THURSDAY, JULY 19, 1900.

THE RELATIONS BETWEEN ETHER AND MATTER.

Æther and Matter. By Joseph Larmor. Pp. xxviii + 365. (Cambridge University Press, 1900.)

THIS work is essentially the same as an essay to which an Adams Prize was awarded by the University of Cambridge. The subject for which the prize was offered was Aberration, and as this phenomenon, together with the Doppler effect on the frequency of light vibrations are the only ones known due to the motion of matter through the ether (the spelling æther is disagreeably cumbrous), it naturally led to a discussion of the connection between ether and matter, and the effect of their relative motion on the phenomena of electro-magnetism.

There is a good deal of similarity between the development of this work and that of Maxwell's treatise. If one reads Maxwell's papers, it is pretty evident that he began with a somewhat definite hypothesis as to the nature of the strains in the ether to which he attributed electromagnetic phenomena; but in his treatise on electricity and magnetism there is hardly a trace of all this except in the reference to molecular vortices by which he justifies his equations for wave-propagation in magnetised media. In a similar way, Mr. Larmor has published papers in which the relations between ether and matter are developed in connection with a suggestion as to the nature of an electron which is only hinted at in the body of the present work, and is relegated to an appendix with some deprecatory remarks as to its being merely an analogy to show that the properties of an electron are not impossible. The hypothetical structure attributed to an electron requires the medium to possess a very remarkable property which we do not find in matter, namely, an elastic reaction against absolute rotation of its elements; and although Mr. Larmor shows that gyrostats connected with these elements might confer such a property on them, he does not go so far as to develop any very definite structure for the medium, contenting himself with having shown that such properties as he assumes are not necessarily anti-dynamical. No structure for the medium that depends on gyrostats supported by a rigid framework can possibly be more than a rough working hypothesis, being, in fact, very little better than the brass wheel and india-rubber band, or tubes full of liquid with circulating pumps, that have been suggested as models to show that Maxwell's equations do not necessarily postulate impossible or adynamical properties for the ether.

But just as Maxwell's treatise is really independent of the dynamical analogies from which it grew, so Mr. Larmor's work is really independent of his suggested working analogy as to the structure of an electron. The whole work is based upon the hypothesis that electricity is atomic in its nature, there being only two kinds of atoms, positive and negative electrons. These electrons are, he supposes, essentially centres of strain in the ether, and move from place to place in much the same way as a drop of water might move through ice, melting in front and freezing up behind. Mr. Larmor leaves it for future investigation to determine whether there is any core, like that of a vortex ring, that accompanies this complex strain wave as it moves through the ether. As to the nature of matter, the only suggestion is that it consists of clusters of electrons in orbital motion round one another; but as the dynamics of such a system has never been worked out, it is impossible either to assert or deny the possibility of a permanent existence of such clusters. If this be the structure of matter, it certainly makes it probable that the transmutation of the elements is a possible development of chemistry, while a structure such as that of knotted vortices would make it improbable that we would ever be able to untie them and thus transmute one atom into another. There is the alternative possibility that we may find means of transmuting elements within any one of their related groups, but that we may find ourselves unable ever to transmute one group into another. Of course, if we ever found out some means of manufacturing electrons and matter we could probably transmute one kind of matter into another, though this latter might be possible according to Mr. Larmor's hypothesis, while the manufacture of either electrons or matter would be impossible.

All theories that explain electric currents by the motion of electrons are really based upon Rowland's classical experiment, that a moving electric charge produces the same magnetic effects as an electric current, and its converse that the electric force due to changing magnetic induction produces the same effect in moving an electric charge that the electric force due to another electric charge would produce, *i.e.* that electric force due to these two causes is the same. Our whole treatment of electro-magnetism is practically based upon these same assumptions, but it is remarkable that so few attempts have been made to repeat this fundamental experiment of Rowland's, and no successful attempt seems to have been made to directly verify its converse. In a recent number of the *Comptes rendus* there is an account of a most interesting attempt to measure the electric current that one would expect to be produced in a surrounding coil when a convection current such as Rowland studied is being started and stopped. M. Cremieu has carried out an experiment on this with great care, and in a form in which one would certainly expect that the changing magnetic induction due to the magnetic force Rowland observed should produce an induced current in a coil of wire. He observed no such effect, and concludes that there is no magnetic force such as Rowland observed due to a moving electric charge. These moving electric charges are, however, in some respects, so imperfectly known that there may yet be some difference between driving a current by mechanical and electrical forces, and that it is still possible there may be some other explanation than that drawn by M. Cremieu as the result of his interesting and important experiment. Mr. Larmor's investigations in this treatise of the effects of moving matter hardly touch the question raised by M. Cremieu, for his investigation is concerned with steady states, while M. Cremieu's experiment is essentially concerned with variable ones. If he is right and there is really no magnetic force due to a moving electric

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charge, and if consequently we must look to some other, possibly accidental, cause for Rowland's observation, it will certainly revolutionise the whole modern treatment of electro-magnetism. The question raised by this experiment is, any way, one of the most fundamental ones in the connection between ether and matter, and it is to be hoped that this question will be settled soon in a conclusive way, either by showing that M. Cremieu's conclusion is not justified by his observation that his experiment really confirms a complete theory, or by overthrowing all our existing views, and leaving a free field for the twentieth century to build a new theory of electro-magnetism on a firmer foundation.

In discussing the result of Michelson and Morley's experiments, from which they concluded that the ether is carried along by the earth in its motion, Mr. Larmor shows that such a hypothesis is quite inconsistent with the fact of aberration and with the untenability of Sir George Stokes's suggestion that ether is like a very soft jelly. How such a soft material could be the means by which tramcars are driven by shearing stresses seems an additional difficulty in the way of this suggestion. Mr. Larmor concludes that the stone support on which the mirrors were borne changed in its dimensions, as it was rotated, by an amount proportional to the square of the ratio of its velocity to the velocity of light, and he justifies this by showing that if matter consists of clusters of electrons, just such a change of dimensions would take place as the experiment shows to take place. There is some difficulty in the hypothesis that the inertia of matter, or any large part of it, is like that of electrons and due to the motion of the neighbouring ether, because this involves the supposition that the inertia would change with the distance between the component electrons. That there may be some very minute effect of this kind is quite possible, though as yet undiscovered, but that any large effect of the kind exists seems extremely improbable. Possibly a careful study of the accuracy of Kepler's laws as applied to the solar system might show some discrepancy depending on a difference between the average distance of the electrons in such different materials as probably constitute Neptune and Mercury.

A previous question to all our explanations of phenomena by analytical dynamics is raised by Mr. Larmor in Appendix B, "On the Scope of Mechanical Explanation: and on the Idea of Force." He has utilised the principle of least action throughout his work, and this appendix is a justification of his doing so, and besides raises questions as to the applicability of dynamical explanation to the growth and decay of vital organisms. Hertz objected to the adequacy of the principle of least action as a complete solution of all possible dynamical systems, because it is not generally applicable when rolling takes place, and we cannot be sure that rolling may not be one of the fundamental facts of the dynamics of the ether. Mr. Larmor dismisses this objection on the doubtful ground that "rolling is foreign to molecular dynamics." Hertz had also objected to the principle of least action for the semi-metaphysical reason that it makes the present state of the system depend on the future as well as on the past. As Mr. Larmor himself uses in his work the vector potential which makes the state at each place depend on what is simultaneously occurring at all parts of the universe, he naturally finds no objection to the principle of least action, because it makes the present depend on all future time. Neither of these methods is unobjectionable; each is an analytical juggle, which has to be most carefully guarded lest it lead us into mistakes. The way in which the vector potential apparently locates the energy in the current instead of in the magnetic field outside it is a most serious objection to its use, although Mr. Larmor seems to have steered clear of the difficulties raised by this curious complication. In a similar way the principle of least action is open to the objection of Hertz of making the present apparently depend on the future to an extent that does not apply to his own principle of the straightest path. It is a question for consideration in connection with Mr. Larmor's discussion on the applicability of dynamics to vital phenomena whether the possibility of determining our actions by considerations as to the future is not connected with the possibility of analytically expressing the dynamics of the present by a formula which involves the future.

It will, from this meagre review, be evident that Mr. Larmor's treatise raises most fundamental and interesting questions, and is one that all who desire to strengthen the foundations of our knowledge of nature should carefully study. GEO. FRAS. FITZGERALD.

LAND RECLAMATION.

The Reclamation of Land from Tidal Waters. By Alexander Beazeley, M.Instit.C.E. Pp. xii + 314. (London: Crosby Lockwood and Son, 1900.)

THE area of this country is gradually diminishing by the continual waste that is going on all round the coast. On the Yorkshire coast it is estimated that two miles have disappeared since the Roman occupation; and more modern records show that towns and villages have disappeared with their houses and churches, and in some cases the whole parish has been washed away. Along the Norfolk coast the only record of several villages is, "washed away by the sea"; and on the Kentish coast, churches and houses have fallen down the cliffs, on which are to be seen the bones formerly deposited in a vanishing churchyard. On the south coast, although the chalk cliffs at the east end of the English Channel are subject to continual falls and slips, more care has been taken to protect them; but along the clay cliffs of Dorsetshire the waste is continuous; here twenty acres slipped down seaward in one night from the cliffs at Axminster. On the west coast, the nets of the fishermen are said to become occasionally entangled with the ruins of houses and buildings buried in the sea some distance from the coast off Blackpool.

As some compensation for all this loss due to the ever-continuous operations of nature, the energy of man has succeeded in reclaiming and recovering a large area of rich cultivatable land in estuaries where rivers have discharged great quantities of detritus picked up along their course. At no time in the history of this country were reclamations carried on to a greater extent than in the time of the Romans, and this is the more remarkable as, compared with the population at that time, land must have been plentiful. It was during this era that the great tract of low land lying on the east of England was reclaimed from the sea by the construction of 50 miles of sea-banks, and the 60,000 acres in the district known as Romney Marsh was protected from the sea by a bank 4 miles long and 20 feet high. From the time of the Romans to the Stuart period very little seems to have been attempted in this way, but at that time there are records of innumerable grants made to "undertakers" and "adventurers" who undertook to reclaim the low lands in the Isle of Axholme, Haxey Chase and the Fens of Lincolnshire and Cambridgeshire, and other parts of the country, in return for a certain proportion of the land reclaimed. Another revival took place during the present century at the time when agriculture was prosperous, and land-owners were tempted, by the high rents then paid, to reclaim from the sea numerous intakes of salt marshes by the construction of sea banks in the estuaries of the Humber, the Wash, the Thames, the Severn and other rivers. Since rents have fallen and land-owners have become impoverished by the low rents, and the heavy charges thrown on estates by the payment of the death duties, little or no inclosing has taken place. Land, however, shows signs of recovering something of its former value. The appearance, therefore, of a book dealing with the reclamation of land from tidal waters may be considered as opportune.

The only standard English book on this subject is that of the late Mr. John Wiggins on the "Practice of Embanking Lands from the Sea," which is now out of print. Instead of publishing a new edition with the extensive alterations of the text that would be required to bring this work up to date, the author of the book now under review was invited by the publishers to undertake the preparation of a new treatise, in which all that was applicable to modern practice in Mr. Wiggins' book has been incorporated.

The author has carried out his task efficiently and well, and his book contains a large amount of information that will be of great service to engineers, and also to landed proprietors and others interested in works of reclamation.

The book makes no pretensions to originality; on the contrary, it may be regarded as an epitome of the information and opinions contained in a vast number of papers contained in the *Minutes of Proceedings* of the Institution of Civil Engineers and the papers of allied societies, and in the works of authors on drainage and Fen history.

A careful perusal of a book of this character, and the principles laid down that should be observed in the reclamation of land, might have saved the expenditure of many thousands of pounds on schemes that never came to maturity or have proved financially disastrous. Of these, as examples, may be quoted the great scheme that was at one time entertained, and still has advocates, for the formation of a new county in the Wash, by the enclosure of the sands; an offshoot of which was the abortive scheme of Sir John Rennie for reclaiming 30,000 acres, the greater part of which was bare sands, which experience has since proved would have been utterly unfit for cultivation; and the Norfolk Estuary Scheme, which received parliamentary sanction in 1846 to reclaim 30,000 acres submerged at high water, and of which up to the present time, after an expenditure of nearly 400,000*l*., there has only been reclaimed 2000 acres of marsh land adjacent to the coast, a great part of which formed the bed of the diverted river. In this case, great benefit has resulted to the drainage of the country by a new direct cut made for the outfall of the river Ouse; but as a land reclamation scheme, it has been a most disastrous failure, owing to the misconception of the promoters as to the action of the sea in forming deposit on the coast, and of the difficulties attending the construction of sea banks.

