to science received recognition on the occasion of the Queen's diamond jubilee, when with only two other scientific men he received the order of knighthood. His accomplished wife, who is his constant coadjutor, was the only woman mentioned in the list of Jubilee honors. Sir Wm. Huggins may be said to be the founder of the so-called 'New Astronomy,' for scarcely more than a quarter of a century ago his spectroscope, turned upon a newly discovered star, first revealed the cause of the sudden lighting up of these beacons in the heavens, and turned upon the nebula showed them to be of glowing gas. Since that time the telescope of the Tulse Hill Observatory, armed with spectroscope and camera, has been constantly and laboriously analyzing the light of star, comet and nebula, to solve the mystery of their constitution. "We never go anywhere," said Lady Huggins; "astronomy, at best, is a heart-breaking object of devotion beneath English skies, and we are always at home to catch every gleam between the clouds."

This book gives, in charming narrative, which would be read with interest by one previously ignorant of the subject, the history of the pioneer work "when nearly every observation revealed a new fact, and almost every night's work was red-lettered by some discovery."

There follow full details of later work, especially of the first detection, by the shifting of the lines of their spectra, of the motion of stars towards us or from us in the line of sight. We learn also how terrestrial chemistry has been enriched by this study of the stars, and how the nature of long known elements like hydrogen and the existence of undiscovered elements like helium have been first made out from stellar spectra.

But, as the supreme problem for the biologist is the development of man, so the supreme problem for the astronomer is that of the evolutional order of the stars. This problem, too, is discussed in the light of the discoveries at Tulse Hill. From the simple but beautiful harmonic system of hydrogen lines which characterizes a white star like Vega, we learn how we pass to the more developed star of a solar type, like Capella, and thence to Arcturus, and Belelgueze, which indicate a still later stage of development. At least this is the theory of the author. Aside from its great theme lucidly discussed the book deserves to be upon every library table as a superb specimen of book-making. For once, beautiful truth is promulgated in fitting guise. Lady Huggins is an artist and archæologist as well as an astronomer, and the initial letters of the chapters are illuminated with original sketches and designs from quaint old manuscripts, which make the book artistically as well as astronomically worthy of the prize which it received from the Royal Society as the most distinguished contribution to the scientific literature of the year.

EXPERIMENTAL MEDICINE.

Anyone who wishes to gain a fairly adequate idea of what experiments on living animals have accomplished for the welfare of the human race and of other animals as well, can now do so by reading 'Experiments on Animals,' by Stephen Paget. Mr. Paget has collected evidence showing the part that animal experiments have played in the progress of physiology, pathology, bacteriology and therapeutics. He has not ventured to offer opinion or even statements unsupported by exact and verifiable facts. A large part of the book's space is filled by original quotations from scientific workers, from Galen down to the recent students of the malaria parasite. It shows plainly that knowledge of the processes of life in health and disease has throughout depended on experiments on living substances. Mr. Paget's book is not dependent for its interest solely on the laudable curiosity to know the worth of animal experiments. For these have been so important in the science of medicine that their story is at the same time the history of a great number of medical discoveries. There is, too, a freshness and biographical interest in the quotations from the famous past and present students of medical science which makes them very readable.

ICHTHYOLOGY FOR ANGLERS.

In his "Familiar Fish, their Habits and Capture," Mr. Eugene McCarthy has put forth a readable volume which doubtless will prove popular among the disciples of Izaak Walton, for it is essentially a book for anglers, written by an angler of experience. A preliminary chapter, devoted to fish-culture, dwells on the destruction of eggs and fry in nature and the necessity for artificial measures. It is a fairly good general outline of the subject, although some of the methods described are obsolete. The many breeders of ornamental fish will wonder whether the author is intentionally facetious in stating that the "famous double-tailed goldfish frequently seen are raised in Japan, and are produced by violently shaking the eggs in a pan."

About a third of the book is devoted to brief accounts of the distribution, food, habits and peculiarities of the fresh-water fishes most sought by anglers, the salmons, trouts, basses and pikes naturally receiving most attention. The remaining pages deal chiefly with the description of angling paraphernalia and methods, camping, boating and useful data for sportsmen. By far the best chapters are those treating of the ouananiche and its capture, as the author writes from ample experience. He gives it first rank among our game fishes and holds that "pound for pound the ouananiche can greatly outfight the salmon, and none of the fresh-water fishes can equal it in this respect; the black bass approaches it the nearest but never equals it."

The volume is freely illustrated with fishing scenes, angling apparatus and twenty-five full-page figures of fishes, all but one of which are copied, without credit, from the reports of the U. S. Fish Commission.

The author submitted his manuscript to President Jordan "to be justified in advancing the claim" that the descriptions of the different fishes "are absolutely reliable and correct," and a prefatory note by Dr. Jordan is in that author's most pleasing style and adds considerably to the literary excellence of the volume; but evidently that distinguished ichthyologist did not believe any responsibility attached to him, for even a cursory glance by him over the manuscript would have eliminated a number of ichthyological incongruities, such as the inclusion of the white bass, one of the Serranidæ, in the same family as the black basses (Centrarchidæ). The author's conception of zoölogical nomenclature and classification is decidedly novel. In the final chapter, on "scientific names of fish mentioned," the first species referred to is *Salmo salar*, of which it is stated that "the word *salmo* is used in connection with a large variety of the trouts, to designate the family or descent. It is the first name given, as is the case with all other kinds of fish, being the specific name indicating the species. The other names following are subspecific." The land-locked salmon of the Saguenay River is by some systematic writers regarded as a variety of the sea salmon, and bears the name *Salmo salar ouananiche* McCarthy. Strange to say, this is the only species in the volume for which the name of the original describer is given, and in explaining his own connection with the fish, Mr. McCarthy says: "McCarthy, so named from his first writing fully regarding the fish!"

To the zoölogist the volume will be of no use, as it embodies few new observations on the fishes considered and is largely a compilation from other well-known works. The author, however, deserves credit for bringing the subject to the attention of anglers in such an attractive form; and, as an attempt to extend the knowledge of the habits, distribution and relationships of our game fishes among this large and influential class of citizens, the volume should be accorded a welcome.

MICROSCOPY OF DRINKING-WATER.

Mr. G. C. Whipple, Director of the Mount Prospect Laboratory of the Brooklyn Waterworks, has prepared a handbook for the water analyst and the waterworks engineer, with the title given above. It deals with the purposes, methods and results of the biological examination of drinking-water, affording means for the identification of the microscopic life found in water supplies and suggesting means for the elimination or control of those organisms which disagreeably affect the color or odor of potable waters. The construction of reservoirs, the storage of surface and of ground waters and the growth of organisms in pipes are also discussed. Though the motive of the book is thus technical, the subject is developed by the author along broad lines in a thoroughly scientific manner, and he has brought together a great deal of information, not only for the sanitary engineer, but also for the physicist, the chemist and the biologist. The problems in limnology, such as the temperature, stagnation and circulation of reservoir waters; the distribution and relative numbers of different organisms and their relation to chemical analyses are discussed in the light of the results of many years' investigation of water-supplies. The seasonal succession of organisms, their movements with respect to light and other stimuli, and their horizontal and vertical distribution, are in like manner fully treated. The scope of the work and the treatment of the subject make the book a valuable one alike for engineering and biological laboratories and for the general library.

THE PROGRESS OF SCIENCE.

The summer laboratories and the scientific expeditions which are employing the vacation period of the men of science in this country would make a long list. A vacation from teaching means to the scientific man a chance to work, and at present there are numerous organized means of enabling him to profit by this chance. The most definite form which such arrangements for summer work have taken is the summer laboratory or experiment station for biologists. Such a station affords conveniently the mechanical appliances for scientific work in a good locality for collecting material to work with. The marine or other forms of life are thus made accessible to those whose professional work during the year keeps them in an unfavorable locality. Besides the laboratory at Woods Holl, which is the nearest American representative of Professor Dohrn's great laboratory at Naples, there is an important summer station at Cold Spring Harbor, Long Island, under the auspices of the Brooklyn Institute, and others cared for by Leland Stanford, Jr. University, the University of Indiana, the Ohio State University and other institutions. It is common to combine teaching with research at these laboratories and in some cases they become essentially summer schools, though generally giving courses of a higher order than the ordinary summer school for nature study. But research is often the chief and sometimes the sole purpose of these stations, and a vast amount of work is done each year. The most important of these summer stations is the Woods Holl Marine Biological Laboratory, situated on the southern coast of Massachusetts, between Buzzard's Bay and Vineyard Sound. This laboratory has been fortunate in having been the summer home at one time or another of a majority of the leading zoölogists of the country. It has been usual for the advanced students in universities to take courses or carry on research there, and Woods Holl training has been a valuable recommendation. The reason is not far to seek. The material advantages, the spirit of zeal for concrete fact, the acquaintance with superior men in the science and with a large number of equals, all help to give the best sort of professional training. Such a place also serves as a refinery where opinions and theories may be purified by healthy criticism and by the subtler influence of example. There is a story of three eminent biologists who got involved in a controversy over a disputed question. They argued for a while. Finally one of them said: "Let us get the eggs in question and study them together." This was done, and the three men spent the afternoon over their microscopes patiently working out the problem together; and they did work it out. One of the great advantages of summer laboratories is that they put fellow-students in a frame of mind in which they can work things out together.

The Woods Holl Laboratory has a right to claim a large share in the credit for three of the most important developments in biology in the last decade—the study of 'cell lineage,' of regeneration of organs and of the influence of abnormal conditions on the development of embryos. Workers there have traced the development of the different cells into which the egg-cell divides and have discovered just what parts of the body arise from each group of cells. They have shown that the way in which the egg divides and redivides is as constant, is as much a part of the nature of the animal, as its adult form and structure are. They have replaced previous vague notions of the development of animals by exact accounts of the cell-origin of different organs of the body. Others have studied the abilities of mutilated animals to reproduce the parts lost and the conditions and limitations of such regeneration. Such studies have greatly broadened our views of the nature of animal tissues. Others have investigated the results of artificial conditions on the development of animals, especially in the earliest stages. For instance, from eggs broken into pieces there have been developed twins, triplets and monsters of various sorts. Such experiments as these are producing data concerning the very fundaments of living matter and are leading biology beyond the mere description of animal structures and functions towards an insight into the elementary principles of development. Among the numerous researches, some seventy in all, which are being carried on at Woods Holl this summer, those of the most general interest are Prof. C. O. Whitman's study of hybrids and Prof. Jacques Loeb's study of artificial fertilization. Prof. Whitman has been breeding pigeons of a large number of species for several years, as a means of studying the phenomena of heredity shown in hybrid forms. More or less incidentally, he has discovered many notable facts about the instincts and habits of the birds and about various physiological functions connected with reproduction. Biologists everywhere are coming to realize the necessity of systematic and continuous study of families of animals through a number of generations. Prof. Whitman's is the most extensive of such studies in this country. The detailed results of Prof. Loeb's continuation of his experiments on the action of various salts on unfertilized eggs will naturally be awaited with great interest. We have already noticed his success in causing unfertilized eggs of the sea-urchin to develop into normal individuals as far as the pluteus stage. He has this year succeeded in producing artificial parthenogenesis not only in starfish *(Asterias)*, but also in worms *(Chaetopterus)*. Through a slight increase in the amount of K-ions in the sea-water, the eggs of the latter can be caused not only to throw out the polar bodies as Mead had already observed, but also to reach the *Trochophore* stage and swim about as actively as the larvæ originating from fertilized eggs.

In the courses of instruction offered at Woods Holl there are two of more than ordinary interest. Professor Loeb's course in physiology departs from the traditional study of physiological functions in the frog and in some mammal, and offers instead experimental work on the simpler invertebrate forms. The phenomena of life are there presented in diagrammatic form, and are interpreted as far as possible in terms of physics and chemistry. The course in nature study, given this year for the first time, offers to students without technical training a chance to learn about animals and plants from specialists. It has shown clearly that the best science is popular, that really scientific work can be done without previous drill in terminology or technique. A novel feature of the course has been the systematic experimental study of the instincts and intelligent performances of animals. The method of offering to intelligent men and women, who wish to know about animal life, but have no time or need for special technical training or detailed anatomical work, a chance to get something better than mere book knowledge or haphazard personal observation, should be widely extended.

The laboratory of the Brooklyn Institute of Arts and Sciences, situated at Cold Spring Harbor, Long Island, is nearly as old as the Woods Holl Laboratory. Prof. C. B. Davenport, its director, is probably the most active worker in this country in the quantitative study of variation, and one of the leading lines of research at Cold Spring Harbor is now and will probably be for some years the attempt to get an exact estimate of normal variation in different animals, of the production of abnormal variations and of the laws of inheritance. Professor Davenport is himself breeding mice extensively and thus securing data. Of the courses offered two deserve special mention. One is the course for teachers of zoölogy in high schools, a chief feature of which is the study of living animals. The other is a course on 'Variation and Inheritance,' which gives advanced students a chance to study the most important question of biology and by the most exact methods. The Cold Spring laboratory has been growing very rapidly of late and seems likely to continue to grow. In general the evolution of the summer laboratory is of interest. An enthusiast or a modest association gathers a few sympathetic workers at some favorable locality. The informality and personal contact are inspiring and the place becomes famous for good work. Then come numbers and with numbers a rapid complication of the social life of the school. The eminent leader is replaced by a dozen different instructors; one no longer knows every one else; organization becomes complex and what was at first a sort of scientific family may turn into a formal institution. The summer laboratory should not become a big summer college at the cost of its single-mindedness.

While special laboratories are open for work in biology, and the universities are extending their sessions through the summer, the common schools are also beginning to realize that they must adapt themselves to an urban civilization. Country schools should adjourn in the summer for obvious reasons, but in the city nothing is gained by turning the children from the schools into the streets. The vacation or play schools now in session in New York City are in every way to be commended. The only drawback is that they cannot hold half of those who wish to attend. Set free from the traditional curriculum the children learn more in the five weeks of 'play school' in the summer, than in twice that period of 'work school' in the winter. Swimming, open-air gymnastics, team games, chess, visits to parks, piers, museums and libraries, excursions in barges and into the country, sketching, whittling, cooking, sewing and the rest do not lose their educational value because the children like them. Such exercises will do a good deal toward curing the indigestion caused by being fed for five years on the three R's, and toward correcting the anti-social atmosphere of the ordinary school-room. Among the commonplaces of modern psychology are: It is not what a person knows but what he does that counts; the way to learn is to act; progress follows from the pleasure of partial success; an individual only exists in his relations with others. Such maxims seem to be as clearly kept in view by the New York Department of Education in the summer as they are forgotten in the winter. The committee on the New York Play Schools consists of Messrs. Seth T. Stewart, John L. N. Hunt and A. P. Marble, to whom and to the teachers who have carried out their plans much honor is due. The report for 1899 is an educational document of importance. Copies can probably be obtained from the Department of Education of the City of New York.

The Paris Exposition and its congresses may be regarded as a great summer school. The applications of science exhibited for amusement, for instruction and for the advantage of commerce and manufactures are bewildering in their multiplicity. It is interesting to note that the group 'Education' heads the catalogue of the Exposition. In the exhibits representing higher instruction, the United States received nine grand prizes and nine gold medals, ranking second to France. On the motion of a French juror, three Americans were mentioned as worthy of special distinction: Prof. H. A. Rowland, Johns Hopkins University; Prof. Nicholas

Murray Butler, of Columbia University; Director Melvil Dewey, University of the State of New York. More than one hundred and fifty international congresses, dealing with various subjects of scientific, industrial and social importance, are held this summer in Paris, and form no small part of the interest of the Exposition, supplementing as they do the exhibits, furnishing the theory, as the exhibits set forth the accomplishments, of art and industry. The magnitude of these congresses may be seen from the fact that the thirteenth International Medical Congress had a registration of over six thousand members, of whom over four hundred were from America.

Friends of scientific investigation and the teaching of science will rejoice at the recent decision in the courts concerning the Fayerweather will case. For the eighth time the grant of $3,000,000 to the colleges has been confirmed. The case will probably be appealed to the Supreme Court of the United States, but the probability is large that Mr. Fayerweather's wishes will in the end be carried out. At the present time, money left to colleges is likely to be used to a very large extent to promote the progress of science. Required courses in linguistics are decreasing, and the extension of college teaching and university research is largely along scientific lines. New departments, such as those of physiography, physical chemistry, anthropology and experimental psychology are being established, while economics and sociology are becoming less speculative and more like the natural sciences in their methods. The college student of to-day gets proportionately more training in the professedly natural sciences than ever before, and gets scientific training in connection with courses which were once mere exercises in learning the opinions of more or less important people.

We called attention last month to the completion of the plans for an international catalogue of scientific literature, and stated that Great Britain and Germany had each subscribed for forty-five of the three hundred sets that must be sold in order to defray the cost. It is obvious that the United States, with such a large number of libraries and educational institutions, should subscribe for its share of the sets, namely, not less than forty-five. The Smithsonian Institution has provisionally undertaken to represent the interests of the catalogue in the United States, and will receive promises of subscriptions. The catalogue will be issued in seventeen volumes, comprising the following subjects: Mathematics, mechanics, physics, chemistry, astronomy, meteorology (including terrestrial magnetism), mineralogy (including petrology and crystallography), geology, geography (mathematical and physical), palæontology, general biology, botany, zoölogy, human anatomy, physical anthropology, physiology (including experimental psychology, pharmacology and experimental pathology) and bacteriology. At least one volume will be given to each subject, and it is proposed that not all the volumes shall be issued at once, but in four groups, as soon as possible after the first of January, April, July and October, respectively. The subscription price for a complete set of the whole catalogue, in seventeen volumes, is £17, say $85. The volumes will vary in price and can be obtained separately, but it is necessary to secure the guarantee of the sale of forty-five sets in America during the month of September, and all libraries used for scientific research, and those individuals who can afford the cost, should send subscriptions to Dr. Richard Rathbun, Assistant Secretary of the Smithsonian Institution, Washington, D. C.

In the July number of the Monthly Dr. H. C. Bolton gave an account of the radio-active substances which have been found in pitchblende, the chief ore of uranium. The subject continues to excite the interest of both chemists and physicists, though just at present the largest amount of work is being done by the chemists, to whom the question is of extraordinary interest as to whether these substances are or are not real chemical elements. Béla von Lengyel, of Budapest, as Dr. Bolton explained, has attacked the problem from the synthetic side, and by fusing inactive barium nitrate with uranium nitrate, he has obtained a barium sulphate which has more or less radio-activity. From this he concludes it is probable that the radio-activity is due rather to a peculiar state of the barium than to a new chemical element. On the other hand, Becquerel has in a somewhat analogous way mixed inactive barium chlorid with uranium chlorid, and from the solution has obtained likewise a radio-active barium. But he finds that the increased activity in the barium salt is attended by a corresponding decrease in the radio-activity of the uranium. Hence it cannot be settled from these experiments whether the uranium salts possess a radio-activity of their own, which can by certain methods be communicated to barium salts, or whether the radio-activity is due to an impurity in the uranium which has thus far eluded isolation.

The director of the Blue Hill Meteorological Observatory, Mr. A. Lawrence Rotch, writes to 'Science' that the highest previous kite-flight was exceeded on July 19, when, by means of six kites attached at intervals to four and three-quarters miles of steel wire, the meteorograph was lifted 15,170 feet above Blue Hill, or 15,800 feet above the neighboring ocean. At the time that the temperature was 78° near the ground, it was about 30° at the highest point reached, the air being very dry and the wind blowing from the northwest with a velocity of twenty-six miles an hour. The altitude reached in this flight probably exceeds the greatest height at which meteorological observations have been made with a balloon in America. The highest observations that have been published were made by the late Professor Hazen, of the Weather Bureau, in an ascent from St. Louis, June 17, 1887, to a height of 15,400 feet.

The U. S. consul at St. Gall, Mr. Du Bois, sends to the Department of State the following account of the trial of the Zeppelin air-ship: At the invitation of Count Zeppelin, I was present at the trial ascent of his air-ship on the afternoon of July 2, at Manzell, on Lake Constance. At seven o'clock the great ship, 407 feet long and 39 feet in diameter, containing seventeen separate balloon compartments filled with hydrogen gas, was drawn out of the balloon house securely moored to the float. At the moment of the ascent the wind was blowing at a rate of about twenty-six feet per second, giving the operators a good opportunity of testing the ability of the air-wheels to propel the great ship against the wind. The cigar-shaped structure ascended slowly and gracefully to about thirty feet above the raft. The balances were adjusted so as to give the ship an ascending direction. The propellers were set in motion, and the air-ship, which has cost considerably over $200,000, started easily on its interesting trial trip. At first the ship moved east against the wind for about two miles, gracefully turned at an elevation of about 400 feet, and, making a rapid sail to the westward for about five miles, reached an altitude of 1,300 feet. It was then turned and headed once more east, and, traveling about a mile against the wind blowing at the rate of twenty-six feet per second, suddenly stopped; floating slowly backwards three miles to the west, it sank into the lake, the gondolas resting safely upon the water. The time of the trip was about fifty minutes; distance traveled, about ten miles; fastest time made, five miles in seventeen and one-half minutes. The cause of the sudden stoppage in the flight of the ship was proved to be a slight mishap to the steering apparatus, but the colossus floated gently with the wind until it settled upon the surface of the lake without taking any water. The raft was then brought up and the ship was easily placed upon it and brought back to the balloon house. The weight is 200 centners (22,000 pounds).

A JOINT meeting of the Royal Society and the Royal Astronomical Society has been held in London to hear preliminary reports from several British expeditions that went out to observe the recent eclipse of the sun. Mr. Christie, the astronomer royal, first presented an account of the observations made by himself and Mr. Dyson at Ovar, in Portugal. There totality lasted 84½ seconds, and though the sky was rather hazy he secured some good photographs. The corona seemed distinctly inferior in brightness, structure and rays to that seen two years ago in India. Sir Norman Lockyer next described the observations made by the Solar Physics Observatory Expedition and the officers and men of H. M. S. Theseus at Santa Pola. Professor Turner spoke of the observations he had made with Mr. H. F. Newall in the grounds of the observatory near Algiers. From observations on the brightness of the corona he concluded that it was many times brighter than the moon—perhaps ten times as bright. Prof. Ralph Copeland described the observations he made on behalf of the joint committee at Santa Pola, endorsing Sir N. Lockyer's remarks as to the advantage of having the aid of a man-of-war. Mr. Evershed presented a preliminary report on his expedition to the south limit of totality. His reason for choosing a site at the limit of totality was that the flash spectrum was there visible very much longer. Unfortunately, he accepted the guidance of the Nautical Almanac Office, and found himself outside the line of totality—about two hundred meters according to his informants, who said a small speck of sunlight was visible all the time. He was successful in obtaining some fine photographs of the flash spectrum.

DURING the last session of Congress a law was enacted, commonly known as the Lacey Act, which places the preservation, distribution, introduction and restoration of game and other birds under the Department of Agriculture; regulates the importation of foreign birds and animals, prohibiting absolutely the introduction of certain injurious species and prohibits interstate traffic in birds or game killed in violation of State laws. Persons contemplating the importation of live animals or birds from abroad must obtain a special permit from the Secretary of Agriculture, and importers are advised to make application for permits in advance, in order to avoid annoyance and delay when shipments reach the custom-house. The law applies to single mammals, birds or reptiles, kept in cages as pets, as well as to large consignments intended for propagation in captivity or otherwise. Permits are not required for domesticated birds, such as chickens, ducks, geese, guinea fowl, pea fowl, pigeons or canaries; for parrots or for natural history specimens for museums or scientific collections. Permits must be obtained for all wild species of pigeons and ducks. In the case of ruminants (including deer, elk, moose, antelopes and also camels and llamas), permits will be issued, as heretofore, in the form prescribed for importation of domesticated animals. The introduction of the English or European house sparrow, the starling, the fruit bat or flying fox and the mongoose, is absolutely prohibited, and permits for their importation will not be issued under any circumstances.

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ADDRESS OF THE PRESIDENT BEFORE THE BRITISH ASSOCIATION.

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TWENTY-SEVEN years ago the British Association met in Bradford, not at that time raised to the dignity of a city. The meeting was very successful, and was attended by about two thousand persons—a forecast, let us hope, of what we may expect at the present assembly. A distinguished chemist, Prof. A. W. Williamson, presided. On this occasion the association has elected for the presidential chair one whose attention has been given to the study of an important department of biological science. His claim to occupy, however unworthily, the distinguished position in which he has been placed, rests, doubtless, on the fact that, in the midst of the engrossing duties devolving on a teacher in a great university and school of medicine, he has endeavored to contribute to the sum of knowledge of the science which he professes. It is a matter of satisfaction to feel that the success of a meeting of this kind does not rest upon the shoulders of the occupant of the presidential chair, but is due to the eminence and active coöperation of the men of science who either preside over or engage in the work of the nine or ten sections into which the association is divided, and to the energy and ability for organization displayed by the local secretaries and committees. The programme prepared by the general and local officers of the association shows that no efforts have been spared to provide an ample bill of fare, both in its scientific and social aspects. Members and associates will, I feel sure, take away from the

* Given at Bradford on September 5, 1900.

Bradford meeting as pleasant memories as did our colleagues of the corresponding Association Française, when, in friendly collaboration at Dover last year, they testified to the common citizenship of the Universal Republic of Science. As befits a leading center of industry in the great county of York, the applications of science to the industrial arts and to agriculture will form subjects of discussion in the papers to be read at the meeting.

Since the association was at Dover a year ago, two of its former presidents have joined the majority. The Duke of Argyll presided at the meeting in Glasgow so far back as 1855. Throughout his long and energetic life, he proved himself to be an eloquent and earnest speaker, one who gave to the consideration of public affairs a mind of singular independence, and a thinker and writer in a wide range of human knowledge. Sir J. Wm. Dawson was president at the meeting in Birmingham in 1886. Born in Nova Scotia in 1820, he devoted himself to the study of the Geology of Canada, and became the leading authority on the subject. He took also an active and influential part in promoting the spread of scientific education in the Dominion, and for a number of years he was Principal and Vice-Chancellor of the McGill University, Montreal.

SCIENTIFIC METHOD.

Edward Gibbon has told us that diligence and accuracy are the only merits which an historical writer can ascribe to himself. Without doubt they are fundamental qualities necessary for historical research, but in order to bear fruit they require to be exercised by one whose mental qualities are such as to enable him to analyze the data brought together by his diligence, to discriminate between the false and the true, to possess an insight into the complex motives that determine human action, to be able to recognize those facts and incidents which had exercised either a primary or only a secondary influence on the affairs of nations, or on the thoughts and doings of the person whose character he is depicting.

In scientific research, also, diligence and accuracy are fundamental qualities. By their application new facts are discovered and tabulated, their order of succession is ascertained and a wider and more intimate knowledge of the processes of nature is acquired. But to decide on their true significance a well-balanced mind and the exercise of prolonged thought and reflection are needed. William Harvey, the father of exact research in physiology, in his memorable work, 'De Motu Cordis et Sanguinis,' published more than two centuries ago, tells us of the great and daily diligence which he exercised in the course of his investigations, and the numerous observations and experiments which he collated. At the same time he refers repeatedly to his cogitations and reflections on the meaning of what he had observed, without which the complicated movements of the heart could not have been analyzed, their significance determined and the circulation of the blood in a continuous stream definitely established. Early in the present century, Carl Ernst von Baer, the father of embryological research, showed the importance which he attached to the combination of observation with meditation by placing side by side on the title page of his famous treatise 'Ueber Entwickelungsgeschichte der Thiere' (1828) the words *Beobachtung und Reflexion.*

Though I have drawn from biological science my illustrations of the need of this combination, it must not be inferred that it applies exclusively to one branch of scientific inquiry; the conjunction influences and determines progress in all the sciences, and when associated with a sufficient touch of imagination, when the power of seeing is conjoined with the faculty of foreseeing, of projecting the mind into the future, we may expect something more than the discovery of isolated facts; their coördination and the enunciation of new principles and laws will necessarily follow.

Scientific method consists, therefore, in close observation, frequently repeated so as to eliminate the possibility of erroneous seeing; in experiments checked and controlled in every direction in which fallacies might arise; in continuous reflection on the appearances and phenomena observed, and in logically reasoning out their meaning and the conclusions to be drawn from them. Were the method followed out in its integrity by all who are engaged in scientific investigations, the time and labor expended in correcting errors committed by ourselves or by other observers and experimentalists would be saved, and the volumes devoted annually to scientific literature would be materially diminished in size. Were it applied, as far as the conditions of life admit, to the conduct and management of human affairs, we should not require to be told, when critical periods in our welfare as a nation arise, that we shall muddle through somehow. Recent experience has taught us that wise discretion and careful provision are as necessary in the direction of public affairs as in the pursuit of science, and in both instances, when properly exercised, they enable us to reach with comparative certainty the goal which we strive to attain.

IMPROVEMENTS IN MEANS OF OBSERVATION.

While certain principles of research are common to all the sciences, each great division requires for its investigation specialized arrangements to insure its progress. Nothing contributes so much to the advancement of knowledge as improvements in the means of observation, either by the discovery of new adjuncts to research, or by a fresh adaptation of old methods. In the industrial arts, the introduction of a new kind of raw material, the recognition that a mixture or blending is often more serviceable than when the substances employed are uncombined, the discovery of new processes of treating the articles used in manufactures, the invention of improved machinery, all lead to the expansion of trade to the occupation of the people, and to the development of great industrial centers. In science, also, the invention and employment of new and more precise instruments and appliances enable us to appreciate more clearly the signification of facts and phenomena which were previously obscure, and to penetrate more deeply into the mysteries of nature. They mark fresh departures in the history of science, and provide a firm base of support from which a continuous advance may be made and fresh conceptions of nature can be evolved.

It is not my intention, even had I possessed the requisite knowledge, to undertake so arduous a task as to review the progress which has recently been made in the great body of sciences which lie within the domain of the British Association. As my occupation in life has required me to give attention to the science which deals with the structure and organization of the bodies of man and animals—a science which either includes within its scope or has intimate and widespread relations to comparative anatomy, embryology, morphology, zoölogy, physiology and anthropology—I shall limit myself to the attempt to bring before you some of the more important observations and conclusions which have a bearing on the present position of the subject. As this is the closing year of the century it will not, I think, be out of place to refer to the changes which a hundred years have brought about in our fundamental conceptions of the structure of animals. In science, as in business, it is well from time to time to take stock of what we have been doing, so that we may realize where we stand and ascertain the balance to our credit in the scientific ledger.

So far back as the time of the ancient Greeks it was known that the human body and those of the more highly organized animals were not homogeneous, but were built up of parts, the *partes dissimilares* (*τὰ ἀνόμοια μέρη*) of Aristotle, which differed from each other in form, color, texture, consistency and properties. These parts were familiarly known as the bones, muscles, sinews, blood-vessels, glands, brain, nerves and so on. As the centuries rolled on, and as observers and observations multiplied, a more and more precise knowledge of these parts throughout the animal kingdom was obtained, and various attempts were made to classify animals in accordance with their forms and structure. During the concluding years of the last century and the earlier part of the present, the Hunters, William and John, in our country, the Meckels in Germany, Cuvier and St. Hilaire in France, gave an enormous impetus to anatomical studies, and contributed largely to our knowledge of the construction of the bodies of animals. But whilst by these and other observers the most salient and, if I may use the expression, the grosser characters of animal organization had been recognized, little was known of the more intimate structure or texture of the parts. So far as could be determined by the unassisted vision, and so much as could be recognized by the use of a simple lens, had indeed been ascertained, and it was known that muscles, nerves and tendons were composed of threads or fibers, that the blood and lymph-vessels were tubes, that the parts which we call fasciæ and aponeuroses were thin membranes and so on.

Early in the present century Xavier Bichat, one of the most brilliant men of science during the Napoleonic era in France, published his 'Anatomie Générale,' in which he formulated important general principles. Every animal is an assemblage of different organs, each of which discharges a function, and acting together, each in its own way, assists in the preservation of the whole. The organs are, as it were, special machines situated in the general building which constitutes the factory or body of the individual. But, further, each organ or special machine is itself formed of tissues which possess different properties. Some, as the blood-vessels, nerves, fibrous tissues, etc., are generally distributed throughout the animal body, whilst others, as bones, muscles, cartilage, etc., are found only in certain definite localities. While Bichat had acquired a definite philosophical conception of the general principles of construction and of the distribution of the tissues, neither he nor his pupil Béclard was in a position to determine the essential nature of the structural elements. The means and appliances at their disposal and at that of other observers in their generation were not sufficiently potent to complete the analysis.