Mr. Beazeley's book is divided into nine chapters, dealing respectively with: (1) General observations; (2) the site for a bank; (3) the construction of sea banks; (4) the drainage of the land reclaimed; (5) maintenance and repair of sea banks; (6) warping land; (7) cultivation after enclosure; (8) examples of reclamation, value and rents; (9) legal requirements; the text being accompanied by numerous illustrations.

THE MAMMALIAN BRAIN.

Handbuch der Anatomie und vergleichenden Anatomie des Centralnervensystems der Säugetiere. Von Dr. Edw. Flatau und Dr. L. Jacobsohn. I. Makroskopischer Teil, mit 126 Abbildungen im Text, und 22 Abbildungen auf 7 Tafeln. Pp. xvi + 578. (Berlin: Verlag von S. Karger, 1899.)

THE handsome volume before us is a welcome addition to works on the comparative anatomy of the mammalian brain. That the literature of this subject is already vast, may be gathered from the fact that nearly 300 papers are quoted at the end of the volume—this list forming indeed a most useful bibliography. So numerous and scattered are these various works, that only those students who have access to very complete libraries can hope to be able to consult the majority of them, and we have long felt the want of a trustworthy account of the structure of the brains of the various orders of mammalia in a more handy form. This want is to a great extent satisfied by the work of Drs. Flatau and Jacobsohn, which is rather of the nature of an original contribution than of a text-book. For it is no mere compilation; but, on the contrary, almost entirely consists of the description of brains studied by the authors themselves in Prof. Waldeyer's Anatomical Institute in Berlin.

With admirable care the authors describe the structure of the central nervous system of representative examples of all the living orders of mammalia. To give the reader some idea of the thoroughness of their method, one may mention that in the case of the brain of the Chimpanzee, for example, we find paragraphs on the brain weight, the relation of the brain to the skull, the general shape and measurements of the brain, followed by detailed accounts of the convolutions of the cerebral hemispheres, the structure of the corpus callosum, fornix, &c., of the Diencephalon, Mesencephalon, Metencephalon, Myelencephalon, and Medulla spinalis. Naturally the types of all the orders are not treated in quite as much detail as the Chimpanzee. At the end of the chapter on monkeys and apes are elaborate tabular statements of the authors' observations compared with those of previous writers on the subject. Throughout, the text is illustrated by excellent figures, almost all of which are original. The general reader will be especially attracted by the ingenious representations of the brain drawn inside the skull as if seen by transparency, and by the really beautiful series of plates at the end of the volume.

The work is essentially a technical and a practical one. Nevertheless, a final chapter is devoted to a general summary and conclusions. Here Drs. Flatau and Jacobsohn aim, not at bringing forth sensational results, but soberly review such general conclusions as may safely be drawn at present. These, it must be confessed, are somewhat disappointing, not, be it understood, through any fault of the authors, but owing to the inherent difficulties and complications of the subject, and the comparatively few data yet at our disposal.

As to the attempt to homologise the fissures of the cerebral hemispheres with one another in the various orders of mammalia, Drs. Flatau and Jacobsohn freely adopt Gegenbaur's conclusion, that this can only be done to a very limited extent. In most of the orders we generally find some small and lowly organised forms with almost smooth brains ; and it must always be borne in mind that the fissures and convolutions may to a great extent have been independently developed in each group.

Of the usefulness of this volume there can be no doubt, and the appearance of the continuation of the work will be awaited with interest by all workers in the subject of brain anatomy.

OUR BOOK SHELF.

The Origin of the British Flora. By Clement Reid, F.R.S., F.L.S., F.G.S. Pp. vii+191. (London : Dulau and Co., 1899.)

THIS is a useful contribution to the literature of geographical botany ; but it is unfortunate that the author has given it the ambitious title of "Origin of the British Flora." Any one entering upon the perusal of the book with the expectation engendered by its title will soon meet with disappointment, but must not be blinded thereby to its real merit, which is great, and consists in the historical records, to which two-thirds of it are devoted. The book is essentially a geologist's account of the palæontological evidence of the distribution of plants in Britain during recent geological periods. Every one will agree with the author in thinking that the historical method is the proper one for determining questions of origin, but that the "problem of the origin of our flora is one which can be solved by this method" is surely a sanguine forecast on his part, even allowing for the fact that the flora of our Tertiary deposits has not been worked out yet with much completeness ; his work is emphatic testimony to the fragmentary character of historical evidence in relation to the British flora that has been obtained up to the present time. In his "Table showing the Range in Time of the British Flora," which includes the names of species, remains of which have been found in deposits of pre-Glacial age onwards, there are not three hundred names, and of these not all have as yet been found in deposits within the present area of Britain ; and, moreover, the finds do not touch elements of the flora which have always been a crux in explanations of its origin. The first fifty pages of the book deal, in the slight manner of the magazine article rather than in the detail of a scientific treatise, with some of the problems of the origin of the present British flora. The author is on the side of those who attribute a more important influence to air-transport than to land-connection as a factor in the making of our existing flora. The Watson-Forbes hypothesis is, in a few sentences, put on one side, and a short chapter is devoted to an account of the transport-mechanism observable in the species of the flora. In Chapter iv. we have an account of the author's idea of the geographical and climatic changes affecting Britain in the late Tertiary times ; the former, the author thinks, "were of no very great importance as bearing on the past history of our flora," although they "must have tended greatly to modify local conditions, and must have sometimes aided, sometimes have hindered, the dispersal of the seeds" ; the latter have left their mark on the flora ; but at the same time "Britain shows signs of a geographical distribution of plants largely independent of that due to climate ; or perhaps we should say not governed by existing climatic conditions." It is not, however, these brief earlier chapters which give value to the book, but the later ones, containing accounts of the deposits in which recent plants have been found and of the positions of these plants.

A Manual of Marine Meteorology for Apprentices and Officers of the World's Merchant Navies. By William Allingham. Pp. viii + 182, and plates. (London: Charles Griffin and Co., Ltd., 1900.)

WE gladly give a word of welcome to this little book, written as it is by a sailor with the view of winning an increase of interest in the subject of meteorology from members of his own profession. The author knows well those for whom he is writing, so that while he has kept his book free from pedantry, he has managed to fill it with practical information and to endow it with the spirit of earnest purpose. The encouragement of a more complete survey of the complicated phenomena manifested, not only in our atmosphere, but in the ocean itself, is highly commendable, and we should imagine the author well qualified by knowledge and experience to interest the class to whom he mainly addresses himself. For he has sailed every ocean in all sorts of weather, and having himself to some extent profited by the systematised experience of others, he seeks now to widen and complete the circle of observation, so that those who come after may have still more trustworthy sources of guidance and readier means for escaping the perilous chances of navigation.

Of course, in many respects marine meteorology goes hand in hand with meteorological inquiries conducted on shore. We may pass over all such details, since the real interest of the book is more closely connected with the practical questions which arise at sea. Among these we may enumerate wave-motion, salinity and temperature of the sea, the direction and velocity of ocean currents, and the construction and use of pilot charts. Such subjects ought to have a profound interest for an intelligent officer, and the method of treatment is likely to call forth the earnest attention of any one who wishes to become really efficient. Some of these subjects may be thought to belong rather to hydrography than to meteorology ; while, again, questions connected with the behaviour of the wind in cyclones, and of the management of the ship in the neighbourhood of cyclonic disturbances, may be said to belong to the domain of seamanship or practical navigation. But there is no fixed line of demarcation between any of these subjects, and trained intelligence is of the greatest service in advancing our knowledge of subjects in which experiment and generalisation play a great part. One can easily conceive that enormous advantages would accrue to science by enlisting the services of a large army of observers, and therefore we welcome any well-considered effort which has for its end so worthy an object. The author knows perfectly well that it is impossible to do justice, within a moderate compass, to the many topics on which he touches ; but his object is served, and well served, if he can arouse an active interest in the many, and induce a few to prosecute inquiries on a more comprehensive basis.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

A Surface-tension Experiment.

SANS rien vouloir enlever à l'interêt de l'experience d'hydrodynamique signalée par Mr. Baker (p. 196), je crois pouvoir dire qu'elle n'est pas nouvelle, au moins, en tant que phénomène.

Ces sortes de formations de "vasques" liquides etaient très usitées, dans les jardins au XVII^{eme} siècle et nous en rencontrons encore aujourd'hui des exemples dans les parcs où le régime des eaux n'a pas changé depuis cette époque. Pour n'en citer qu'un, que connaissent sans doute beaucoup de vos lecteurs. je rappelerai qu' à Burgos le "paseo del Espalon viejo" possède une fontaine où l'on peut voir une belle réalisation de cette experience. Seulement, là le jet d'eau est dirigé de bas en haut et vient se briser sur un disque placé horizontalement au dessus de lui; puis retombant, il forme autour du tuyau la surface *fermée* si élégante décrite par M. Baker.

Je crois me souvenir que dans un ouvrage publié en 1663 à Nuremberg par George André Boeckler sous le titre "Architectura curiosa nova," il y a de nombreuses planches représentant des jets d'eau d'effets très variés. Peut-être la forme signalée par Mr. Baker s'y trouve-t-elle?

Il serait intéréssant de le vérifier, comme aussi de chercher la figure mathématique de cette surface fermée.

HENRY BOURGET,
de l'Université de Toulouse.

Duration of Totality of Solar Eclipses at Greenwich.

IN NATURE (vol. lxii. p. 64 and p. 86) will be found an estimate of the maximum duration of totality for a solar eclipse under the most favourable conditions, the result being 7m. 40s for a place in north latitude 4° 52′. For Greenwich I estimate the maximum duration at 5m. 47s. There is good evidence for believing that the "Nautical Almanac" diameter of the moon, used in computing eclipses, is too large. It is almost exactly 2160 miles, and should be reduced probably to 2158 miles. This reduction would alter the above estimates to 7m. 34s. and 5m. 42s. respectively. That all the conditions necessary to produce the maximum totality of 5m. 42s. will ever be simultaneously satisfied for Greenwich is extremely improbable.

Leeds, July 14. CHAS. T. WHITMELL.

THE NEW YORK MEETING OF THE AMERICAN ASSOCIATION.

AT the forty-ninth meeting of the American Association for the Advancement of Science, which was held on June 23-30, at Columbia University, New York City, two experiments were tried. The one was a change of date and the other a somewhat radical change in the character of the meeting. Heretofore, it may be remembered, the American Association has met at about the third week in August, approximately at the same time as the meeting of the British Association. The long summer vacation of the American colleges and universities usually lasts from about the end of June until nearly the beginning of October. It therefore resulted that men engaged in educational work were obliged to interrupt their summers at the seaside or the mountains, to attend the Association meetings. This has been found to be very inconvenient to many on account of the long distances in the States and the widely separated places of meeting. The present year was thought to be a particularly favourable one in which to try a change of date, since many members expected to start for Europe after the close of their college terms, and New York, as the principal port of debarkation, was chosen as the place of meeting for much the same reason.

The other experiment was in the doing away, to a large extent, with the social features and entertainments which had characterised previous meetings. It was distinctly understood that no entertainment fund would be raised in New York, and that the Association would pay its own expenses. It was, therefore, a more distinctively working scientific meeting than has been held before. The attendance was not large, and only 450 members registered. Fifteen affiliated societies held their meetings at the same time, including several which have heretofore not affiliated themselves with the older society. These were the American Mathematical Society, the American Physical Society, and the American Psychological Association. The other societies in attendance were the American Forestry Association, the Geological Society of America, the American Chemical Society, the Society for the Promotion of Agricultural Science, the Association of Economic Entomologists, the Botanical Society of America, the Society for the Promotion of Engineering, Education, the American Folk-Lore Society, and the American Microscopical Society.

The session was opened by the retiring President, Mr. G. K. Gilbert, who was elected at the December meeting of the Council to fill the vacancy caused by the death of Dr. Edward Orton last autumn. Mr. Gilbert introduced the incoming President, Prof. R. S. Woodward, of Columbia University, who thereafter presided over all the general sessions of the Association. A cordial and eloquent address of welcome was made by Mr. Seth Low, President of Columbia University; and Mr. James Wilson, the Secretary of Agriculture in President McKinley's Cabinet, upon being invited to address the Association, made a strong plea for applied science. On Tuesday afternoon the addresses of five of the Vice-Presidents were given, the other four being postponed until next year.

Vice-President Asaph Hall, junr., addressed the Section of Mathematics and Astronomy on the teaching of astronomy in the United States. Prof. Hall urged that elementary astronomy should be taught in the high schools and preparatory schools as well as in the colleges. Elementary astronomy he defines as meaning such part of the science as can be learned by an intelligent student without mathematical training. He advocated the study of the history of astronomy as a culture study in the colleges, showing that the earliest religious festivals depended upon astronomical observations. An interesting feature of this historical side would be the philosophical study of the different theories of the universe. He advocated the more general teaching of spherical astronomy and the elements of celestial mechanics, and showed that during the past twenty years great advances in astronomical teaching have been made in the States. In his opinion the best equipped observatory for teaching purposes is at Princeton, and the theses in practical astronomy produced in America compare favourably with those presented in Germany and France.

Vice-President Merritt addressed the Section on Physics on the subject of "Kathode Rays and some Related Phenomena," referring to the various views which have been advanced concerning the nature of the kathode rays, and the general adoption of the Crookes' theory of electrified particles. He gave an account of the progress made during the last ten years, and discussed recent experiments concerning the size of the ray particles and the speed at which they travel. Minor difficulties in the present theory were pointed out, and the probable direction of further progress was indicated. Lantern views were shown illustrating various vacuum tube phenomena related to kathode rays.

The address of Vice-President Howe before the Section of Chemistry was on the subject, "The Eighth Group of the Periodic System and some of its Problems." It was pointed out that in the early work of Newlands and of Mendeléeff, which subsequently developed into the periodic law, a serious difficulty was met with in dealing with iron, cobalt, nickel, and the metals of the platinum group.

In his first summing up of the principles of the periodic law in 1869, Mendeléeff concludes that "elements which are similar as regards their chemical properties have atomic weights which are either of nearly the same value (*e.g.* platinum, iridium, osmium) or which increase regularly (*e.g.* potassium, rubidium, cæsium)." So in most schemes for representing the periodic system, each triplet of these elements is considered as a single element, and because even then they do not seem to fall into regular periodic arrangement, they are cast out, Ishmael-like, into an anomalous eighth group. This is doubtless the reason they have been relatively so much neglected by chemists, and possibly it is not incorrect to say that the chemistry of these metals is less known than that of any other group of well characterised elements. Yet there are certainly no nine nearly related elements which present so many interesting chemical problems, the solution of which will so much further our knowledge of chemistry in general. Prof. Howe dealt in detail with this eighth group and some of its many problems.

The ordinary division of these nine metals is into three groups, viz., the common metals, iron, cobalt and nickel, with an atomic weight of from 56 to 59 and a specific gravity of 7·8 to 8·9; the lighter platinum metals, ruthenium, rhodium and palladium, with an atomic weight 101·5 to 106·5 and a specific gravity of about 12; and the heavy platinum metals, osmium, iridium and platinum, of atomic weight 191 to 195 and specific gravity 21·5 to 22·5. These nine metals are held to fulfil every definition of an element, and are just as much to be looked upon as simple elementary substances as any of those substances which are called elements. Though refined determinations may change, to a slight extent, the atomic weights of some of these elements, especially those of ruthenium and osmium, the weights of these elements relative to each other, and hence their position in the periodic system, will probably remain unchanged. This carries with it the conclusion that in the periodic table an element may have an atomic weight slightly lower than that of the element which precedes it.

Reference was made to the natural grouping of the elements of the eighth group into three triplets, iron, ruthenium, osmium; cobalt, rhodium, iridium; and nickel, palladium, platinum. That this is a natural grouping is attested by a comparison of the compounds of these metals. However, in considering now some of these compounds, the evidence of this grouping is only incidentally presented; Prof. Howe directed attention to some of the more unusual of these compounds, especially with reference to problems which this group presents, and to problems of other groups, suggested by the chemistry of this group.

Vice-President Kemp, before the Section of Geology and Geography, spoke upon the "Pre-Cambrian Sediments in the Adirondacks." He showed that the Adirondack area of ancient crystallines in Northern New York covers about 12,000 square miles. It has long been known that in the gneisses and eruptive rocks which constitute it, crystalline limestones of undoubted sedimentary origin occur in many places. The address presented the results of the work of the last ten years upon these sediments. It has been recently learned that ancient sandstones are also present, and many gneisses, which are doubtless altered shales. The crystalline limestones are in greatest individual areas in the north-west, where the belts have been shown to be from twenty to thirty-five miles long and from two to six miles broad; but they are most numerous on the east, where the speaker has now located over fifty different localities of relatively thin beds. In their structural relations these narrow beds on the east are interstratified with the gneisses, and are more especially associated with fragmental sediments. From these relations the argument is drawn that the sediments were extensive, that they involved more limestone on the west and more sandstone and shale on the east, and that many gneisses represent former shales. It was further shown that these strata are profoundly metamorphosed, and in such a way that the changes must have been produced while the rocks were under a heavy over-lying load, and were deeply buried. Evidence was brought forward to prove that this burden consisted of pre-Cambrian rocks. The speaker said that, inasmuch as there are abundant eruptive rocks present of a coarsely crystalline type, which were likewise produced under deep-seated conditions, it is assumed that they represent the deeper rocks of an old and very extensive volcanic area, whose tufas and lavas built up the burden of pre-Cambrian rocks, which have now disappeared, and which made possible the metamorphosis of the ancient sediments.

Vice-President Trelease, before the Section of Botany, delivered an address under the title, "Some Twentieth Century Problems," passing in review the great utilitarian development of botanical science during the present century, and indicating its probable greater advancement along utilitarian lines during the next hundred years. He made a general statement of the great problems to be met and solved, and considered in detail the necessity and means of co-operation in the treatment of species and their nomenclature, and in details of publication which are becoming daily of more evident importance for the greatest possible advancement of science. In conclusion he made a strong plea for the establishment of a Government Reservation in the Redwood (*Sequoyia sempervirens*) Forests in California, not only as a means of preserving a forest growth which can never be reproduced, but as furnishing the means of solving many problems closely connecting biology and meteorology, which may ultimately be of the greatest economic utility.

The address of the retiring President, Mr. G. K. Gilbert, was delivered on Tuesday evening at the American Museum of Natural History. His subject was "Rhythms and Geologic Time." This address appears in another part of the present number of NATURE.

The programmes of the sectional meetings were very full, and the discussions in the sections of mathematics and astronomy, physics, chemistry and botany were especially animated and prolonged.

Several important matters were decided upon by the Council. Perhaps that of the greatest general interest to members of the Association was the decision to try the experiment during the year beginning January 1, 1901, of publishing all official notices and proceedings of the Association in the journal *Science*, and of sending that journal to all members of the Association at the expense of the Association itself, and without charge to members beyond their annual dues. This will not make *Science* precisely the official organ of the Association, since the management and the editor will remain as before, and the Association will have no strict supervision of the conduct of the journal. The annual volume of proceedings will be reduced during that year, and possibly for future years, should the experiment prove a success, to a business record of the affairs of the Association, including lists of members and fellows, the text of the constitution, and possibly a list of the papers presented at the meetings.

Amendments to the constitution were adopted, establishing a new section of Physiology and Experimental Medicine (Section K), and lengthening the term of office of the Treasurer of the Association from one year to five. A discussion of the new International Association for the Advancement of Science, Art and Education was introdnced, and conservative action was taken which simply expressed approval of the idea of international co-operation in the field of science, and promised to designate a delegate to a national conference having that end in view.

Grants were made to the Committee on Anthropometric Measurements; to the Committee on the Quantitative Study of Biological Variation; to the Committee on the Study of Blind Vertebrates; and to the Committee on Study of the Relation of Plants to Climate. The last two committees were established at this meeting. The one on Blind Vertebrates consists of Mr. Theodore N. Gill (chairman), Messrs. A. S. Packard, C. O. Whitman, S. H. Gage, H. C. Bumpus and C. H. Eigenmann. The one on Relation of Plants to Climate consists of Messrs. Wm. Trelease, D. T. MacDougall and J. M. Coulter.

Resolutions were adopted urging upon the Government of the United States (1) the establishment of a bureau of standards in connection with the U.S. Office of Standard Weights and Measures; (2) the establishment of a Government Reservation in the Primeval Redwood Forest, situated in the Santa Cruz Mountains in California; and (3) the establishment of a Government Reservation in some portion of the hard wood forests of the Southern Appalachian region.

At the meeting of the General Committee held on the evening of the June 28, the city of Denver, Colorado, was chosen as the place for the next meeting, and the time selected was the week ending August 31. The choice of Pittsburg, Pa., as a meeting place in 1902 was recommended by formal resolution.

On the same evening the following officers for the ensuing year were elected:—For President, Prof. Charles Sedgwick Minot, of the Harvard Medical School; for Vice-Presidents, as follows:—Section A, Mathematics and Astronomy, Prof. James MacMahon, of Cornell University; Section B, Physics, Prof. D. T. Brace, of the University of Nebraska; Section C, Chemistry, Prof. John H. Long, of the North-western University; Section D, Mechanical Science and Engineering, Prof. H. S. Jacoby, of Cornell University; Section E, Geology and Geography, Prof. C. R. Van Hise, of the University of Wisconsin; Section F, Zoology, Prof. D. S. Jordan, of Stanford University; Section G, Botany, Mr. B. T. Galloway, of the U.S. Department of Agriculture; Section H, Anthropology, Mr. J. Walter Fewkes, of the Bureau of American Ethnology; Section I, Social and Economic Science, Mr. John Hyde, Statistician, U.S. Department of Agriculture. General Secretary, Prof. Wm. Hallock, Columbia University; Secretary to the Council, Dr. D. T. MacDougall, New York Botanical Gardens.

THE WELLCOME RESEARCH LABORATORIES.

IT is a remarkable sign of the times when the head of a firm principally distinguished for the introduction into this country of American methods of dealing with drugs, *i.e.* by putting them up in new and convenient shapes and doses, goes out of his way to fit up extensive research laboratories. This is what Mr. Wellcome has done. In 1896 laboratories were established in the business premises of the firm in Snow Hill. Now, after four years, during which the work continued to grow, it has been found necessary to give a complete house to the department. A well-built modern house has been secured at No. 6 King Street, Snow Hill, and has been converted into a series of three commodious and well-fitted laboratories, a library and office, and a store-room and workshop-laboratory. Each laboratory is self-contained, and each is connected with the other and with the directors' office by means of telephones. The basement contains a good-sized electric motor, and a dark room for polarimetric and photographic work. Use has been made of the electric mains to heat radiators for the distillation of ether, benzene and other inflammable liquids. The whole is under the direction of Dr. T. B. Power, F.I.C., who has a staff of four assistants, all men who have been carefully selected for their attainments and skill in actual research.

Mr. Wellcome is to be congratulated on his enterprise. His firm, considering the nature of their business, might well have acted on the supposition that research was not strictly within their province. They might have argued, "Research is the business of the drug manufacturer and the manufacturing chemist; it does not concern the compounder of medicines." Their success in former years is a solid argument in favour of such a view, which can be very easily strengthened by a consideration of the success of many firms who have pursued an exactly similar line of business.

Mr. Wellcome intends to carry on his laboratories in no narrow spirit; this means, I presume, that he has other views than the conversion of his business into a chemical manufacturing concern. Though much work is done towards the perfection of the firm's preparations, time has been found for several researches which have been published, and other work of this kind is in hand. At present the bulk of the work is carried out on the natural drugs, very little having been undertaken in the direction of investigations leading to the discovery or further knowledge of the properties of artificial medicinal substances. There is undoubtedly a vast field in the direction so far pursued, but every one must hope that the other will not be neglected, and that at length this country may make a contribution to the number of substances of medicinal value derived directly and not through the medium of plant or other life from the carbon compounds of the aromatic series.