Attempts were made in the third decennium of this century to improve the methods of examining minute objects by the manufacture of compound lenses, and, by doing away with chromatic and spherical aberration, to obtain, in addition to magnification of the object, a relatively large flat field of vision with clearness and sharpness of definition. When in January, 1830, Joseph Jackson Lister read to the Royal Society his memoir "On Some Properties in Achromatic Object-Glasses Applicable to the Improvement of Microscopes," he announced the principles on which combinations of lenses could be arranged, which would possess these qualities. By the skill of our opticians, microscopes have now for more than half a century been constructed which, in the hands of competent observers, have influenced and extended biological science with results comparable to those obtained by the astronomer through improvements in the telescope.

In the study of the minute structure of plants and animals the observer has frequently to deal with tissues and organs, most of which possess such softness and delicacy of substance and outline that, even when microscopes of the best construction are employed, the determination of the intimate nature of the tissue, and the precise relation which one element of an organ bears to the other constituent elements, is, in many instances, a matter of difficulty. Hence additional methods have had to be devised in order to facilitate study and to give precision and accuracy to our observations. It is difficult for one of the younger generation of biologists, with all the appliances of a well-equipped laboratory at his command, with experienced teachers to direct him in his work, and with excellent text-books, in which the modern methods are described, to realize the conditions under which his predecessors worked half a century ago. Laboratories for minute biological research had not been constructed, the practical teaching of histology and embryology had not been organized, experience in methods of work had not accumulated; each man was left to his individual efforts, and had to puzzle his way through the complications of structure to the best of his power. Staining and hardening reagents were unknown. The double-bladed knife invented by Valentin, held in the hand, was the only improvement on the scalpel or razor for cutting thin, more or less translucent slices suitable for microscopic examination; mechanical section-cutters and freezing arrangements had not been devised. The tools at the disposal of the microscopist were little more than knife, forceps, scissors, needles; with acetic acid, glycerine and Canada balsam as reagents. But in the employment of the newer methods of research care has to be taken, more especially when hardening and staining reagents are used, to discriminate between appearances which are to be interpreted as indicating natural characters, and those which are only artificial productions.

Notwithstanding the difficulties attendant on the study of the more delicate tissues, the compound achromatic microscope provided anatomists with an instrument of great penetrative power. Between the years 1830 and 1850 a number of acute observers applied themselves with much energy and enthusiasm to the examination of the minute structure of the tissues and organs in plants and animals.

CELL THEORY.

It had, indeed, long been recognized that the tissues of plants were to a large extent composed of minute vesicular bodies, technically called cells (Hooke, Malpighi, Grew). In 1831 the discovery was made by the great botanist, Robert Brown, that in many families of plants a circular spot, which he named areola or nucleus, was present in each cell; and in 1838 M. J. Schleiden published the fact that a similar spot or nucleus was a universal elementary organ in vegetables. In the tissues of animals also structures had begun to be recognized comparable with the cells and nuclei of the vegetable tissues, and in 1839 Theodore

Schwann announced the important generalization that there is one universal principle of development for the elementary part of organisms, however different they may be in appearance, and that this principle is the formation of cells. The enunciation of the fundamental principle that the elementary tissues consisted of cells constituted a step in the progress of biological science which will forever stamp the century now drawing to a close with a character and renown equalling those which it has derived from the most brilliant discoveries in the physical sciences. It provided biologists with the visible anatomical units through which the external forces operating on, and the energy generated in, living matter come into play. It dispelled forever the old mystical idea of the influence exercised by vapors or spirits in living organisms. It supplied the physiologist and pathologist with the specific structures through the agency of which the functions of organisms are discharged in health and disease. It exerted an enormous influence on the progress of practical medicine. A review of the progress of knowledge of the cell may appropriately enter into an address on this occasion.

STRUCTURE OF CELLS.

A cell is a living particle, so minute that it needs a microscope for its examination; it grows in size, maintains itself in a state of activity, responds to the action of stimuli, reproduces its kind and in the course of time it degenerates and dies.

Let us glance at the structure of a cell to determine its constituent parts and the rôle which each plays in the function to be discharged. The original conception of a cell, based upon the study of the vegetable tissues, was a minute vesicle inclosed by a definite wall, which exercised chemical or metabolic changes on the surrounding material and secreted into the vesicle its characteristic contents. A similar conception was at first also entertained regarding the cells of animal tissues; but as observations multiplied, it was seen that numerous elementary particles, which were obviously in their nature cells, did not possess an inclosing envelope. A wall ceased to have a primary value as a constituent part of a cell, the necessary vesicular character of which therefore could no longer be entertained.

The other constituent parts of a cell are the cell plasm, which forms the body of the cell, and the nucleus embedded in its substance. Notwithstanding the very minute size of the nucleus, which even in the largest cells is not more than one-five-hundredth of an inch in diameter, and usually is considerably smaller, its almost constant form, its well-defined sharp outline and its power of resisting the action of strong reagents when applied to the cell, have from the period of its discovery by Robert Brown caused histologists to bestow on it much attention.

Its structure and chemical composition; its mode of origin; the part which it plays in the formation of new cells, and its function in nutrition and secretion have been investigated.

When examined under favorable conditions in its passive or resting state, the nucleus is seen to be bounded by a membrane which separates it from the cell plasm and gives it the characteristic sharp contour. It contains an apparently structureless nuclear substance, nucleoplasm or enchylema, in which are embedded one or more extremely minute particles called nucleoli, along with a network of exceedingly fine threads or fibers, which in the active living cell play an essential part in the production of new nuclei within the cell. In its chemical composition the nuclear substance consists of albuminous plastin and globulin; and of a special material named nuclein, rich in phosphorus and with an acid reaction. The delicate network within the nucleus consists apparently of the nuclein, a substance which stains with carmine and other dyes, a property which enables the changes, which take place in the network in the production of young cells, to be more readily seen and followed out by the observer.

The mode of origin of the nucleus and the part which it plays in the production of new cells have been the subject of much discussion. Schleiden, whose observations, published in 1838, were made on the cells of plants, believed that within the cell a nucleolus first appeared, and that around it molecules aggregated to form the nucleus. Schwann again, whose observations were mostly made on the cells of animals, considered that an amorphous material existed in organized bodies, which he called cytoblastema. It formed the contents of cells, or it might be situated free or external to them. He figuratively compared it to a mother liquor in which crystals are formed. Either in the cytoblastema within the cells or in that situated external to them, the aggregation of molecules around a nucleolus to form a nucleus might occur, and, when once the nucleus had been formed, in its turn it would serve as a center of aggregation of additional molecules from which a new cell would be produced. He regarded, therefore, the formation of nuclei and cells as possible in two ways—one within preëxisting cells (endogenous cell-formation), the other in a free blastema lying external to cells (free cell-formation). In animals, he says, the endogenous method is rare, and the customary origin is in an external blastema. Both Schleiden and Schwann considered that after the cell was formed the nucleus had no permanent influence on the life of the cell, and usually disappeared.

Under the teaching principally of Henle, the famous Professor of Anatomy in Göttingen, the conception of the free formation of nuclei and cells in a more or less fluid blastema, by an aggregation of elementary granules and molecules, obtained so much credence, especially amongst those who were engaged in the study of pathological processes, that the origin of cells within preëxisting cells was to a large extent lost sight of. That a parent cell was requisite for the production of new cells seemed to many investigators to be no longer needed. Without doubt this conception of free cell-formation contributed in no small degree to the belief, entertained by various observers, that the simplest plants and animals might arise, without preëxisting parents, in organic fluids destitute of life, by a process of spontaneous generation; a belief which prevailed in many minds almost to the present day. If, as has been stated, the doctrine of abiogenesis cannot be experimentally refuted, on the other hand it has not been experimentally proved. The burden of proof lies with those who hold the doctrine, and the evidence that we possess is all the other way.

MULTIPLICATION OF CELLS.

Although von Mohl, the botanist, seems to have been the first to recognize (1835) in plants a multiplication of cells by division, it was not until attention was given to the study of the egg in various animals and to the changes which take place in it, attendant on fertilization, that in the course of time a much more correct conception of the origin of the nucleus and of the part which it plays in the formation of new cells was obtained. Before Schwann had published his classical memoir in 1839, von Baer and other observers had recognized within the animal ovum the germinal vesicle, which obviously bore to the ovum the relation of a nucleus to a cell. As the methods of observation improved, it was recognized that, within the developing egg, two vesicles appeared where one only had previously existed, to be followed by four vesicles, then eight, and so on in multiple progression until the ovum contained a multitude of vesicles, each of which possessed a nucleus. The vesicles were obviously cells which had arisen within the original germ-cell or ovum. These changes were systematically described by Martin Barry so long ago as 1839 and 1840 in two memoirs communicated to the Royal Society of London, and the appearance produced, on account of the irregularities of the surface occasioned by the production of new vesicles, was named by him the mulberry-like structure. He further pointed out that the vesicles arranged themselves as a layer within the envelope of the egg or zona pellucida, and that the whole embryo was composed of cells filled with the foundations of other cells. He recognized that the new cells were derived from the germinal vesicle or nucleus of the ovum, the contents of which entered into the formation of the first two cells, each of which had its nucleus, which in its turn resolved itself into other cells, and by a repetition of the process into a greater number. The endogenous origin of new cells within a preëxisting cell and the process which we now term the segmentation of the yolk were successfully demonstrated. In a third memoir, published in 1841, Barry definitely stated that young cells originated through division of the nucleus of the parent cell, instead of arising, as a product of crystallization, in the fluid cytoblastema of the parent cell or in a blastema situated external to the cell.

In a memoir published in 1842, John Goodsir advocated the view that the nucleus is the reproductive organ of the cell, and that from it, as from a germinal spot, new cells were formed. In a paper, published three years later, on nutritive centers, he described cells, the nuclei of which were the permanent source of successive broods of young cells, which from time to time occupied the cavity of the parent cell. He extended also his observations on the endogenous formation of cells to the cartilage cells in the process of inflammation and to other tissues undergoing pathological changes. Corroborative observations on endogenous formation were also given by his brother, Harry Goodsir, in 1845. These observations on the part which the nucleus plays by cleavage in the formation of young cells by endogenous development from a parent center—that an organic continuity existed between a mother cell and its descendants through the nucleus—constituted a great step in advance of the views entertained by Schleiden and Schwann, and showed that Barry and the Goodsirs had a deeper insight into the nature and functions of cells than was possessed by most of their contemporaries, and are of the highest importance when viewed in the light of recent observations.

In 1841 Robert Remak published an account of the presence of two nuclei in the blood corpuscles of the chick and the pig, which he regarded as evidence of the production of new corpuscles by division of the nucleus within a parent cell; but it was not until some years afterwards (1850 to 1855) that he recorded additional observations and recognized that division of the nucleus was the starting-point for the multiplication of cells in the ovum and in the tissues generally. Remak's view was that the process of cell division began with the cleavage of the nucleolus, followed by that of the nucleus, and that again by cleavage of the body of the cell and its membrane. Kölliker had previously, in 1843, described the multiplication of nuclei in the ova of parasitic worms, and drew the inference that in the formation of young cells within the egg the nucleus underwent cleavage, and that each of its divisions entered into the formation of a new cell. By these observations, and by others subsequently made, it became obvious that the multiplication of animal cells, either by division of the nucleus within the cell, or by the budding off of a part of the protoplasm of the cell, was to be regarded as a widely spread and probably a universal process, and that each new cell arose from a parent cell.

Pathological observers were, however, for the most part inclined to consider free cell-formation in a blastema or exudation by an aggregation of molecules, in accordance with the views of Henle, as a common phenomenon. This proposition was attacked with great energy by Virchow in a series of memoirs published in his 'Archiv,' commencing in Vol. 1, 1847, and finally received its death-blow in his published lectures on Cellular Pathology, 1858. He maintained that in pathological structures there was no instance of cell development *de novo*; where a cell existed, there one must have been before. Cell-formation was a continuous development by descent, which he formulated in the expression *omnis cellula e cellulâ.*

KARYOKINESIS.

While the descent of cells from preëxisting cells by division of the nucleus during the development of the egg, in the embryos of plants and animals, and in adult vegetable and animal tissues, both in healthy and diseased conditions, had now become generally recognized, the mechanism of the process by which the cleavage of the nucleus took place was for a long time unknown. The discovery had to be deferred until the optician had been able to construct lenses of a higher penetrative power, and the microscopist had learned the use of coloring agents capable of dyeing the finest elements of the tissues. There was reason to believe that in some cases a direct cleavage of the nucleus, to be followed by a corresponding division of the cell into two parts, did occur. In the period between 1870 and 1880 observations were made by Schneider, Strasburger, Bütschli, Fol, van Beneden and Flemming, which showed that the division of the nucleus and the cell was due to a series of very remarkable changes, now known as indirect nuclear and cell division, or karyokinesis. The changes within the nucleus are of so complex a character that it is impossible to follow them in detail without the use of appropriate illustrations. I shall have to content myself, therefore, with an elementary sketch of the process.

I have previously stated that the nucleus in its passive or resting stage contains a very delicate network of threads or fibers. The first stage in the process of nuclear division consists in the threads arranging themselves in loops and forming a compact coil within the nucleus. The coil then becomes looser, the loops of threads shorten and thicken, and somewhat later each looped thread splits longitudinally into two portions. As the threads stain when coloring agents are applied to them, they are called chromatin fibers, and the loose coil is the chromosome (Waldeyer).

As the process continues, the investing membrane of the nucleus disappears, and the loops of threads arrange themselves within the nucleus so that the closed ends of the loops are directed to a common center, from which the loops radiate outwards and produce a starlike figure (aster). At the same time clusters of extremely delicate lines appear both in the nucleoplasm and in the body of the cell, named the achromatic figure, which has a spindle-like form with two opposite poles, and stains much more feebly than the chromatic fibers. The loops of the chromatic star then arrange themselves in the equatorial plane of the spindle, and bending round turn their closed ends towards the periphery of the nucleus and the cell.

The next stage marks an important step in the process of division of the nucleus. The two longitudinal portions, into which each looped thread had previously split, now separate from each other, and whilst one part migrates to one pole of the spindle, the other moves to the opposite pole, and the free ends of each loop are directed toward its equator (metakinesis). By this division of the chromatin fibers, and their separation from each other to opposite poles of the spindle, two star-like chromatin figures are produced (dyaster).

Each group of fibers thickens, shortens, becomes surrounded by a membrane, and forms a new or daughter nucleus (dispirem). Two nuclei therefore have arisen within the cell by the division of that which had previously existed, and the expression formulated by Flemming—*omnis nucleus e nucleo*—is justified. Whilst this stage is in course of being completed, the body of the cell becomes constricted in the equatorial plane of the spindle, and, as the constriction deepens, it separates into two parts, each containing a daughter nucleus, so that two nucleated cells have arisen out of a preëxisting cell.

A repetition of the process in each of these cells leads to the formation of other cells, and, although modifications in details are found in different species of plants and animals, the multiplication of cells in the egg and in the tissues generally on similar lines is now a thoroughly established fact in biological science.

In the study of karyokinesis, importance has been attached to the number of chromosomes in the nucleus of the cell. Flemming had seen in the Salamander twenty-four chromosome fibers, which seems to be a constant number in the cells of epithelium and connective tissues. In other cells, again, especially in the ova of certain animals, the number is smaller, and fourteen, twelve, four and even two only have been described. The theory formulated by Boveri that the number of chromosomes is constant for each species, and that in the karyokinetic figures corresponding numbers are found in homologous cells, seems to be not improbable.

In the preceding description I have incidentally referred to the appearance in the proliferating cell of an achromatic spindle-like figure. Although this was recognized by Fol in 1873, it is only during the last ten or twelve years that attention has been paid to its more minute arrangements and possible signification in cell-division.

The pole at each end of the spindle lies in the cell plasm which surrounds the nucleus. In the center of each pole is a somewhat opaque spot (central body) surrounded by a clear space, which, along with the spot, constitutes the centrosome of the sphere of attraction. From each centrosome extremely delicate lines may be seen to radiate in two directions. One set extends towards the pole at the opposite end of the spindle, and, meeting or coming into close proximity with radiations from it, constitutes the body of the spindle, which, like a perforated mantle, forms an imperfect envelope around the nucleus during the process of division. The other set of radiations is called the polar and extends in the region of the pole towards the periphery of the cell.

The question has been much discussed whether any constituent part of the achromatic figure, or the entire figure, exists in the cell as a permanent structure in its resting phase; or if it is only present during the process of karyokinesis. During the development of the egg the formation of young cells, by division of the segmentation nucleus, is so rapid and continuous that the achromatic figure, with the centrosome in the pole of the spindle, is a readily recognizable object in each cell. The polar and spindle-like radiations are in evidence during karyokinesis, and have apparently a temporary endurance and function. On the other hand, van Beneden and Boveri were of opinion that the central body of the centrosome did not disappear when the division of the nucleus came to an end, but that it remained as a constituent part of a cell lying in the cell plasm, near to the nucleus. Flemming has seen the central body with its sphere in leucocytes, as well as in epithelial cells and those of other tissues. Subsequently Heidenhain and other histologists have recorded similar observations. It would seem, therefore, as if there were reason to regard the centrosome, like the nucleus, as a permanent constituent of a cell. This view, however, is not universally entertained. If not always capable of demonstration in the resting stage of a cell, it is doubtless to be regarded as potentially present, and ready to assume, along with the radiations, a characteristic appearance when the process of nuclear division is about to begin.

One can scarcely regard the presence of so remarkable an appearance as the achromatic figure without associating with it an important function in the economy of the cell. As from the centrosome at the pole of the spindle both sets of radiations diverge, it is not unlikely that it acts as a center or sphere of energy and attraction. By some observers the radiations are regarded as substantive fibrillar structures, elastic or even contractile in their properties. Others, again, look upon them as morphological expressions of chemical and dynamical energy in the protoplasm of the cell body. On either theory we may assume that they indicate an influence, emanating, it may be, from the centrosome and capable of being exercised both on the cell plasm and on the nucleus contained in it. On the contractile theory, the radiations which form the body of the spindle, either by actual traction of the supposed fibrillæ or by their pressure on the nucleus which they surround, might impel during karyokinesis the dividing chromosome elements toward the poles of the spindle, to form there the daughter nuclei. On the dynamical theory, the chemical and physical energy in the centrosome might influence the cell plasm and the nucleus and attract the chromosome elements of the nucleus to the poles of the spindle. The radiated appearance would therefore be consequent and attendant on the physico-chemical activity of the centrosome. One or other of these theories may also be applied to the interpretation of the significance of the polar radiations.

CELL PLASM.

In the cells of plants, in addition to the cell wall, the cell body and the cell juice require to be examined. The material of the cell body, or the cell contents, was named by von Mohl (1846) protoplasm, and consisted of a colorless tenacious substance which partly lined the cell wall (primordial utricle) and partly traversed the interior of the cell as delicate threads inclosing spaces (vacuoles) in which the cell juice was contained. In the protoplasm the nucleus was embedded. Nägeli, about the same time, had also recognized the difference between the protoplasm and the other contents of vegetable cells, and had noticed its nitrogenous composition.

Though the analogy with a closed bladder or vesicle could no longer be sustained in the animal tissues, the name 'cell' continued to be retained for descriptive purposes, and the body of the cell was spoken of as a more or less soft substance inclosing a nucleus (Leydig). In 1861 Max Schultze adopted for the substance forming the body of the animal cell the term 'protoplasm.' He defined a cell to be a particle of protoplasm in the substance of which a nucleus was situated. He regarded the protoplasm, as indeed had previously been pointed out by the botanist Unger, as essentially the same as the contractile sarcode which constitutes the body and pseudopodia of the Amœba and other Rhizopoda. As the term 'protoplasm,' as well as that of 'bioplasm" employed by Lionel Beale in a somewhat similar though not precisely identical sense, involves certain theoretical views of the origin and function of the body of the cell, it would be better to apply to it the more purely descriptive term 'cytoplasm' or 'cell plasm.'

Schultze defined protoplasm as a homogeneous, glassy, tenacious material, of a jelly-like or somewhat firmer consistency, in which numerous minute granules were embedded. He regarded it as the part of the cell especially endowed with vital energy, whilst the exact function of the nucleus could not be defined. Based upon this conception of the jelly-like character of protoplasm, the idea for a time prevailed that a structureless, dimly granular, jelly or slime destitute of organization, possessed great physiological activity, and was the medium through which the phenomena of life were displayed.

More accurate conceptions of the nature of the cell plasm soon began to be entertained. Brücke recognized that the body of the cell was not simple, but had a complex organization. Flemming observed that the cell plasm contained extremely delicate threads, which frequently formed a network, the interspaces of which were occupied by a more homogeneous substance. Where the threads crossed each other, granular particles (milkrosomen) were situated. Bütschli considered that he could recognize in the cell plasm a honeycomb-like appearance, as if it consisted of excessively minute chambers in which a homogeneous more or less fluid material was contained. The polar and spindle-like radiations visible during the process of karyokinesis, which have already been referred to, and the presence of the centrosome, possibly even during the resting stage of the cell, furnished additional illustrations of differentiation within the cell plasm. In many cells there appears also to be a difference in the character of the cell plasm which immediately surrounds the nucleus and that which lies at and near the periphery of the cell. The peripheral part (ektoplasma) is more compact and gives a definite outline to the cell, although not necessarily differentiating into a cell membrane. The inner part (endoplasma) is softer and is distinguished by a more distinct granular appearance and by containing the products specially formed in each particular kind of cell during the nutritive process.

By the researches of numerous investigators on the internal organization of cells in plants and animals, a large body of evidence has now been accumulated, which shows that both the nucleus and the cell plasm consist of something more than a homogeneous, more or less viscid, slimy material. Recognizable objects in the form of granules, threads, or fibers can be distinguished in each. The cell plasm and the nucleus respectively are therefore not of the same constitution throughout, but possess polymorphic characters, the study of which in health and the changes produced by disease will for many years to come form important matters for investigation.

(To be concluded.)

THE BUBONIC PLAGUE.

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THE province of Yunnan in China adjoins French Tonkin and British Burmah. It is of interest to the student of epidemiology because from this mountainous and difficultly accessible region there has issued but recently a disease which has been considered as practically extinct. Frightful as have been the ravages of the pest in the middle ages, it is noteworthy that during the past hundred years, with the exception of two slight outbreaks (Noja in Italy in 1815, and Vetlianka in Russia in 1878), the disease has been unknown in Europe. During this time the pest has not been extinct, but has existed to a greater or less extent in certain parts of Asia and in Africa. Four and possibly five of these endemic foci are known to-day. The province of Yunnan is one of these regions. The mountainous district of Gurhwal, lying along the southern slope of the Himalayas, is another center where the pest has continued to prevail. The recent travels of Koch in eastern Africa have brought to light a third region about Lake Victoria, in the British province of Uganda, and the German Kisiba, where the plague has existed from time immemorial, cut off as it were from the outer world. Only last year Sakharoff called attention to a fourth focus in northeastern China, and it is quite likely that a fifth focus exists in Arabia. These regions are of great importance in so far as the existence of permenent endemic foci sheds not a little light upon the development and spread of those great epidemics which, like great tidal waves, have in the past swept over whole countries and even continents.

It is not known when or from whence the pest was first introduced into Yunnan. Unquestionably, it has existed in the extreme western parts of the province for many decades. Eventually the disease spread throughout the province, and frightful ravages are known to have occurred in 1871-73. Repeated visitations of this dread disease have taught the natives of Yunnan, as well as those of Gurhwal and of Uganda, to desert their villages as soon as an unusual mortality is found to prevail among the rats. In spite of the frequent recurrence of the plague, it did not spread to neighboring provinces, largely because of the fact that little or no communication exists between Yunnan and the adjoining Chinese states. Recently, however, the plague did succeed in crossing the frontier, and, in so doing, it has given rise to an epidemic which, as will be presently seen, has already made an unenviable record and has a future that no one can foretell.

The way in which the disease spread from Yunnan has been quite clearly established. Along the Tonkin frontier, throughout the provinces of Quan-si and Yunnan, the Chinese maintain a large number of military posts. Mule supply-trains for these posts passed from province to province over the difficult mountain paths. The mule-drivers were natives of Yunnan. In 1892 the plague existed in Yunnan, and it was in the summer of 1893 that the disease appeared at Long-Cheou in Quansi among the Yunnan mule-drivers. These drivers arriving at the post of Lieng-Cheng, after one of their journeys from Yunnan, repaired to the city of Long-Cheou, about ten miles distant. During their sojourn in this city the muleteers developed the first known cases of the plague. From these men the disease spread throughout the city and to the neighboring posts and villages.

From Long-Cheou the plague descended the Canton River and reached Naning-Phu. From thence it followed overland to the seaport Pakhoi, some hundred and fifty miles distant. A few months later, in February, 1894, it reached Canton, either by descending the river from Naning-Phu or by boat from Pakhoi. That the plague at Canton, in 1894, had not lost any of its old-time destructiveness is seen in the fact that it is estimated to have caused not less than one hundred thousand deaths in Canton in the short space of two months.

From Canton the plague spread to Hong Kong in April, 1894. It was during the existence of this epidemic that the first bacteriological studies of the disease were made and resulted in the discovery of the plague bacillus. In the fall of 1894, the disease died out in Hong Kong, but it reappeared in 1895 and 1896. Considering the fact that Hong Kong is one of the most important maritime centers, it is not surprising to find that in the spring of 1896 the plague was carried by shipping to the Island of Formosa. It is quite certain that about the same time the plague was carried from Hong Kong to Bombay. At all events, the existence of this disease was recognized in Bombay in September, 1896, by Doctor Viegas. Previous to this date, the mortality in Bombay was abnormally high, undoubtedly due to the very unsanitary condition of the overcrowded city.

The existence of famine in India, together with the filthy, overcrowded condition of the population, enabled the plague to gain a firm foothold in a relatively short time. Indeed, there can be no doubt but that the disease was well established at the time it was first recognized. It is no wonder, then, that in spite of the most stringent precautions, it spread like wildfire, so that in a short time the weekly deaths from the plague rose to nearly 2,000. In the face of such a relentless enemy, it is but natural that a large proportion of the population should seek safety in flight. It is believed that fully 300,000 people left Bombay shortly after the plague developed. There can be no doubt but that these refugees, directly or indirectly, carried the disease to the neighboring villages, and thus contributed to the enormous dissemination of the pest throughout Western India. In the Presidency of Bombay there were reported, in less than three years, more than 220,000 cases, with more than 164,000 deaths. When it is furthermore recognized that the natives concealed the existence of the disease as much as possible, it will be evident that these figures reveal a partial but, nevertheless, a grim truth.

With Bombay and the surrounding country thus seriously infected, it became merely a question of time when the disease would be carried to other ports and countries, by vessels and by overland routes. In spite of the sanitary perfection which we may flatter ourselves on having attained in recent years, it is nevertheless a fact that the disease is slowly but steadily and, as it were, stealthily invading port after port. That the sanitary methods, however, are not at fault is seen in the fact that when an early and prompt recognition occurred, the disease has been held in check. The insidious spread of the disease is rather due to the enormous development of commerce and to the rapid means of communication with distant countries.

From Bombay the plague has spread to ports on the Persian Gulf, on the Red Sea, and has reached Alexandria. Aden, Djeddah, Port Said, Cairo, have all had outbreaks of the disease. Beirut and Smyrna have each developed straggling cases. Isolated cases have been met with in London, at St. Petersburg and in Vienna. However, only three appreciable outbreaks have as yet occurred on European soil. The first was that at Oporto in Portugal, where one hundred and sixty cases, with fifty-five deaths, have developed up to the present time. The second outbreak occurred at Kolobovka, a village near Astrakhan. Of the twenty-four cases that developed there in July and August, 1899, twenty-three died. The last outbreak is that at Glasgow, where the disease made its appearance but a few weeks ago.

In addition to following the great international highway of Suez, the disease has insidiously spread to the countries of East Africa. Mauritius and Madagascar, with the adjoining mainland of Mozambique and Lorenzo Marquez, have become more or less infected, and, if reports are to be credited, it has also appeared in one of the Boer towns and also on the Ivory Coast in Western Africa. Last fall the disease reached South America. It apparently was first recognized at Santos, in Brazil, during October, although early in September, according to reports, a peculiar disease, causing swelling of the glands and death within forty-eight hours, was reported at Asunçion, the capital of Paraguay. At the present time Rio Janeiro is infected.

The sanitary condition of these South American cities is far from being the best, and, consequently, there is but little hope that the disease will be eradicated or even held in check. With South America more or less thoroughly infected, it is evident that the United States, as well as Europe, are now threatened from all sides. The gravity of the situation is seen in the fact that already last November two cases of the plague were found in New York harbor aboard a coffee ship from Santos. Several cases have also developed on ships bound from the latter city for Mediterranean ports.

The United States is threatened not merely from the East Atlantic and South Atlantic, but also from the Pacific. As a matter of fact, the danger to our Pacific ports is greater, owing to the direct communication with the Orient. It has been already indicated that Hong Kong has continued to be infected ever since 1894. On several occasions it disappeared during the winter months, only to reappear in spring. With the more or less constant prevalence of the plague at this great seaport, it necessarily will lead directly or indirectly to a dissemination of the disease along the entire Pacific. Already it has prevailed at Amoy, and has even extended to other Chinese ports as far as Niu-Chwang. For several years it has already persisted on the island of Formosa. Japan was invaded last fall at Kobe and at Osaka, and although it disappeared during the winter, yet only a few weeks ago it has reappeared at the latter city. Sidney in Australia, and Noumea in New Caledonia, are also infected at the present time.

Manila, Honolulu and San Francisco have successively become infected. In all these places the disease, with but very few exceptions, has attacked the native or Oriental population. The extinction of the plague in the Hawaiian Islands since the end of March is a splendid demonstration of what energetic, vigorous measures can accomplish. The presence of the plague since March 8 in Chinatown, in San Francisco, is readily recognized as a most serious condition, especially after the courts have granted an injunction restraining the health officers from carrying out the necessary vigorous preventive measures.

A few words should be given here to the overland dissemination of the disease. Europe is not merely threatened by infected ships which may come from China, India, Eastern Africa or South America. The overland routes from China and India are fully as grave a source of danger. Indeed, as will be presently shown, these are the routes along which the great epidemics of cholera and plague have always traveled in the past.

One of these great caravan routes leads from Lahore in Punjab through Afghanistan into the Russian province of Turkestan, where it meets the Trans-Caspian railway. This railway begins at Samarcand in Turkestan, and passes through Bokhara, Merv, Askabad and ends at Uzun Ada on the Caspian Sea opposite Baku. Early in 1899 an outbreak of the plague occurred near Samarcand, undoubtedly brought up from India. The precautions taken to prevent the spread were entirely successful, and although no accounts have been officially published as to the means employed, nevertheless it will be seen that the radical procedure employed by Loris Melikoff some twenty years ago was again resorted to. Inasmuch as the entire village was said to be afflicted it was surrounded by troops, and no one was allowed to enter or leave. The village and all that it contained was destroyed by fire. With this route open continually it is evident that fresh importation must be expected sooner or later.

Apparently a new plague focus, independent of that in Yunnan and Hong Kong, has been recently discovered in Manchuria. The plague seems to have existed in this province for more than ten years under the name of Tarabagan plague, and is believed to be spread by a rodent, the Arctomis cobuc, which is subject to a hemorrhagic pneumonia. The presence of such an independent endemic focus in Manchuria indicates the possibility of the spread of the disease by caravan to Lake Baikal, and thence by the Siberian railroad to Russia. Indeed, the epidemic of pneumonic type which began July, 1899, at Kolobovka, in Astrakhan, while it may have been imported from Persia, might also owe its origin to the Mongolian focus.

Russia, however, is not the only country endangered by the overland transmission of the disease. There are commercial highways which lead from Northwestern India through Baluchistan and Persia to the Caucasus, and through Turkey to Constantinople. Grave danger threatens from this source, and more especially from the cities along the Persian Gulf. Two important cities here are already infected, namely, Bushire, in Persia, and Bassorah on the Tigris, in Turkey. It would appear as if Turkey and Persia would escape with difficulty from a visitation of this dread disease.

Such, then, is the geographical distribution of the present outbreak of the plague. This, an apparently extinct disease, has suddenly reappeared and given evidence of its power to spread death and desolation. Fortunately, however, modern sanitary precautions are quite able to restrict its progress, provided they be applied at the proper time and place. Filth and overcrowding, protracted wars and famine, have been the powerful allies of the plague in the past. Through their aid this disease has made a deep impression upon the pages of history. It may not be out of place, therefore, to turn from the present outbreak of the disease and trace its grewsome past.

In ancient writings references are found which would seem to indicate the existence of the plague at a very early date. The Bible contains several such references (Deuteronomy, Chapter 28, paragraph 27.