The laboratories were informally opened on June 18, when at Mr. Wellcome's invitation a number of gentlemen interested in science, together with some representatives of the Press, were received by Dr. Power and conducted over the building. All interested in the advance of chemistry, whether pure or applied, will wish Mr. Wellcome success, and also that he may find imitators among the numbers of firms who are meditating an advance in the direction of a more scientific method of conducting their manufactures. R. J. FRISWELL.

NOTES.

IN the House of Commons on Tuesday, Mr. Goschen announced that a committee of experts would be appointed to inquire into the efficiency of water-tube boilers in actual operation in different types of ships of H.M. Navy.

THE Additional Estimate for the Navy for the year 1900–1901 includes 9500*l.* for wireless telegraphy apparatus; 3600*l.* for telescopic sights for quick-firing guns; and 16,500*l.* for gyroscopes for Whitehead torpedoes.

THE scientific congresses to be opened in connection with the Paris Exposition during the present month are:—July 19–25, applied mechanics; July 23–28, applied chemistry; July 19–21, naval architecture and construction; July 28–August 3, navigation; July 28–August 4, chronometry; July 23–28, photography; July 18–21, homœopathy; July 23–28, professional medicine; July 27–29, medical press; July 27–August 1, electrology and medical radiology.

WE have been notified that the title of the subject for discussion at the joint meetings of the Institution of Electrical Engineers and the American Institute of Electrical Engineers to be held in the American Pavilion in the Paris Exhibition on the morning of Thursday, August 16, is "The relative advantages of alternate and continuous current for a general supply of electricity, especially with regard to interference with other interests." We understand it is specially desired to discuss how far interference with other undertakings, rather than ordinary commercial and industrial conditions, will come to be a determining factor in the selection between continuous and alternating currents. It is expected that many members of the American Institute will spend a few days in London on their way to the joint meeting in Paris. Arrangements are being made to entertain the visitors, and it is hoped that a large number of the British members will assist in making the visit a memorable one.

A CIRCULAR-LETTER has, this week, been addressed to the students of the Institution of Electrical Engineers informing them that the Council of the Institution propose to grant 5*l.* to each of twenty selected students to assist them to visit the electrical exhibits in the Paris Exhibition. Intending candidates must send in their applications by Saturday, July 28. In the selection, the Council will give preference, other things being equal, to those who, being still students of the Institution, have either, or both, read papers before the students' section, or been members of the committee of that section.

THE Paris Société d'Encouragement has awarded the following medal and prizes:—Gold medal to M. Potier for his work in physics; 2000 francs to M. Codron for his works on machine tools; 2000 francs to MM. Charabot Dupont and Pilet for their work on essential oils; 500 francs to M. Halphen for his work on the analysis of fatty bodies, and to M. Blanc for his work on the constitution of camphor; 500 francs to M. Granger for his study of the application of tungsten blue to ceramics; and 1000 francs to MM. Coudon and Boussard for their study of the potato.

THE Paris correspondent of the *Chemist and Druggist* announces that the late M. Milne-Edwards, director of the Paris Museum of Natural History and professor of zoology at the Paris School of Pharmacy, has bequeathed his scientific library, which is exceptionally complete and valuable, to the Paris Museum. The books are to be sold, and the proceeds will be applied towards maintaining the professorship of zoology, which the deceased *savant* occupied with so much distinction. M. Milne-Edwards also bequeathed 20,000 francs to the Paris Geographical Society, of which he was president, and 10,000 francs to the Société des Amis des Sciences.

FOR several days in last week the weather was very warm over a large part of England, and in London the temperature frequently exceeded 80°. This week the temperature has still further increased, and on Monday the thermometer in the screen registered 94° at Greenwich, which is the highest reading in July since 1881, and is higher than in any summer since 1893, while in all there have only been seven days during the last sixty years with so high a temperature there. At Camden Town the shade temperature registered 95°·2, the highest reading there since 1858. Thunderstorms developed at the beginning of the week over a large part of the country, but no appreciable amount of rain has fallen in London for about a fortnight.

WE learn from *Science* that it is proposed to celebrate the 70th birthday of Prof. Wilhelm Wundt, which will occur on August 16, 1902, by the publication of a "Festschrift," to which his former students are invited to contribute. The manuscripts must be forwarded to Prof. Külpe, Würzburg, not later than January 1, 1902.

IT was recently stated in the public press that postal packets containing plants for transmission to England were refused at Swiss post-offices on the ground that the plants would not be permitted to enter England. The Board of Customs has, however, just stated that there is no objection to the importation of plants from Switzerland, if they are sent by parcel post or letter post. But plants must not be sent by sample post, and the refusal of packets presented for transmission as samples appears to have produced the impression that the importation of flowers is not allowed.

AN exhibition and conference and other meetings will be held at the Crystal Palace, Sydenham, on July 20 and 21, in celebration of the bicentenary of the introduction of the sweet pea to Britain from Sicily in 1700. Some authorities hold that two forms, having a general relationship one to the other, were introduced, one from Sicily and the other from Ceylon. The history of the sweet pea and its earlier development will be dealt with at the conference meetings which are to be held in connection with the celebration. Many foreign horticulturists are giving the celebration their support in various ways; and one of the papers at the conference will deal with the culture and development of the sweet pea in the United States, where many fine varieties have been cultivated.

THE *Times* states that the construction of the vessel designed by Mr. W. E. Smith, one of the chief constructors to the Admiralty, for the National Antarctic Expedition, is now in active progress at the yard of the Dundee Shipbuilders' Company. The ship, which is to be named the *Discovery*, is to be barque-rigged and to have three decks. Accommodation for those on board will be provided under the upper deck. The stem will be of the ice-breaker type, with strong fortifications. The length of the vessel between perpendiculars is 172 feet; beam, 34 feet, and depth, 19 feet. The timbers are of oak dowelled and bolted together, and the keel, deadwoods, the stem, and the stem-posts are also of oak. The planking is of American elm and pitch pine, and the inside beams are of oak. With the object of avoiding the magnetic influence of iron on the scientific instruments on board, it has been decided that for a considerable radius amidships the knees and fastenings shall be of naval brass. In case the *Discovery* should have to winter in the ice, a heavy waggon cloth awning of strong woollen felt is to be provided. The fittings and equipment of the vessel will be of the most modern type. The engines, which are to indicate 450-horse-power, are to be constructed by Messrs. Gourlay Brothers and Co., Dundee.

NEWS has just reached this country of the death of a well-known geologist, Prof. G. H. F. Ulrich, F.G.S., who, since 1878, held the position of director of the School of Mines connected with the Otago University, New Zealand. Prof. Ulrich fell from a cliff while gathering rock specimens at Port Chalmers, and the injuries he received terminated fatally. Prof. Ulrich was born at Clausthal-Zillerfeld, Germany, in 1830, and was educated in his native town at the High School, and subsequently graduated at the Royal School of Mines, Clausthal, Hartz. He went to Forest Creek, Victoria, in 1854, and was appointed in 1857 assistant secretary and draughtsman to the Royal Mining Commission in Victoria. He was afterwards appointed assistant field geologist under Mr. Selwyn in the Geological department of Victoria. He continued an officer of the Geological Survey department until its abolition in 1869, when he became curator of the mining section under Mr. Newbery, superintendent of the industrial and technological museum and lecturer in mining at the University of Melbourne. He was appointed by the South Australian Government to report on their copper mines and goldfields, and in 1875 he paid his first visit to New Zealand and reported on the Otago goldfields. In 1877, the Otago University Council having decided to institute a school of mines, the Chancellor secured the services of Prof. Ulrich for the Otago University. The School of Mines was for some years small, and not very fully equipped, but in 1887 additional lecturers were appointed, and as the advantages of the course came to be appreciated, the number of students increased rapidly, and the attendance is now very large. Through the energy of Prof. Ulrich the models and appliances which had been procured from time to time became a valuable collection, especially in the mineral department, to which he was constantly adding from his own private collections of minerals and stones.

THE Committee on Indexing Chemical Literature presented their report of progress at the recent meeting of the American Association. From it we learn that Dr. Alfred Tuckerman has completed and sent to the Smithsonian Institution a supplement to his index to the literature of the spectroscope, which covers the period from 1887 to 1899. Dr. H. Carrington Bolton's second supplement to his select bibliography of chemistry, containing a list of 7500 chemical dissertations, is passing through the press; it will form a volume of the Smithsonian Miscellaneous Collections. Mr. A. G. Smith, of Cornell University, is engaged on an index to the literature of selenium and tellurium, which, it is expected, will be completed this summer. Dr. Frank I. Shepherd proposes to make a bibliography of the alkaloids. Mr. Frank R. Fraprie contemplates preparing an index to the literature of lithium.

IN the *Revue Générale des Sciences*, M. Louis Olivier gives some further particulars of Poulsen's "telegraphone," which is attracting attention at the Paris Exhibition. He describes several devices for increasing the volume of sound, or "intensifying" the record, to use the language of the photographer. The steel band with the consequent poles, which forms the original record, is made to pass between the poles of an electromagnet, which transfers the record to another band. This may be done several times over, and the record taken simultaneously from all the bands. In another arrangement the record is intensified by passing it very rapidly through the second magnetic field, which, as we know, has the effect of increasing the induced currents, and therefore also the intensity of the secondary record.

A NOVEL type of Newton's rings is described by Mr. A. C. Longden in the current number of the *American Journal of Science*. They are prepared by exposing a glass plate to the kathode rays emitted from a small globule of selenium. The film thus deposited is thickest at the point exactly opposite the globule, and tapers off towards the sides. The result is a film in the shape of a very flat lens, the upper and lower surfaces of which reflect light somewhat in the same manner as the upper and lower surfaces of the air film in Newton's device, with the difference, however, that in Mr. Longden's arrangement the film tapers outward instead of inward. Hence the rings increase in breadth and brilliancy away from the centre, and the order of the colours is reversed. The effect is described as very pretty.

THE annual list of the staffs of the Royal Gardens, Kew, and of botanical departments and establishments at home, and in India and the Colonies, in correspondence with Kew, has just been issued as an appendix to the *Bulletin of Miscellaneous Information*. We notice that sixty-six of the officers of the various botanic gardens have been trained at Kew, and seventeen others were appointed on the recommendation of the director of the Royal Gardens. With so many efficient observers distributed over our possessions it is not surprising that Kew is able to be of great service to the Empire as well as to science.

PLAGUE has now been established in Sydney for several months, and in an address delivered before the New South Wales Branch of the British Medical Association, Dr. Frank Tidswell of Sydney recently discussed a variety of interesting questions relating to the disease. Referring to his remarks on rats, the *Lancet* points out that there are instances which show that the presence of a plague-rat is often responsible for the illness in man. For example, a number of dead rats found one morning in a cotton factory at Bombay were removed by twenty coolies. Within the three following days about half of them fell sick with plague, whilst those in the store who had not touched the rats were not affected. Again, the coachman of an English family in Bombay found a dead rat in a stable and removed it. Three days later he fell sick with plague and died in a few hours, no other person in the same house being affected. Many persons, however, have caught plague without handling plague rats, and many persons have handled plague rats without catching plague. To explain this difficulty Simond has suggested that the infection is carried by the fleas natural to the rats. Perfectly healthy rats harbour very few fleas, and are very expert in removing them, but fleas are abundant on sick rats. After death, as the body becomes cold, the fleas leave it. In this way Simond accounted for the fact that a plague rat may be handled with impunity some hours after death. If the fleas from the dead rat reach another rat or a human being, they may inoculate the bacilli they acquired by ingesting the blood of their former host. In some of Simond's experiments sick and healthy rats in separate cages were enclosed in a glass jar, and it was found that when no fleas were present the healthy animals did not become infected.