Samuel I, Chapter 5, paragraphs 6, 9). The latter especially deals with the plague which attacked the Philistines after they took the ark. The rôle of rats in the dissemination of the disease is, as some believe, apparently referred to in the trespass offering of "five golden emerods and five golden mice." The return of the ark, together with this trespass offering, brought also the plague, "because they had looked into the ark of the Lord, even He smote of the people fifty thousand and threescore and ten men." Poussin's painting of this Philistine plague, exhibited in the Louvre, shows several dead rats on the streets. It is evident that the susceptibility of the rat to the plague had been noticed even at this early date. The plague of boils visited upon the Egyptians as related in Exodus (Chapter 9, paragraphs 9 and 10) has also been taken to indicate the pest of to-day, but neither of these scriptural references can be said to be sufficiently definite.

The Attic plague, which ravaged the Peloponnesus 430 years before Christ, has been accurately described by an eye-witness, the historian Thucydides. His narration may be considered the earliest exact record of an epidemic. Like all the great epidemics of subsequent ages, it was ushered in by the overcrowding, the misery and the famine consequent upon prolonged wars. The combustible material was there, and all that was necessary was the spark to begin the work of death and devastation. It is noteworthy that the origin of the pest was traced by Thucydides to Egypt or Ethiopia, from whence it spread gradually overland to Asia Minor and thence by boat to Athens. The nature of this first great historic epidemic is and will remain uncertain. There are those who consider the Attic pestilence as one of bubonic plague, but the fact that in the very careful description of the disease no mention is made of buboes and the statement that death occurred from the seventh to the ninth day would indicate that the disease was something else. Buboes are characteristic, it is true, of the plague, but it should be remembered that outbreaks of the pneumonic form, with little or no glandular enlargement, are not uncommon. Death, however, in the case of plague is very common on the second or third day, and is less liable to occur in more protracted cases. These facts lead to the commonly accepted belief that the Attic pest was not the bubonic plague. It may have been typhus fever, possibly smallpox.

The great pestilence which devastated Rome and its dependencies in 166, Anno Domini, is known as the plague of Antoninus or of Galen. This prolonged epidemic was brought to Rome by the returning legions from Seleucia. It was not characterized by buboes, and it is very probable that it was largely smallpox. On the other hand, the plague of Saint Cyprian, which prevailed from 251 to 266 Anno Domini, may have been partly bubonic in nature, since it prevailed during the fall and winter months and ceased during the hot summer. The disease was said to be communicated by means of clothing and by the look. It spread from Ethiopia to Egypt and thence through the known world.

Although the above early epidemics cannot be identified with the bubonic plague, there is nevertheless excellent evidence of the existence of this disease in remote antiquity. The first undoubted testimony on this point is that furnished by Rufus of Ephesus, who lived in the first century of the Christian era. The writings of this author are no longer extant, but they are quoted by Oribasius, the physician and friend of Julian the Apostate, who lived in the fourth century. The writings of Oribasius were discovered in the Vatican Library and were published early in this century by Cardinal Mai. In the forty-fourth "Book of Oribasius" occurs the extract taken from Rufus of Ephesus, from which it appears that "the so-called pestilential buboes are all fatal and have a very acute course, especially when observed in Libya, Egypt and in Syria. Dionysius mentions it. Dioscorides and Posidonius have described it at length in their treatise upon the plague which prevailed during their time in Libya." The description which then follows of the buboes and of the disease is an exact counterpart of the present plague. The writings of the authors quoted by Rufus are no longer extant, but one thing is certain, and that is that the Dionysius referred to lived not later than 300 years before Christ. The other two physicians lived in Alexandria contemporaneous with the birth of Christ. It may, therefore, be considered as an established fact that the plague existed in Egypt, Libya and Syria as early as 300 years before Christ. This is of especial interest in view of the recent discovery by Koch of an endemic plague focus in British Uganda and German Kisiba, at the headwaters of the Nile. Whether it ever invaded European territory prior to the sixth century is unknown.

The great plague of Justinian which broke out in 542, Anno Domini, appeared first in Egypt, and from thence it spread east and west throughout the known world and persisted for more than a half century. So unknown was the plague in Europe at that time that the physicians of Constantinople considered it a new disease. Procopius, who was an eye-witness of the plague at Constantinople, states that the daily mortality in that city was at times over 10,000.

The pandemic of Justinian resulted in the distribution of the plague for the first time throughout the length and breadth of known Europe. From that time on the early chroniclers make repeated mention of devastating plagues consequent upon the miseries of war and famine. The descriptions of these pestilences are, as a rule, insufficient to identify them with the bubonic plague. Typhus, scurvy, smallpox and other diseases undoubtedly alternated in the work of destruction. Of the scores of epidemics thus recorded during the eight centuries following this first visitation few, indeed, can be identified to a certainty with the bubonic plague, and yet there can be no doubt but that this disease occupied no second rank during the dreary darkness of the middle ages. This era in history may be said to have been ushered in by the Justinian plague, and it was closed by an even more disastrous outbreak of this same disease. All the ravages and slaughter consequent upon the great historic battles, when taken together, pale into insignificance on comparison with that dread visitation of the fourteenth century, the 'black death'.

It is noteworthy that this great historic epidemic did not originate in Egypt, as did many of its predecessors. Without exception the contemporaneous writers ascribe its origin to Cathay, or the China of today. This fact is of interest when it is borne in mind that at the present time we know of the existence of two endemic foci in China, besides that of Gurhwal in India, of Beni Cheir in Arabia and of Uganda and Kisiba in Africa. Whatever may have been its source, the fact is that it advanced from the Orient along the three principal routes of travel. One of these led from the Persian Gulf through Bassorah and Bagdad along the Euphrates, across Arabia to Egypt and Northern Africa. Another route passed from India through Afghanistan, and skirting the southern borders of the Caspian and Black Seas, eventually reached Asia Minor. A third route from Turkestan and China led around the northern shore of the Caspian Sea to Crimea, and thence to Constantinople. It was along these several routes that the plague advanced and spread over most of Western Asia and Northern Africa.

The European black death, however, can be traced with accuracy to the Crimean peninsula. Gaffa, a town in Crimea, now known as Theodosia, had been founded and fortified by the Genoese. It, as well as other cities along the Black Sea, was largely populated by Italians. One of these, Gabriel de Mussis, a lawyer in Gaffa, has left a faithful account of his experience and share in the introduction of the plague into Europe. In 1346 in the Orient numberless Tartars and Saracens were attacked with an unknown disease and sudden death. In the city of Tanais, through some excess, a racial struggle ensued between the Tartars and the Italian merchants. The latter eventually escaped and took refuge in Gaffa, which in time was besieged by the Tartars. During the siege, which lasted three years, the Tartar hordes were attacked by the plague, which daily carried off many thousands. The besiegers, despairing of reducing the city by direct attack, attempted to do so in another way. By means of their engines of war they projected the dead bodies into the beleaguered city, which, as a result, soon became infected. The Christian defenders took to their ships, and abandoning Gaffa, sailed westward, touching at Constantinople, Greece, Italy and France.

Wherever the infected vessels touched they left the plague. Constantinople thus became infected early in 1347. During the summer Greece, Sardinia, Corsica and parts of the Italian coast developed the disease. In the fall it reached Marseilles. The following year it spread inland into Italy, France, Spain, and even into England. In another year or two it spread over Germany, Russia, and crossed to the Scandinavian peninsula. Within four years it had completed the circuit of Europe, spreading untold death and misery. No greater catastrophe has been recorded in the history of the world.

The rapidity with which the disease spread among the fugitives from Gaffa, and in the cities visited by their ships, is despairingly narrated by De Mussis, who, returning in one of the ships to Genoa, says: "After landing we entered our homes. Inasmuch as a grave disease had befallen us, and of the thousands that journeyed with us scarcely ten remained, the relatives, friends and neighbors hastened to greet us. Woe to us who brought with us the darts of death, who scattered the deadly poison through the breath of our words." According to this writer 40,000 died in Genoa, leaving scarcely a seventh of the original population. Venice was said to have lost 100,000, Naples 60,000, Sienna 70,000, Florence 100,000. All told, Italy lost half of its population.

Of the contemporaneous writers none has printed the horrors of the plague more vividly than does Boccaccio in his introduction to the 'Decameron.'

"What magnificent dwellings, what notable palaces were then depopulated to the last person! What families extinct! What riches and vast possessions left, and no known heir to inherit! What numbers of both sexes in the prime and vigor of youth, whom in the morning either Galen, Hippocrates, or Æsculapius himself but would have declared in perfect health, after dining with their friends here have supped with their departed friends in the other world!"

From Marseilles the plague spread through Provence with disastrous results. In some monasteries not even a single survivor was left. In one of these Petrarch's brother buried thirty-four of his companions. At Avignon, the seat of the Pope, 1,800 deaths occurred in three days. In Paris more than fifty thousand died of the plague.

In England the black death appeared in August, 1348, and continued till the autumn of 1349, when it disappeared. London, which at that time probably had a population of 45,000, had a mortality of about 20,000. No exact statement can be made of the relative mortality in England, although many undoubtedly extravagant guesses are recorded by contemporaneous writers.

It is estimated that the population of Europe previous to the outbreak of the black death was about one hundred and five millions. One quarter of the population, or about twenty-five millions, are said to have died of the plague. This may be but a mere estimate, it may be grossly inaccurate, but it nevertheless indicates the deadly character of the pestilence. According to a report made to Pope Clement VI, the total mortality for the known world was placed at forty-three millions. One-half the population of Italy succumbed. The Order of Minorites in Italy lost 300,000 members. The Order of Capuchins in Germany lost 126,000 members, while the total of deaths in Germany was placed at 1,200,000.

The invasion of Europe by the black death was sudden and rapid. The seeds of the disease, once planted on European soil, persisted, as might be expected, for no little time. Although the great epidemic was said to have lasted till 1360, it must not be inferred that it then ceased altogether. Diverse localities retained the infection, and, as a result, new outbreaks, though to a less extent, continued to outcrop during the following years. From that time on every decade or two witnessed more or less pronounced outbreaks of the disease in France, England and Italy. The chroniclers of those local outbreaks during the latter half of the fourteenth and during the entire fifteenth century did not always make it clear that the pestilence described was the real plague. It was but natural to include typhus and other diseases under the dreaded term of pest. Nevertheless, the frequency of these outbreaks indicates the persistence and the wide dissemination of the plague during those years.

During the sixteenth century the plague apparently began to show a decrease in its frequency, although during this period, as before, other epidemic diseases were mistaken for it. Germany, Holland, certain cities in France, and especially in Italy were scourged by the plague during this century. The noteworthy outbreak in Italy in 1575-77 was due to fresh importation from the Orient. The disease spread throughout Italy, and the devastation it caused was not inferior to that of the great plague two centuries before. For example, in 1576 in Venice 70,000 died of the disease.

During the seventeenth century the plague asserted itself with great severity. Following a famine, it prevailed in Russia in 1601-1603, and some idea of its destructiveness may be gained when it is stated that in Moscow alone 127,000 lives were taken. During the following decade even greater epidemics prevailed in Western Europe. France and England were invaded, and in Switzerland it even penetrated to the highest Alps. Basel in 1609-1611 had 4,000 deaths, while London in 1603 yielded 33,000.

The terrible epidemic which ravaged Northern Italy in 1629-1631 deserves more than a passing notice. During those years more than a million died of the disease. Scarcely a town in Northern Italy escaped. The city which, perhaps, suffered the most was Milan, where, in 1630, the deaths from all diseases are said to have amounted to 186,000. The Milan outbreak has been graphically described by Manzoni, in his celebrated 'I Promessi Sposi.' Unrecognized, the disease entered Milan in October, 1629. The mild cases which were met with during the winter months lulled the fears of the people and encouraged the mass of physicians to deny the existence of the plague. But in April the disease began to assert itself in terrible earnest. The frenzied populace, blind to the contagiousness of the disease, were possessed with the strange hallucination that obtained during former plague epidemics in other Italian cities, that the pest spread because of poison scattered about by evil-minded persons. Suspicious strangers were, as a result, stoned in the streets, imprisoned and even put to death by legal process because of such fanatical beliefs. To offset the growing pestilence, the people demanded of the Archbishop that a solemn religious procession be held, and that the holy relics of Saint Charles be exposed. At first this was refused, but eventually it was granted. The procession bearing the saintly body was solemnly held on the 11th of June. The fanatical security which these devotions engendered was rudely shattered when, a few days later, the disease burst forth with renewed activity among all classes in all parts of the city. Nevertheless, as Manzoni observes, the faith was such that none recognized that the procession itself was directly the cause of the new outburst of the disease by facilitating the spread of the contagion. Again the belief asserted itself that the 'untori,' or poisoners, mixed with the crowd and with their unguents and powders had infected as many as possible. From that day the fury of the contagion continued to grow to such an extent that scarcely a house remained exempt from the disease. The number of patients in the pesthouse rose from 2,000 to 12,000, and later reached 17,000. The daily mortality rose from 500 to 1,200, then 1,500, and is even said to have reached 3,500. Milan, before the epidemic, was said to have had a population of from 200,000 to 250,000. The loss by death has been variously estimated at from 140,000 to 186,000. All these deaths were not due to the plague. Thus, large numbers of children died as a result of starvation consequent upon the death of their parents from the plague.

The horrors attendant upon such a dreadful visitation can well be imagined. Scarcity of help in removing the dead and in taking care of the sick made itself felt, to say nothing of the lack of food. Enormous trenches, one after another, were filled with the bodies of the victims, carried thither by the hardened *monatti*, the counterpart of the Florentine *becchini*, so well portrayed by Lord Lytton in his 'Rienzi.' These bearers of the sick and dead were naturally recruited from the lowest criminal classes, and it can, therefore, cause but little wonder that an epidemic of the worst of crimes was associated with that of the plague.

In 1656 Italy was again invaded by the plague, and on that occasion Genoa lost 65,000 of its population by death. About the same time terrible epidemics of the disease ravaged Russia, Turkey and Hungary.

London, in 1665, suffered dreadfully from the plague. The disease appears to have been imported from Holland, where it was known to have existed for some time. The progress of the disease in London has been vividly portrayed by Defoe in the 'Journal of the Plague Year' and in the 'Due Preparations for the Plague.'

It is supposed that the pest had been imported in bales of goods from Smyrna into Holland in 1663. From thence it crossed over to London, where the first deaths were reported about the first of December in 1664. Toward the end of that month another death occurred in the same house, but during the following six weeks no new case developed. About the middle of February, however, a person died of the plague in another house. From that time only occasional cases of plague were reported, although the weekly mortality was rapidly rising and was greatly in excess of the usual rate. Thus, while the ordinary weekly mortality ranged from two hundred and forty to three hundred, this was gradually increased, so that in the third week in January it had risen to four hundred and seventy-four. After a slight remission, the mortality again rose, so that early in May plague cases were reported more frequently. It soon became evident that the plague, as in Milan in 1630, had slowly but surely gained a firm foothold. The increased mortality was undoubtedly due to unsuspected plague cases of either the pneumonic or the septicemic type.

During May, and especially during the hot weather in June, the disease continued to spread. At the same time, the panic-stricken people began to leave the city in large numbers. In July the condition was truly deplorable. To quote Defoe:

"London might well be said to be all in tears; the mourners did not go about the streets, indeed, for nobody put on black or made a formal dress of mourning for their nearest friends; but the voice of mourning was truly heard in the streets. The shrieks of women and children at the windows and doors of their houses, where their dearest relations were perhaps dying, or just dead, were so frequent to be heard as we passed in the streets, that it was enough to pierce the stoutest heart in the world to hear them. Tears and lamentations were seen almost in every house, especially in the first part of the visitation; for toward the latter end men's hearts were hardened, and death was so always before their eyes, that they did not so much concern themselves for the loss of their friends, expecting that themselves should be summoned the next hour."

London at this time had a population of nearly half a million. The deaths from the plague during 1665, as reported in the bills of mortality, are 68,596. By far the larger number of these occurred in August, September and October. The weekly mortality from the disease rose from a few cases in May to over 7,000 per week in September. It may, indeed, be close to the truth when Defoe states that 3,000 were said to have been buried in one night.

The great plague of London in 1665 was by no means the only visitation of that kind. From the time of the black death in 1348, London had a continuous record of plague infection. On an average it had an epidemic of plague every fifteen years. Some of these were fully as severe as that of 1665. Thus, in 1603, with a population of 250,000, there were over 33,000 reported deaths from the plague. In 1625, 41,000 died of pest out of a population of 320,000.

One of the most remarkable facts in connection with the great plague is this—that it was the last in England. The great fire of 1666 is supposed to have extinguished the plague, but this cannot be said to be true. The disease continued to a slight extent in 1666 and isolated cases were reported as late as 1679, but after that date it disappeared completely and from that time until this year England has been absolutely free from the plague. The sudden extinction of the plague in England after it had becomes domesticated, so to speak, for nearly three centuries, is indeed difficult to explain. Creighton sees an inhibiting influence in the growth of the practice of burial in coffins. But the absence of famine, together with the cessation of domestic wars and strife and the abeyance of want and misery, had not a little effect. As will presently be seen, the extinction of the plague in England was no more remarkable than its disappearance from Western Europe.

The history of plague in the seventeenth century does not close with the London epidemic. From 1675-1684 the disease ravaged Northern Africa, Turkey, and from thence invaded Austria and even reached Southern Germany. The Vienna outbreak of 1679 can be said to have been no less terrible than that of Milan or of London. The deaths from the plague in Vienna in that year have been variously estimated at from 70,000 to double that number.

From Vienna the plague reached Prague, where in 1861 it is said to have caused no less than 83,000 deaths. It is not to be wondered at that a nation scourged by thirty years of relentless warfare, by religious persecution and finally tried thus severely by the plague should inscribe upon the equestrian statue of their patron saint the heart-rending appeal, 'Lord, grant that we do not perish.'

The close of the seventeenth century saw the disappearance of the plague from Western Europe. In Eastern Europe, however, the disease continued to exist even during the eighteenth century. Nevertheless, a change had taken place for the better, and as the years went on the retrogression of the plague became more and more distinct.

During the first two decades of the eighteenth century the plague was widely distributed in Eastern Europe. It was present especially in Constantinople and in the Danubian provinces. From the latter it extended to Russia (Ukraine), and from thence to Poland. The disastrous invasion of Russia by Charles XII. of Sweden, ending in his defeat at Poltawa in 1709, led to its further dissemination to Silesia, Eastern Prussia, the Baltic provinces and seaports, and even to Scandinavia. It was during this epidemic that Dantzic, in 1709, lost 33,000, and Stockholm 40,000 by the plague. During the years 1709 and 1710 the plague mortality in the Baltic provinces exceeded 300,000. Three years later, in 1713, the plague spread up the Danube and reached Vienna, Prague and even Bavaria.

During these two decades Western Europe was entirely free from the dread disease. In 1720 the disease suddenly developed in Marseilles and extended from thence to neighboring towns and the country districts of Provence. Terrible as was this visitation it is of interest, inasmuch as it was the last occurrence of the plague on French soil, and the last in Western Europe until the recent outbreak in Portugal.

The plague was said to have been imported into Marseilles by a merchant vessel, the 'Grand Saint Antoine', from Syria. On its way to Marseilles several deaths occurred on shipboard, but the cause was overlooked. On the 25th of May, 1720, two days after the arrival of the vessel, another death occurred among the crew. The disease was still not believed to be the plague, and although quarantine was instituted, new cases appeared among the crew and the dock laborers employed in unloading the vessel, and it was not until the disease reached the city that its true nature was recognized. The germs of the disease had then been scattered broadcast. Unsanitary a city as Marseilles is to-day, it must have been vastly more so in 1720. The result of the addition of plague germs to the want, misery and filthy condition was at once evident. During August the mortality averaged four and even five hundred per day. In September the daily mortality rose to 1,000. So great was the terror of the populace that it became impossible to secure bearers of the dead, to obtain nurses and attendants. The dead were left in heaps upon the streets, so that it became necessary to transfer to the city 700 galley slaves, who were required to remove the bodies. These same galley slaves were even pressed into service as nurses. The diseased were abandoned by friends and relatives, and under such conditions it need not be wondered at that they received little or no attention from others. Food and water were denied to the unfortunates, and when food was administered to the pesthouses it was thrown into the windows by machinery.

The disease continued in Marseilles until December, 1721, but isolated cases persisted until April, 1722. During the fifteen months of its duration it carried off 40,000 of the population. According to Defoe, there died of the plague in Marseilles and within a league of its walls 60,000.

From Marseilles the plague reached Aix, and in the winter of 1720 and 1721 it carried off 18,000 of its people. It also reached Arles, where, in 1721, out of a population of 23,000, 10,000 died (forty-five per cent). The same year, in Toulon, which had a population of 26,000, the plague attacked 20,000 of the population, and of these 13,000, or about one-half of the original population, died.

The country districts about Marseilles were likewise invaded. Out of a population of 248,000, there died of the plague 88,000, or fully thirty-five per cent.

It is evident from this description that the plague of 1720 was in nowise inferior to that of 1348. Fortunately, the disease did not spread beyond Provence. It is noteworthy that in many instances, in Marseilles, people secluded themselves in their houses, avoiding all communication with the outer world, and in this way escaped. Similar isolation of cloisters, insane asylums, likewise resulted in freedom from the disease which stalked so freely throughout the stricken city. It was experience of this kind in isolation of the healthy which led Defoe to write his 'Due Preparations for the Plague.'

Toward the middle of the century the plague reasserted itself in the Danubian provinces, the constant battleground between the Turks and Russians and Austrians. In 1738 it not only prevailed in Russia but also invaded Hungary. Of more importance than this occurrence is the outbreak of the plague in 1743 in Sicily. The last epidemic of plague had occurred in Messina in 1624. After a lapse of one hundred and twenty years, it reappeared with terrible results. In Messina, as in Marseilles and in London, the first cases were not recognized as plague cases and, as a result, the infection spread until, like a veritable explosion, the disease developed all over the city. The plague, with its attendant misery of lack of food, and even of water, was in vain combated by religious processions. The plague corpses were in heaps in the streets, as in Marseilles, and cremation was resorted to in order to effect their removal. That year 30,000 died of plague in the city of Messina. With the exception of a slight epidemic at Noja in 1815, this outbreak in Messina in 1743 was the last one to appear in Italy.

In 1755, the plague was introduced into Transylvania by an Armenian merchant from the Black Sea. Before it was extinguished, 4,300 deaths were recorded.

Next to that of Marseilles and of Messina, the most noteworthy outbreak of plague was that which occurred in 1771 in Moscow. The disease was introduced by troops returning from the Danubian provinces. As so often has been the history of plague, the first cases were not recognized, and the existence of pest was denied. When the plague was demonstrated to be present, it is said by Haeser that three-fourths of the populace deserted the city. The disease began early in March and increased during the early summer months. In August over 7,000 deaths resulted, while in September the records show that 21,000 died. In October the plague decreased, but still 17,000 deaths attested to its fearful power. Early in January it became extinct, after a duration of ten months, and after having caused the death of more than 52,000 people.

Toward the close of the eighteenth century, at the time of the Napoleonic invasion of Egypt and Syria, the French armies came into contact with the plague. Bonaparte's visit to the pest-stricken soldiers at Jaffa has been perpetuated in the historic canvas which is to be seen at Versailles.

During the nineteenth century the plague ravaged Northern Africa on diverse occasions. Constantinople was invaded in 1802, 1803, 1808. It was also present to a slight extent in the Caucasus and in Astrakhan. A notable plague epidemic appeared in Egypt in 1812, and soon spread through Turkey and Southern Russia. Constantinople and Odessa were severely scourged. In Odessa out of a population of 28,000 there died 12,000.

It is a noteworthy fact that the Napoleonic wars, with all their incident hardships and misery, did not develop or spread the plague in Europe. The outbreaks of the disease were limited during this period to Africa and to Turkey, Bosnia, Roumania, Dalmatia and to Southern Russia. Two exceptions, however, are to be noted. In 1812 the Island of Malta was infected and more than 6,000 of its people yielded to the disease. The epidemic of 1815 at Noja, in Apulia, was the first recurrence of the plague on Italian soil since 1743, and thus far it has been the last.

The Balkan Peninsula and Southern Russia were visited from time to time by the plague up to about 1841. For nearly forty years Europe was wholly free from the disease, which, however, continued its existence in Northern Africa, in Mesopotamia and in India. The Russo-Turkish war of 1878 brought the Russian troops into contact with the disease in the Caucasus, and the epidemic at Vetlianka on the lower Volga was unquestionably introduced by such returning soldiers.

Such, then, has been the history of the bubonic plague. No other epidemic disease can be traced authentically as far back as the 'Black Death.' The characteristic symptoms, the rapid death, the excessive mortality are all features which have been noted through more than twenty centuries. The plague bacillus discovered in 1894 by Yersin, judged by its effect, is neither more nor less virulent than its early progenitors. It has often died out in a given locality or country, it has even been forced back to its original ancestral home, but still the same type, the same species has perpetuated itself unchanged. If the plague on its present world-wide journey does not cause such terrible outbreaks as it has in the past, it will be not because the germ has been altered by time, but because man has changed in so far as he has slowly learned and profited by the lessons of previous epidemics.

GASOLINE AUTOMOBILES.

BY WILLIAM BAXTER, JR.

TO understand the operation of a gasoline vehicle it is necessary to be somewhat familiar with the principle on which gasoline motors act. Briefly stated, it is as follows: The gasoline is converted into a vapor, and in this state is mixed with a sufficient amount of air to cause it to ignite when heated to a proper temperature. This mixture of air and vapor is admitted into a cylinder in which a piston moves freely, this part being substantially the same as in a steam engine. By means of an electric spark or a hot tube, the mixture is ignited, burning so violently as to expand the products of the combustion with such rapidity as virtually to become an explosion. The force of this explosion pushes the piston to the further end of the cylinder, and by means of a connecting rod and a crank this movement imparts a rotary motion to a shaft.

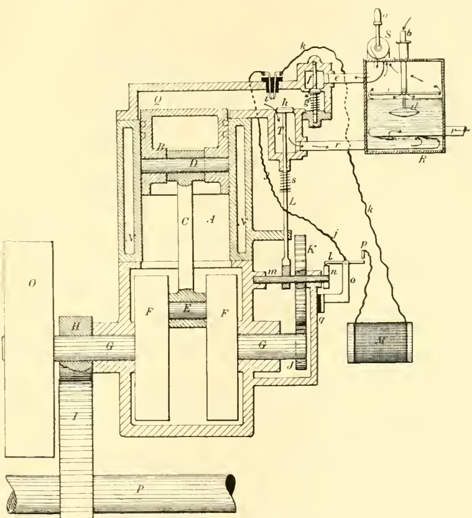


FIG. 1. GASOLINE MOTOR.

The entire operation is made perfectly clear by the aid of Fig. 1, which is a simple diagram of a single cylinder motor. The chamber R contains the gasoline. Air enters this chamber through tube b, as indicated by the arrow, and passes out between the plate c and the surface of the gasoline. The float d keeps the plate c in the proper position regardless of the amount of liquid in the reservoir. The heated gases exhausted from the cylinder pass through the pipe r, and thus heat the gasoline so that it vaporizes freely and the air passing under c becomes charged with the necessary proportion of vapor. The mixed air and vapor enter a valve chamber S, from which the flow into pipe e is regulated by the movement of handle a. In this chamber there is another valve, operated by an independent handle, and by means of this more air can be admitted into the mixture when desired. Through the pipe e and the valve f the vapor enters chamber Q, which connects with the top of the cylinder. Suppose the shaft G is rotating, then the piston will be drawn down from the position in which it is shown and thus a vacuum will tend to form in chamber Q. This action will cause the valve f to open and the mixture of air and vapor will flow into Q until the piston reaches its lowest position and begins to ascend. At this instant the valve f will close, and then the upward movement of the piston will compress the mixture in the chamber Q. When the piston reaches the upper position, after completing the down and up strokes, the lever l and the contact point p will come together, and an electric current developed in the induction coil M will pass through the wires j and k and produce a spark at i between the ends of the metallic terminals passing through the plug of insulating material, which is shown in dark shading. This spark will cause the mixed air and vapor to ignite, producing an explosion that will force the piston down for the second time. On the second upward movement of the piston the gases produced by the combustion of the vapor will be forced out through the valve h into the chamber T and the pipe r. The valve h and the lever l are operated by cams mounted on the shaft m, and they are so set that the spark at i occurs when the chamber Q is full of the explosive mixture and the piston is at the top of the cylinder. The valve opens when the piston begins to move upward after the explosion has forced it to the bottom position.

As will be seen, the piston must move down to draw in a supply of the explosive mixture; it then moves upward to compress it, and on the second down stroke it is pushed by the force of the explosion. From this action it can be clearly realized that the power developed by the motor comes from the force exerted by explosions at every alternate revolution of the shaft. On that account the cams that move the valve h and the lever l are placed on a separate shaft, which is geared to the main shaft in the ratio of two to one; that is, the wheel K is twice the diameter of the wheel J. As the force of the piston acts on the shaft only once in every two revolutions it is necessary to provide a heavy fly wheel *O*, which will store up enough momentum to continue the rotation of the motor through the ineffective revolution. Before the motor can put forth an effort it is necessary for the piston to move downward so as to draw in a supply of explosive gases and then to move up so as to compress them and produce an explosion; therefore, the motor will not start of its own accord, but must be set in motion. In the act of starting the wheel *O* is turned by hand.

The combustion of the gasoline vapor within the chamber *Q* and the upper end of the cylinder develops a large amount of heat, and unless means are provided for dissipating it the temperature will soon rise to a point that will interfere with the proper action of the motor. Two ways are employed to carry off the heat. One is by surrounding the cylinder with a water jacket, as shown in the diagram at *NN*; and the other is to provide the exterior of the cylinder with numerous thin

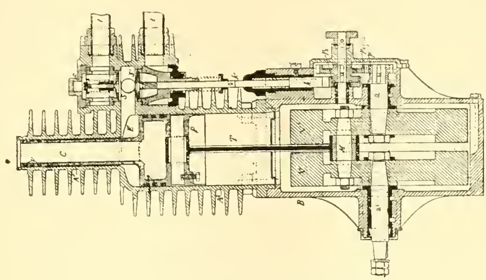


Fig. 2. Petroleum Spirit Motor.

ribs so as to increase the surface exposed to the air and thus increase the radiation.

The electric spark is a very effective igniter for the explosive mixture, and, by properly setting cam *n* the explosion can be made to take place just at the position of the piston that may be found the most desirable; but the points at *i* are liable to get out of order, and the battery that actuates the induction coil *M* and the coil itself can become a source of more or less trouble, and on that account the igniting is effected in some motors by means of a hot tube. When this is used the cam *n*, the lever *l* and the electrical parts of the apparatus are not required. In their stead a tube is placed on the upper side of the chamber *Q* and this tube is maintained at a red heat by means of a flame impinging against its outer surface. When the explosive mixture is compressed it rises in the interior of the hot tube, and when it reaches the portion that is hot enough to produce combustion an explosion takes place. By many engineers this arrangement is regarded as superior to the electric spark on account of its simplicity.

Gasoline motors are made with one, two or more cylinders, but in each cylinder the action that takes place is that described above. The actual construction of a motor is not so simple as might be assumed from the appearance of Fig. 1; many details are required which are not here shown. A more perfect idea of the actual construction of a gasoline motor can be had from Fig. 2, which is a working drawing of a recent European invention. In this design it will be noticed that the cylinder is cooled by radiation into the surrounding air, the exterior surface being increased by numerous circular ribs and also by extending a hollow trunk from the upper side of the piston, so as not only to increase the radiating surface, but also to allow the hot air to escape from the chamber *T* in which the crank discs revolve. In this drawing *E* is the explosion chamber, corresponding to *Q* in Fig. 1, and

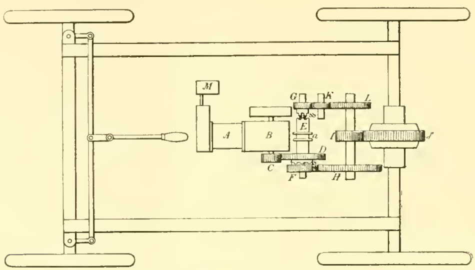


Fig. 3. Reversing Mechanism.

the valve *s* is the counterpart of *f*, while *s'* corresponds to the valve *h*. The upper pipe *t* is the pipe *e* of Fig. 1 and the lower pipe *t'* is the pipe *r* of the same figure. Although the crank discs, connecting rods and other details are different in shape, it will readily be seen that their relation to each other is the same.

Since a gasoline motor cannot start of its own accord, it is necessary in vehicles in which they are used so to arrange the driving gear that the motor may be kept in motion all the time and always in the same direction, hence, to reverse the direction of the carriage, reversing mechanism, independent of the motor, must be provided. The most simple mechanism for a gasoline vehicle employing spur gearing exclusively is shown in diagrammatic form in Fig. 3. In this figure *A* represents the cylinder of the motor, *B* the crank disc chamber and *M* the vaporizing receptacle, which is generally called the carburator. The pinion *C*, on the end of the motor shaft, meshes into a gear *D* which is mounted upon a sleeve *E* which revolves freely round shaft *G*. This sleeve has its ends formed so as to engage with the gears mounted upon shaft G, and by means of a lever, which is not shown, but which works in groove a, the clutch either s or ss can be thrown into engagement with its corresponding gear. If s is thrown into gear, as shown in the drawing, the wheel F will turn H and the pinion I will rotate the gear J which is mounted upon the axle of the carriage. If the clutch ss is thrown into engagement, the gear G will turn K and this wheel will turn l; but, as can be clearly seen, the direction in which l will revolve

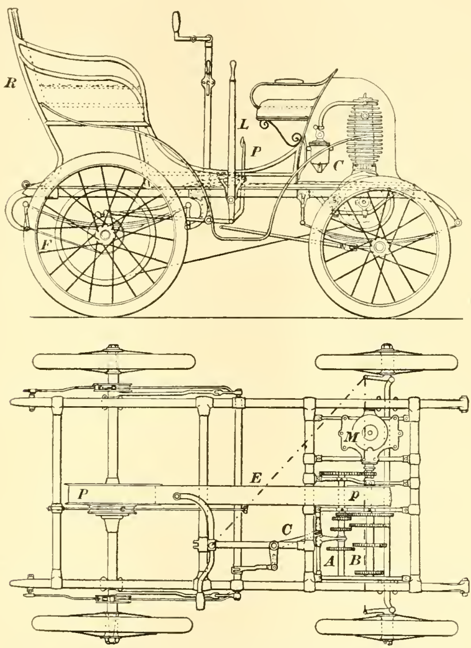


FIG. 4. PLAN AND ELEVATION OF UNDERBERG MOTOR VOITURETTE.

will be opposite to its motion when driven through F and H, therefore, if when F drives the carriage runs forward, when G drives it will run backward, and when E is moved to the central position, so that neither s nor ss engages with their respective gears, the vehicle will stand still, but the motor will continue to revolve.

This diagrammatic arrangement is more simple than the gearing actually used and is not as complete in action as many of the devices, as it only provides means whereby the direction of rotation of the axle may be changed, while in many carriages the gearing also varies the ratio between the speed of the motor and the driving wheels. It is also quite common to combine in the train of gearing spur gears and sprocket wheels, and in some instances even belts. Fig. 4 illustrates a French gasoline automobile made by Underberg, of Nantes. The first figure is a side view, and the second is a plan of the truck and driving mechanism.

The motor, which is of the single cylinder type, cooled by radiation into the air, is located at *N*. The pinion on the end of the motor shaft engages with the wheel on the end of shaft *A*. This shaft carries four gears, which can be moved by means of lever *C*, so as to engage with corresponding gears on shaft *B*, thus providing four different speeds. The motion of *B* is transmitted to the rear axle by means of a belt that runs over the pulleys *p* and *P*, the latter being carried by a differential gear, so as to run the two driving wheels at proper velocities.

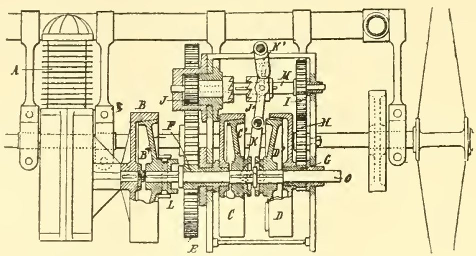


FIG. 5. CHERRIER TWO-SPEED GEAR.

The circular ribs surrounding the motor cylinder are well shown in the figure, in which the carburator of *C* is also seen. The housing for the motor is open at the sides so as to give air currents free access. In Fig. 4 the speed changing gears are shown, the reversing train being omitted; but if it were also drawn in, the diagram would be far more elaborate than Fig 3.

Another form of variable speed gear is shown in Fig. 5. This provides for two speeds. The large wheel *E* is on the carriage axle, and it is driven either by a pinion *F*, or by *J*. Upon the shaft *O* there are two friction clutches *C D*, and when *C* acts the pinion *F* drives *E*, and when *D* acts the pinion *G* drives *H*, which in turn drives *I*, and this wheel is mounted on the same shaft as *J*.

Some of the best-known makers of gasoline vehicles do not employ variable gears and depend for changes in the speed wholly upon variation in the velocity of the motor. The De Dion carriages are made in this way, the gearing being substantially as illustrated in Fig. 3.

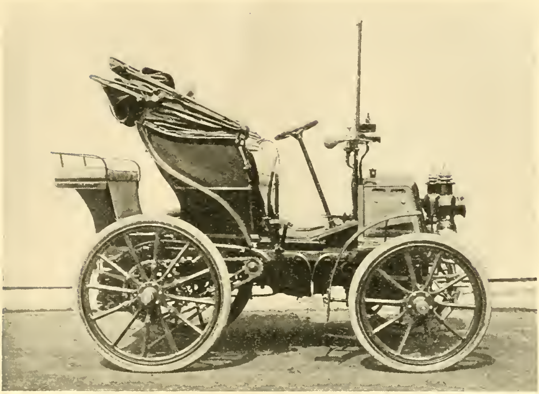


FIG. 6. PANHARD & LEVASSOR VEHICLE.

Fig. 6 shows a gasoline vehicle made by Panhard & Levassor, who are perhaps the best known French manufacturers of automobiles, as their vehicles have been the winners in all the notable races held within the past few years. The motor they use is shown in Fig 7, and, as can

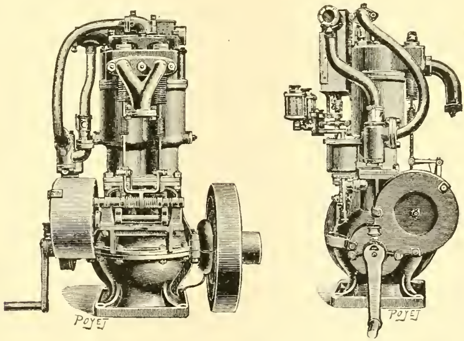


FIG. 7. MOTOR OF VEHICLE.

be readily seen, is of the two-cylinder type, cooled by a water jacket, just as in Fig. 1. The explosion is produced by means of a hot tube, as explained in connection with the last-named figure. This motor is placed under the body of the vehicle, and is connected with the rear axle by means of a train of gearing which terminates in sprocket wheels and chains that connect with driving wheels, each one being operated by a separate chain. In Fig. 6 the sprocket wheel and chain are well defined, and forward of these can be seen the outline of the casing enclosing the gearing.

Fig. 8 shows another European design, in which a variable-speed

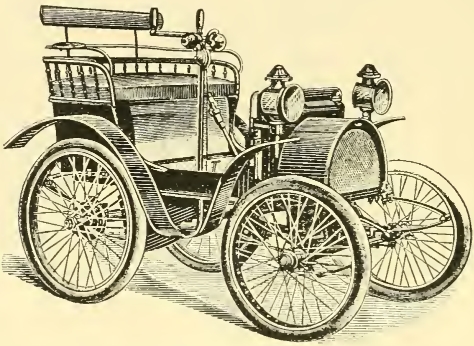


Fig. 8. General View of Renault Voiturette.

gear is used. The plan of the truck, showing the general arrangement of the mechanism, is presented in Fig. 9, and the details of the variable-speed gear are shown in Fig. 10. The motor is located at *A*, and through a friction clutch *B*, and the variable speed gear *C*, it rotates the shaft *H*, which runs lengthwise of the vehicle. Motion is imparted to the hind axle by means of bevel gears contained within the casing *D*. The large

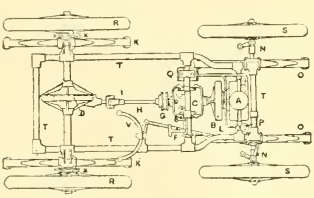


Fig. 9. Plan of the Truck.

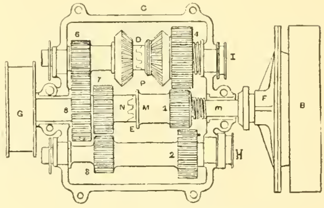


Fig. 10. Variable Speed Gear.

bevel gear on the axle is of the differential type, so as to drive the wheels *R R* at the proper velocities.

When a high speed is desired, the variable speed gear, Fig. 10, is set so that shaft *M* drives *N* direct, the clutch at *E* being moved so as to interlock. *N* is the end of shaft *H*, so that with this connection the bevel pinion, which meshes into the axle gear at *D*, revolves at the same velocity as the motor shaft. By moving the handle *V*, Fig. 9, to the right, an intermediate speed is obtained, and by moving it to the left, the carriage is run at the lowest velocity. When the handle V is turned to the right, the ends M and N, which form the clutch E, Fig. 10, are separated, and at the same time the lower shaft H is moved toward M, so as to cause gear 1 to mesh into gear 2, and also 3 into 7. By this means the end N of the axle-driving shaft is rotated through the train of gears 1, 2, 3 and 7. If the handle V is turned to the left, the shaft I is moved toward M, so as to cause gear 1 to mesh into gear 4, and gear 6 into 8, the latter being secured to end N of the axle-driving shaft. The speeds obtained by these changes are in the ratio of nearly 1, 2 and 4.

Fig. 11 shows the plan of a light French carriage, which is equipped with a double cylinder motor, set in a horizontal position above the front

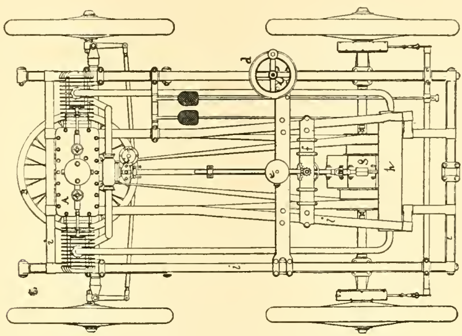


Fig. 11. Plan of the Turgan-Foy Voiturette.

axle, and arranged to impart motion to the hind axle by means of belts. The motor, which is located at A, turns a vertical shaft, and this, through spur gears, rotates a horizontal fly wheel, B. Two pulleys are mounted upon the motor shaft, and from these belts run to tight and loose pulleys on a countershaft, S. From the latter the rear axle is driven through two sets of spur gearing, which give two different speeds. By means of the belts, two other speeds are obtained, thus giving, in all, four different velocities. To stop and start, the belts are shifted from the tight to the loose pulleys by a belt-shifter, f. At h, a muffling chamber is located, into which the motor exhausts, so as to reduce the noise.

The elevation and plan of one of the celebrated French racing-machines, the Vallée car, is shown in Fig. 12. The motor of this machine is of sixteen horse-power capacity, has four cylinders, and is connected so as to impart motion to the hind axle by means of a single wide belt, which is marked *G* in both the line drawings. The driving-pulley on the motor shaft is located at *H*, and the axle pulley at *H'*. Within the latter there is a train of gears for reversing the direction of rotation of the axle, and also for obtaining the differential velocities of the two driving wheels. There is no mechanism for variable speed, this being obtained wholly by changes in the velocity of the motor. The motor speed can be made to vary through a wide range by using four cylinders, with which it is possible to reduce the velocity so low that it would be likely to bring the machine to a standstill if provided with one, or even two, cylinders. The change in the motor velocity is obtained in part by the action of a governor located in a chamber at *A*, and in part by the action of the electric ignition device which is arranged so that the time when the spark is produced can be varied. The rear axle is so held that it can be moved through a short distance, horizontally, by manipulating the lever *D*, and in this way the belt *G* can be made tight or loose, thus affording another means for varying the speed. A brake is provided which presses against the inner side of the axle pulley, *H*.

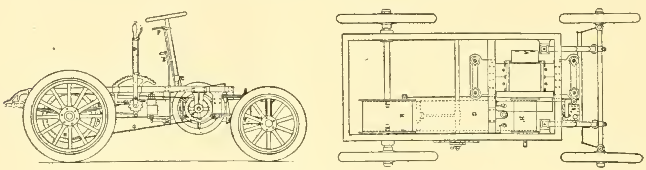


Fig. 12. Elevation and Plan of Vallée Car.

This brake is used ordinarily, but in the case of an emergency another brake can be operated which presses against the outside of the wheel in the space between the two sides of the belt. It is claimed for this vehicle that by the elimination of mechanical speed-changing devices, a great deal of weight is saved, and that this is more than enough to compensate for the extra weight of the motor, arising from the use of four cylinders. In most gasoline carriages it is necessary to provide a slow-speed gear for hill-climbing, as the motor cannot put forth a sufficient effort to ascend a steep grade at the normal velocity. With this racing-machine such a gear is not required owing to the enormous power of the motor.

There are quite a number of gasoline automobiles manufactured in this country, and, as in the case of the steam and the electric carriages, they compare most favorably with the best European products in so far as the artistic effect is concerned. That such is the case can be realized at once by an examination of Figs. 13 and 14. We regret our inability to illustrate the mechanism of these vehicles, but the truth is, that the manufacturers appear to be unwilling to make public the details of their designs. In the phaeton shown in Fig. 13, a single-cylinder motor is used, and it is so arranged that it can run at different velocities, so that no variable speed mechanism is required, except a single train of gears, which is thrown into action when running uphill. The motor

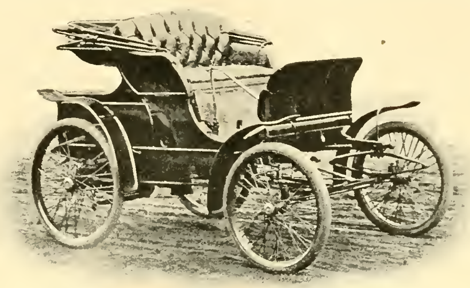


FIG. 13. WINTON PHAETON.

itself can be run at any velocity from 200 to 800 revolutions per minute, thus giving a speed variation of four to one. A carriage of this make competed in the last international automobile race from Paris to Lyons, France, and although it failed to come in first, it made a remarkable

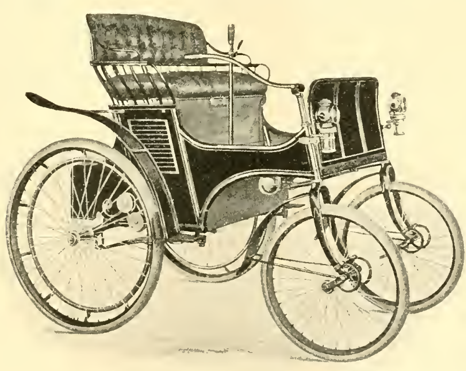


FIG. 14. OAKMAN VEHICLE.

showing, which might have been considerably improved if it had not been for an accident which compelled it to retire from the contest.

The vehicle shown in Fig. 14 is of small size and light construction, although amply strong for the purpose for which it is intended. The power of the motor, which is located under the seat, is transmitted through friction wheels. In looking at the illustration it will be noticed that the hind wheels have a circular rim attached to the inner side, and of a diameter somewhat smaller than the wheel itself. Two small friction wheels are placed so that either one may be pressed against the inner surface of this rim. The shape of the rim, as well as that of the small wheels, is such that they hug each other firmly, so that the rim is carried around in a direction which corresponds with the direction of rotation of the friction wheel. In operating the carriage the motor is set in motion, and then one or the other of the two friction wheels is pressed against the rim on the driving wheel, according to whether it is desired to run forward or backward. While this arrangement might not operate with entire success if applied to a heavy vehicle, it appears to be all that could be desired for a light carriage.

Three-wheel vehicles have been used, but there is a difference of opinion as to their value, as the construction has disadvantages as well as advantages. It is evident that such a vehicle can be steered with greater ease than one running on four wheels, but on country roads, where the wagon wheels roll down a smooth surface, and leave the space between in a rough condition, it is equally evident that the third wheel, in passing over this uneven surface, would jolt the vehicle to a considerable extent. On a smooth pavement the three-wheel vehicle will run fully as well as the four-wheel; but, on the other hand, on such a pavement the latter can be steered with as little effort as the former, so that the question of superiority of design is one that probably depends upon individual taste.

From the descriptions of automobiles given in this and the two preceding articles, it will be seen that although many of them are used, especially in France, they are not entirely free from objectionable features. The electrical vehicles are provided with the most simple and durable machinery, and, being noiseless, odorless and free from smoke, are all that could be desired in so far as their operation is concerned; but they are heavy and can only be used in places where the batteries can be recharged. The steam vehicles are light, have simple mechanism and can run anywhere; but they exhaust steam into the air, which is clearly visible in cold or wet weather, and the heat from the engine and boiler is an objection, at least in summer time. The gasoline vehicles run well, but are noisy, and the odor of the gasoline is disagreeable as well.

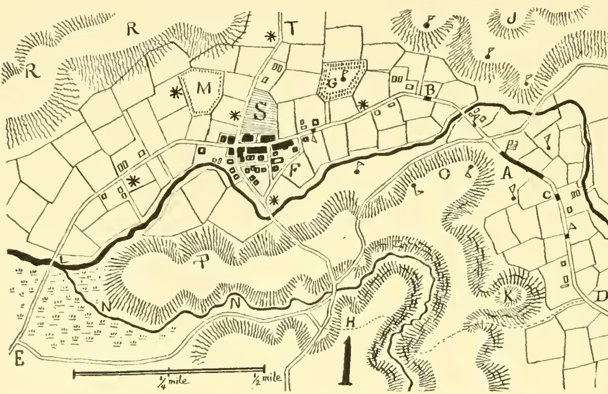
SOME SCIENTIFIC PRINCIPLES OF WARFARE.

BY WILLIAM J. ROE.

As in boxing, fencing, saber and bayonet exercises, there are comparatively few postures, guards, thrusts and strokes, so in warfare, whether the numbers be large or small, the arms most modern or ancient, there are just a few principles to whose steady adherence and skilful manipulation all success is due. In order that these may become apparent without irksome study of military details, let us imagine a command of say a thousand men, fairly well drilled, of good ordinary intelligence and engaged in a cause worthy of being fought for. We have been in camp for some time, but an order has now come to join the main army. This is a long distance off, the railway communications have been broken, and the intervening country, though possessed of good roads, is more or less in the hands of the enemy.

Our scouts have kept us informed as to the condition of the country for several miles around; our first day's march is, therefore, not hampered with any especial dread of surprise. We move quickly and at ease. Safe as everything appears to be, the commander relaxes none of the needful precautions; at least fifty men, under command of an experienced officer, are sent quite far to the front, the distance varying with the nature of the country—the farther, the more broken it may be. The best roads are followed; the men are allowed to march at ease, though always preserving their company organization, while the officers are always more or less on the alert. There is a small rear guard, but it is upon the advance that the main responsibility falls. Of the fifty thrown forward, about half will remain together; the rest are scattered; some far to the front along the highway; others on either side of the route, riding up the hills on either hand, making sure that no deep gorge, dense growth of forest or thicket, nor even a field of grain conceals an enemy. It is upon the alertness of those vedettes on front and flanks that the safety of the force in great measure depends. History records many relaxations of this principle of precaution, and for lack of it sudden ambushes and deplorable disasters. It was thus, in spite of Washington's repeated warnings, that Braddock fell into a cunning ambuscade, and thus (not to multiply examples) that Custer and his command were massacred to a man among the high Rockies.

On the annexed map the men may be located at 'A' marching from 'D' in the direction of the village, 'F'. The advance is at 'B', the rear guard at 'C'. The commander rides with the main column, near the front. The black dots, with pennons, indicate the general position of the vedettes at this point, though, of course, they are continually advancing. The commander has noted on his map a foot path, beginning at 'D', leading over the rugged hills. By taking this path a considerable distance could be saved; but it is quite impracticable for the wagons, and the troops, therefore, continue along the high road. The valley is gently undulating, with a gradual slope from the low hills towards the stream.



The projecting hills near the head of the column form an especially dangerous point. What easier than for an enemy to plant batteries here on either side of the road. A sudden, heavy fire would throw a negligent force at once into disorder; a situation to be taken instant advantage of by a vigorous adversary; a charge of horse concealed behind the hill at 'O', and nothing might be left except flight, with great loss of life, and surrender with loss—if not of honor, at least of reputation as a safe leader.

Happily, we shall avoid both alternatives. Our scouts have explored most thoroughly every possible vantage ground. They have not been content with any mere glances; their instructions are to take nothing for granted. That field, marked 'G', looks innocent enough, but the tall, thick rye or corn may cover a skilfully placed battery. The plot marked 'M' may be simply a vineyard; but it does no harm to inquire. The inhabitants of the country are friendly, and, therefore, the chances are not favorable to this sort of surprise; but in war it is often not the likely, but the unexpected that happens; the commander who knows his business guards against the remote possibility.

Though we have imagined a force of a thousand, it must not be lost sight of that the same kind of precautions should be employed for very much larger numbers; indeed, you need only alter the scale of the map, imagine additional roads, a railway line or two, increase to thousands, if necessary, the fifty of our vanguard, and the result is but an application of the very first principle of warfare: Eternal vigilance is the price of safety as well as of liberty.

The troops have been in camp for some time; their condition is excellent for a long march. As the corn and rye are not yet gathered, the time is early summer. The roads are in prime condition. They set out by sunrise and halted for perhaps two hours at noon. It is by thus sparing his troops during the heat of the day that the colonel will have a body of men fresh enough at nightfall to march, if necessary, all night. But no such urgency exists; it is nearing sunset, and preparations are now being made to encamp. By his map the colonel has informed himself in the matter of distances, and has decided that they shall pitch their tents somewhere in the vicinity of the village ('F'). The scouts report an eligible location for camp at 'S', and this is finally chosen. It has several advantages, being comparatively level, and yet upon high ground, and has in close proximity several wells of good water. The train containing provisions and ammunition is parked in the safest locality, the horses picketed, and the guns—perhaps two or three field pieces and machine guns—placed where they can be most easily handled.

By all means, give the men as good a supper as the neighborhood affords. It will be wise not to encroach upon the rations, but rather draw supplies from the village; there are, no doubt, purveyors of one sort or another to be found ready enough to supply us, the more so that they will be amply paid.

Refreshed by their supper the men are ready to turn in at tattoo; by the time 'taps' have sounded most are soundly sleeping. But some are awake; if doing their full duty, wider awake than ever they are likely to be in times of peace. The same attention to the bodily comfort of his men which impelled the colonel to give them a long rest at mid-day and a comfortable meal, applies with increased force to those detailed early in the morning for the night's guard; during the march these have been spared as far as possible, even being allowed a lift now and then in an ambulance. Such privileges are not granted by a commander who knows his craft as a concession to the laziness, but rather as a preparation for the effectiveness of his men. This is a principle of action, and may apply to business as well as war, that the strong head never withholds reasonable and proper indulgence; the better, it may be said, to enforce at needful times reasonable and proper exertions.

As soon as the camp is established the guards are posted. If great precautions were needed during the day, much more are they by night.

If fifty were sufficient on the march we need a hundred during the hours of darkness. In the case of a large army an elaborate system of night guards is necessary: First, 'advanced guards', occupying strong positions at some distance from the main body; beyond these are the picket guards; further still towards the front what are called 'grand guards', from which are thrown forward the outposts, to which the line of sentinels is directly attached. In case of alarm, the sentinels fall back upon the outposts; these upon the grand guards; they, in turn, if necessary, upon the pickets; the necessities of the case and the strength of the enemy's demonstration determining the movements of the defense, even perhaps to the 'long roll' and rousing of the entire army.

In our case, no such elaborate system is possible; we content ourselves with outposts and the line of sentinels, all that will be needed, if vigilant, to guard against surprise. The colonel, attended by the officer in command of the guard, will select the sites for outposts. These, five in number, are marked by stars upon the map. The direction from which an attack is most probable is from the ridge ('R', 'R').

The men are usually on the sentinel line for two hours at a time, with opportunity for four hours' sleep; that is, with shifts, or, as they are called, 'reliefs' of three parties, two hours on and four off. This is not, however, invariable, it being sometimes wiser to relieve the men oftener or not so often, this being regulated by circumstances—the state of weather, distance of posts apart, fatigue of the men, etc., etc. The sentinels will be posted on clear nights generally upon high ground; in bad or foggy weather the foot of the slope is preferable. The officer will see that no obstacle prevents the sentinel from retreating upon his outpost if attacked. The men will be directed to take advantage of any cover that offers, always to keep in easy touch with one another and watchful, never to raise a false alarm, but quickly and decidedly a real one, and while not failing to discover the meaning of anything unusual in their front, never to expose themselves from mere bravado.

What measures shall be taken in case of an attack in force must, of course, depend entirely upon circumstances. A night attack, intended merely as an annoyance, or 'feeler', or at most to stampede some of the cattle, or to gather information as to strength, resources, etc., is quite a different affair from one planned for the purpose of complete victory, either the destruction, dispersal or capture of the command.

A mere night foray is generally executed by comparatively few. The opposing chief may be desirous of getting information concerning the force that his scouts have reported is advancing down the valley. A little expedition like ours sometimes serves as a disguise for a momentous strategical movement. The chief determines to find out all he can as to our purpose. He has found us vigilant by day; he resolves to try what the night may disclose. This sort of surprise is apt to produce better results than the project of some dashing subaltern, anxious for the bauble reputation.

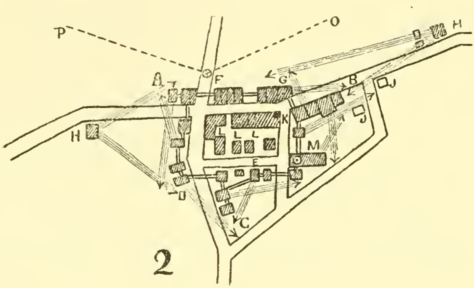
For such an attack an hour near midnight is usually selected, that the information may be gathered or the mischief done and a retreat effected under cover of darkness. A dark, wet, blustering, or—if the time be winter—an especially cold night is chosen. The degree of success to be attained depends naturally upon the element of surprise. Unless this be complete the attacking party will find their attempt usually quite futile.

The other sort of attack—that which has for its object the capture of the position—is usually planned to take place during the extreme darkness just preceding daybreak. The enemy has perhaps crawled on hands and knees up the slopes towards the line of sentinels. The van of this force is composed entirely of picked men, officered by the coolest heads. Signals are agreed upon, exact times for action arranged, and everything calculated to a nicety to insure that suddenness which is the very soul of success.

It is in the planning of such an expedition that true qualities of generalship are shown. It is the fashion rather to decry the military merits of Washington; yet I know of few events in history that show more sagacity than the swift crossing of the wintry Delaware and the surprise of Trenton. It was sagacious chiefly for the accurate comprehension of the probabilities. Washington knew the convivial habits of Rahl's Hessians, especially at Christmas-tide; he reckoned upon finding them in the midst of carousals, and the result proved the value of his forethought.

Under ordinary circumstances, on the march, to quarter a command inside four walls is never advisable. The men are not as readily under the eye of their officers; in case of surprise they cannot be called into the ranks as quickly; discipline insensibly relaxes, and the machine (for an armed force ought to be that, however intelligent its units) fails to respond instantaneously to the word of the chief. In case of a serious attack, however, the village may serve a most important purpose. Should the houses be substantial ones of stone or brick, each may become a most efficient, if temporary fortification. One consideration which might have prevented its occupation has now no longer any weight. Apart from any natural feeling of good will for our fellow citizens, how unwise it would be to unnecessarily exasperate them. But now in the face of the enemy, it will be surprising if any soul is churl enough to grudge a patriotic hospitality. Most of the denizens will, indeed, make haste to hide their precious persons in the cellar, but will seldom grumble at the necessity.

With the utmost celerity the baggage and horses are moved to the most sheltered spot; the guns, under strong guards, posted where they may be best utilized; some of the men, previously detailed for just such an emergency, are engaged in throwing up earthworks, piling logs, stones, anything that can be utilized for barricades. The officer charged with that duty, if possible a skilled engineer, goes quickly from place to place, hurriedly indicating the lines of defense; these connecting the several buildings in such a manner as to enclose the entire command within lines of quite formidable intrenchments. All this time the troops, having taken possession of the houses, have poured an uninterrupted fire upon the assailants, obliging them to retire, or at least giving the diggers—or sappers, as they are called—time to complete their labor of defense. Surrounded by a force sufficiently large to make resistance in the field quite hopeless, we are at least in position to protract the struggle, and one capable of defense, except against an assault in overwhelming numbers, or against heavy artillery. The latter they are not provided with, or the measures we are taking might all go in the end



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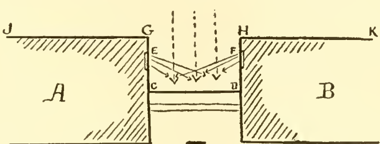
for nothing. Several assaults are attempted during the day, but are easily repulsed with no small loss. The enemy at last withdraws, and we now see that he is busy throwing up intrenchments. Meanwhile, we have not been idle. To facilitate communication, and to enable us to concentrate our forces under cover, passageways have been constructed between the various buildings, inner partitions preventing free access from room to room within the houses have been broken through, and the débris, together with beds broken up, mattresses and 'any old thing' capable of arguing with a bullet, piled in the window embrasures, leaving loopholes here and there, as occasion offers, while galleries may be constructed with loopholes in the floor to fire downwards.

One of the most important matters to be attended to is the securing of as many good positions as possible, from which fire may be concentrated upon exposed points. In a regular siege the points of attack selected will always be those most exposed, on account of their projecting beyond the line of defense. In the case of a village like this resisting an attempt at capture the principles are identical; it will certainly be the points that project that will be danger spots and which will therefore require especial attention.

You observe on the enlarged map of the village that there are double lines between the outer buildings; these are the improvised intrenchments. Notice that they have not been constructed flush with the face of the outer walls in any instance; but always considerably retired. The object of this arrangement is more effectually to defend the barricades. In the annexed sketch (No. 3) 'A' and 'B' represent the two adjacent buildings and the lines 'CD' the breastwork. In the buildings are windows—'E' and 'F'—from which a heavy fire can be concentrated upon the assailants, as may be seen from the direction of the arrow heads. On the outer line are several projecting, and, therefore, especially exposed points; such as those at 'A', 'B' and 'C'. The arrow heads show the direction of protective fire. As additional protection, it might be wise to hold the two buildings ('H', 'H') outside the village. If not held, they ought, if possible to be destroyed, as also those marked 'JJ', not included in the defensive lines, as they offer excellent cover



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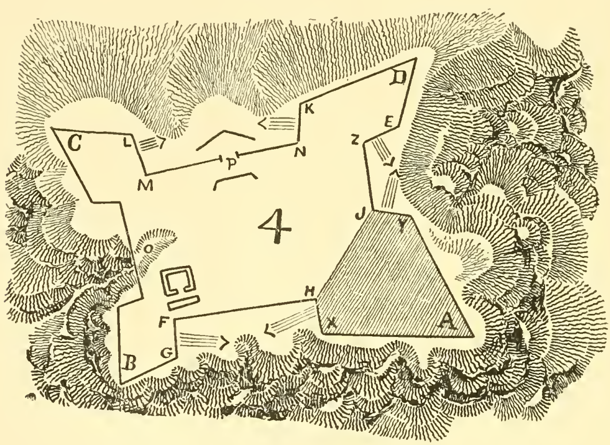
for the enemy. The utmost care should be taken to provide a safe magazine for the ammunition and to cover well the place selected for a hospital. The wagons and horses would be best protected in the space marked 'LLL'.

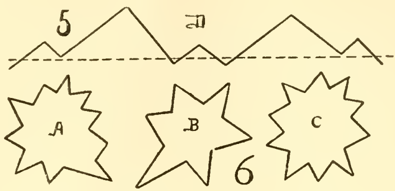
Should our defense prove too obstinate for direct assault, it may be that the enemy will construct regular intrenchments from which to dig a trench deep enough to protect, and large enough to hold a body of troops, thus enabling them to approach sufficiently near to assail some weak point, without too great risk. The modern repeating rifle, dangerous at a thousand yards, and fatal at a hundred, has given the defense so great preponderance that it requires quick work indeed to capture a stronghold. Observe the broken lines 'OF' and 'PF'; these show the direction of possible trenches dug by the enemy. But 'OF' would be raked by the fire from the outlying house, 'H'; the other is, therefore, the only feasible mode of approach.