COLOUR photometry is a subject that Sir William Abney has made his own, and in his last communication to the Royal Society he describes a method of estimating the luminosity of coloured surfaces that is especially applicable when the source of light is a large surface, such as the sky. In "Colour Photometry, Part iii." it was shown that only one ray of the spectrum, a greenish-yellow, progressed in luminosity at the same rate as white light. If, for example, red, greenish-yellow, blue and white lights are made of equal luminosity, and the illuminating beams are simultaneously and equally reduced in intensity, the luminosity of the red will diminish the most rapidly, that of the blue the least rapidly, the other two remaining equal. Moreover, the colour disappears more quickly than the luminosity (except in the case of pure red), tending towards greyness, so that colours of feeble luminosity are more easy to match than bright colours. The new method of colour photometry is based upon these facts. By means of concentric rotating discs, which are, when necessary, slit radially and interlaced, the proportion of black and white that matches first a green and then a yellow disc is determined. The comparisons are facilitated by observing the rotating discs through a "black transparent medium," such as an unstained developed photographic film, which may be so dense that the colour practically disappears, giving place to a dull grey. The value of a red disc is ascertained by interlacing it with the green and blue discs to produce a grey, which is then matched with the black and white. Thus, having three standard colours of known values, the luminosity of any other colour can be ascertained by substituting a disc of it for one of the standard colours to produce a grey, and matching the grey as before. The results given by this method agree closely with those obtained by the method previously described by the author. Sir William Abney has in this way determined the luminosities of various coloured surfaces and calculated the amount of black necessary for each, so that they shall be reduced to equal luminosity. He has then prepared a disc divided into several annuluses, each partly coloured and partly black, so that when rotated the whole appears of equal luminosity when illuminated by the light for which it is calculated. By the selection of suitable colours such a disc is a very convenient and effective test for any defect in either the colour sensitiveness of a photographic plate, or in the coloured screen used to compensate its inherent deficiencies in this matter. For the rotating disc, which is equally luminous throughout, will give, when the negative is developed, an image of equal density throughout, if the sensitive plate and colour screen are properly adjusted to each other.

THE U.S. Weather Bureau has published a *Bulletin* (No. 29), entitled "Frost fighting," by Mr. A. G. McAdie. A bulletin on the same subject was recently issued by the Bureau, but it is believed that the more recent experiments made in California are sufficiently valuable to extensive fruit interests to justify this second publication, and that the loss due to frosts in that State, hitherto considered unavoidable, can be prevented. The problem is of a two-fold nature: accurate forecasting of the frost period, and efficient methods of raising the temperature at critical times. The various protective methods, based on irrigation, the production of cloud or fog, and devices for screening the fruit trees are photographically illustrated. Of all the methods proposed, with the exception of the use of wire screens, irrigation has the largest amount of evidence in its favour; hot water from a boiler is forced through a number of furrows, and the temperature of the air is heated by the rising of the water-vapour.

WE have received from the Rev. W. Sidgreaves a copy of the results of meteorological and magnetical observations at Stonyhurst College Observatory, near Blackburn, for the year 1899. This observatory is fully equipped with self-recording instruments, and has for many years published valuable observations both independently and in connection with the Meteorological Office. During the past year a special report of hourly rainfall from 1891 to 1898 was prepared for that office. Much attention is given to solar observations and to the connection of sun-spots with terrestrial phenomena. The movements of the upper clouds, and the determination of the magnetic elements, also occupy the special attention of the small available staff of the observatory. An appendix contains observations taken at St. Ignatius College, Malta.

IN a paper on malformed specimens of the common pond-mussel, published in the last issue of the *Journal of Malacology*, Mr. H. H. Bloomer shows that in certain instances this mollusc is able to repair severe injuries to the mantle-lobes, but cannot make good damage inflicted on the gills.

DR. H. L. BRUNER communicates to vol. xvi. No. 2 of the *Journal of Morphology* the results of observations on the hearts of lungless salamanders, in which it is shown that with the lungs disappears also the septum between the auricles of the heart. Since, however, the normal circulation is not yet fully understood, it would be premature to discuss the reason for this loss.

IN the June issue of the *American Naturalist*, Miss Rathbun continues her invaluable illustrated synopsis of North American invertebrates, dealing in this section with certain groups of crabs. It may be hoped that, when complete, this synopsis will be reissued in book-form.

THE phylogeny of the butterflies of the family Pieridæ (best known by the ordinary British "whites") is discussed by Mr. A. R. Grote in No. 161 of the *Proceedings* of the American Philosophical Society. The author is of opinion that the family is an offshoot from the Hesperiidæ, or skippers, which is itself related to the Nymphalidæ, and that the "blues" may likewise be another offshoot from the same stock. From the scant evidence afforded by fossil forms, it further seems evident that the blues and the whites are modern types of butterflies, while the skippers and the nymphalids are of greater antiquity.—Anthropologists will find considerable interest in a paper on the divisions of the South Australian Aborigines, by Mr. R. H. Mathews, which appears in the same serial.

IN a paper published in the *Comunicaciones* of the Buenos Aires Museum (vol. i. No. 6) Dr. F. Ameghino describes and figures certain mammalian remains from the areniscan formation of southern Patagonia. These remains are stated to be found in association with those of dinosaurs as well as of fishes of the genera Synechodus, Lepidotus and Ceratodus, and the formation is accordingly correlated with the lower Cretaceous of Europe and the United States. The mammalian remains are, however, of such a highly specialised type that it is almost impossible to believe they can be of such great antiquity; and it seems probable that some other explanation of their alleged association with Cretaceous types will have to be found.

WE learn from the *American Naturalist* that a school of applied agriculture and horticulture will be established near New York City, to open in September, for study and practical training. Students will have the use of the laboratories and of the extensive collection of plants in the museum and conservatories and in the grounds of the New York Botanic Garden. The work will be under the direction of Mr. George T. Powell.

THE following facilities for the practical study of biology during the summer vacation are offered in the United States, in addition to those already announced. The Biological Laboratory of the Brooklyn Institute of Arts and Sciences at Cold Spring Harbour, Long Island, will be open from July 1 to August 25, under the guidance of Prof. Davenport. The Lake Laboratory of the Ohio State University at Sandusky, Lake Erie, will be open for eight weeks from July 2. Four courses of lectures will be given in zoology, and three in botany. The Rhode Island summer school for nature study is holding its session at Kingston, R.I., from July 5 to 20. Beloit College, Wisconsin, will hold a summer school on Madeline Island, Lake Superior, from July 26 to Aug. 30. The natural science camp for boys will hold its eleventh session at Canandaigua, N.Y., under the management of Mr. Albert L. Arey. Instruction will be given in biology, entomology, taxidermy, and photography.

THE *Biologisches Centralblatt* for June 15 and July 1 contains a detailed biography of the late eminent diatomist, Comte Abbé F. Castracane, together with a complete bibliography of his very numerous contributions to botanical literature.

Bulletin No. 10 (February 1900) of the Michigan State Agricultural College Experiment Station (Agricultural Department), is devoted entirely to investigations in the cultivation of the sugar-beet, by Mr. J. D. Towar, chiefly in relation to the advantages of different soils and manures.

PROF. L. ERRERA reprints from the *Revue de l'Université de Bruxelles* a paper on spontaneous generation, one of a series of essays on botanical philosophy. After a historical account of the controversy, he sums up thus:—"Si donc la génération spontanée est encore irréalisée dans nos laboratoires, rien ne prouve qu'elle soit à jamais irréalisable."

WE have received the *Transactions* of the British Mycological Society for the season 1898–1899. It contains the address of the President, Dr. C. B. Plowright, on the recent additions to our knowledge of the Uredineæ and Ustilagineæ, with special reference to British species, a report of the New Forest fungus foray, and five papers on new or rare fungi.

THE economic geology of the United States is very amply dealt with in the larger reports of the Geological Survey, while individual States publish reports on particular subjects. One of these on the clays of Alabama, by Dr. E. A. Smith and Dr. H. Ries, has just reached us. The State yields china clay, fire clay, pottery clay, and brick clay, all of which are very fully described with regard to their characters, geological age and distribution, and a number of analyses are given. In addition to the local account, there is also a general discussion of clays, their chemical, physical and mineral characters, such as will be of great use to any one studying the subject from a scientific as well as economic point of view. Mention is made of beds of white pulverulent silica, which when mixed with clay has been used in the manufacture of a paint.

WE have received from the Geological Survey of Canada, Part I of a "Catalogue of Canadian Birds," by Mr. J. Macoren, dealing with water-birds, gallinaceous birds, and pigeons.

THE third volume of Prof. G. O. Sars's "Account of the Crustacea of Norway," dealing with the anomalous group Cumacea, is in course of publication by the Bergen Museum. Parts v. and vi., devoted to the Diastylidæ, have just been issued.

PART 10 of Memoir III. of the Australian Museum, Sydney, on "The Atoll of Funafuti" has now been issued. It is the concluding part of the memoir, and contains lists of the contributors and plates, and an index to the whole work.

MESSRS. ISENTHAL AND CO., have issued a revised edition of their list of apparatus and accessories for work with Röntgen rays. Particular attention is given by this firm to the design and construction of instruments for radiographic work, and any one contemplating an installation for this purpose will find the list just issued well worth examination.

THE additions to the Zoological Society's Gardens during the past week include a Patas Monkey (*Cercopithecus patas*, ♀) from West Africa, presented by Mr. W. B. Davidson Houston; a Rhesus Monkey (*Macacus rhesus*) from India, presented by Mrs. Heigham; a Common Marmoset (*Hapale jacchus*) from South-east Brazil, presented by Mrs. Alexander Grant; two Grey-headed Love-Birds (*Agapornis cana*) from Madagascar, presented by Mrs. Harry Blades; a Cuckoo (*Cuculus canorus*), European, presented by Mr. L. W. Wiglesworth; an Entellus Monkey (*Semnopithecus entellus*, ♀) from India, a —— Bear (*Ursus*, sp. inc.) from Kuldja, a Himalayan Snow Partridge (*Tetrogallus himalayensis*) from the Himalayas, two Brazilian Tortoises (*Testudo tabulata*) from South America, deposited; a Sharp-nosed Badger (*Meles leptorhynchus*) from China, a Rough Fox (*Canis rudis*) from South America, purchased; a Little Bittern (*Ardetta minuta*), European, received in exchange; a Brindled Gnu (*Connochoetes taurina*, ♀), an Altai Deer (*Cervus eustephanus*), born in the Gardens.

RHYTHMS AND GEOLOGIC TIME.[1]

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 vigour or prestige. It has been a marked favourite, 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.

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 geological 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 favour 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 unequal in 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 biological inference does not therefore stop. The oldest known fauna,

[1] Abridged from an address to the American Association for the Advancement of Science, at New York, June 26, by the retiring President, Mr. G. K. Gilbert. By the courtesy of the Editor of *Science*, advance proofs of the address were received.

the Eocambrian, does not represent the beginnings of life, but a well advanced stage, characterised 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 geological 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 cannot 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. Realising 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 geologist must employ from three to five digits, while the physicists need but one or two. When these enormous discrepancies were first realised, 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 colour, 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 colour 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 characterised 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 neighbouring 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.[1] 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. 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 centre, or is 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 theoretical 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.

[1] An attempt to frame a working hypothesis of the cause of glacial periods on an atmospheric basis. *Journ. Geol.*, vol. vii., 1899.

Now, the point of interest in the present connection is that the astronomical 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.[1]

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 centre 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 astronomical cause the alterations 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 astronomical rhythm of geological 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 emphasised; 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 geological 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 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 geological scroll bears many separate lines, one for each district where rocks are well displayed, but these are not independent, for they are labelled 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 neighbouring 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

[1] 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.

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 nto 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 cannot be expected to characterise 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, cannot 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 20,000 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 astronomical 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 behaviour 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 geological process which obtains in a particular province and in a particular era, but whenever the conditions are favourable 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 unfrequently 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 standpoints, 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 RELATION OF STIMULUS TO SENSATION.

NOTHING has done more to place on a scientific footing the discussion of the phenomena which the study of matter and energy presents to the eye of reason, than the establishment of a doctrine of quantitative equivalence. So much oxygen and hydrogen, so much water; this amount of energy of chemical separation gone, that amount of sensible heat gained. In a similar way, nothing is likely to do more to give support to the hypothesis that sentience or consciousness is a concomitant of certain physiological processes than the establishment of a quantitative relation between stimulus and sensation.

It has, indeed, long been obvious that some general relation of this kind holds good. Increased physical pressure is, within certain limits, increasingly felt; more light gives a higher degree of visual sensation; the greater the amplitude of the vibrations of a violin-string the fuller and louder the sound. Such statements are, however, indefinite. We want to know how much the physical increase must be to give just so much increment in sensation. If we double the strength of the stimulus, do we double also the strength of the sensation? If not, by how much do we increase it? Ernst Heinrich Weber sought to express the quantitative relation with some exactness; Gustav Theodor Fechner and other more recent inquirers have built upon the foundations laid by Weber; and a provisional law of the relation of physical stimulus to felt sensation has gradually gained wide acceptance.