The principle of defense, shown by the direction of the arrow heads in the case of the beleaguered village, is applicable to all conditions where ramparts are used. Suppose the command whose fortunes we have followed had been attacked while on the march at the point 'A' on Map 1. The opposing force was manifestly too strong for resistance in the field; they retreat to the rocky eminence 'K' and there proceed to fortify the position. A glance at Diagram 4 will show what they will try at least to accomplish. In military language that shaded portion of the work to be constructed is called a bastion; it consists of two faces ('AX' and 'AY'), and the two flanks ('JY' and 'HX'). The faces of this bastion are defended (as the arrow heads indicate) by the flanks of adjacent bastions; that is, the face 'AY' is swept by a raking fire from



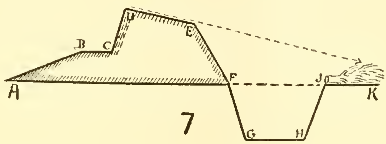
'ZE', and the face 'AX' from 'FG'. Reciprocally, 'HX' rakes the face 'BG', and 'JY' the face 'ED', and so on round the intrenchment.

All that has been said as to protecting the ammunition and stores will apply to this work as it did to the village. If a spring of water can be included, as at 'O', this will be found of incalculable advantage. Of all forms of defensive ramparts the straight line is the worst; if time does not permit a work with bastions, however irregular, an enclosure shaped somewhat like a star is serviceable (shown in Diagram 6, Figs. 'A', 'B' and 'C'). Should an enclosed work be impracticable, the line should have its ends (or 'flanks') strongly guarded, and be broken up, as in Diagram 5 'D' into short straight lines nearly at right angles, to serve for mutual support. This principle of mutual support, however achieved, is called that of 'defensive relations', and is capable of adaptation to all kinds of defensive works, whether of a few men beleaguered in an improvised fortification, a considerable number in a scientifically constructed work—permanent or field fortification—a fortress with an



entire army behind its ramparts, or a cordon of forts surrounding a great city.

The ground plan of the work having been decided upon and staked out the men start in with pick and shovel, digging, if possible, a ditch, and throwing the material into the shape of the shaded portion of Diagram 7. The ditch, outside the fort, indicated by the figure 'FGHJ', serves the twofold purpose of getting material for the parapet 'ABCDEF', and for embarrassing an enemy in any attempt at assault. To further

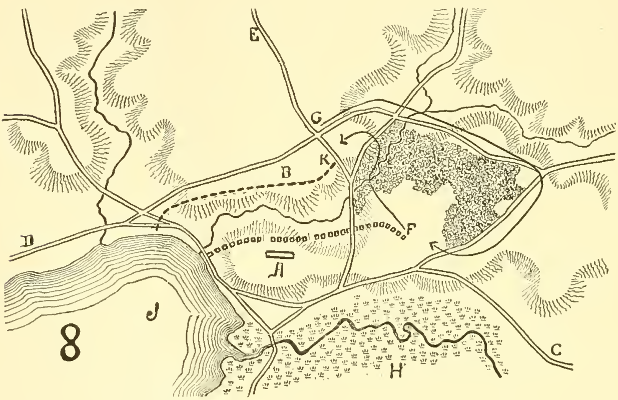


embarrass him every sort of obstacle that may be at hand should be put to use—trees, butts turned our way, boughs interlacing; stakes driven deep into the soil close together; barbed wires wound in and out; in short, every expedient that may delay his advance and keep him as long as possible exposed to our most effective fire.

The drawing (7) was made with no attempt at exactness of proportion, and simply to show the essentials; the slope 'EF' is made as steep as the nature of the soil will permit; 'DE' slopes enough to enable a soldier standing upon 'BC' to fire upon an enemy entangled among the obstacles at 'J', but never enough to weaken the mass of earth at and near 'D'.

Observe how common-sensible all these arrangements are; not one too many or too few; just the things that a practical man, if he could think as he felt, would do if suddenly called to command with an enemy advancing upon him. Unfortunately, perhaps, for the purposes of a patriotic and peaceful people, men are inclined, even though brave as courage itself, to get nervous or nerveless in the immediate presence of danger. This is the reason, rather than for any especial erudition involved in war's art, that we need trained soldiers—men trained to think mechanically and to act automatically amid the uproar of battle.

We have carefully, if briefly, considered the requirements of the first maxim of strategy—CAUTION—the need of it, and the practical methods of securing it; and also of the second maxim—DEFENSIVE RELATIONS—their necessity, and how to secure them. It now remains to consider the meaning of that phrase, 'turning a position', or 'flanking' an enemy, as to which of late we read so much in the daily press. The map (marked 8) gives an idea of a section of country where two armed bodies meet under conditions that permit one flank to be completely



guarded from attack; these are the left flank of the force 'A', and the right flank of 'B'. Both rest upon a lake or broad river. A steep precipice or deep morass, as at 'H', would serve as well. Suppose our force has advanced from the direction 'C', the enemy down the road from 'E' to 'G'. Soon they form opposed lines facing each other, the reserve somewhat to the rear and sheltered by some inequality of ground, the 'thin blue line', almost, but not quite, touching elbows, stretched along the crest of the ridge in front, taking advantage of every chance to protect themselves—trees, stone walls, ditches; kneeling, crawling, lying face down, eyes along the rifle barrel, finger on trigger, keen and murderous, but prudent, and parsimonious of life. The solid formations, such as went out of vogue with old-time weapons, would melt away before machine guns and Krag-Jörgensens like frost before an

August sun. It seems as if all chivalry had departed; it has but changed its ways.

The object of 'flanking' a position is to so manage as to turn that attenuated line into a mass of men upon which to let loose with dire effect either the quick-firing guns or the sharp edges of our horsemen's sabers.

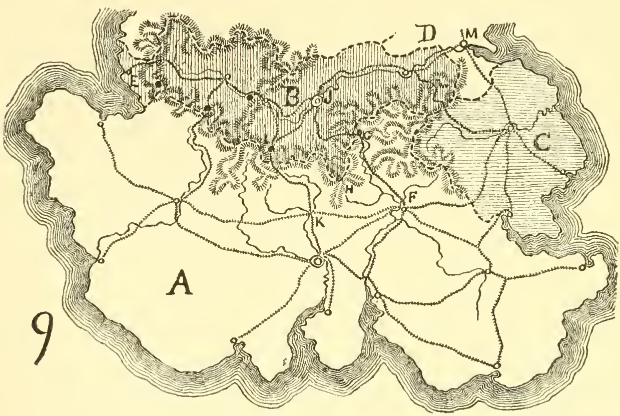
Notice those long, bent, black lines, bending like fish hooks. The arrow heads indicate the direction of a flanking attack; from 'F', through the woods, up the ravine, to fall upon the exposed end of the enemy's front at 'K'. Such would be our most feasible method of flanking; the foe might, however, have anticipated us, either by providing a bloody hospitality somewhere in that ravine, or by a flank movement of his own, as the bent black line shows, around the woods, to fall upon our right flank at 'F'. Such an operation, if successful for them, would be utterly disastrous to us.

Surprised by a sudden and unexpected attack upon the weakest point and unable to change front in time, men lose heart, forget discipline, huddle in masses, confused and disorganized, or fly like sheep, in either case food for firearms, gluttonous of such occasions. It requires sometimes but a very small force upon a flank to produce great results; the appearance upon the field, even at a distance, of Joseph E. Johnston's corps at the first Bull Run was sufficient to demoralize the whole Union army, and at the battle of Arcola, Bonaparte completely flanked the Austrians with a few flourishes of his trumpets.

So we have for a third maxim of war the necessity of PROTECTED FLANKS. If we know or think that a Johnston lurks on either hand, we ought to be sure of our Pattersons; if we apprehend an unfriendly visit from a Blucher, we should see to it that our Grouchy is trustworthy.

Let us now broaden our view of operations, that we may see how the principles established for a limited number of men on the march, in the field, or behind fortifications, may apply upon a larger scale. To this end a brief study of the map (9) will show four contiguous countries—'A', very populous, powerful and wealthy, having a navy capable of control of the high seas, and a large and efficient army; 'C' represents a country even more populous, but not aggressive, 'D' an insignificant power, while 'B' is a country considerable in extent, but largely mountainous, and sparsely inhabited by a rude but warlike people.

A cause of war comes up between 'A' and 'B'. In ancient times the ruder nation would have been the aggressor, tempted by the wealth and invited by the enervated populace of the larger civilization. Now the conditions are likely to be reversed. However, war begins; the forces of 'A' move hastily towards the frontier, while his fleet blockades 'B's' solitary seaport at the point 'E'. The maxim of CAUTION now naturally expands; instead of information culled by a few daring riders from a narrow circuit, it should be made to embrace the widest area of country and the utmost latitude of information—the condition of the enemy as to armament, resources, position of forces, possible disaffection among the people—everything. In war no item comes amiss. The wealthier country will here have a manifest advantage; it can afford to hire spies, and can even (as England did during the Revolution) purchase the treason of some disaffected chief. Caution for the lesser country will—if good generalship prevails—take the shape of occupying and strengthening the natural strategic positions. These are nothing but flanks of a bastion on a large scale. Upon the map round black dots represent strategic positions along the frontier. They are points



9

susceptible of thorough fortification which control the several passes in the mountain range between the two nations; also heads of valleys, where several meet, and from which attacks could be made at will in a number of directions. This entire frontier, which may be hundreds of miles broad, is mountainous, capable of being fortified at countless points, and having natural 'defensive relations' needing only the art of warcraft to render them almost impregnable. Modern murderous arms lend their services more readily to defense than to offense. It is even possible that the country 'B', warned in due season of the purposes of her powerful rival, may have plotted out each rod of ground among those mountain passes, and that artillery service, once a matter of gunnery, has now become a matter of mathematics.

We now come to the fourth maxim of war; it is that of efficient

SUPPLY. An army, as the saying is, moves on its belly. An invading force must ordinarily provide for all its needs from some safe place in the rear, called a 'base of operations'; it must also provide that the line of transit of its provisions and ammunition to the front shall not be liable to interference. Assuming that at 'F' is a strongly fortified city, the railway line or the adjacent rivers would furnish 'A' with a practical base; his line of advance would be in the direction 'FG', called the 'line of operations'; 'G', a fortified pass, the proximate, and 'J', the capital of 'B', the ultimate objective point of the campaign. But it will be noted with what facility a determined enemy could fall upon 'A's' communications from the point 'H', which would also be the case were the advance made from 'K' towards 'L'.

Of course, in the end, the larger resources will prevail; but it may be that 'A', baffled and exasperated by a stubborn resistance, and finding that 'B' is being supplied through the neutral and insignificant country 'D', may finally conclude, "in the interests of a higher civilization," to violate their territory, seize the port 'M', and thus, by a far-reaching and bold flank movement, gain entrance into 'B's' country. Such devices are not unknown in the history of war. Such a course would be a distinct violation of the 'law of nations'; but there would be apologies and ample indemnity to 'D', with which, doubtless, she would be satisfied.

In imagining such a campaign no account has been taken of the attitude of the country 'C', or of that of any foreign nation. In war these things must be reckoned with. Neutral nations are always liable, however disposed to maintain neutrality, to be touched at some sensitive point by one or the other of the contending parties.

MODERN MONGOLS.

By F. L. OSWALD, M.D., A.M.

THE political supremacy of the Caucasian race was supposed to have been decided by the fall of Carthage, more than two thousand years ago, but was thrice afterwards imperiled by an encounter with a rival of long-unsuspected resources.

The Scythians of Strabo were probably not Tartars, but Slavs ('Sarmatians'), or, like their allies, the Getæ, Slavs, mingled with Teutons. Parthia, too, had a semi-Aryan population; but the campaign of Attila gave the champions of Europe a chance to measure their strength with that of a new foe, as shifty as the Semites, and of far greater staying-power. His Huns were undoubtedly Mongols, and came so near overpowering the inheritors of Roman strategy that at one time the fate of western civilization hung upon the issue of a single battle. The western coalition triumphed, yet its victory on the plains of Chalons (October, 451), was due to the numerical inferiority of their enemies as much as to the predominance of their own skill or valor. The very retreat of the vanquished chief established his claim to the prestige of a superlative tactician.

Again, in 1402, only the accidental quarrel of two Mongol conquerors saved Europe from the fate of its ravaged borders. Sultan Bajazet had vanquished all his western foes, and the union of his forces with those of Tamerlane would undoubtedly have sealed the doom of the Mediterranean coast lands, if not all of Christendom.

A hundred years later the generals of Solyman II. came very near retrieving the neglected chance. They vanquished Austrian, Hungarian and Italian armies, and in 1560 defeated the combined armadas of the Christian sea-power at Port Jerbeh—so completely, indeed, that the allies were eager to make peace by betraying each other.

And it would be a great mistake to ascribe these victories to a mere triumph of brute strength. That same Solyman, with all his fanaticism, was a patron of every secular science, and at a time when western princes had to sign their names by proxy, Mohammed Baber Khan, the conqueror of India, wrote essays in four different languages and published memoirs abounding with shrewd comments on social and ethical questions and problems of political economy. He was a poet, too, and liberal enough to compose a dirge in memory of a prince whom he had slain in single combat.

Ethnologically, there is, therefore, nothing abnormal in the outburst of intellectual vigor that has lifted Japan to the front rank of civilized nations. It is merely a revival, analogous to the dambreak of pent-up energies that followed the collapse of mediæval despotism. Instead of having to work out their salvation by tentative efforts, the Japanese, it is true, had the advantage of ready-made patterns, but that difference has perhaps been more than offset by achievements affecting the reforms of four centuries in as many decades, and by modifications which, in more than one instance, have improved upon Caucasian models.

"The organization of the Japanese transport system," says a press dispatch from Taku, "was a revelation to western staff officers; bodies of troops, with their equipments of stores and camping outfit, were landed without a hitch, in quick succession, and moved to the front without a moment's loss of time. No delay, no confusion, no blockades of wharf-boats and baggage carts; everything worked in smooth grooves and in evident conformity with a prearranged and oft-rehearsed plan."

And in 1897, after the affront of the Russian intervention, the victorious islanders, compelled to forfeit half the rewards of their valor, proceeded to make the very best of the other half, and their provoked diplomats managed to preserve their dignity, as well as their complete presence of mind. The Japanese police enforces law and order without waging Blue-Law wars against harmless amusements; there are no associations for the prosecution of bathing youngsters, no anti-concert crusades, no suppression of outdoor sports on the day when ninety-nine of a hundred wage-earners find their only chance for leisure.

The 'Yankees of the Orient' have a code of honor without duellos, trade syndicates without 'trusts', giant cities and ghetto suburbs without anarchists. Their labor riots are settled by a dispassionate court of appeal. Their schools, Professor Arnold informs us, are hampered by 'fads' and experiment committees, but not by boards of bigot trustees. In spite of Buddhist conventicles, the emergence of the educated classes from the shadows of religious feudalism is a complete emancipation. The Japanese 'Council of Finance' has adopted American custom-house methods and Belgian systems of graded taxation. There is, indeed, a good deal of eclecticism in the supposed surrender of indigenous institutions; foreign methods have been adopted only on the evidence of their efficiency, and always with a view to making them subservient to national purposes. The key to the distinctive characteristics of the North Mongols can be found in Sir Edwin Randall's definition of 'Perseverance combined with shiftiness.' The Asiatic Yankees can turn, dodge and deviate while keeping a pre-determined aim steadily in view, and it is by no means improbable that Mongol influences have impressed similar peculiarities on the character of the northeastern Slavs. Muscovy was a Tartar Khanate for a number of centuries, and

Russian diplomats, since the days of Czarina Katherine, have accommodated themselves to emerging circumstances by crawling or strutting, without ever losing sight of the road to Constantinople.

In the shaggy Ainos of Yesso (probably the original home of our 'Shetland' ponies), that perseverance takes the form of mulish stubbornness. They strenuously object to foreign imports and stick to their sheepskin cloaks like Scotch Highlanders to their kilts, but in stress of famine seem now to take an interest in the harpoon-guns of their Russian neighbors, and now and then sell specimens of their poodle-faced youngsters to the agents of a transpacific museum.

Japan still produces athletes, as well as unrivaled acrobats, partly, no doubt, on account of bracing climatic influences, but partly, also, of a vice-resisting worship of physical prowess. About sixty years ago the slums of the large seaport towns were expurgated by a national revolt against the spread of the opium habit, and the consequent reform movement appears to have kept step with the Swedish crusade against the spread of the alcohol curse.

China may be forced into the arena of regeneration, but thus far seems to view the collapse of her ring-wall only as a blessing in a rather effective disguise. The policy of non-intercourse, indeed, had the sanction of a physical necessity in the opinion of as shrewd a statesman as the vizier of the great Kooblai Khan, who conquered rebels from Mantchooria to Siam, but recognized the hopelessness of ordinary measures for protecting the peaceful toilers of the eastern provinces against the predatory hordes of the northwest. A standard army of home-guards, he argued, would have to be composed either of natives who could not fight, or of foreign auxiliaries who might revolt; so, all things considered, it was deemed best to bar a foe that could not be beaten. Strategically, the plan succeeded, stone walls being then so inexpugnable to spear-armed besiegers that the proprietors of a stone-built robber castle could defy the wrath of the public for a series of generations. The Tartar marauders were kept at bay, but so were trading caravans and traveling philosophers; the disadvantages of all obstacles to free competition began to assert themselves. The nation, as it were, sickened in a marasmus of intellectual inbreeding. Protected incompetence propagated its species; monopolies flourished. The survival of the fittest no longer favored the brave; cowards and weaklings could find refuge under the telamonian shield of the big wall.

Within the last hundred years that process of degeneration has been hastened by two incidental afflictions—spring floods and summer droughts. The rapid increase of population has driven home-seekers into the highlands of the far west, and the destruction of land-protecting forests avenged itself in the usual manner. Every heavy snowfall in the mountains became a menace to the settlers of the lowlands; a sudden thaw was always apt to turn brooks into rivers and rivers into raging seas. The summers, at the same time, became warmer and drier. Famines, such as only India had seen before, crowded the cities with refugees. Charitable institutions were managed by agents of a paternal government, and paupers were rarely suffered to perish in wayside ditches, but hundreds of thousands were huddled together in parish suburbs and fed on minimum rations of the cheapest available food.

It was then that the masses were forced to apostatize from the dietetic tenets of Buddhism; abstinence from animal food became impossible; sanitary scruples had to be disregarded; whole settlements of famine victims were compelled to subsist exclusively on offal.

Millions of mechanics had to fight to struggle for existence by reducing their wants. The prices of food had doubled, and in order to pay the cost of one daily meal all luxuries had to be relinquished. Sleep and oblivion of misery became the only alternatives of hopeless toil, and those who could save a few *taels* yielded to the temptation of supplementing those blessings by means of chemical anodynes. Opium-smoking became a national vice.

The 'opium war' did not rivet the yoke of that curse. It merely clinched the grip of a British trading company. The Chinese government had attempted to cancel their franchise, but only with a view to diverting its profits into the pockets of their own speculators. The total suppression of the traffic would have been not only difficult, but practically impossible. We might as well try to prohibit tobacco in North America.

Yet the results of these coöperating factors of degeneracy have stopped short of the extremes that might have been expected in a land of earth-despisers. Buddhism in its orthodox Chinese form is radically pessimistic. It inculcates a belief in the worthlessness of all terrestrial blessings, and considers life a disease, with no cure but death. And not death by suicide, either; the victims of misery must drain life's cup to the dregs, to cure the very love of existence, and thus prevent the risk of re-birth.

The value of health and wealth is thus depreciated in a manner that might tend to aggravate the recklessness of life-weariness; yet the South Mongol is conservative, even in his vices. An inalienable instinct of thrift makes him shrink from senseless excesses. Tavern brawls are less frequent in Canton than in Edinburgh; the topers of the Flowery Kingdom get less efflorescent than ours, their love-crazed swains less extravagant. Absolute imbecility, as a consequence of poison habits, is a rare phenomenon in Mongoldom; nine out of ten sots remain self-supporting; the heritage of industrial habits is hardly ever lost altogether.

Nor should we forget to distinguish the primitive rustics of the inland provinces from the vice-worn population of the coast plains. Degeneration has not left its marks far above tide-water, and has hardly begun to affect the natives of the highlands, the Yunan hunting tribes, for instance, who, though South Mongols, have renounced the tenets of Buddha and adopted those of militant Mohammed.

Their chieftains welcomed war for its own sake, while the lowland conscripts were in the predicament of desert dwellers, caught in the flood of a sudden cloudburst. Thousands at first succumbed almost without a struggle; the levies drilled to oppose the Japanese invasion stood to be slaughtered like sheep, being, moreover, morally handicapped by a misgiving that the war with the champions of the north had been wantonly provoked.

Discipline has begun to break the spell of that apathy, but the desperate valor that surprised the veterans of the allies at Taku and Yangtsun had a very different significance. Fury supplied the defects of military training; the listless life-renouncers had at last been goaded into a frenzy of nationalistic resentment. It was the same delirium of retributive wrath that rallied a million Frenchmen around the standards of the invaded Republic, and hurled a horde of Russian volunteers into the bullet-storm of Borodino.

'A united nation of fifteen millions is not vincible', wrote Jean Jacques Rousseau, in reply to an appeal of the Polish patriots. South Mongols were supposed to be hardly worth an expedition of Caucasian regulars, but even a world coalition might find use for intrenchments if the vendetta rage of a war for national existence should arouse a land of 385,000,000 inhabitants.

Whether that storm will purify the social atmosphere of the vast empire or subside into the calm of exhaustion, is a different question. It would even be premature to accept the appearance of a few able leaders as a propitious omen of regeneration. In a land ten times the size of France the crisis of a fearful peril will always evolve a Carnot, a Danton and a Dumouriez, if not a storm-compelling Bonaparte.

The days of the West Mongol Empire, the dominion of the turbaned Turk, are undoubtedly numbered, but not as a result of national decrepitude. The successor of Sultan Bajazet will succumb, not as a 'sick man', but as a cripple; an invalid worn out in a fight against hopeless odds. Within the last hundred years the stadtholders of the Prophet had to defend their throne against Russian, Austrian, Greek, French and British attacks, and more than once against a West-European alliance, backed by African and Asiatic insurgents. Within that period 3,000,000 Mongol Mussulmans have perished on the battlefield, a million for every generation of an impoverished and not specially reproductive race. Their empire will collapse, but its defenders are still the hardiest soldiers of Europe, the most unconquerable by hardships, wounds and hunger. The burden-carriers of Constantinople are still the stoutest men of our latter-day world. We might as well impeach the degeneracy of the Circassian highlanders, who resisted the power of the Russian monarchy for sixty-five years, and in their last stronghold stood at bay with drawn hunting knives—after blunting their sabres and exhausting a stock of ammunition purchased by the sacrifice of their herds and harvests. For these heroic mountaineers, too, were Mongols, kinsmen of the martial Turkomans and chivalrous Magyars. The Turanian race—a synonym of the Pan-Mongolians—comprises as many different types as the Aryans and Semites taken together.

In 1863 some twenty clans of the vanquished highlanders left the Caucasus *en masse* to settle in the mountains of the Turkish province of Adrianople. They will share the fate of their protectors, and may soon be obliged to follow their flight across the Hellespont.

But the final expulsion of the West Mongols will, after all, mean only that the Caucasians have recovered lost ground, and freed at least Europe from an intrusive tribe of their most persistent and most formidable rivals.

RELIGIOUS BELIEFS OF THE CENTRAL ESKIMO.*

By Professor FRANZ BOAS.

THE Eskimo who inhabit the coasts of Arctic America subsist mainly by the chase of sea-mammals, such as seals of various kinds, walruses and whales. Whenever this source of supply is curtailed, want and famine set in. The huts are cold and dark—for heat and light are obtained by burning the blubber of seals and whales—and soon the people succumb to hunger and to the terrors of the rigorous climate. For this reason the native does everything in his power to gain the good-will of the sea-mammals and to insure success in hunting. All his thoughts are bent upon treating them in such a manner that they may allow themselves to be caught. On this account they form one of the main subjects of his religious beliefs and customs. They play a most important part in his mythology, and a well-nigh endless series of observances regulates their treatment.

The mythological explanation of all the prevailing customs in regard to sea-mammals is contained in a tale which describes their origin:

"A girl named Avilayuk refused all her suitors, and for this reason she was also called 'She who does not want to marry.' There was a stone near the village where she lived. It was speckled white and red. The stone transformed itself into a dog and took the girl to wife.

"She had many children, some of whom became the ancestors of various fabulous tribes. The children made a great deal of noise, which annoyed Avilayuk's father, so that he finally took them across the water to a small island. Every day the dog swam across to the old man's hut to get meat for his family. His wife hung around his neck a pair of boots that were fastened to a string. The old man filled the boots with meat, and the dog took them back to the island.

"One day, while the dog was gone for meat, a man came to the island in his kayak† and called the young woman. 'Take your bag and come with me,' he shouted. He had the appearance of a good-looking, tall man, and the woman was well pleased with him. She took her bag, went down to the kayak, and the man paddled away with her. After they had gone some distance, they came to a cake of floating ice. The

* A description of the religious beliefs of the Central Eskimo, based upon observations made by the writer, was published in the Sixth Annual Report of the Bureau of Ethnology. The following account embodies observations which Capt. James S. Mutch, of Peterhead, Scotland, following a suggestion of the writer, had the kindness to make. The material for this study was collected by Capt. Mutch during a long-continued stay in Cumberland Sound.

† The one-man hunting canoe of the Eskimo.

man stepped out of the kayak on to the ice. Then she noticed that he was quite a small man, and that he appeared large only because he had been sitting on a high seat. Then she began to cry, while he laughed and said, 'Oh, you have seen my seat, have you?' [According to another version, he wore snow-goggles made of walrus-ivory, and he said, 'Do you see my snow-goggles?' and then laughed at her because she began to cry.] Then he went back into his kayak, and they proceeded on their journey.

"Finally they came to a place where there were many people and many huts. He pointed out to her a certain hut made of the skins of yearling seals, and told her that it was his, and that she was to go there. They landed. The woman went up to the hut, while he attended to his kayak. Soon he joined her in the hut, and staid with her for three or four days before going out sealing again. Her new husband was a petrel.

"Meanwhile her father had left the dog, her former husband, at his house, and had gone to look for her on the island. When he did not find her, he returned home, and told the dog to wait for him, as he was going in search of his daughter. He set out in a large boat, traveled about for a long time, and visited many a place before he succeeded in finding her. Finally he came to the place where she lived. He saw many huts, and, without leaving his boat, he shouted and called his daughter to return home with him. She came down from her hut, and went aboard her father's boat, where he hid her among some skins.

"They had not been gone long when they saw a man in a kayak following them. It was her new husband. Soon he overtook them, and when he came alongside he asked the young woman to show her hand, as he was very anxious to see at least part of her body, but she did not move. Then he asked her to show her mitten, but she did not respond to his request. In vain he tried in many ways to induce her to show herself; she kept in hiding. Then he began to cry, resting his head on his arms, that were crossed in front of the manhole of the kayak. Avilayuk's father paddled on as fast as he could, and the man fell far behind. It was calm at that time and they continued on their way home. After some time they saw something coming from behind toward their boat. They could not clearly discern it. Sometimes it looked like a man in a kayak. Sometimes it looked like a petrel. It flew up and down, then skimmed over the water, and finally came up to their boat and went round and round it several times and then disappeared again. Suddenly ripples came up, the waters began to rise, and after a short time a gale was raging. The boat was quite a distance away from shore. The old man became afraid lest they might be drowned; and, fearing the revenge of his daughter's husband, he threw her into the water. She held on to the gunwale; then the father took his hatchet and chopped off the first joints of her fingers. When they fell into the water they were transformed into whales, the nails becoming the whalebone. Still she clung to the boat; again he took his hatchet and chopped off the second joints of her fingers. They became transformed into ground seals. Still she clung to the boat; then he chopped off the last joints of her fingers, which became transformed into seals. Now she clung on to the boat with the stumps of her hands, and her father took his steering-oar and knocked out her left eye. She fell backward into the water and he paddled ashore.

"Then he filled with stones the boots in which the dog was accustomed to carry meat to his family, and only covered the top with meat. The dog started to swim across, but when he was halfway the heavy stones dragged him down. He began to sink and was drowned. A great noise was heard while he was drowning. The father took down his tent and went down to the beach at the time of low water. There he lay down and covered himself with the tent. The flood tide rose and covered him, and when the waters receded he had disappeared."

This woman, the mother of the sea-mammals, may be considered the principal deity of the Central Eskimo. She has supreme sway over the destinies of mankind, and almost all the observances of these tribes are for the purpose of retaining her good-will or of propitiating her if she has been offended. Among the eastern tribes of this region she is called Sedna, while the tribes west of Hudson Bay call her Nuliayuk. She is believed to live in a lower world, in a house built of stone and whale-ribs. In accordance with the myth, she is said to have but one eye. She cannot walk, but slides along, one leg bent under, the other stretched forward. Her father lives with her in this house, and lies covered up with his tent. The dog watches the entrance, being stationed on the floor of the house.

The souls of seals, ground seals and whales are believed to proceed from her house. After one of these animals has been killed its soul stays with the body for three days. Then it goes back to Sedna's abode, to be sent forth again by her. If, during the three days that the soul stays with the body, any taboo or prescribed custom is violated, the violation becomes attached to the animal's soul. Although the latter strives to free itself of these attachments, which give it pain, it is unable to do so, and takes them down to Sedna. The attachments, in some manner that is not explained, make her hands sore, and she punishes the people who are the cause of her pains by sending to them sickness, bad weather and starvation. The object of the innumerable taboos that are in force after the killing of these sea animals is therefore to keep their souls free from attachments that would hurt their souls as well as Sedna.

The souls of the sea animals are endowed with greater powers than those of ordinary human beings. They can see the effect of the contact with a corpse, which causes objects touched by it to appear of a dark color; and they can see the effect of flowing blood, from which a vapor rises that surrounds the bleeding person and is communicated to every one and every thing that comes in contact with such a person. This vapor and the dark color of death are exceedingly unpleasant to the souls of the sea animals, that will not come near a hunter thus affected. The hunter must therefore avoid contact with people who have touched a body, or with such as are bleeding. If any one who has touched a body or who is bleeding should allow others to come in contact with him he would cause them to become distasteful to the seals and therefore also to Sedna. For this reason the custom demands that every person must at once announce if he has touched a body or if he is bleeding. If he does not do so, he will bring ill luck to all the hunters.

These ideas have given rise to the belief that it is necessary to announce the transgression of any taboo. The transgressor of a custom is distasteful to Sedna and to the animals, and those who abide with him will become equally distasteful through contact with him. For this reason it has come to be an act required by custom and morals to confess any and every transgression of a taboo, in order to protect the community from the evil influences of contact with the evil-doer. The descriptions of Eskimo life given by many observers contain records of starvation which, according to the belief of the natives, was brought about by some one transgressing a law and not announcing what he had done.

I presume this importance of the confession of a transgression with a view to warning others to keep at a distance from the transgressor has gradually led to the idea that a transgression, or we might say a sin, can be atoned for by confession. This is one of the most remarkable religious beliefs of the Central Eskimo. There are innumerable tales of starvation brought about by the transgression of a taboo. In vain the hunters try to supply their families with food; gales and drifting snow make their endeavors fruitless. Finally the help of the angakok* is invoked, and he discovers that the cause of the misfortune of the people is due to the transgression of a taboo. Then the guilty one is searched for. If he confesses, all is well, the weather moderates, and the seals will allow themselves to be caught; but if he obstinately maintains his innocence, his death alone will soothe the wrath of the offended deity.

While thus the reason appears clear why the taboos are rigorously

* The medicine-man or shaman of the Eskimo.

enforced by public opinion, the origin of the taboos themselves is quite obscure. It is forbidden, after the death of a sea mammal or after the death of a person, to scrape the frost from the window, to shake the beds, or to disturb the shrubs under the bed, to remove oil-drippings from under the lamp, to scrape hair from skins, to cut snow for the purpose of melting it, to work on iron, wood, stone, or ivory. Women are, furthermore, forbidden to comb their hair, to wash their faces and to dry their boots and stockings.

A number of customs, however, may be explained by the endeavors of the natives to keep the sea mammals free from contaminating influences. All the clothing of a dead person, more particularly the tent in which he died, must be discarded; for if a hunter should wear clothing made of skins that had been in contact with the deceased, these would appear dark and the seal would avoid him. Neither would a seal allow itself to be taken into a hut darkened by a dead body, and all those who entered such a hut would appear dark to it and would be avoided.

While it is customary for a successful hunter to invite all the men of the village to eat of the seal that he has caught, they must not take any of the seal meat out of the hut, because it might come in contact with persons who are under taboo, and thus the hunter might incur the displeasure of the seal and of Sedna.

It is very remarkable that the walrus is not included in this series of regulations. It is explicitly stated that the walrus, the white whale and the narwhal are not subject to these laws, which affect only the sea animals that originated from Sedna's fingers. There is, however, a series of laws that forbid contact between walrus, seal and caribou. It is not quite clear in what mythical concept these customs originate. There is a tradition regarding the origin of walrus and caribou which is made to account for a dislike between these two animals. A woman created both these animals from parts of her clothing. She gave the walrus antlers and the caribou tusks. When man began to hunt them, the walrus upset the boats with his antlers and the caribou killed the hunter with his tusks. Therefore the woman called both animals back and took the tusks from the caribou and gave them to the walrus. She took the antlers, kicked the caribou's forehead flat and put the antlers on to it. Ever since that time, it is said, walrus and caribou avoid each other, and the people must not bring their meat into contact. They are not allowed to eat caribou and walrus meat on the same day except after changing their clothing. The winter clothing which is made of caribou-skin must be entirely completed before the men will go to hunt walrus. As soon as the first walrus has been killed, a messenger goes from village to village and announces the news. All work on caribou-skins must cease immediately. When the caribou-hunting season begins, all the winter clothing, and the tent that has been in use during the walrus-hunting season, are buried, and not used again until the following walrus-hunting season. No walrus hide, or thongs made of such hide, must be taken inland, where is the abode of the caribou.

Similar laws, although not quite so stringent, hold good in regard to contact between seal and walrus. The natives always change their clothing or strip naked before eating seal during the walrus season.

The soul of the salmon is considered to be very powerful. Salmon must not be cooked in a pot that has been used for boiling other kinds of meat. It is always cooked at some distance from the hut. Boots that were used while hunting walrus must not be worn when fishing salmon, and no work on boot-legs is allowed until the first salmon has been caught and placed on a boot-leg.

The fact that these taboos are not restricted to caribou and walrus suggests that the mythical explanation given above does not account for the origin of these customs, but must be considered as a later effort to explain their existence.

The transgressions of taboos do not affect the souls of game alone. It has already been stated that the sea mammals see their effect upon man also, who appears to them of a dark color, or surrounded by a vapor which is invisible to ordinary man. This means, of course, that the transgression also affects the soul of the evil-doer. It becomes attached to it and makes him sick. The shaman is able to see, by the help of his guardian spirit, these attachments, and is able to free the soul from them. If this is not done the person must die. In many cases the transgressions become attached also to persons who come in contact with the evil-doer. This is especially true of children, to whose souls the sins of their parents, and particularly of their mothers, become readily attached. Therefore when a child is sick the shaman, first of all, asks its mother if she has transgressed any taboos. The attachment seems to have a different appearance, according to the taboo that has been violated. A black attachment is due to removing oil-drippings from under the lamp. As soon as the mother acknowledges the transgression of a taboo, the attachment leaves the child's soul and the child recovers.

The souls of the deceased stay with the body for three days. If a taboo is violated during this time the transgression becomes attached to the soul of the deceased. The weight of the transgression causes the soul pain, and it roams about the village, endeavoring to free itself of its burden. It seeks to harm the people who, by their disobedience to custom, are causing its sufferings. It causes heavy snows to fall and brings sickness and death. Such a soul is called a tupilak. Toward the middle of autumn it hovers around the doors of the huts. When a shaman discovers the tupilak he advises the people, who assemble, and prepare to free it of its burden. All the shamans go in search of it, each a knife in hand. As soon as they find it, they stab it with their knives, and thus cut off the transgressions. Then the tupilak becomes a soul again. The knives with which it was stabbed are seen by the people to be covered with blood.

The Central Eskimo believe that man has two souls. One of these stays with the body, and may enter temporarily the body of a child which is given the name of the departed. The other soul goes to one of the lands of the souls. Of these there are several. There are three heavens, one above another, of which the highest is the brightest and best. Those who die by violence go to the lowest heaven. Those who die by disease go to Sedna's house first, where they stay for a year. Sedna restores their souls to full health and then she sends them up to the second heaven. Those who die by drowning go to the third heaven. People who commit suicide go to a place in which it is always dark and where they go about with their tongues lolling. Women who have had premature births go to Sedna's abode and stay in the lowest world.

The other soul stays with the body. When a child has been named after the deceased, the soul enters its body and remains there for about four months. It is believed that its presence strengthens the child's soul, which is very light and apt to escape from the body. After leaving the body of the infant, the soul of the departed stays nearby, in order to re-enter its body in case of need. When a year has elapsed since the death of the person, his soul leaves the grave temporarily and goes hunting, but returns frequently to the grave. When the body has entirely decayed it may remain away for a long time.

Evidently the Eskimo also believe in the transmigration of souls. There is one tradition in which it is told how the soul of a woman passed through the bodies of a great many animals, until finally it was born again as an infant. In another story it is told how a hunter caught a fox in a trap and recognized in it the soul of his departed mother. In still another tale the soul of a woman, after her death, entered the body of a huge polar bear in order to avenge wrongs done to her during her lifetime.

Almost the sole object of the religious ceremonies of the Eskimo is to appease the wrath of Sedna, of the souls of animals, or of the souls of the dead, that have been offended by the transgressions of taboos. This is accomplished by the help of the guardian spirits of the angakut. The most important ceremony of the Eskimo is celebrated in the fall. At this time of the year the angakut, by the help of their guardian spirits, visit Sedna and induce her to visit the village, and they endeavor to free her of the transgressions that became attached to her during the preceding year. One angakok throws her with his harpoon, another one stabs her, and by this means they cut off all the transgressions. The ceremony is performed in a darkened snow-house. After the ceremony the lamps are lighted again and the people see the harpoon and the knife that were used in the ceremony covered with blood. If the angakut should fail to free Sedna from the transgressions, bad weather and hunger would prevail during the ensuing winter. On the following day Sedna sends her servant, who is called Kaileteta, to visit the tribe. She is represented by a man dressed in a woman's costume and wearing a mask made of seal-skin. On this day the people wear attached to their hoods pieces of skin of that animal of which their first clothing was made after they were born. It seems that the skins of certain animals are used for this purpose, each month having one animal of its own. It is said that if they should not wear the skin of the proper animal, Sedna would be offended and would punish them.

The angakut also cure sick persons and make good weather with the help of their guardian spirits. They discover transgressions of taboos and other causes of ill luck. One of the most curious methods of divination applied by the angakut is that of 'head-lifting.' A thong is placed around the head of a person who lies down next to the patient. The thong is attached to the end of a stick which is held in hand by the angakok. Then the latter asks questions as to the nature and outcome of the disease, which are supposed to be answered by the soul of a dead person, which makes it impossible for the head to be lifted if the answer is affirmative, while the head is raised easily if the answer is negative. As soon as the soul of the departed leaves, the head can be moved without difficulty.

Amulets are extensively used as a protection against evil influences and to secure good luck. Pregnant women wear the teeth of wolves on the backs of their shirts. These same teeth are fastened to the edge of the infant's hood. The string which passes under the large hood of the woman who carries her child on her back is fastened at one end to a bear's tooth, which serves to strengthen the child's soul. When the child begins to walk about, this string and the bear's tooth are attached to its shirt and worn as amulets. Pyrites, when thrown upon a spirit, are believed to drive it away.

As compared with the beliefs of the Greenlanders, the beliefs of the Central Eskimo are characterized by the great importance of the Sedna myth and the entire absence of the belief in a powerful spirit called Tonarssuk, which seems to have been one of the principal features of Greenland beliefs. There is an evident tendency among the Central Eskimo to affiliate all customs and beliefs with the myth of the origin of sea animals. This tendency seems to have been one of the principal causes that molded the customs and beliefs of the people into the form in which they appear at the present time.

MENTAL ENERGY.*

By EDWARD ATKINSON.

ACCORDING to the common conception, political economy is held to deal with material forces only; with land, labor and capital; with the production, distribution and consumption of the materials of human existence. These are food, clothing and shelter. It, therefore, bears the aspect of a purely material study of material forces. Yet no more purely metaphysical science exists, and there can be, in my view of the subject, no more ideal conceptions than those which are derived from the study of these purely material forces. Many of the errors commonly presented under the name of the 'claims of labor' have arisen from the limited and partial conception of the function of economic science.

We have become accustomed to deal with the so-called material forces of nature and with the physical work and labor of man under the general term of 'Energy'. What man does by his own labor or physical energy is to convert the products of land and sea, of mine and forest, into new forms from which he derives shelter, food and clothing. In a material sense all that any one can get in or out of life, be he rich or poor, is what we call our board and clothing. Such being the fact, what a man consumes is his cost to the community; what he spends yields to others the means of buying the supplies for their own wants; their consumption is then their cost to the community.

The physical forces of nature are limited. The earth is endowed with a fixed quantity of materials that we call gaseous, liquid and solid. It receives a certain amount of heat from the sun which, for all practical purposes, may be considered a fixed quantity of energy, even if in eons it may be exhausted. The physical energy of man is devoted to the transformation of these physical forces under the law of conservation; he can neither add to nor diminish the quantity. He can transform solid into gas and gas into liquid. He can, according to common speech, consume some of these products, but his consumption is only another transformation. His own body is but one of the forms of physical energy on the way toward another form. These elements of nature, formerly limited to earth, air and water, are now listed under many titles of what are called elements; I believe over sixty that have not yet been differentiated, but all may yet be resolved into a unit of force.

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* Presented before the New York meeting of the American Association for the Advancement of Science.

You will observe that in our arithmetic we have ten numerals which can be divided into fractions. In our music we deal with seven notes and their variants. In our alphabet we have twenty-six letters. These factors correspond in some measure to what we call elements in nature. There is a limit to the number of combinations that can be made of the numerals and their fractions, to the notes of music and their variants, and of the letters of the alphabet; but in each case this limit is so remote as to be negligible, like the exhaustion of the heat of the sun. May we not deal with the elements of nature in the same way? Can any one prescribe a limit to their conversion and reconversion to the use of mankind? Is it not in these processes of conversion that we derive our subsistence?

We make nothing. All that we can do is to move something. We move the soil and we move the seed; nature gives the harvest. We direct the currents of falling water, of heat and of steam; nature imparts the force or energy to which man has only given a new direction. We are now imparting new directions to the force that we call electricity, and to what we call cold. What is the force from which we derive this power of transforming physical energy? May we not call it mental energy? Is not mental energy the factor in mankind by which he is differentiated from the beast? Does not man only accumulate experience, and is there any limit to the power of mind over matter?

If these points are well taken, mental energy is the fourth and paramount factor in providing for material existence, and the science of political economy, which deals with land, labor and capital, becomes a purely metaphysical science when we admit the force of mental energy into the combination.

We deal, as I have said, with sixty elements, so-called, more or less, but the unity of nature is the most important fact ever proved by science; the correlation of all forms of physical energy leading logically from the idea of manifold forces or gods to the unity of creation, necessarily ending in the conception of unity of a creator, or the one God. This modern development of mental science is but the Hebrew concept of the creation in a new form. The Hebrew race was the first one of the historic races with whom the unity of creation and the unity of the creator became an article of faith. I doubt not that it was in that concept and the power derived from it that the Hebrew intellect asserted its preëminence in the history of the world. According to that concept, to man is given "dominion over the fish of the sea and over the fowl of the air and over every living thing that moveth upon the earth." By what force does man hold dominion unless it is through his mental energy and his capacity to accumulate experience?

All the industrial arts are antedated by the industries of animals. The tailor finds his prototype in the tailor bird; the mason in the wasp; the farmer in the agricultural ant; the bridge-builder in the spider; the weaver in the weaver bird; the creator of water power in the beaver, and so on. Yet no other animal except man has developed or extended any of these arts. No other animal except man has learned to make and use fire and not to run away from it.

If, then, man by his power of mental energy converts the original and crude forces with which the earth is endowed into new forms, and by giving them new direction increases his power of production of the means of his own subsistence and enjoyment of life, *does it not follow that creation is a continuous procession in which man is a factor?* "There is a divinity that shapes our ends, rough hew them as we may." The ideal of 'an honest God the noblest concept of man' becomes the converse of an honest man the noblest work of God—honest in a broad sense in his dealings with the forces of nature; true to his function.

There is a painful side to statistical and economic study. The penalty of being able to read what is written between the lines and the columns of the figures is the conclusion that after we have all done the best work that the present conditions of science will permit, the entire product barely suffices to keep mankind in existence; his fixed capital, so-called, is at the mercy both of time and of the inventor who substitutes better methods which at less cost of effort or labor yield more abundance to the community as a whole. But on the other hand, no matter how hard the struggle for existence may be, we find the promise of future abundance even in the insufficient product which has been derived from the application of science and invention up to date. Witness the relative progress of the last century as compared with all the previous centuries; then attempt to conceive what will be the condition of humanity a century hence, knowing, as we do, that the applications of science through mental energy now proceed in geometric progression, reversing the dogma of Malthus and leading to the concept of production unlimited, consumption limited.

If it be true that there is no conceivable limit to the power of mind over matter or to the number of conversions of force that can be developed, providing in increasing measure for the wants of the human body, it follows that pauperism is due to poverty of mental energy, not of material resources.

The next step in the development of this theory may be presented in this form: *No man is paid by the measure in time or physical effort, for the work or labor that he performs.* No man can claim payment in money or in kind on the ground that he has done a day's work of a greater or less number of hours. In all civilized countries we are members one of another; rich or poor; whether we work with our hands or our heads, or both combined. Material existence is supported by conversion of one form of physical energy into another. Social energy is maintained by the exchange of one form of service for another. The measure of compensation is not the number of hours of labor put into the product or service. *The standard by which services are measured is what the buyer is saved from doing, not what the seller does.* Each of us might possibly be able to house, clothe and feed ourselves if we were cast upon an island possessing sufficient natural resources. If a hundred persons representing all the classes in society were wrecked upon such an island, each adult or each person above ten years old would probably find a way to house, feed and clothe himself. Why do we not house, feed and clothe ourselves, and why would not the hundred representatives of different classes wrecked on an island each do his own part of the work for himself only? Simply for the reason that men are either endowed from birth with different aptitudes, or different aptitudes are developed in their environment. Each one finds out that by delegating to another certain kinds of work he saves his own time and energy. Each one finds out what he can do for the next man, while the next man finds out what he can do for him.

There is in every transaction of life an unconscious cerebration or estimate of the services rendered to us, saving each of us mental or manual energy, whenever we buy any product or service from another. That unconscious cerebration affects the minds or habits or acts of both parties in every purchase and sale. There may be errors in regard to the service itself. The ignorant man will buy quack medicines that he had better let alone, but what he pays under the false impression of benefit to himself is his measure of what he hopes to save; while the quack medicine vender, taking advantage of the ignorance of others, filches from them the means of subsistence, even of wealth, under the pretext of service. As time goes on, however, false measures of service are eliminated with increasing intelligence, and true benefits constitute more and more the vast proportion of the exchanges.

The same ignorance which leads the masses of the people of every country to submit to military dictation, even in a bad cause, also leads to the wars of tariffs among nations by which prejudice and animosity are kept up. The false conception that in international commerce what one nation gains another must lose, is promoted by the advocates of protection, many of whom very honestly believe that through the exclusion of foreign goods domestic industry may be promoted, wholly ignoring the fact that arts and industries are developed by intelligence and not by legislation.

The advocates of bounties and of special legislation also ignore the fact that in this country, where mental energy is more nearly free in its action than in any other, manufactures and the mechanic arts develop in due proportion according to the age and the natural resources of the territory or state, nine-tenths or more of the occupations which are listed under these titles being free in the nature of things from any possibility of foreign competition through the import of a product of like kind.

There may be nothing new in this essay, but until my own observation had led me to the conclusion that land, labor and capital were alike inert and incapable without the coördinating power of mental energy, the doubt continued to exist in my mind which is often expressed about the possibility of economic science having any real existence or right to the title. Also, until my own observation led me to the conclusion that the cost of a man to the community is what he consumes, and not what he secures in the way of income, the correlation of wealth and welfare had not been satisfactorily reconciled. I think that a very large part of what is written under the title of political economy would be greatly modified, and perhaps never have been written, had these concepts been derived by the writers from experience, as they have been in my own observation.

I have not much patience with abstract or *à priori* theories, my own method being one of observation, then referring to the various authorities in order to find out whether my observations or their abstract theories have been shallow and superficial.

Again, I find in the ideal of the continuous miracle of creation in which man is a factor the solution of many intellectual difficulties. In the face of such a perception of the methods of the universe, the larger part of the dogmas that have been put forth under the name of religion take their place with much of the historic rubbish which passes under the name of history. When it becomes plain that every man has his place in the progress of continuous creation, and is a factor in it; that nothing is constant but change; that there is no such thing as fixed capital; all the doubts and fears regarding the future of humanity vanish in the light of sure progress.

What greater stimulus can there be than for every man each in his own way rendering service for service, his objective point being only the welfare of himself and his family, when he attains the conviction that by so much as his mental energy adds to the sum of the utilities by which mankind lives, so may that part which he consumes and which represents his cost to the community be fully justified, even though it is earned with more apparent ease and less physical exertion than are called for from his poorer neighbors.

Incomplete as his studies were, I have always found in the 'Harmonies' of Frederic Bastiat the greatest encouragement and the greatest incentive to the work which I have undertaken under the name of political economy, leading more and more to the conviction that war and warfare, whatever influence they may have had in developing progress in the past, are now due to ignorance and greed; the war of tariffs due to selfishness and stupidity; and the contest of labor and capital due to the errors of the ignorant workman and the ignorant capitalist alike. All interests are harmonious. The evolution of science and invention will surely bring them together on the lines of righteousness, peace and material abundance.

This essay has been condensed from a lecture prepared and given before a Clergymen's Club some months ago. In it I tried to show the necessary connection of religion and life as developed by economic study, the law of mutual service being the rule by which commerce lives and moves and has its being. This lecture has since been read to several clubs of very different types of men, and from the great interest excited I am led to think there is something in it fit for the student of facts and figures to say.

I may, therefore, venture to repeat the statement of two principles which are presented in this treatise, which I think have been seldom if ever fully developed in any of the standard works upon political economy. To my own mind these are basic principles which when applied may profoundly modify many of the concepts of students of economic science. I join in the view that the family is the unit of society, the home the center. The end of all production is consumption. Nothing is constant but change, and there is no such thing as fixed material capital of any long duration in the progress of time. The two principles which I have endeavored to enforce are as follows:

First. The cost of each person or head of the family is what he and his immediate dependents consume. His income, whether measured in terms of money or in products, is, therefore, no measure of his cost; what he distributes in payment for service rendered being expended by those who receive it in procuring the commodities which constitute their cost to the community.

Second. No person who is occupied or is in the employment or service of others is paid for what he does. His work may occupy long hours and may be applied to arduous manual labor, or it may be done in a short number of hours per day, with but little physical effort. Neither the hours nor the effort constitute any measure on which payment can be based. The measure of payment is fixed by the measure of the work saved to him who makes the payment, consciously or unconsciously estimated.

These two precepts or principles, coupled with the theory that there is no conceivable limit to the power of mind over matter, or to the number of transformations of physical energy to which direction may be given in the material support of humanity, bring the visions of the Utopians within the scope of a law of progress in material welfare to which no limit can be put in time or space.

CHAPTERS ON THE STARS.

By Prof. SIMON NEWCOMB, U. S. N.

VARIABLE STARS.

IT is a curious fact that the ancient astronomers, notwithstanding the care with which they observed the heavens, never noticed that any of the stars changed in brightness. The earliest record of such an observation dates from 1596, when the periodical disappearance of Omicron Ceti was noticed. After this, nearly two centuries elapsed before another case of variability in a star was recorded. During the first half of the nineteenth century Argelander so systematized the study of variable stars as to make it a new branch of astronomy. In recent years it has become of capital interest and importance through the application of the spectroscope.

Students who are interested in the subject will find the most complete information attainable in the catalogues of variable stars, published from time to time by Chandler in the 'Astronomical Journal.' His third catalogue, which appeared in 1896, comprises more than 300 stars whose variability has been well established, while there is always a long list of 'suspected variables'—whose cases are still to be tried. The number to be included in the established list is continually increasing at such a rate that it is impossible to state it with any approximation to exactness. The possibility of such a statement has been yet further curtailed by the recent discovery at the Harvard Observatory that certain clusters of stars contain an extraordinary proportion of variables. Altogether at the time of the latest publication, 509 such stars were found in twenty-three clusters. The total number of these objects in clusters, therefore, exceeds the number known in the rest of the sky. They will be described more fully in a subsequent chapter. For the present we are obliged to leave this rich field out of consideration and confine our study to the isolated variable stars which are found in every region of the heavens.

Variable stars are of several classes, which, however, run into each other by gradations so slight that a sharp separation cannot always be made between them. Yet there are distinguishing features, each of which marks so considerable a number of these stars as to show some radical difference in the causes on which the variations depend.

We have first to distinguish the two great classes of irregular and periodic stars. The irregular ones increase and diminish in so fitful a way that no law of their change can be laid down. To this class belong the so-called 'new stars', which, at various periods in history, have blazed out in the heavens, and then in a few weeks or months have again faded away. It is a remarkable fact that no star of the latter class has ever been known to blaze out more than once. This fact distinguishes new stars from other irregularly variable ones.

Periodic stars are those which go through a regular cycle of changes in a definite interval of time, so that, after a certain number of days, sometimes of hours, the star returns to the same brightness. But even in the case of periodic stars, it is found that the period is more or less variable, and, in special cases, the amount of the variation is such that it cannot always be said whether we should call a star periodic or irregular.

The periodic stars show wide differences, both in the length of the period and in the character of the changes they undergo. In most cases they rapidly increase in brightness during a few days or weeks, and then slowly fade away, to go through the same changes again at the end of the period. In other cases they blaze up or fade out, from time to time, like the revolving light of a lighthouse. Some stars are distinguished more especially by their maximum, or period of greatest brightness, while others are more sharply marked by minima, or periods of least brightness. In some cases there are two unequal minima in the course of a period.

Chandler's third catalogue of variable stars gives the periods of 280 of these objects, which seem to have been fairly well made out. A classification of these periods, as to their length, will be interesting. There are, of periods:

Less than 50 days	63	Stars.
Between 50 and 100 days	6	"
" 100 " 150 "	9	"
" 150 " 200 "	18	"
" 200 " 250 "	29	"
" 250 " 300 "	40	"
" 300 " 350 "	44	"
" 350 " 400 "	44	"
" 400 " 450 "	18	"
" 450 " 500 "	6	"
" 500 " 550 "	1	"
" 550 " 600 "	1	"
" 600 " 650 "	1	"

It will be seen from this that, leaving out the cases of very short period, the greater number of the periods fall between 300 and 400 days. From this value the number falls off in both directions. Only three periods exceed 500 days, and of these the longest is 610 days. We infer from this that there is something in the constitution of these stars, or in the causes on which their variation depends, which limits the period. This limitation establishes a well-marked distinction between the periodic stars and the irregular variables to be hereafter described.

Returning to the upper end of the scale, the contrast between the great number of stars less than fifty days, and the small number between fifty and one hundred, seems to show that we have here a sharp line of distinction between stars of long and those of short period. But, when we examine the matter in detail, the statistics of the periods do not enable us to draw any such line. About eight periods are less than one day, and the number of this class known to us is continually increasing. About forty are between one and ten days, and from this point upwards they are scattered with a fair approach to equality up to a period of one hundred days. There is, however, a possible distinction, which we shall develop presently.

The law of change in a variable star is represented to the eye by a curve in the following way. We draw a straight horizontal line *A X* to

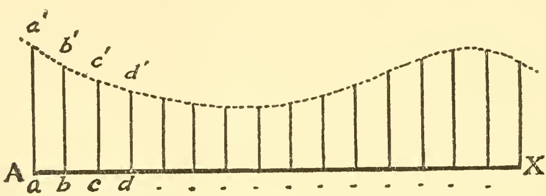

FIG. 1. THE LAW OF CHANGE IN A VARIABLE STAR.

represent the time. A series of equidistant points, *a*, *b*, *c*, *d*, etc., on this will represent moments of time. One of the spaces, *a*, *b*, *c*, etc., may represent an hour, a day, or a month, according to the rapidity of change. We take *a* to represent the initial moment, and erect an ordinate *aa′*, of such length as to represent the brightness of the star on some convenient scale at this moment. At the second moment, *b*, which may be an hour or a day later, we erect another ordinate *bb′*, representing the brightness at this moment. We continue this process as long as may be required. Then we draw a curve, represented by the dotted line, through the ends of all the ordinates. In the case of a periodic star it is only necessary to draw the curve through a single period, since its continuation will be a repetition of its form for any one period.

We readily see that if a star does not vary, all the ordinates will be of equal length, and the curve will be a horizontal straight line. Moreover, the curve will take this form through any portion of time during which the light of the star is constant.

There are three of the periodic stars plainly visible to the naked eye at maximum, of which the variations are so wide that they may easily be noticed by any one who looks for them at the right times, and knows how to find the stars. These stars are:

Omicron Ceti, called also *Mira Ceti.*
Beta Persei, or Algol.
Beta Lyræ.

It happens that each of these stars exemplifies a certain type or law of variations.

Omicron Ceti. On August 13, 1596, David Fabricius noticed a star in the constellation Cetus, which was not found in any catalogue. Bayer, in his 'Uranometria', of which the first edition was published in 1601, marked the star Omicron, but said nothing about the fact that it was visible only at certain times. Fabricius observed the star from time to time, until 1609, but he does not appear to have fully and accurately recognized its periodicity. But so extraordinary an object could not fail to command the attention of astronomers, and the fact was soon established that the star appeared at intervals of about eleven months, gradually fading out of sight after a few weeks of visibility. Observations of more or less accuracy having been made for more than two centuries, the following facts respecting it have been brought to light:

Its variations are somewhat irregular. Sometimes, when at its brightest, it rises nearly or quite to the second magnitude. This was the case in October, 1898, when it was about as bright as Alpha Ceti. At other times its maximum brightness scarcely exceeds the fifth magnitude. No law has yet been discovered by which it can be predicted whether it shall attain one degree of brightness or another at maximum.

Its minima are also variable. Sometimes it sinks only to the eighth magnitude; at other times to the ninth or lower. In either case it is invisible to the naked eye.

As with other stars of this kind, it brightens up more rapidly than it fades away. It takes a few weeks from the time it becomes visible to reach its greatest brightness, whatever that may be. It generally retains this brightness for two or three weeks, then fades away, gradually at first, afterward more rapidly. The whole time of visibility will, therefore, be two or three months. Of course, it can be seen with a telescope at any time.

The period also is variable in a somewhat irregular way. If we calculate when the star ought to be at its greatest brightness on the supposition that the intervals between the maxima ought to be equal, we shall find that sometimes the maximum will be thirty or forty days early, and at other times thirty or forty days late. These early or late maxima follow each other year after year, with a certain amount of regularity as regards the progression, though no definable law can be laid down to govern them. Thus, during the period from 1782 to 1800 it was from thirteen to twenty-four days late. In 1812 it was thirty-nine days late. From 1845 to 1856 it was on the average about a month too early. Several recent maxima, notably those from 1895 to 1898, again occurred late. Formulæ have been constructed to show these changes, but there is no certainty that they express the actual law of the case. Indeed, the probability seems to be that there is no invariable law that we can discover to govern it.

Argelander fixed the length of the period at 331.9 days. More recently, Chandler fixed it at 331.6 days. It would seem, therefore, to have been somewhat shorter in recent times. It was at its maximum toward the end of October, 1898. We may, therefore, expect that future maxima will occur in July, 1901; June, 1902; May, 1903; April, 1904, and so on, about a month earlier each year. During the few years following 1903 the maxima will probably not be visible, owing to the star being near conjunction with the sun at the times of their occurrence. The most plausible view seems to be that changes of a periodic character, involving the eruption of heated matter from the interior of the body to its surface, followed by the cooling of this matter by radiation, are going on in the star.

The star *Algol*, or *Beta Persei*, as it is commonly called in astronomical language, may, in northern latitudes, be seen on almost any night of the year. In the early summer we should probably see it only after midnight, in the northeast. In late winter it would be seen in the northwest. From August until January one can find it at some time in the evening by becoming acquainted with the constellations. It is nearly of the second magnitude. One might look at it a score of times without seeing that it varied in brilliancy. But at certain stated intervals, somewhat less than three days, it fades away to nearly the fourth magnitude for a few hours, and then slowly recovers its light. This fact was first discovered by Goodrick in 1783, since which time the variations have been carefully followed. The law of variation thus defined is expressed by a curve of the following form:

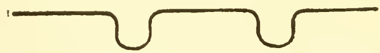

Fig. 2. Law of Variation of a Star of the Algol Type.

The idea that what we see in the star is a partial eclipse caused by a dark body revolving round it, was naturally suggested even to the earliest observers. But it was impossible to test this theory until recent times. Careful observation showed changes in the period between the eclipses, which, although not conclusive against the theory, might have seemed to make it somewhat unlikely. The application of the spectroscope to the determination of radial motions, enabled

Vogel, of Potsdam, in 1889, to set the question at rest. His method of reasoning and proceeding was this:

If the fading out which we see is really due to an eclipse by a dark body, that body must be nearly or quite as large as the star itself, else it could not cut off so much of its light. In this case, it is probably nearly as massive as the star itself, and therefore would affect the motion of the star. Both bodies would, in fact, revolve around their common center of gravity. Therefore, when after the dark body has passed in front of the star, it has made one-fourth of a revolution, which would require about seventeen hours, the star would be moving towards us. Again, seventeen hours before the eclipse, it ought to be moving away from us.

The measurement of six photographs of the spectrum, of which four were taken before the eclipses and two afterward, gives the following results:

Before eclipses: Velocity *from* the sun equals 39 km. per second.
After eclipses: Velocity *toward* the sun equals 47 km. per second.

These results show that the hypothesis in question is a true one, and afforded the first conclusive evidence of a dark body revolving around a distant star. A study of the law of diminution and recovery of the light during the eclipse, combined with the preceding motions, enabled Vogel to make an approximate estimate of the size of the orbit and of the two bodies. The star itself is somewhat more than a million of miles in diameter; the dark companion a little less. The latter is about the size of our sun. Their distance apart is somewhat more than three millions of miles; the respective masses are about one-half and one-fourth that of the sun. These results, though numerically rather uncertain, are probably near enough to the truth to show us what an interesting system we here have to deal with. We can say with entire certainty that the size and mass of the dark body exceed those of any planet of our system, even Jupiter, several hundred fold.

The period of the star is also subject to variations of a somewhat singular character. These have been attributed by Chandler to a motion of the whole system around a third body, itself invisible. This theory is, however, still to be proved. Quite likely the planet which causes the eclipse is not the only one which revolves around this star. The latter may be the center of a system like our solar system, and the other planets may, by their action, cause changes in the motion of the body that produces the eclipses. The most singular feature of the change is that it seems to have taken place quite rapidly, about 1840. The motion was nearly uniform up to near this date; then it changed, and again remained nearly uniform until 1890. Since then no available observations have been published.

It is found that several other stars vary in the same way as Algol; that is to say, they are invariable in brightness during the greater part of the time, but fade away for a few days at regular intervals. This is a kind of variation which it is most difficult to discover, because it will be overlooked unless the observer happens to notice the star during the time when an eclipse is in progress, and is thoroughly aware of its previous brightness. One might observe a star of this kind very accurately a score of times, without hitting upon a moment when the partial eclipse was in progress. On the principle that like effects are due to like causes, we are justified in concluding that in the cases of all stars of this type, the eclipses are caused by the revolution of a dark body, now called 'Algol variables,' round the principal star.

A feature of all the Algol variables is the shortness of the periods. The longest period is less than five days, while three are less than one day. This is a result that we might expect from the nature of the case. The nearer a dark planet is to the star, the more likely it will be to hide its light from an observer at a great distance. If, for example, the planet Jupiter were nearly as large as the sun, the chances would be hundreds to one against the plane of the orbit being so nearly in the line of a distant observer that the latter would ever see an eclipse of the sun by the planet. But if the planet were close to the sun, the chances might increase to one in ten, and yet farther to almost any extent, according to the nearness of the two bodies.

Still, we cannot set any definite limit to the period of stars of this type; all we can say is that, as the period we seek for increases, the number of stars varying in that period must diminish. This follows not only from the reason just given, but from the fact that the longer the interval that separates the partial eclipses of a star of the Algol type, the less likely they are to be detected.

STARS OF THE BETA LYRÆ TYPE.