Weber's classical experiments dealt with what is termed the "least observable difference." If, for example, a weight of one pound be laid upon the hand, it gives rise to a sensation of pressure. If, now, an extra ounce be added no difference is felt, nor is the added weight of two or of three ounces perceptible. The sensation is not increased, and then only just perceivably increased, till one-third of a pound is added. This, then, is said to be the least observable difference. We now start afresh with a load of two pounds, and add, as before, one-third of a pound. But there is no observable difference; nor is there any felt increase in sensation until two-thirds of a pound are added. Starting once more with an initial load of three pounds, we find that neither the addition of one-third, nor that of two-thirds of a pound affords any observable difference in the sensation experienced. A full pound must be added for the increment to be felt. The least observable differences, therefore, are between

$$1 \text{ lb. and } 1 + \tfrac{1}{3} \text{ lb.}$$
$$2 \text{ lb. ,, } 2 + \tfrac{2}{3} \text{ lb.}$$
$$3 \text{ lb. ,, } 3 + \tfrac{3}{3} \text{ lb.}$$

If, then, we extend and generalise the results of such experiments, we find that, within certain limits, to obtain an orderly series of just observable differences in sensation we must always add the same fraction—one-third of the weight—at each constant step of the series.

Now Fechner assumed that these just perceivable increments of sensation are all of the same value, or are constant; in which case they form an arithmetical series—that is to say, one that is produced by successive additions of the same amount. But the corresponding series of stimuli are not in arithmetical progression, since the successive increments are not of the same amount. The increase is, however, always by the same proportional amount. Each successive stimulus has to be multiplied by a constant factor, $\frac{4}{3}$. The series, therefore, forms an orderly sequence in geometrical progression.

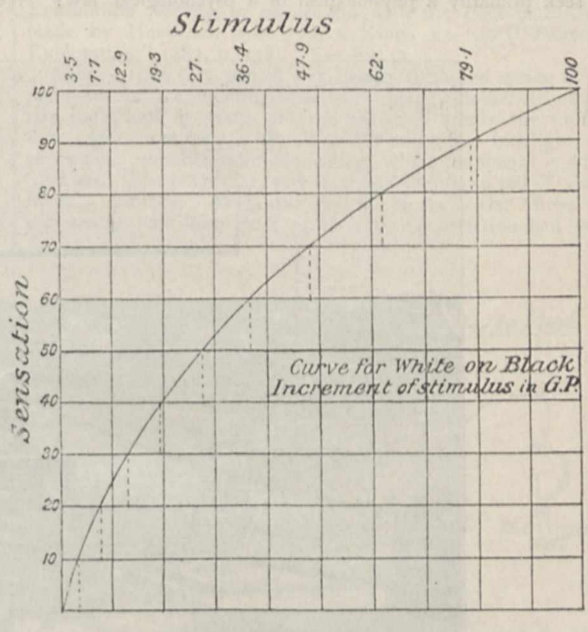
We thus reach what is known as the Weber-Fechner formula, by which the relation of stimulus to sensation is expressed in quantitative terms. It may be thus stated:—To obtain an arithmetical series of sensations a geometrical series of stimuli is required. To give the former, equal increments of sensation are added; to obtain the latter we must multiply the successive stimuli by a constant factor.

It must be admitted, however, that the results of a great number of carefully-conducted observations are by no means in satisfactory accordance with this formula. Hering and his pupils have shown that for very small stimuli, lying near the threshold of sensation, both stimulus and sensation increase very nearly *pari passu* in arithmetical progression. The Weber-Fechner formula cannot, therefore, at present be regarded as more than an approximation to the truth.

In extracting the Weber-Fechner formula from the data afforded by observations on the method of least observable difference, it is necessary to piece together the results observed singly and in succession. But from the nature of the field of vision it is possible to obtain a series of increments of stimulus which shall afford a scale of sensation visible as a whole and at a glance. In the current number of the *Psychological Review* (vol. vii. No. 3, p. 217) I have published in detail the results of an investigation "On the relation of stimulus to sensation in visual impressions," by which I have been led to suggest a modification of the Weber-Fechner formula. Stripped as far as possible of technicalities, the method and results may be here briefly described.

It is well known that if a disc with white and black sectors be rapidly rotated, the effect on the eye is a uniform grey. If the white sectors are proportionally small, occupying, for example, only 5 per cent. of the disc, the effect is that of a very dark grey; if they are relatively large, occupying, say, 90 per cent. of the disc, the effect is that of a very light grey. With such sectors the same proportional amount of white is introduced in all parts of the disc, so as to give in each case the same shade of grey throughout its whole extent. But it is possible to introduce varying proportions of white from centre to circumference, and when this is done the rotating disc no longer presents all over its surface the same uniform shade of grey, but shows varying shades. Let us now endeavour to reduce these varying shades to order. Let us arrange the proportions of white stimulus which we introduce, in such a way as to leave a ring of full black (with no white) at the circumference, and to give a ring of full white (with no black) near the centre, and between these extremes to obtain a perfectly smooth and even gradation of shades of grey from one so dark as to be scarcely distinguishable from black, to one so light as to be scarcely distinguishable from white. We may then, when the disc is rapidly rotating, run our eye from white near the centre, through deepening and deepening grey, to black at the circumference, with nowhere any observable jump in sensation—nowhere, so to speak, a steeper slope of change than elsewhere; as if, in fact, we were passing along a perfectly even inclined plane of sensation from the lowest depth of black to the extreme height of white. If we succeed in this—and it is by no means easy of attainment—we shall have secured an arithmetical series of sensation. From one end to the other we have at successively equal distances constant increments of white sensation, just as in ascending a uniform incline we gain equal increments of height for every yard we progress towards our goal. This even slope of sensation is produced by the juxtaposition of all the least observable differences whose sum gives the full scale. Having obtained this result we are able to ascertain, by careful angular measurements of the proportional areas of white at different parts of our disc, the exact amounts of stimulus which are affecting the eye from these several parts. We may, for example, subdivide the area of the disc lying between the inner white circle and the outer ring of black, by drawing nine concentric circles equidistant from each other, and at these nine distances make angular measurements of the proportional amounts of white to black; and then, by plotting, sweep a curve of stimulus through points representing these measured amounts.

When these amounts are tabulated and dealt with by appropriate mathematical methods, it is found that they are *not* in accordance with the Weber-Fechner formula. Nor does a disc prepared in accordance with this formula give the smooth and evenly-graded incline of an arithmetical series in sensation. For details the reader may be referred to the paper in which the observations and calculations are set forth. The accompanying figure gives the results plotted in a curve on the graphic method. The dotted steps indicate the nine measured increments. The vertical distance of any point on the curve, measured from below, upwards, gives the percentage of sensation. The horizontal distance, measured from left to right, gives the corresponding percentage of white stimulus. The law which results from a discussion of these observations, and of others where red,



orange and blue stimuli were used instead of white (each of which gives a different curve on the same principle), may be thus formulated:—*For constant increments of sensation the concomitant increments of stimulus are in geometrical progression.* This differs from the Weber-Fechner formula in assigning the geometrical progression to the successive *increments* of stimulus.

The subjoined table gives the increments and sums of

White on Black.

Stage	Sensation		Stimulus		Observed percentage of stimulus
	Increments	Sums	Increments	Sums	
10	10	100	20·90	100	100
9	10	90	17·13	79·10	79
8	10	80	14·03	61·97	62
7	10	70	11·51	47·94	48
6	10	60	9·43	36·43	35·8
5	10	50	7·73	27	27
4	10	40	6·33	19·27	19·5
3	10	30	5·20	12·94	13
2	10	20	4·25	7·74	7·9
1	10	10	3·49	3·49	3·5
0	0	0	0	0	0

stimulus and sensation at ten stages between black and white. A comparison of the last two columns will show the extent of agreement between observation and calculation. The numbers given under the head of stimulus are calculated on the basis of the suggested law, the number 27 per cent. of stimulus, as the concomitant of 50 per cent. of sensation, being taken over from observation as a basis for calculation.

Although I venture to hope that the results of this investigation contribute something towards a solution of the problem, still it will be seen that we have as yet by no means reached the stage at which we can claim that a law expressing the quantitative relation of stimulus to sensation is established beyond question. But from the work of many observers we may at least draw the conclusion that there is some well-defined relation, though its law at present eludes the grasp of our generalisation. And this so far lends support to the doctrine of concomitance.

There has been much discussion as to the true meaning of the relation. Is it primarily a relation between physical stimulus and physiological response, or between physiological response and psychological concomitant? In other words, is the law we seek primarily a physiological or a psychological law? We cannot enter upon the discussion here. Attention may, however, be drawn to two facts:—First, that Prof. Pfeffer claims to have shown that the attractive influence of malic acid on the spermatozoids of ferns is approximately in accordance with the Weber-Fechner formula; and secondly, that Dr. Augustus Waller's researches on the excitation of muscle and nerve indicate some such relation, though not exactly this relation, between stimulus and physiological response. In view of these facts it seems not improbable, therefore, that the relation may prove to be primarily physiological. In which case we may infer that sensation is directly proportional to the molecular disturbance in the nerve-centres concerned.

C. LLOYD MORGAN.

ANEMOMETER TESTS.

THE U.S. *Monthly Weather Review* for February contains an important contribution by Prof. C. F. Marvin on anemometer tests. The paper gives the results of a series of experiments to determine the factor of an anemometer specially designed for use with kites at considerable altitudes in the free air. For that purpose the anemometer has necessarily to be very small and light, and in the present case the cups were only 1·22 inch in diameter, and the length of the arms, from the centre of cup to the spindle, only 1·96 inch. The author describes at length the whirling apparatus used in making the experiments, and which had been previously used in the year 1888, but in an enclosed space, instead of in the free air. He points out that a whirling apparatus is absolutely necessary for testing anemometers, because we have no other means of accurately measuring the speed of the wind to which the instrument is exposed, unless we employ for that purpose some other anemometer, which must itself be first tested. In the author's view, the effect of using the whirler in the open air is to alternately add to and subtract from the artificial wind resulting from the steady motion of the whirler, so that the actual resultant wind affecting the anemometer acquires a *gusty* character which is analogous to the conditions always existing in the free air, and the artificial gusty wind thus secured affords a highly appropriate test-wind for anemometers that are to be used in the open air. The apparatus employed is shown in a plate, which we reproduce.

The arm, on the extreme end of which the anemometer is placed, is 28 feet long, and is made to rotate either by hand-power or by means of the engine used in the kite experiments. By hand-power any speed up to thirty-five miles an hour could be obtained, and by the engine the velocity could be raised to nearly sixty miles an hour. A good break-circuit seconds pendulum clock was employed, in conjunction with an astronomical chronograph, to record results, and the series of comparisons appears to have been carried out with much care and completeness.

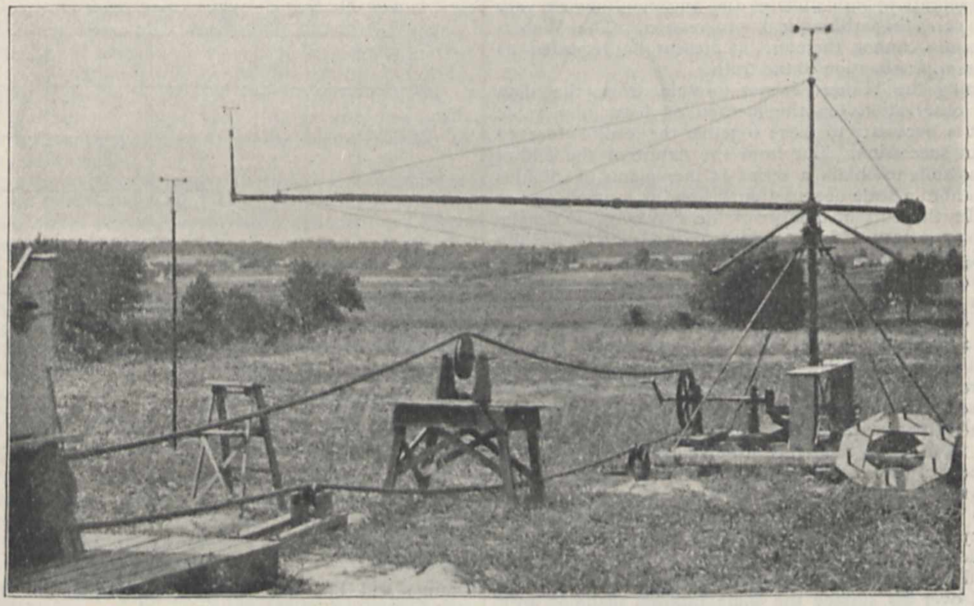


FIG. 1.—Whirling Machine and Driving Belt for Anemometer Tests.