The star Beta Lyræ shows variations quite different in their nature from those of Algol, yet having a certain analogy to them. Anyone who looks at the constellation Lyræ a few nights in succession and compares Beta with Gamma, a star of nearly the same brightness in its neighborhood, will see that while on some evenings the stars are of equal brightness, on others Beta will be fainter by perhaps an entire magnitude.

A careful examination of these variations shows us a very remarkable feature. On a preliminary study, the period will seem to be six and one-half days. But, comparing the alternate minima, we shall find them unequal. Hence the actual period is thirteen days. In this period there are two unequal minima, separated by equal maxima.

That is to say, the partial eclipses at intervals of six and one-half days are not equal. At the alternate minima the star is half as bright again as at the intermediate minima.

It is impossible to explain such a change as this merely by the interposition of a dark body, and this for two reasons. Instead of remaining invariable between the minima, the variation is continuous during the whole period, like the rising and falling of a tide. Moreever, the inequality of the alternating minima is against the theory.

Pickering, however, found from the doubling of the spectral lines that there were two stars revolving round each other. Then Prof. G. W. Myers, of Indiana, worked out a very elaborate mathematical theory to explain the variations, which is not less remarkable for its ingenuity than for the curious nature of the system it brings to light. His conclusions are these:

Beta Lyræ consists of two bodies, gaseous in their nature, which revolve round each other, so near as to be almost touching. They are of unequal size. Both are self-luminous. By their mutual attraction they are drawn out into ellipsoids. The smaller body is somewhat darker than the other. When we see the two bodies laterally, they are at their brightest. As they revolve, however, we see them more and more end on, and thus the light diminishes. At a certain point one begins to cover the other and hide its light. Thus the combined light continues to diminish until the two bodies move across our line of sight. Then we have a minimum. At one minimum, however, the smaller and darker of the two bodies is projected upon the brighter one, and thus diminishes its light. At the other minimum, it is hiding behind the other, and therefore we see the light of the larger one alone.

This theory receives additional confirmation from the fact, shown by the spectroscope, that these stars are either wholly gaseous, or at least have self-luminous atmospheres. Some of Professor Myers's conclusions respecting the magnitudes are summarized as follows:

The larger body is about 0.4 as bright as the smaller.

The flattening of the ellipsoidal masses is about 0.17.

The distance of centers is about 1¾ the semi-major axis of the larger star, or about 50,000,000 kilometers (say 30,000,000 miles).

The mass of the larger body is about twice that of the smaller, and 9½ times the mass of the sun.

The mean density of the system is a little less than that of air.*

It should be remarked that these numbers rest on spectroscopic results, which need further confirmation. They are, therefore, liable to be changed by subsequent investigation. What is most remarkable is that we have here to deal with a case to which we have no analogy in

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* 'Astrophysical Journal', Vol. VII, January, 1898.

our solar system, and which we should never have suspected, had it not been for observations of this star.

The gap between the variable stars of the Algol type and those of the Beta Lyræ type is, at the present time, being filled by new discoveries in such a way as to make a sharp distinction of the two classes difficult. It is characteristic of the Algol type proper that the partial eclipses are due to the interposition of a dark planet revolving round the bright star. But suppose that we have two nearly equal stars, *A* and *B*, revolving round their common center of gravity in a plane passing near our system. Then, *A* will eclipse *B*, and, half a revolution later, *B* will eclipse *A*, and so on in alternation. But, when the stars are equal, we may have no way of deciding which is being eclipsed, and thus we shall have a star of the Algol type, so far as the law of variation is concerned, yet, as a matter of fact, belonging rather to the Beta Lyræ type. If the velocity in the line of sight could be measured, the question would be settled at once. But only the brightest stars can, so far, be thus measured, so that the spectroscope cannot help us in the majority of cases.

The most interesting case of this kind yet brought to light is that of Tau Cygni. The variability of this star, ordinarily of the fourth magnitude, was discovered by Chandler in December, 1886. The minima occurred at intervals of three days. But in the following summer he found an apparent period of 1 d. 12 h., the alternate minima being invisible because they occurred during daylight, or when the star was below the horizon. With this period the times of minima during the summer of 1888 were predicted.

It was then found that the times of the alternate minima, which, as we have just said, were the only ones visible during any one season, did not correspond to the prediction. The period seemed to have greatly changed. Afterward, it seemed to return to its old value. After puzzling changes of this sort, the tangle was at length unraveled by Dunér, of Lund, who showed that the alternate periods were unequal. The intervals between minima were one day nine hours, one day fifteen hours, one day nine hours, one day fifteen hours, and so on, indefinitely. This law once established, the cause of the anomaly became evident. Two bright stars revolve round their common center of gravity in a period of nearly three days. Each eclipses the other in alternation. The orbit is eccentric, and, in consequence, one-half of it is described in a less time than the other half. If we could distinguish the two stars by telescopic vision, and note their relative positions at the four cardinal points of their orbit, we should see the pair alternately single and double, as shown in the following diagrams:

	A		B
Position (1), stars at pericenter	*		*
Interval, 16 hours.			
Position (2), A eclipses B		*	
Interval, 20 hours.			
	B		A
Postion (3), stars at apocenter	*		*
Interval, 20 hours.			
Position (4), B eclipses A		*	
Interval, 16 hours.			
Position (1) is repeated	*		*

U Pegasi is a star which proved as perplexing as Tau Cygni. It was first supposed to be of the Algol type, with a period of about two days. Then it was found that a number of minima occurred during this period, and that the actual interval between them was only a few hours. The great difficulty in the case arises from the minuteness of the variation, which is but little more than half a magnitude between the extremes. The observations of Wendell, at the Harvard Observatory, with the polarizing photometer, enabled Pickering to reach a con-

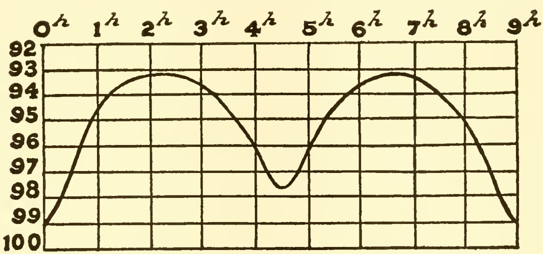

FIG. 3. LIGHT CURVE OF U PEGASI, OF THE BETA LYRÆ TYPE, FROM OBSERVATIONS BY WENDELL AT THE HARVARD OBSERVATORY. MAGNITUDE AT MAXIMUM, 9.32; AT PRINCIPAL MINIMUM, 9.90; AT SECONDARY MINIMUM, 9.76. PERIOD, 9 HOURS.

clusion which, though it may still be open to some doubt, seems to be the most likely yet attainable. The star is of the Beta Lyræ type; its complete period is 8 hours 59 minutes 41 seconds, or 19 seconds less than nine hours; during this period it passes through two equal maxima, each of magnitude 9.3, and two unequal minima 9.76 and 9.9, alternately.

The difference of these minima, 0m. 14, is less than the errors which really ordinarily affect measures of a star's magnitude with the best photometers. Some skepticism has, therefore, been felt as to the reality of the difference which, if it does not exist, would reduce the periodic time below four and one-half hours, the shortest yet known.

But Pickering maintains that, in observations of this kind upon a single star, the precision is such that the reality of the difference, small though it be, is beyond reasonable doubt.

Taking Pickering's law of change as a basis, Myers has represented the light-curve of *U* Pegasi on a theory similar to that which he constructed for Beta Lyræ. His conclusion is that, in the present case, the two bodies which form the visible star are in actual contact. A remarkable historic feature of the case is that Poincaré has recently investigated, by purely mathematical methods, the possible forms of revolving fluid masses in a condition of equilibrium, bringing out a number of such forms previously unknown. One of these, which he calls the apiodal form, consists of two bodies joined into one, and it is this which Myers finds for *U* Pegasi.

Quite similar to these two cases is that of Zeta Herculis. This star, ordinarily of the seventh magnitude, was found, at Potsdam, in 1894, to diminish by about one magnitude. Repeated observations elsewhere indicate a period of very nearly four days. Actually it is now found to be only ten minutes less than four days. The result was that during any one season of observation the minima occur at nearly the same hour every night or day. To an observer situated in such longitude that they occur during the day, they would, of course, be invisible.

Continued observations then showed a secondary minimum, occurring about half-way between the principal minima hitherto observed. It was then found that these secondary minima really occur between one and two hours earlier than the mid-moment, so that the one interval would be between forty-six and forty-seven hours and the other between forty-nine and fifty. The time which it takes the star to lose its light and regain it again is about ten hours. More recent observations, however, do not show this inequality, so that there is probably a rapid motion of the pericenter of the orbit.

It will be seen that this star combines the Algol and Beta Lyræ types. It is an Algol star in that its light remains constant between the eclipses. It is of the Beta Lyræ type in the alternate minima being unequal.

From a careful study, Seliger and Hartwig derived the following particulars respecting this system:

Diameter of principal star, 15,000,000 kilometers.
" smaller " 12,000,000 "
Mass of the larger star, 172 times sun's mass.
Mass of the smaller star, 94 times sun's mass.
Distance of centers, 45,000,000 kilometers.
Time of revolution, 3d. 23h. 49m. 32.7s.

It must be added that the data for these extraordinary numbers are rather slender and partly hypothetical.

Beta Lyræ is always of the same brightness at the same hour of its period, and Algol has always the same magnitude at minimum. It is true that the length of the period varies slowly in the case of these stars. But this may arise from the action of other invisible bodies revolving around the visible stars. This general uniformity is in accord with the theory which attributes the apparent variations to the various aspects in which we see one and the same system of revolving stars.

Another variable star showing some unique features is Eta Aquilæ. What gives it special interest is that spectroscopic observations of its radial motion show it to have a dark body revolving round it in a very eccentric orbit, and in the same time as the period of variation. It might therefore be supposed that we have here a star of the Algol or Beta Lyræ type. But such is not the case. There is nothing in the law of variation to suggest an eclipsing of the bright star, nor does it seem that the variations can readily be represented by the varying aspects of any revolving system.

The orbit of this star has been exhaustively investigated by Wright from Campbell's observations of the radial motion. The laws of change in the system are shown by the curves below, which are reproduced, in great part, from Wright's paper in the 'Astrophysical Journal.'

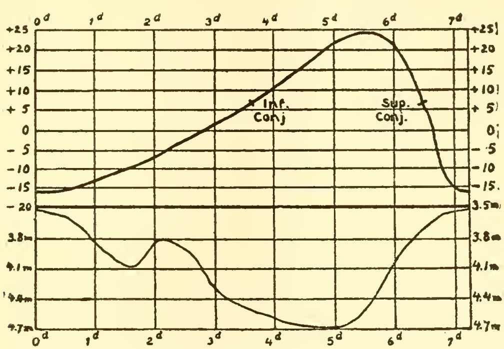

Fig. 4. Light-Curve and Radial Velocity of Eta Aquilæ.

The lower curve is the light-curve of the star during a period of 7.167 days. Starting from a maximum of 3.5 mag., it sinks, in the course of 5 days, to a minimum of 4.7m. It was found by Schwab that the diminution is not progressive, but that a secondary maximum of 3.8m. is reached at the end of the second day. After reaching the principal minimum it rises rapidly to the principal maximum in 2¼ days.

The upper curve shows the radial velocity of the star during the period of variation. It will be seen that the epoch of greatest negative velocity, which referred to the center of mass of the system, is 16.2 km. per second, occurs at the time of maximum brightness. The greatest positive velocity, 23.9 km., occurs during the sixth day of the period just after the time of minimum brightness.

Finally, the moments of inferior and superior conjunction of the dark body with the bright one are neither of them an epoch of minimum brightness, which takes place half-way between the two.

The most plausible conclusion we can draw is that the light of the star is affected by the action of the dark body during its revolution. But how the change may be produced we cannot yet say.

CLASSIFICATION OF VARIABLE STARS.

A classification of variable stars, based on the period of variation and the law of change, was proposed by Pickering. It does not, however, seem that a hard and fast line can yet be drawn between different types and classes of these bodies, one type running into another, as we have found in the case of the Algol and Beta Lyræ types. Yet the discovery of the cause of the variation in these types makes it likely that a division into two great classes, dependent on the cause of variation, is possible. We should then have:

(1) Stars, or systems, constituting to vision a single star, of which the apparent variability arises from the rotation of the system as a whole, or from the revolution of its components around each other.

(2) Stars of which the changes arise from other and as yet unknown causes.

The main feature of the stars of the first class is that we are under no necessity of supposing any actual change in the amount of light which they emit. Their apparent variations are purely the effect of perspective, arising from the various aspects which they present to us during their revolution round each other. If we could change our point of view so that the plane of the orbit of Algol's planet no longer passed near our system, Algol would no longer be a variable star. Under the same circumstances the apparent variations in a star of the Beta Lyræ type would cease to be noticeable, if they did not disappear entirely.

The stars of this class are also distinguished by the uniformity and regularity with which they go through their cycle of change.

The stars of the other class, which we may call the Omicron Ceti type, are different not only in respect to the length of the period, but in the character of the variation. There are certain general laws of variation and irregularities of brightness which stars of this class go through. Starting from the time of the minimum, the increase of light is at first very slow. It grows more and more rapid as the maximum is approached, in which time there may be as great an increase in two or three days as there formerly was in a month. The diminution of light is generally slower than the increase. The magnitude at corresponding times in different periods may be very different. Thus, as we have already remarked, Omicron Ceti is ten times as bright at some maxima as it is at others. The periods also, so far as they have been made out, vary more widely than those of stars of the other type.

The idea has sometimes been entertained that these variations of light are due to a revolution of the star on its axis. A very little consideration will, however, show that this explanation cannot be valid. However bright a star might be on one side, or however dark on the other, any one region of its surface would be visible to us half the time and a change of brightness from different degrees of brilliancy on different sides would be gradual and regular.

It is not impossible that the variability may be in some way connected with the action of a body revolving round the star. This seems to be the case with Eta Aquilæ. The radial motion of this object shows the existence of a dark body revolving round it in the same period as that of the star's variation.

From what has been said, it will be seen that, although a sharp line cannot be drawn, there seems to be some distinction between the stars of short and long periods. The number of stars which have been known to belong to the first class is quite small, only about fifteen, all told. On the other hand, there are still left some stars having a period less than ten days, which are otherwise not distinguishable from the Omicron Ceti type. It seems quite likely that the variations in the periods of these stars are, in some way, connected with the revolution of bright or dark bodies round them.

They also vary more widely than those of stars of the other two types. This might easily happen in the case of stars really variable through a cycle of changes going on in consequence of the action of interior causes.

The periodic stars of short period, which have not been recognized as of the Algol or Beta Lyræ type, form an interesting subject of study. Although the separation between them and the stars of long period is not sharp, it seems likely to have some element of reality in it. But no conclusions on the subject can be reached until the light-curves of a large number of them are carefully drawn; and this requires an amount of patient and accurate observation which cannot be carried out for years to come.

SUSPECTED VARIATIONS IN THE COLOR OF STARS.

The question whether certain stars vary in color without materially changing their brightness has sometimes been raised. This was at one time supposed to be the case with one of the stars of Ursa Major. This suspected variation has not, however, been confirmed, and it does not seem likely that any such changes take place in the color of stars not otherwise variable.

POSSIBLE SECULAR VARIATIONS IN THE BRILLIANCY OF STARS.

All the variations we have hitherto considered take place with such rapidity that they can be observed by comparisons embracing but a short interval of time—a few days or months at the outside. A somewhat different question of great importance is still left open. May not individual stars be subject to a secular variation of brilliancy, meaning by this term a change which would not be sensible in the course of only one generation of men, but admitting of being brought out by a comparison of the brightness of the stars at widely distant epochs? Is it certain that, in the case of stars which we do not recognize as variable, no change has taken place since the time of Hipparchus and Ptolemy? This question has been investigated by C. S. Pierce and others. The conclusion reached is that no real evidence of any change can be gathered. The discrepancies are no greater than might arise from errors of estimates.

There is, however, an analogous question which is of great interest and has been much discussed in recent times. In several ancient writings the color of Sirius is described as red. This fact would, at first sight, appear to afford very strong evidence that, within historic times, the color of the brightest star in the heavens has actually changed from red to a bluish white.

Two recent writers have examined the evidence on this subject most exhaustively and reached opposite conclusions. The first of these was Dr. T. J. J. See, who collated a great number of cases in which Sirius was mentioned by ancient writers as red or fiery, and thus concluded that the evidence was in favor of a red color in former times. Shortly afterwards, Schiaparelli examined the evidence with equal care and thoroughness and reached an opposite conclusion, showing that the terms used by the ancient authors, which might have indicated redness of color, were susceptible of other interpretations; they might mean fiery, blazing, etc., as well as red in color, and were therefore probably suggested by the extraordinary brightness of Sirius and the strangeness with which it twinkled when near the horizon. In this position a star not only twinkles, but changes its color rapidly. This change is not sensible in the case of a faint star, but if one watches Sirius when on the horizon, it will be seen that it not only changes in appearance, but seems to blaze forth in different colors.

It seems to the writer that this conclusion of Schiaparelli is the more likely of the two. From what we know of the constitution of the stars, a change in the color of one of these bodies in so short a period of time as that embraced by history is so improbable as to require much stronger proofs than any that can be adduced from ancient writers. In addition to the possible vagueness or errors of the original writers, we have to bear in mind the possible mistakes or misinterpretations of the copyists who reproduced the manuscripts.

THE PARALLAXES OF THE STARS.

It needs only the most elementary conceptions of space, direction and motion to see that, as the earth makes its vast swing from one extremity of its orbit to the other, the stars, being fixed, must have an apparent swing in the opposite direction. The seeming absence of such a swing was in all ages before our own one of the great stumbling blocks of astronomy. It was the base on which Ptolemy erected his proof that the earth was immovable in the center of the celestial sphere. It was felt by Copernicus to be a great difficulty in the reception of his system. It led Tycho Brahe to suggest a grotesque combination of the Ptolemaic and Copernican systems, in which the earth was the center of motion, round which the sun revolved, carrying the planets with it.

With every improvement in their instruments, astronomers sought to detect the annual swing of the stars. Each time that increased accuracy in observations failed to show it, the difficulty in the way of the Copernican system was heightened. How deep the feeling on the subject is shown by the enthusiastic title, *Copernicus Triumphans,* given by Horrebow to the paper in which, from observations by Roemer, he claimed to have detected the swing. But, alas, critical examination showed that the supposed inequality was produced by the varying effect of the warmth of the day and the cold of the night upon the rate of the clock used by the observer, and not by the motion of the earth.

Hooke, a contemporary of Newton, published an attempt to determine the parallax of the stars, under the title of "An Attempt to Prove the Motion of the Earth," but his work was as great a failure as that of his predecessors. Had it not been that the proofs of the Copernican system had accumulated until they became irresistible, these repeated attempts might have led men to think that perhaps, after all, Ptolemy and the ancients were somehow in the right.

The difficulty was magnified by the philosophic views of the period. It was supposed that Nature must economize in the use of space as a farmer would in the use of valuable land. The ancient astronomers correctly placed the sphere of the stars outside that of the planets, but did not suppose it far outside. That Nature would squander her resources by leaving a vacant space hundreds of thousands of times the extent of the solar system was supposed contrary to all probability. The actual infinity of space; the consideration that one had only to enlarge his conceptions a little to see spaces a thousand times the size of the solar system look as insignificant as the region of a few yards round a grain of sand, does not seem to have occurred to anyone.

Considerations drawn from photometry were also lost sight of, because that art was still undeveloped. Kepler saw that the sun might well be of the nature of a star; in fact, that the stars were probably suns. Had he and his contemporaries known that the light of the sun was more than ten thousand million times that of a bright star, they would have seen that it must be placed at one hundred thousand times its present distance to shine as a bright star. If, then, the stars are as bright as the sun, they must be one hundred thousand times as far away, and their annual parallax would then have been too small for detection with the instruments of the time. Such considerations as this would have removed the real difficulty.

The efforts to discover stellar parallax were, of course, still continued. Bradley, about 1740, made observations on γ Draconis, which passed the meridian near his zenith, with an instrument of an accuracy before unequalled. He thus detected an annual swing of 20″ on each side of the mean. But this swing did not have the right phase to be due to the motion of the earth; the star appeared at one or the other extremity of its swing when it should have been at the middle point, and *vice versa.* What he saw was really the effect of aberration, depending on the ratio of the velocity of the earth in its orbit to the velocity of light. It proved the motion of the earth, but in a different way from what was expected. All that Bradley could prove was that the distances of the stars must be hundreds of thousands of times that of the sun.

An introductory remark on the use of the word parallax may preface a statement of the results of researches now to be considered.

In a general way, the change of apparent direction of an object arising from a change in the position of an observer is termed *parallax.* More especially, the parallax of a star is the difference of its direction as seen from the sun and from that point of the earth's orbit from which the apparent direction will be changed by the greatest amount. It is equal to the angle subtended by the radius of the earth's orbit, as seen from the star. The simplest conception of an arc of one second is reached by thinking of it as the angle subtended by a short line at a distance of two hundred and six thousand times its length. To say that a star has a parallax of 1″ would therefore be the same thing as saying that it was at a distance of a little more than two hundred thousand times that of the earth from the sun. A parallax of one-half a second implies a distance twice as great; one of one-third, three times as great. A parallax of 0″20 implies a distance of more than a million times that of our unit of measure.

The first conclusive result as to the extreme minuteness of the parallax of the brighter stars was reached by Struve, at Dorpat, about 1830. In the high latitude of Dorpat the right ascension of a star can be determined with great precision, not only at the moment of its transit over the meridian, but also at transit over the meridian below the pole, which occurs twelve hours later. He, therefore, selected a large group of stars which could be observed twice daily in this way at certain times of the year, and made continuous observations on them through the year. It was not possible, by this method, to certainly detect the parallax of any one star. What was aimed at was to determine the limit of the average parallax of all the stars thus observed. The conclusion reached was that this limit could not exceed one-tenth of a second and that the average distance of the group could not, therefore, be much less than two million times the distance of the sun; if, perchance, some stars were nearer than this, others were more distant.

By a singular coincidence, success in detecting stellar parallax was reached by three independent investigators almost at the same time, observing three different stars.

To Bessel is commonly assigned the credit of having first actually determined the parallax of a star with such certainty as to place the result beyond question. The star having the most rapid proper motion on the celestial sphere, so far as known to Bessel, was 61 Cygni, which is, however, only of the fifth magnitude. This rapid motion indicated that it was probably among the stars nearest to us, much nearer, in fact, than the faint stars by which it is surrounded.

After several futile attempts, he undertook a series of measurements with a heliometer, the best in his power to make, in August, 1837, and continued them until October, 1838. The object was to determine, night after night, the position of 61 Cygni, relative to certain small stars in its neighborhood. Then he and his assistant, Sluter, made a second series, which was continued until 1840. All these observations showed conclusively that the star had a parallax of about 0″.35.

While Bessel was making these observations, Struve, at Dorpat, made a similar attempt upon Alpha Lyræ. This star, in the high northern latitude of Dorpat, could be accurately observed throughout almost the entire year. It is one of the brightest stars near the Pole and has a sensible proper motion. There was, therefore, reason to believe it among the nearest of the stars. The observations of Struve extended from 1835 to August, 1838, and were, therefore, almost simultaneous with the observations made by Bessel on 61 Cygni. He concluded that the parallax of Alpha Lyræ was about one-fourth of a second. Subsequent investigations have, however, made it probable that this result was about double the true value of the parallax.

The third successful attempt was made by Henderson, of England, astronomer at the Cape of Good Hope. He found from meridian observations that the star Alpha Centauri had a parallax of about 1″. This is a double star of the first magnitude, which, being only 30° from the south celestial pole, never rises in our latitudes. Its nearness to us was indicated not only by its magnitude, but also by its considerable proper motion.

Although subsequent investigation has shown the parallax of this body to be less than that found by Henderson, it is, up to the time of writing, the nearest star whose distance has been ascertained. The extreme difficulty of detecting movements so slight as those we have described, when they take six months to go through their phases, will be obvious to the reader. He would be still more impressed with it when, looking through a powerful telescope at any star, he sees how it flickers in consequence of the continual motions going on in the air through which it is seen and how difficult it must be to fix any point of reference from which to measure the change of direction.

The latter is the capital difficulty in measuring the parallax. How shall we know that a star has changed its direction by a fraction of a second in the course of six months? There must be for this purpose some standard direction from which we can measure.

The most certain of these standard directions is that of the earth's axis of rotation. It is true that this direction varies in the course of the year, but the amount of the variation is known with great precision, so that it can be properly allowed for in the reduction of the observations. The angle between the direction of a star and that of the earth's axis, the latter direction being represented by the celestial pole, can be measured with our meridian instruments. It is, in fact, the north polar distance of the star, or the complement of its declination. If, therefore, the astronomer could measure the declination of a star with great precision throughout the entire year, he would be able to determine its parallax by a comparison of the measures. But it is found impossible in practice to make measures of so long an arc with the necessary precision. The uncertain and changing effect of the varying seasons and different temperatures of day and night upon the air and the instrument almost masks the parallax. After several attempts with the finest instruments, handled with the utmost skill, to determine stellar parallax from the declinations of the stars, the method has been practically abandoned.

The method now practiced is that of relative parallax. By this method the standard direction is that of a small star apparently alongside one whose parallax is to be measured, but, presumably, so much farther away that it may be regarded as having no parallax. In this assumption lies the weak point of the method. Can we be sure that the smaller stars are really without appreciable parallax? Until recent times it was generally supposed that the magnitude of the stars afforded the best index to their relative distances. If the stars were of the same intrinsic brilliancy, the amount of light received from them would, as already pointed out, have been inversely as the square of the distance. Although there was no reason to suppose that any such equality really existed, it would still remain true that, in the general average, the brighter stars must be nearer to us than the fainter ones. But when the proper motions of stars came to be investigated, it was found that the amount of this motion afforded a better index to the distance than the magnitude did.

The diversity of actual or linear motion is not so wide as that of absolute brilliancy. Stars have, therefore, in recent times, been selected for parallax very largely on account of their proper motion, without respect to their brightness. It is now considered quite safe to assume that the small stars without proper motion are so far away that their parallax is insensible.

Ever since the time of Bessel the experience of practical astronomers has tended toward the conclusion that the best instrument for delicate measurements like these is the heliometer. This is an equatorial telescope of which the object glass is divided along a diameter into two semicircles, which can slide along each other. Each half of the object glass forms a separate image of any star at which the telescope may be pointed. By sliding the two halves along each other, the images can be brought together or separated to any extent. If there are two stars in proximity, the image of one star made by one-half of the glass can be brought into coincidence with that of the other star made by the other half. The sliding of the two halves to bring about this coincidence affords a scale of measurement for the angular distance of the two stars.

The most noteworthy forward steps in improving the heliometer are due to the celebrated instrument-makers of Hamburg, the Messrs. Repsold, aided by the suggestions of Dr. David Gill, astronomer at the Cape of Good Hope. The latter, in connection with his coadjutor, Elkin, made an equally important step in the art of managing the instrument and hence in determining the parallax of stars. The best results yet attained are those of these two observers and of Peter, of Germany.

Yet more recently, Kapteyn, of Holland, has applied what has seemed to be the unpromising method of differences of right ascension observed with a meridian circle. This method has also been applied by Flint, at Madison, Wis. Through the skill of these observers, as well as that of Brünnow and Ball, in applying the equatorial telescope to the same purposes, the parallax of nearly 100 stars has been measured with some approach to precision.

A rival method to that of the heliometer has been discovered in the photographic telescope. The plan of this instrument, and its application to such purposes as this, are extremely simple. We point a telescope at a star and set the clock-work going, so that the telescope shall remain pointed as exactly as possible in the direction of the star. We place a sensitized plate in the focus and leave it long enough to form an image both of the particular star in view and of all the stars around it. The plate being developed, we have a permanent record of the relative positions of the stars which can be measured with a suitable instrument at the observer's leisure. The advantage of the method consists in the great number of stars which may be examined for parallax, and in the rapidity with which the work can be done.

The earliest photographs which have been utilized in this way are those made by Rutherfurd in New York during the years 1860 to 1875. The plates taken by him have been measured and discussed principally by Rees and Jacoby, of Columbia University. Before their work was done, however, Pritchard, of Oxford, applied the method and published results in the case of a number of stars.

One of the pressing wants of astronomy at the present time is a parallactic survey of the heavens for the purpose of discovering all the stars whose parallax exceeds some definable limit, say 0″1. Such a survey is possible by photography, and by that only. A commencement, which may serve as an example of one way of conducting the survey, has been made by Kapteyn on photographic negatives taken by Donner at Helsingfors.

These plates cover a square in the Milky Way about two degrees on the side, extending from 35° 50′ in declination to 36° 50′, and from 20h. 1m. in R. A. to 20h. 10m. 24s. Three plates were used, on each of which the image of each star is formed twelve times. Three of the twelve impressions were made at the epoch of maximum parallactic displacement, six at the minimum six months later, and three at the following maximum. The parallaxes found on the plates can only be relative to the general mean of all the other stars, and must therefore be negative as often as positive. The following positive parallaxes, amounting to 0″1, came out with some consistency from the measures:

Star, B. D., 3972	Mag. 8.6	R. A. 20h., 2m. 0s.	Dec. +35°.5	Par. +0″.11
Star, B. D., 3883	Mag. 7.1	R. A. 20h., 2m. 3s.	Dec. +36°.1	Par. +0″.18
Star, B. D., 4003	Mag. 9.2	R. A., 20h., 4m. 58s.	Dec. +35°.4	Par. +0″.10
Star, B. D., 3959	Mag. 7.0	R. A., 20h., 9m. 14s.	Dec. +36°.3	Par. +0″.10

Against these are to be set negative parallaxes of —0″.09, —0″.08 and several a little smaller, which are certainly unreal.

The presumption in favor of the actuality of one or more of the above positive values, which is created by their excess over the negative values, is offset by the following considerations: The area of the entire sky is more than 40,000 square degrees, or 10,000 times the area covered by the Helsingfors plates. We cannot well suppose that there are 1,000 stars in the sky with a parallax of 0″.10, or more without violating all the probabilities of the case. The probabilities of the case are therefore against even one star with such a parallax being found on the plates. Yet the cases of these four stars are worthy of further examination, if any of them are found to have a sensible proper motion.

On an entirely different plan is a survey just concluded by Chase with the Yale heliometer. It includes such stars having an annual proper motion of 0″.05 or more as had not already been measured for parallax. The results, in statistical form, are these:

2 stars have parallaxes between + 9″.20 and + 0″.25.
6 stars have parallaxes between + 0″.15 and + 0″.20.
11 stars have parallaxes between + 0″.10 and + 0″.15.
24 stars have parallaxes between + 0″.05 and + 0″.10.
34 stars have parallaxes between + 0″.00 and + 0″.05.
8 stars have parallaxes between – 0″.05 and 0″.00.
5 stars have parallaxes between – 0″.10 and – 0″.05.
2 stars have parallaxes between – 0″.15 and – 0″.10.

92, total number of stars.

It will be understood that the negative parallaxes found for fifteen of these stars are the result of errors of observation. Assuming that an equal number of the smaller positive values are due to the same cause, and subtracting these thirty stars from the total number, we shall have sixty-two stars left of which the parallax is real and generally amounts to 0″.05, more or less. The two values approximating to 0″.25 seem open to little doubt. We might say the same of the six next in the list. The first two belong to the stars 54 Piscium and Weisse, 17h., 322.

DISCUSSION AND CORRESPONDENCE.

THE MEETINGS OF THE AMERICAN ASSOCIATION.

THE American Association for the Advancement of Science has a membership ranging from 1,900 to 2,000. Of this number probably at no one time was there an aggregate of 300 persons present at the recent annual meeting in New York.

When the Association meets in an Eastern city the attendance is generally twice if not three times as large as when it convenes in the West. So little was made of the recent meeting, locally or officially, that an intelligent resident of the city remarked: "Why, I intended to have attended some of the meetings, but seeing no reference in the daily papers, it entirely escaped my mind."

Of the 2,000 members, about 800 are fellows; the 1,200 and more registered as members are, presumably, persons devoting little or no time to independent research along scientific lines, but persons who while not actively so engaged are more than ordinarily interested in the discussion of scientific topics. These have in the past paid dues and attended the meetings of the Association with more or less regularity. It is a question in the minds of some of the 1,200 if their attendance at the meetings is desired. Their membership, so far as it relates to the five dollars initiation fee and three dollars dues, is without question acceptable, and to persons reading papers in the various sections their presence is preferable to empty seats, but in view of the fact that during recent years the management of the Association has eliminated, so far as possible, the popular features of the general programme, the question is reasonably asked: "Does the management desire the attendance of the 1,200, or is their financial support all that is desired?"

It was stated some years ago that the purpose of the Association was to furnish not only an occasion for scientists to present original papers, but also to interest the public by holding the meetings annually in different parts of the country; but if attendance is not secured (by preparation and publication of interesting features of a programme) no great interest will be awakened by a meeting held in any part of the country.

I should like to suggest the following ways of increasing the interest of the meetings:

The general daily sessions might be made occasions of rare interest by the introduction of prominent men of science who would make at least brief remarks. This would make it possible for those who have limited time to become familiar with the faces of those whom they would like to know, and the little 'sample' of scientific thought thrown out would doubtless awaken desire for more.

It will be objected that the meetings of the council immediately preceding the general session prevent holding an official meeting at that hour. The public and the 1,200 would care little whether the session were official or unofficial so it were interesting and instructive.

The officers of the several sections could easily secure distinguished representatives of their respective sciences to give brief addresses followed by discussion, and thus the morning hour would prove an attraction to citizens and others who might be unable to attend the sessions following.

Again, citizens, where the meetings are held, would be pleased to provide excursions to points of local interest and extend social courtesies, if they were given in return the mental food in digestible form, with which the Association is so amply supplied.

It remains with the management to decide whether attendance shall be restricted to the few actively engaged in scientific pursuits, or whether it shall include the 1,200 and more who would be glad to avail themselves of the benefits of a programme suited to average scholarship and intellectual capacity.

There is no better medium for discussion of the above views than through the widely read pages of THE POPULAR SCIENCE MONTHLY.

M. E. D. TROWBRIDGE.
Detroit, Mich.

[THE questions brought up by our correspondent have been carefully considered by all those who are interested in the American Association for the Advancement of Science. When the Association was founded fifty years ago there was no division into sections; the papers and discussions were intelligible and interesting to all members. At that time there were but few members, the scientific life of the country was small, and it was a privilege for a city to entertain the Association. But fifty years have brought changes in many directions. Specialization in science has become essential for its further progress, and it has been necessary to divide the Association into numerous sections and to found special societies. Hospitality can now only be provided at great expense, and Eastern cities no longer regard it as a privilege to entertain the numerous societies that gather within their hotels. The newspapers do not regard a meeting of the Association as an important event and will not devote space to it.

The Association must do the best it can to adapt itself to existing conditions. The recent meeting in New York had perhaps the largest attendance of scientific men of any in the history of the Association with the exception of the anniversary meeting two years ago, but New York City, especially in the month of June, is not a desirable place for social functions. It is not reasonable for a member interested in science as an amateur to expect to purchase for three dollars a week's entertainment. His dues secure reduced railway and hotel rates; he can meet his friends and become acquainted with scientific men; he can always find on the programme papers that are of interest; he receives the annual volume of 'Proceedings' and the weekly journal, 'Science,' the cost of which is five dollars per year. But apart from these direct returns, he is surely repaid for membership by knowing that he is one of those who are united for the advancement of science in America.—EDITOR, POPULAR SCIENCE MONTHLY.]

THE COLOR RED.

TO THE EDITOR OF THE POPULAR SCIENCE MONTHLY: Mr. Havelock Ellis, in your August number, in 'The Psychology of Red,' says, 'A great many different colors are symbolical of mourning . . . . but so far as I am aware, red never.' The following may possibly be of interest in this connection:

"Our English Pliny, Bartholomew Glantville, who says after Isydorus, 'Reed clothes ben layed upon deed men in remembrance of theyr hardynes and boldnes, whyle they were in theyr bloudde.' On which his commentator, Batman, remarks: "It appereth in the time of the Saxons that the manner over their dead was a red cloath, as we now use black. The red of valiauncie, and that was over kings, lords, knights and valyaunt souldiers; white over cleargie men, in token of their profession and honest life, and over virgins and matrons.' "—(Dr. Furness's Variorum. Merchant of Venice, p. 56.)

CHAS. E. DANA.
University of Pennsylvania.

SCIENTIFIC LITERATURE.

MENTAL AUTOMATISM.

A RECENT work by Prof. Th. Flournoy, entitled 'Des Indes à la Planète Mars,'* contains an account of a remarkable case of mental automatism, or subconscious personality. The subject is a young woman of about thirty years, apparently in good health, but always of a nervous and imaginative type. She developed tendencies towards lapses of consciousness, hallucinations and automatic actions; and these developed later, under the inspiration of spiritualistic séances, into a series of cycles, or automatic dramas, in which the medium speaks or writes and acts under the influence of several diverse subordinate personalities. In one of these cycles—which, it must be understood, are continued from one sitting to another, although in her intermediate normal life she knows nothing of what she has said or done in the trance—she becomes Marie Antoinette, and is said to act the part with unusual dramatic skill. In another and far more elaborate cycle the scene is transferred to the planet Mars, and the houses, scenery, plants and animals, peoples, customs and goings-on of the planet are described; sketches are made, and reproduced in the volume, of these extra-mundane appearances. Still more remarkable is the appearance of the Martian language, which in successive séances the subject hears, speaks, sees before her in space, and, in the end, even writes. From the mystery of Mars we are taken to the equally mysterious Hindu cycle; here the medium becomes an Indian princess of the fifteenth century, reveals her history and that of her associates in the Oriental life, tells of herself as Simandini; of Sivrouka, her prince, who reigned over Kanara and built in 1401 the fortress of Tschandraguiri. Wonderful to relate, these names are not fictitious, but are mentioned by one De Marlès in a volume published in 1828; the author, however, does not enjoy a high reputation as a historian. When occasional utterances of the Hindu princess are taken down, they are found in part to have close resemblance to Sanskrit words; while in her normal condition the medium is as ignorant of Sanskrit as she is of any language except French, and is entirely ignorant of both De Marlès and the people of India five hundred years ago. Surely this is a tale, bristling with mystery and improbability, which, if told carelessly or with a purpose, we should dismiss as a willful invention! M. Flournoy has been unusually successful in revealing the starting points of the several automatisms and of connecting them with intelligible developments of the medium's mental life; and the manifestations, though they remain as remarkable examples of unconscious memory and elaboration of ideas, nowhere transcend these limitations. The sketches of Martian scenery are clearly Japanesque or vaguely Oriental; the Martian language is pronounced an 'infantile' production, and is clearly modeled after the French, the characters being the result of an attempt to make them as oddly different from our own as possible; the Sanskrit goes no farther than what one could get from a slight acquaintance with a Sanskrit grammar; and while there is a copy of De Marlès in the Geneva Library (where the medium lives), no connection can be established between either De Marlès or the grammar and the subject of this study. Most of this knowledge of these remarkable sub-conscious states would have been impossible were it not for 'spirit con-

* The book has just been published by the Harpers in an English version, under the title 'She Lived in Mars.'

trol' of one Leopold, who, in accordance with the doctrine of reincarnation which permeates the several cycles, was in his life the famous Cagliostro. By suitable suggestion, Leopold can be induced to make the entranced subject speak, write, draw, or interpret her strange messages from other worlds; and where Leopold says 'nay' all progress is stopped. This case has many analogies with other cases that have been recorded, but goes beyond most of them in the complexity and bizarre character of the unconscious elaborations and in the feats of memory and creative imagination which it entails. These accomplishments, it should be well understood, never appeared suddenly or fully developed, but only after a considerable period of subliminal preparation, and then only hesitatingly, and little by little, just as is the case with the acquisitions of normal consciousness; and all these acquisitions bear unmistakable marks of belonging to the same person. The special value of this account thus lies in the accuracy of the description and the success with which the account has been made thoroughly intelligible and significant.

THE MOSQUITOES OF THE UNITED STATES.

Dr. L. O. Howard, the entomologist of the United States Department of Agriculture, has just published a bulletin entitled, "Notes on the Mosquitoes of the United States: Giving some Account of their Structure and Biology, with Remarks on Remedies." The author has, for some years, been interested in the general subject of the biology of mosquitoes and of remedies to be used against them, and has brought together in this bulletin all the published and unpublished notes which he has been collecting during this period. The bulletin contains synoptic tables of all North American mosquitoes, prepared by Mr. D. W. Coquillett, and gives detailed facts regarding the geographical distribution of the different species mentioned. All the five North American genera are illustrated and full, illustrated accounts are given of the life history of the two principal genera, Culex and Anopheles, as studied in *Culex pungens* and *Anopheles quadrimaculatus*. The author calls special attention to the two genera of large mosquitoes, Psorophora and Megarhinus, and urges the importance of the study of these two genera, especially by physicians in the South, in regard to their possible relation to the spread of malaria. Considerable space is given to the subject of remedies, the principal ones considered being kerosene on breeding pools, the introduction of fish in fishless ponds, the artificial agitation of water and general community work. It is clearly shown not only that the mosquito may be, in many localities, readily done away with at comparatively slight expense, but that by careful work many malarious localities may be made healthy. The subject of mosquitoes and malaria is not discussed in the bulletin, which contains simply references to available papers on this subject, like the article by Dr. Patrick Manson, published in The Popular Science Monthly for July, the aim of the author being to bring together all available facts about the mosquitoes of the United States, in order to assist physicians who are studying the malarial relation from the point of view of local conditions.

THE PROGRESS OF SCIENCE.

The British, French and German Associations for the Advancement of Science have held their annual meetings in the course of the past month. In each of these countries and in most other European countries, as well as in America, there are migratory scientific congresses of the same general character. As these have grown up somewhat independently, they evidently meet a common need. Science cannot be advanced by a man working independently and in isolation. The printing press was essential to the beginnings of modern science, while at the same time it was usual for the scientific student to travel from place to place that he might learn and teach. Then in the seventeenth and eighteenth centuries, as the cultivation of science became more general, royal academies were founded. The Royal Society was established at London in 1660 under the patronage of Charles II., the Academy of Sciences at Paris in 1666 under Louis XIV., the Royal Academy at Berlin in 1700 under Frederick I., the Imperial Academy at St. Petersburg in 1724 under Peter the Great, and in other cities similar academies were founded under similar auspices. Then in the first half of the present century, as science continued to grow, the more democratic organizations for the advancement of science were established. The Society of German Scientific Men and Physicians was formed, chiefly through the efforts of Humboldt, in 1822; the Swiss Association in 1829, and the British Association in 1831. Our own Association was established in 1847, but was then the intergrowth of a society dating from 1840. These associations are significant of the spread of science among all the people. Science is no longer the concern of a few men under royal patronage, but the two great movements of the present century—the growth of democracy and the growth of science—have united for their common good.

The British Association held its annual meeting at Bradford, beginning on September 5, under the presidency of Sir William Turner, professor of anatomy in the University of Edinburgh. We are able to publish, from a copy received in advance of its delivery, his presidential address, which traces the growth during the present century of knowledge regarding fundamental biological problems. The addresses of the presidents before the sections are usually written in a way that can be readily understood by those who are not specialists, and are consequently of greater interest to a general audience than some of the corresponding addresses before the American Association. The addresses at Bradford were: Before the section of mathematical and physical science Dr. Joseph Larmor discussed recent developments of physics with special reference to the extent to which explanation can be reduced purely to description; before the section of chemistry Prof. H. W. Perkin argued that radical changes should be made in the methods of teaching inorganic chemistry; before the section of geology Prof. W. J. Sollas spoke of the development of the earth, including the different critical periods in its history; before the section of zoölogy Dr. R. H. Traquair chose as his subject the bearing of fossil fishes on the doctrine of descent; before the section of geography Sir George Robertson considered certain geographical aspects of the British Empire and the changes brought about by improved means of intercommunication; before the section of economic science and statistics Major P. G. Craigie spoke of the use of statistics in agriculture;

before the section of mechanical science Sir Alexander Binnie traced the historical development of science; before the section of anthropology Prof. John Rhys dealt with the ethnology of the British Isles, with special reference to language and folk-lore; before the section of botany Prof. Sidney H. Vines reviewed the development of botany during the present century. In addition to these addresses, evening discourses were given by Prof. Francis Gotch on 'Animal Electricity,' and by Prof. W. Stroud on 'Range Finders.' The usual lecture to workingmen was given by Prof. Sylvester P. Thompson, his subject being 'Electricity in the Industries.'

Bradford is situated in the coal regions, and is an industrial center devoted especially to the manufacture of textiles. More attention was paid to local interests than is usual at the meetings of the American Association. An exhibit was arranged to show the development of the elaborate fabrics from the unwashed fleeces, and another consisting of a collection of carboniferous fossils found in the neighborhood. A joint discussion was arranged between the sections of zoölogy and botany on the conditions which existed during the growth of the forests which supplied material for the coal, and there were a number of papers devoted to the coal measures and the fossils which they contain. Another subject connected with the place of meeting was the report of the committee on the underground water system in the carboniferous limestone. By the use of chemicals the course of the underground waters has been traced, including their percolation through rock fissures, and excursions were made to the site of the experiments. The local industries received treatment from several sides. Among other discussions of more than usual interest was that on 'Ions' before the physical section and on 'What is a Metal?' before the chemical section. Features of popular interest were accounts of adventures in Asia, Africa and the Antarctic regions, by Captain Deasy, Captain George and Mr. Borchgrevinck, respectively, and Major Ross's paper on 'Malaria and Mosquitoes.'

The French Association met at Paris in the month of August, with the numerous other congresses. General Sebert, in his presidential address, reviewed the progress of the mechanical industries during the century and devoted the last third of his time to a discussion of international bibliography, but without mentioning the International Catalogue which now seems to be an accomplished fact. The secretary of the Association, in his review of the year, devoted special attention to the joint meetings of the British and French associations last summer at Dover and Calais. The treasurer was able to make a report that the treasurers of other national associations will envy. The capital is over $250,000, and the income from all sources about $17,000, of which about $3,000 was awarded for the prosecution of research and to defray the cost of publication of scientific monographs. The national association for the advancement of science of Germany—the 'Gesellschaft deutscher Naturforscher und Aerzte'—held its annual meeting at Aachen toward the middle of September. An account of the proceedings has not yet reached us, but the congresses are always largely attended and the combination of addresses of general interest, of special papers before the numerous sections and of social functions, is perhaps more effective than in any other society. It also appears to be a considerable advantage for medical men and scientific men to meet together.

While from the scientific point of view the present century has been notable for the development of national associations for the advancement of science, its latter decades have witnessed a growth of international scientific meetings which may be expected to become dominant in the twentieth century. There are at least one hundred congresses, having more or less reference to science, meeting at Paris during the present summer. Perhaps the most noteworthy of these, from the point of view of the organization of science, is the International Association of Academies, which was established last year at a conference held at Wiesbaden. In this Association eighteen of the great academies of the world, including our own National Academy of Sciences, have been united to promote the interests of science. Literature is also included—of the eighteen academies, twelve include in their scope both science and literature, four are devoted to science only and two to literature only. It is planned to have a general meeting every three years, to which each academy will send as many delegates as it regards as desirable, though each academy will have but one vote. In the interval between the general meetings, the business of the Association is to be directed by a committee, on which each academy is represented. The object of the Association is to plan and promote scientific work of international interest which may be proposed by one of the constituent academies, and generally to promote scientific relations between different countries. The Royal Society has proposed the measurement, by international coöperation, of an extended arc of the meridian in the interior of Africa.

The International Congress of Physics marked an advance owing to the fact that it met for the first time this year, and it appears that the proceedings were of unusual interest. This was in a large measure due to the arrangements of the French Physical Society, which did not simply make up a programme from a mass of heterogeneous researches, but secured some eighty reports on the present condition of physical science. These were prepared by many of the leading physicists of the world and when published—as they are about to be in three volumes—will set forth the condition of the science with completeness and authority. There were in all seven sections. In the first, which was concerned with measurement, in addition to numerous reports several propositions were brought forward in regard to units, which, being international in character, are specially fitted for discussion at such a congress. As the members, however, were not in most cases delegates from governments and scientific bodies, no definite action was taken, though some recommendations were made. The decimalization of time was not recommended, nor was the proposal to give a name to units of velocity and acceleration. It was, however, decided that the 'Barrie' be adopted as the unit of pressure. The other sections were for mechanical physics, for optics, for electricity, for magneto-optics and radio-activity, for cosmical physics and for biological physics. Among the reports and papers of commanding interest only two can be mentioned—the introductory address by M. Poincaré, discussing the relations between experimental and mathematical physics, and one by Lord Kelvin on the waves produced in an elastic solid traversed by a body acting on it by attraction or repulsion, in which, from a strictly mathematical point of view, he advanced the hypothesis of a movable atom surrounded by an immovable ether. In addition to various receptions, a session was held at the Sorbonne, where Messrs. Becquerel and Curie gave demonstrations with radioactive substances, and one at the Ecole Polytechnique, where President Cornu showed apparatus which had been used in the determination of the velocity of light. At the close of the congress the foreign secretaries placed a crown on the tomb of Fresnel.

While a physical congress was meeting at Paris this year for the first time, the Geological Congress, which was one of the first international congresses to be organized, held its eighth session, beginning on August 16. America, in spite of the number and importance of the inventions it has given to the world, has not as yet done its share for the advancement of physical science, but in geology it occupies a foremost place. It was natural, therefore, that while American physicists were scarcely represented on the programme of the Physical Congress, they occupied a prominent place on the programme of geological papers. Among the three hundred members present, the representation from America included Messrs. Stevenson, Hague, Osborn, Ward, Willis, White, Cross, Scott, Todd, Kunz, Choquette, Adams, Mathew and Rice, and they presented a number of the more important papers. M. Karpinsky, the retiring president, gave the opening address, which was followed by an address of welcome by M. Gaudry, the president of the congress. A geological congress can offer special attractions in the way of excursions, and these were admirably arranged on the present occasion—both the shorter excursions to the classic horizons in the neighborhood of Paris and the more extended ones that followed the close of the meeting. The guide for the twenty long excursions and numerous shorter trips, prepared by the leading French geologists, was an elaborately illustrated volume representing the present condition of our knowledge of French geology. The ninth geological congress will be held at Vienna three years hence.

The International Congress of Mathematics met for the second time at Paris, though there had been a preliminary meeting on the occasion of the Chicago Exposition. There were about two hundred and twenty-five mathematicians in attendance, including seventeen from the United States. M. Poincaré presided, and the vice-presidents, some of whom were not present, were Messrs. Czuber, Gordon, Greenhill, Lindelöf, Lindemann, Mittag-Leffler, Moore, Tikhomandritzky, Volterra, Zeuthen and Geiser. The sections and their presiding officers were as follows: (1) Arithmetic and Algebra: Hilbert; (2) Analysis: Painlevé; (3) Geometry: Darboux; (4) Mechanics and Mathematical Physics: Larmor; (5) Bibliography and History: Prince Roland Bonaparte; (6) Teaching and Methods: Cantor. Valuable papers were presented by M. Cantor on works and methods concerned with the history of mathematics, by Professor Hilbert on the future problems of mathematics and by Professor Mittag-Leffler on an episode in the life of Weierstrass, but the programme appears to have been not very full nor particularly interesting. Time was found for a half-day's discussion of a universal language, but not to carry into effect the plans begun at Zurich three years ago for a mathematical bibliography. The next congress will meet four years hence in Germany, probably at Baden-Baden.

The untimely death of James Edward Keeler, director of the Lick Observatory, is a serious blow to astronomy and to science. Born at La Salle, Ill., forty-three years ago, he was educated at the Johns Hopkins University and in Germany. When only twenty-one years old he observed the solar eclipse of 1878, and drew up an excellent report. Three years later he was a member of the expedition to Mt. Whitney under Professor Langley, whose assistant he had become at the Allegheny Observatory, and whose bolometric investigations owe much to him. He became astronomer at the Lick Observatory while it was in course of erection, and in 1891 he succeeded Professor Langley as director of the Allegheny Observatory. He was called to the directorship of the great Lick Observatory in 1898. Keeler's work in astrophysics, including his photographs of the spectra of the red stars and his spectroscopic proof of the meteoric constitution of Saturn's rings, demonstrated what he could accomplish at a small observatory unfavorably situated. At Mt. Hamilton he was able in the course of only two years to organize thoroughly the work of the Observatory, and to adapt the Crossley reflector for his purpose, taking photographs of the nebulæ that have never been equalled. His discovery that most nebulæ have a spiral structure is of fundamental importance. It is not easy to overestimate what might have been accomplished by Keeler in the next twenty or thirty years, both by his own researches and by his rare executive ability, for it must be remembered that his genius as an investigator was rivaled by personal qualities which made his associates and acquaintances his friends.

Henry Sidgwick, late Knightbridge professor of moral philosophy at Cambridge, died on August 28, at the age of sixty-two years. There are usually not many events to record in the life of a university professor, but Sidgwick had an opportunity to prove his character when he resigned a fellowship in Trinity College because holding it implied the acceptance of certain theological dogmas. Liberalizing influences, however, were at work, of which he himself was an important part, and he was later elected honorary fellow of the same college, and in 1883 became professor of moral philosophy in the University. Sidgwick published three large works—'Methods of Ethics' (1874), 'Principles of Political Economy' (1883) and 'Elements of Politics' (1891)—in addition to a great number of separate articles. All these works, especially the 'Ethics,' show an intellect to a rare degree both subtle and scientific. There was a distinction and a personal quality in what he wrote that made each book or essay a work of art, as well as a contribution to knowledge. Those who knew Professor Sidgwick—and the writer of the present note regards it as one of the fortunate circumstances of his life that he was for several years a student under him—realize that the qualities of the man were even more rare than those of the author. His hesitating utterance, always ending in exactly the right word, but represented the caution and correctness of his thought. Subtlety, sincerity, kindliness and humor were as happily combined in his daily conversation as in his writings. It is said that he was never 'entrapped into answering a question by yes or no,' but his deeds and his influence were positive without qualification or limitation.

Friedrich Wilhelm Nietzsche, who died on almost the same day as Sidgwick, was also a writer on ethics and once a university professor, but the life and writings of the two men present a strange contrast. Where Sidgwick's touch was light as an angel's, Nietzsche trampled like a bull; the one was the embodiment of reason, caution, consideration and kindliness, the other represented paradox, recklessness, violence and brute force. Still Nietzsche deserves mention here, as his ethical views, based on the Darwinian theory of the survival of the fit, are not unlikely to be urged hereafter by saner men, and to become an integral part of ethics when ethics becomes a science. As a matter of fact, after resigning his professorship at Zurich, and even while writing his remarkable books, Nietzsche suffered from brain disease, and during the past eleven years his reason was completely lost.

INDEX.

NAMES OF CONTRIBUTORS ARE PRINTED IN SMALL CAPITALS.

VOL. LVII.] ESTABLISHED BY EDWARD L. YOUMANS. [No. 1.

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EDITED BY WILLIAM JAY YOUMANS.

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FOR a magazine whose field has no limitations except those of science, it is quite impossible to make a comprehensive announcement of its contents a year ahead. The Popular Science Monthly aims to keep its readers in touch with the most recent advances and discoveries as they are applicable to the promotion of human welfare and social progress. We believe that science is the force which has done the most in this direction in the past, and that it is what we must look to for growth in the future. We take advantage of every opportunity to secure articles that shall be entertaining as well as instructive without sacrificing accuracy, and we especially seek those authors who have the ability to write upon scientific subjects in a clear and instructive way.

The most characteristic feature of the nineteenth century, and especially of its latter half, is the truly wonderful advance of science, both theoretical and practical. Coincident with this advance, and very largely dependent upon it, has been the unprecedented development of commerce and manufactures, of social organization and national wealth. A comparison of the potentiality of an unskilled laborer of one hundred years ago with that of a like workman of to-day brings out most strikingly what this scientific advance has accomplished in solving the problems of life and raising the standard of comfort; so that the luxuries of a few years ago are the necessities of to-day, and new pleasures have been added and even become common which were formerly beyond the reach of the most wealthy. In view, then, of this prominently scientific aspect, the most important and instructive portion of nineteenth-century history will be that of its scientific achievements, which, as Mr. Alfred Russel Wallace has so well pointed out in his "Wonderful Century," far exceed in number as well as in importance those of all the centuries that have preceded it.

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THE RACE QUESTION.

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Of equal importance with all these branches of knowledge, and an essential prerequisite to receiving and rendering them available for use, is education. The Monthly has in the past given this subject prominent attention and preference, and will continue to do so. We have always aimed to make the articles in this field not only of general philosophical interest, but more especially to select subjects and modes of treatment which should be suggestive and practically valuable to the working teacher.

VOL. LVII.] [No. 2.

THE POPULAR SCIENCE MONTHLY.

JUNE, 1900.

EDITED BY J. McKEEN CATTELL.

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For the coming year we are pleased to announce we have secured for our readers the best features of the magazine's existence. We have arranged for articles by the best authors on a wide range of topics. Our fiction will be the best the language affords. Here are some of the good things in store for our readers :

Rudyard Kipling's New Stories of South Africa

In this number will be found the first of Kipling's South African stories. More are to come. Here we have Kipling at his best. Once more he is with Tommy Atkins, in describing whom he gained his first enduring fame. Kipling is to-day the foremost writer of English fiction—a position won by merit.

The First Literary Fruit of the Boer War

Original in conception, vigorous in treatment, human in everything, he puts life and intense interest into anything he touches, whether it be an iron bridge or a woman. These stories are the first literary fruit of the Boer war. They are intensely interesting and will greatly add to the author's fame.

A Prisoner Among Filipinos

In the August number Commander Gilmore will begin his personal narrative of his captivity among the Filipinos in Northern Luzon. While a naval lieutenant Mr. Gilmore was despatched with a small boat to land scouts. He was ambushed, captured and for months suffered intensely as a prisoner, sometimes among the savage tribes, where his life was almost miraculously spared.

Lieut.-Commander James C. Gilmore

As the most conspicuous of the Americans captured by Aguinaldo's men his story will prove to be of surpassing interest. It is not only that his personal story is interesting that makes the narrative notable, but his observations on the native life and customs will prove of the highest value. The copious illustrations have been prepared under Mr. Gilmore's personal supervision.

Pen Portraits of Politicians

In this number begins a series of non-partisan pen portraits of leading politicians of all parties by William Allen White, Editor of the Emporia (Kansas) *Gazette*, and author of the Boyville stories. These articles are certain to arouse an unprecedented amount of interest. Mr. White wields a vigorous pen; his wit and wisdom are proverbial, and his candor is unqualified. The nature of these articles can be best judged by reading that on Mr. Bryan in this issue. In September a prominent Republican will have his portrait thrown on the canvas. It will be equally entertaining.

Unpublished American History

We have engaged a series of articles on hitherto unpublished American history by authors who write with authority. In this issue is for the first time given to the public the full story of our recent cordial relations with Great Britain. It is something of the highest interest to every American citizen.

An International Wheat Corner

That Russia a few years ago seriously proposed to the United States that the two nations get up a wheat trust and fix the price at one dollar per bushel seems hardly credible. Yet it is true, and we will shortly publish the most astonishing story of its kind ever printed, with some official documents.

The End of the Confederacy

We have secured the private diary of the late Stephen R. Mallory, Secretary of the Navy in the Confederate Cabinet at its fall. This diary was expanded into a narrative by Mr. Mallory when a prisoner at Fort Lafayette, while the events of a few weeks before were fresh in his mind. He tells most vividly of the fall of Richmond, the flight of the Cabinet, the surrender of Johnston, and many other incidents of the time. It contains many important contributions to history. After lying in a garret for thirty-five years it is now to be published in McClure's Magazine.

In China and Siberia

To give our readers the facts about conditions in the far East Mr. Frederick Palmer, the celebrated journalist, traveler and war correspondent, is traveling in Asia, and will furnish a series of articles. Some of them will be:

"Baikal, the Chicago of Siberia."
"Making a Russian out of a Chinaman."
"Russian Railways to the Pacific."

We are as a nation not only deeply interested in the Eastern question, but we are in and of it. For good or ill our lot is cast in with those who control that situation. A few years ago it was to most Americans a mere abstraction. To-day it affects our national life.

Stories of the Woods, by W. D. Hulbert

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EDITED BY J. McKEEN CATTELL.

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of that city, and illustrated from life by Frederic R. Gruger, who spent some time in Chicago for the purpose, working under the author's direction. These are not fiction of the ordinary sort. The author does not tell her stories merely as creative works of the imagination. She strives to give exact impressions of the various phases of life in that wonderful city, and uses the story form only as the best medium for her purpose. She paints her portraits sometimes in delicate tints, sometimes in the impressionistic method, and sometimes in a bold, vigorous coloring. These will form a new contribution to Western literature and will attract unusual attention.

POLITICIANS AS THEY ARE

Probably no article about a politician, written from a non-partisan standpoint, ever created such widespread attention as that on Bryan in the July issue of McClure's Magazine, written by

William Allen White

the vigorous young editor of the Emporia (Kansas) *Gazette*. In the next issue will be found the second of the series, and others are to follow. Mr. White is a man of views, but not of prejudices. His candor is complete, his style graphic, and his sympathies broad. In that refreshing manner of his he makes his subjects living beings to those who have thought of them as mere abstractions. The reader can claim almost personal intimacy with the men he describes. A number of other pen portraits are to follow.

MERRY TALES OF SCOTLAND

When James V. ruled over Scotia there was fun galore. The gallant young King was canny and kept his subjects guessing much of the time. Some of his experiences under the general title of "The Jimmy Stories," written by

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will appear in forthcoming numbers. Here we have the author at his best. There is humor, vivid description, sage counsel, and continuous interest. While the stories are not told as history, they are historically correct in time, place and atmosphere. They will add to the author's fame.

NORTHWESTERN TALES

Of recent authors who have suddenly leaped into fame with promise of a more famous future, none is more noteworthy than

Jack London

whose stories of Alaska are remarkable for originality in conception and vigor in treatment. Mr. London is well under thirty, and by no means confines his stories to the Klondike. His name is connected with that region because his first fame came from tales of it. We have secured a number of stories from his pen which will be published in the next few months. He is looked upon as one of the coming men in literature.

ANIMALS OF THE FOREST

In this number will be found the first of a remarkable series of animal stories from the pen of

William Davenport Hulbert

who writes of his friends from long and close intimacy. Circumstances led the author to live for many years in the deep woods of Michigan, not as a hunter, nor even as a naturalist. The animals became his associates, and he writes of them not as a man of science, but as one who has entered as far as may be into their life and habits. There is a vein of sympathy and perfection of comprehension in his stories that distinguish them from other literature of their kind. Our readers will learn from them to know animals as never before.

UNPUBLISHED AMERICAN HISTORY

Much that is of most importance as history is of necessity kept from the public for a long time. The State Department's rule is to keep its files of important negotiations secret for at least thirty years.

We have secured a number of articles by well-known men about matters of the highest interest never before published. One of these is:

Russia's Attempt to Corner Wheat

This article will be found in this issue and is of unusual interest.

Forthcoming articles are:

The Fall of the Confederacy

By STEPHEN R. MALLORY

Secretary of the Navy in the Confederate Cabinet. This narrative was written in Fort Lafayette while Mr. Mallory was a prisoner of war. It is the most graphic description ever written of the fall of Richmond, the flight of the Cabinet, the surrender of Johnston, and the capture of Jefferson Davis. It throws entirely new light on this momentous page in our history.

Refunding Six Per Cent. Bonds

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A remarkable story of our financial operations abroad after the war, involving a tragico-humorous situation.

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All eyes are now turned toward China, whose future is fraught with grave consequences to the Eastern world. In order to give our readers the exact situation in Asia,

Frederick Palmer

well known as a journalist and war correspondent, is spending some months in that part of the world, and will furnish a series of articles of unusual interest. He will deal with China and the surrounding powers, their relations to each other, and with the rest of the world. No subject is of more interest to the American people at this time.

THE POWERS THAT PREY

A series of remarkable stories of criminal life begins in this issue. They are written by one who knows the "Under-World" from long association with the lawless classes. These stories are by

Josiah Flynt

in collaboration with Francis Walton. They are fictitious only in the sense that the characters are fanciful. The incidents are true and the characters are actual types of criminals known to the authors. In these stories the public learns the exact attitude of criminals toward society, and their relations with the official classes. This is the first time such an important work has been undertaken in so serious a manner. Mr. Flynt has travelled with social outcasts for fifteen years and is an expert in this branch of sociology. His effort is to paint the "powers that prey" just as they are. He writes with knowledge and with rare power. These stories are not only of surpassing interest but of real ethical value.

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McClure's Magazine has the distinction of having introduced to the literary world some of its most distinguished lights. Its constant aim is to discover talent.

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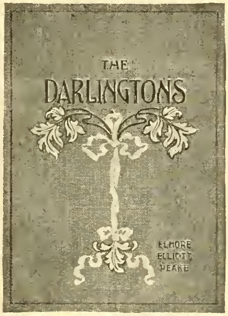

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