The experiments included a redetermination of the constants for a "standard aluminium cup anemometer," in which the cups were 4·07 inches in diameter, and the arms 6·65 inches in length. This instrument had been used in the investigations of 1888, and the values now obtained gave a slightly lower rate of speed of the cups in a given wind than had been formerly deduced. But as the differences did not exceed 2 per cent., it is fair to conclude that, upon the whole, the agreement was satisfactory.

The author also points out that another result of the experiments is to confirm a conclusion arrived at in 1888, viz. that an anemometer with large cups, as compared with the length of the arms, runs at a speed bearing a more nearly constant ratio to that of the wind than an anemometer with relatively larger arms. In the case of the small kite anemometer now investigated, the factor is practically constant for velocities from ten to fifty miles an hour, the extreme variation being only about 1·5 per cent.

THE GREAT ALPINE TUNNELS.[1]

THE subject for this evening's discourse is that of the three great tunnels through the Alps—viz. the Mont Cenis, the St. Gothard, and that which is now in course of construction, the Simplon.

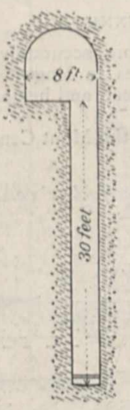
But before dealing with the details of these particular works, it will be desirable to consider what tunnelling is, and also some of the more remarkable instances of it in bygone days.

One great drawback in connection with the subject—so far as a discourse is concerned—is its unsuitability for the photographic art. Unlike a battleship, or a splendid bridge, or a grand block of buildings which can be made into fine views and pictures, the work of the mole is hardly adapted to the sensitive plate. I therefore propose to make use of the "language of the pencil," and to make a few rough sketches on the blackboard: by these means I trust I may be able to explain some of the difficulties which have to be encountered, and also show how a tunnel is constructed. The child's definition of drawing, "first you think, and then you draw a line round your think," will come to our aid.

The art of tunnelling dates back to very remote ages, and there are records of such works which were constructed 500 to 600 years before the Christian era.

An interesting account is given by one of your most distinguished members, in an article in the "Encyclopædia Britannica," of the tunnel under the river Euphrates at Babylon. This city, similar in some respects to London, lay half on one side and half on the other side of the river. High walls, penetrated by occasional gates, surrounded the city, and lined each of the banks of the river. These gates (of which a pair of the great hinges can be seen in the British Museum) were closed at night and during war; and a tunnel was constructed below the bed of the river by means of what is technically known as the "cut-and-cover" system. In those days the Greathead shield was unknown, and consequently the river had to be diverted, so that the excavation could be made in the dry bed and cut open to daylight, the arch being built, the ground restored, and the river allowed to resume its former course. The tunnel is said to have been 15 feet in width, and 12 feet in height, built of brick.

Fig. 1.



CROSS SECTION of the AQUEDUCT of EUPALINOS. In the Island of SAMOS.

Herodotus gives an account of the diversion of the river into a great excavation or artificial lake forty miles square, and states that the besieging enemy, so soon as the water was drawn off, entered into the city by the river bed. It is believed that this same excavation was made use of for the construction of the tunnel. It is, however, desirable to state that doubts have been thrown on the subject, and it is possible that it may have to be relegated to mythology.

The next instance of a tunnel is that referred to by Herodotus in the Island of Samos ("Herodotus," iii. p. 60) (see Fig. 1), and it is satisfactory to know that although very considerable doubts were expressed as to the accuracy of his statements, recent investigations prove that he was exactly correct. The description given by him, when expressed in English words and figures, is as follows: "They have a mountain which is 910 feet in height; entirely through this they have made a passage, the length of which is 1416 yards. It is, moreover, 8 feet high, and as many wide. By the side of this there is also an artificial canal, which in like manner goes quite through the mountain; and though only 3 feet in breadth, is 30 feet deep. This, by the means of pipes, conveys to the city the waters of a copious spring."

The commentators on this passage say that Herodotus must have made a mistake, but the Rev. H. F. Tozer, in his book "The Islands of the Ægean," p. 167, gives the results of a personal visit.

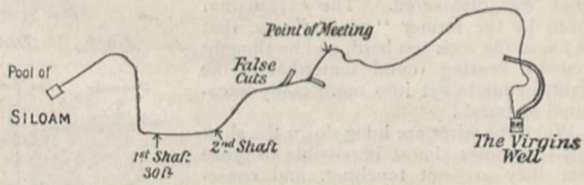
He says the tunnel is 7 to 8 feet in width; that two-thirds of its width are occupied by a footpath, the other third being a water-course, 30 feet deep at one end. He and other writers consider that insufficient allowance was made for the fall of the water, and that the water channel had to be deepened. To describe it in more modern language, the resident engineer evidently made a mistake in his levels, necessitating a much deeper excavation than was at first anticipated.

Another, and if possible a more interesting, instance of tunnelling is that described in the *Proceedings* of the Palestine Exploration Society, in connection with the Pool of Siloam, made by Hezekiah, B.C. 710, 2 Kings xx. 20 ("Palestine Exploration," 1882, p. 178). See Fig. 2.

About 710 B.C. a tunnel was driven from the spring to the well—by actual tunnelling—the work being commenced at the two ends, and by shafts, and the workmen met in the middle. The tunnel was only 2 feet in width and 3 feet in height, except at the probable point of meeting, where the height is 4 feet 6 inches. The length is 1708 feet, and there is a fall of 1 foot in this distance. About the middle of its course there are apparently two false cuts, as if a wrong direction had been taken: but possibly these were intentional, and provided passing places for the workmen and material.

Fig. 2.

Plan of Tunnel from Spring to Pool of Siloam.



(Not to scale.)

On the soffit of the tunnel is carved an inscription, of which the following is a translation:—

"Behold the excavation. Now this had been the history of the excavation. While the workmen were still lifting up the pick, each towards his neighbour, and while 3 cubits (4 feet 6 inches) still remained to cut through, each heard the voice of the other, who called to his neighbour, since there was an excess of rock on the right hand and on the left. And on the day of the excavation the workmen struck each to meet his neighbour pick against pick, and there flowed the waters from the spring to the pool for a thousand two hundred cubits (1820 feet), and a hundred cubits (151 feet) was the height of the rock over the head of the workmen."

A Roman engineer gives an account of a tunnel which was being driven under his directions for an aqueduct. And as he was only able to visit the work occasionally, he describes how on one of his visits he found the two headings had missed each other, and he says that had his visit been deferred much longer there would have been two tunnels.

The accurate meeting of the headings or driftways of a tunnel can only be attained by the exercise of great care, both as regards direction as well as level.

We need not go very far to find instances of such an error as inaccurate meeting, but there is one well-known case on an important main line in the Midland Counties where the engineers failed to meet, and to this day reverse curves exist in the tunnel to overcome the difficulty.

To attain this accurate meeting fine wires are hung down the

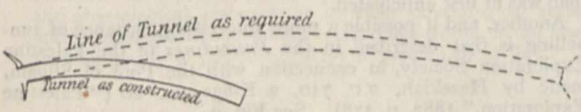
[1] A discourse delivered at the Royal Institution on Friday, May 25, by Francis Fox, Mem.Inst.C.E.

shafts of a tunnel, with heavy plumb-bobs suspended from them in buckets of water, or of tar, to bring their oscillations to rest; the accurate direction being given by means of a theodolite or transit instrument on the surface.

The wires are capable of side movement by means of a delicate instrument, and are gradually brought exactly into the same vertical plane: hence, if they are correct at "bank," or surface, they must also be correct below ground. The engineers below have to drive the galleries or headings so that only *one* wire is visible from their instrument: so long as one wire exactly eclipses the other wire, the gallery is being driven in the right direction.

As regards accuracy in levels, this is done by ordinary levelling; but it will be seen at once how much depends on care being devoted to both these operations.

Fig. 3. PLAN.



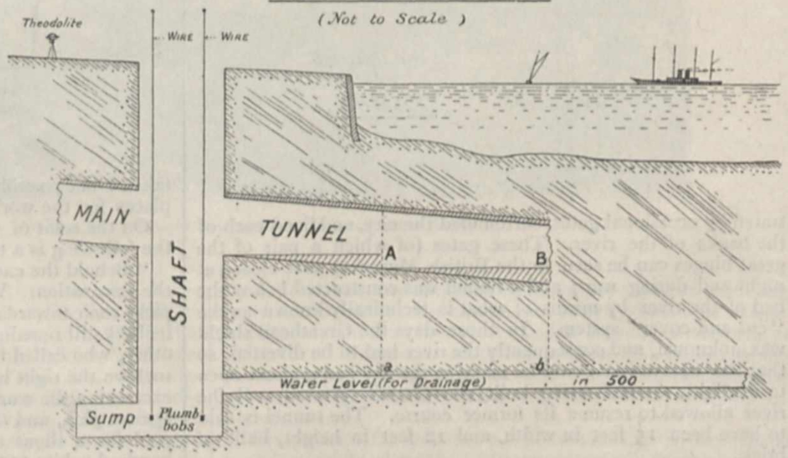
Assume two shafts, 1000 yards apart, between which a gallery has to be driven; and, allowing a distance of 10 feet between the wires, which are $\frac{1}{16}$th inch in diameter, an error of the diameter of the wire at the shaft will cause a mistake of nearly 4 inches at the point of meeting, or of $7\frac{1}{2}$ inches if a similar error occurs at the other shaft in the opposite direction. The trickling of water down the wires increases their diameter so appreciably, and therefore conduces to further inaccuracy, that it is found necessary to fix a small shield or umbrella on the wire to deflect the water.

Some years ago, a tunnel which had been commenced, but not finished, had to be completed. The first thing to be done by the engineers was to make an accurate survey of the then condition of the work—this rough sketch (see Fig. 3) indicates what was discovered. The explanation given by the former "ganger" was, that he found the rock too hard, and he thought that by bearing round somewhat to the right, he might get into more easily excavated material!

When the wires are hung down the shaft it is sometimes almost impossible to prove that they are not touching, and consequently being deflected from the true vertical line by some rope or pipe, staging or timber in the shaft. To overcome this, an electrical current was passed down the wire—a galvanometer being in circuit. If the wire proved absolutely silent, and no deflection was obtained in the galvanometer, the conclusion could be safely drawn that the wire was hanging freely and truly.

In driving the necessary adit or heading for drainage purposes beneath a sub-aqueous tunnel, a rising gradient from the shaft bottom of 1 in 500 is allowed, to enable the water at the "face" to flow away from the workmen to the pumps in the "sump" or shaft bottom (see Fig. 4).

Fig. 4. Diagrammatic Section to illustrate method of constructing Tunnel below River Bed.



When the heading is driven sufficiently forward to justify the commencement of the main tunnel, a fresh difficulty presents itself. This main tunnel has to be driven down hill, and consequently the water collects at the working face A: the bottom cannot therefore be removed until a bore-hole is put down from A to *a*. When this is done the remaining excavation can be taken out, and a further length of tunnel driven to B. A bore-hole is now sunk from B to *b*, whilst that from A to *a* can be plugged up: and thus the tunnel is gradually advanced.

By the adoption of the Greathead shield much of this difficulty can be avoided; but one sub-aqueous tunnel through water-bearing strata, at considerable depth, is sufficient for a lifetime.

As an illustration of the danger to which men are exposed in such work, it is stated, with much regret, that in a certain tunnel, notwithstanding every precaution being taken, all the men engaged in driving the drainage heading by means of a tunnelling machine have died; and in the case of the first Vyrnwy tunnel crossing of the River Mersey—driving by Greathead shield under pressure—the mortality was great.

Having explained in very general terms some of the difficulties of tunnel construction, we will proceed to the case of the great tunnels through the Alps, and for the purpose of rendering the subject more easily intelligible, the following particulars may be given:—

	St. Gothard	Mont Cenis	Arlberg	Simplon
Length of tunnel in miles	9·3	7·98	6·36	12·26
North or east portal above sea-level, feet	3639	3766	4296	2254
South or west portal above sea-level, feet	3757	4164	3998	2080
Highest level	3788	4248	4300	2314
Maximum grade in tunnel per 1000 ...	5·82	30	15	7
Maximum height of mountain above tunnel, feet...	5598	5428	2362	7005
Possible maximum temperature of rock, deg. Fahr.	85°	85°	65°	104°

MONT CENIS TUNNEL.

The Mont Cenis, or as it is more accurately called, the Frejus Tunnel, is nearly eight miles in length. It is for a double line of way—width being 26 feet, and height above rails 20 feet 6 inches.

In consequence of the gradients in the Mont Cenis ascending from both ends, the smoke cannot get away, and it remains in a dull, heavy cloud in the tunnel. It is worse during cold and rainy weather, and particularly during the winter, when the air is sometimes so deficient in oxygen that the plate-layers cannot work.

Trains coming from France with an ascending gradient of 1 in 40 against them for a length of 7 kilometres, when followed by a current of air in the same direction, produce a disastrous state of things. In this, as in all other steep tunnels, engines having a heavy load behind them go through with their regulators full open, ejecting great volumes of smoke and steam which travel concurrently with the train, and the inconvenience and discomfort produced are very great.

At each kilometre in the tunnel, a refuge or "grande chambre" is provided for the men, and this is supplied with compressed air, fresh water, a telephone in each direction out, a medicine chest, barometer and thermometer.

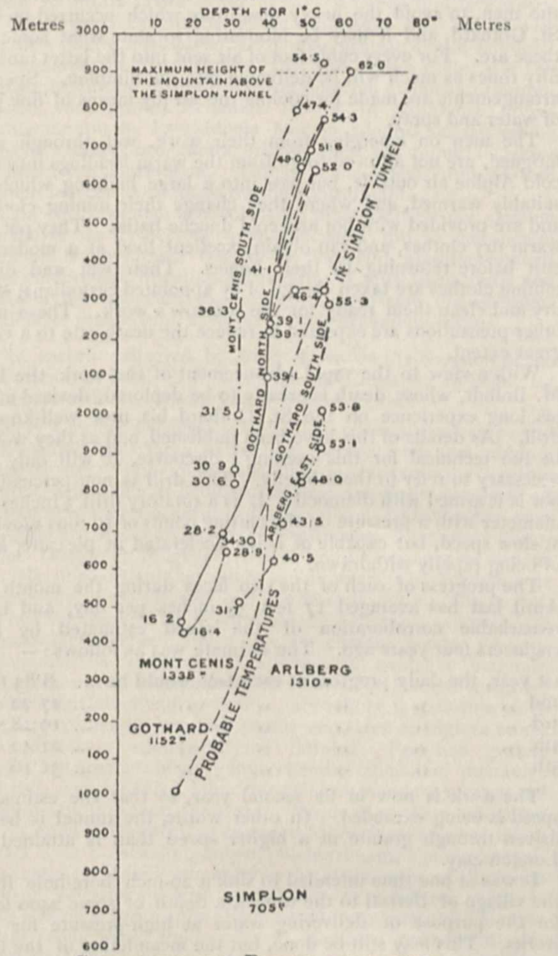
The cost of the tunnel was about 3,000,000*l*., or 220*l*. per yard, and occupied ten years in construction.

The temperature in the middle of the tunnel remains nearly constant, summer and winter, and is about 19° to 20° C. = 66° to 68° Fahr.

The altitude of the tunnel is 4248 feet above sea-level, and the height of the mountain above the tunnel is 5428 feet: the temperature of the rock is greatly influenced by this latter fact.

The question of the temperature of the rocks passed through in the construction of a tunnel is one of great interest, as it depends upon several conditions: (1) the character of the rock;

Fig. 5.



CURVES SHOWING DEPTHS CORRESPONDING TO AN INCREASE IN TEMPERATURE OF 1° C. FOR THE MONT CENIS, GOTHARD AND ARLBERG TUNNELS.

(With curve of probable temperature for the Simplon Tunnel.)

(2) the inclination of the beds—those which attain a vertical or nearly vertical position being less able to confine the heat than those which are more or less horizontal; (3) the height of the mountain above the tunnel, or in other words, the thickness of the blanket.

A diagram is shown (Fig. 5), giving the temperature actually encountered in the St. Gothard and Arlberg Tunnels, and from these, aided by the carefully prepared geological section along the centre line of the Simplon Tunnel, an approximate line is given of the temperatures which are expected.

The possibility of cooling the rocks and the air of the tunnel will be dealt with later on, but there is in addition a permanent lowering of the temperature after the tunnel is complete, particulars of which will be given under the description of the St. Gothard.

For each 144 feet of superincumbent rock or earth the increase is found to be 1° Fahr.

THE ST. GOTHARD TUNNEL.

This, which is at present the longest railway tunnel in the world, is 9·3 miles in length, and constitutes the summit of the "Gothard bahn," that is, the railway which runs from Lucerne to Chiasso near the Italian frontier.

The altitude of the tunnel at its north portal is 3639 feet, and at its south portal 3757 feet above the sea. A gallery of direction was driven throughout, and the gradient of the rails is only such as to provide for efficient drainage, viz. 5·82 per thousand, or about 1 in 172.

The following table may be of interest, giving the result of investigations as to the cooling of the rocks.

TEMPERATURE OF THE ROCK IN THE ST. GOTHARD TUNNEL.

Date.	7·3 kilo. from the North Portal.			7·05 kilo. from the South Portal.		
	Temperature.	Lowering.		Temperature.	Lowering.	
		Successive.	Total.		Successive.	Total.
April and May 1880, the year when the tunnel was pierced	° 30·46	° ...	° ...	° 30·53	° ...	° ...
June 1882	23·73	6·73	...	23·39	7·14	...
July 1883	22·20	1·53	8·26	23·1	0·29	7·43

Above are Centigrade.

Although the works were carried on with energy, and with all the best appliances then known, the time occupied was ten years; but the most serious feature of the work was the heavy mortality amongst the men: no less than 600 deaths occurred, including those of both the engineer and contractor.

From the experience then gained, great improvements have been introduced into the works of the Simplon, as will be described later on; but the heavy loss of life in the St. Gothard was due to insufficient ventilation; the high temperature; the exposure of the men to the Alpine climate after emerging from the tunnel; the want of care as to the changing of the men's wet mining clothes; and the poor character of the food with which the men supplied themselves. All this has been greatly ameliorated, and even in English tunnels certain improvements have been introduced, which were brought from Switzerland.

The traffic through the tunnel has so largely increased that the question of ventilation became of pressing importance, and the system of Signor Saccardo, the well-known Government inspector of railways and engineer of Bologna, has been installed, which is an ingenious application of the injector system. One of the first introductions of this method was in the case of the Pracchia Tunnel, on the main line between Florence and Bologna, through the Apennines. This is a railway of single line, and was built many years ago by the late Mr. Brassey. There are 52 tunnels in all, but those on the eastern side are of comparatively little importance. On the western slope the gradient nearly throughout is 25 per thousand (or 1 in 40), and it is here the greatest difficulty exists. There are several tunnels whose lengths approximate to 1000, 2000 and 3000 yards, and the traffic is both heavy and frequent, the locomotives very powerful, with eight wheels coupled.

Under any conditions of wind the state of the longest tunnel is bad, but when the wind is blowing in at the lower end at the same time that a heavy goods or passenger train is ascending the gradient, a state of affairs is produced which is almost insupportable, and one might as conveniently travel in a furnace flue.

A heavy train of dining and sleeping carriages, with two engines, conveying one of the crowned heads of Europe and suite, arrived at the exit of Pracchia Tunnel with both enginemen and both firemen insensible; and in other cases passengers have been seriously affected.

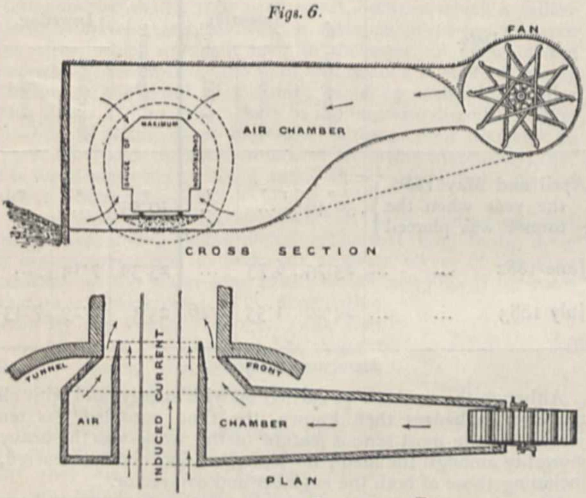
Owing to the height of the mountain no shafts are available; but Signor Saccardo places a ventilating fan near the mouth of the tunnel, and blows air into it through the annular space which exists between the arch of the tunnel and the gauge of maximum construction (Fig. 6). The results are remarkable; the volumes of air thrown into the tunnel per minute being as follows:—

	cub. ft.
Direct from the fan	161,860
Induced draught through open tunnel mouth	48,140
Total	210,000

Or 100 cubic metres per second.

The temperature of the tunnel air before the fan was started was 107° F., with 97 per cent. of moisture, whereas, after the fan had been running a few minutes the temperature was 81° F., or a lowering of 26° F., and the tunnel was cool and free from smoke and vapour.

Figs. 6.



THE SACCARDO SYSTEM OF VENTILATING TUNNELS.

One can travel through with both windows open and feel no inconvenience, the only remark of the brakesman riding on the top of the waggons and carriages being that he finds it almost too cold.

This application is without doubt the solution of the difficult problem of tunnel ventilation under high mountains, and elsewhere where shafts are not available, and where electric traction is not applicable.

This system has within the last twelve months been brought into operation on the St. Gothard, with the most satisfactory results. Careful experiments are being made, but there is no doubt that the problem has been solved.

In addition to these tunnels, the Saccardo system has been applied to the Giovi Tunnel near Genoa—3300 metres in length—and is being installed on the Giovi Tunnel on the Genoa-Ronco Railway, 8303 metres in length, besides on some seven other tunnels in Italy; and plans are being prepared for the Mont Cenis.

THE SIMPLON TUNNEL.

This tunnel is now in rapid course of construction, the total length of gallery driven up to the end of April being as follows:—

	yards
On the north or Brigue side of the Alps ...	3228
On the south or Iselle	2350

Or over three miles in little more than eighteen months, including the necessarily slow progress at the commencement.

The total distance between the two portals will be 21,564 yards, or 12·26 miles. A gallery of direction has been driven at both ends until the actual tunnels are reached, so as to form a directly straight line for the accurate alignment of the work from end to end.

This great undertaking will consist of two single-line tunnels running parallel one to the other, at a distance apart from centre to centre of 55 feet 9 inches; and one of the chief features is the much lower altitude of the rails above sea-level than any of the other Alpine tunnels. This altitude is at its highest point 2314 feet, being 1474 feet lower level than that of the St. Gothard, 1934 feet lower than that of the Mont Cenis, and 1986 feet than that of the Arlberg. This is a matter of great importance in the question of haulage of all the traffic.

The tunnel enters the mountain at the present level of the railway at Brigue, so that no costly approaches are requisite on this side.

Admirable arrangements have been made for the welfare of the men, to avoid the heavy death-rate which occurred on the St. Gothard, and it may be interesting to state what some of these are. For every cubic foot of air sent into the latter tunnel, fifty times as much will be delivered into the Simplon. Special arrangements are made for cooling the air by means of fine jets of water and spray.

The men on emerging from their work, wet through and fatigued, are not allowed to go from the warm headings into the cold Alpine air outside, but pass into a large building which is suitably warmed, and where they change their mining clothes and are provided with hot and cold douche baths. They put on warm dry clothes, and can obtain excellent food at a moderate cost before returning to their homes. Their wet and dirty mining clothes are taken charge of by appointed custodians, who dry and clean them ready for the morrow's work. These and other precautions are expected to reduce the death-rate to a very great extent.

With a view to the rapid advancement of the work, the late M. Brandt, whose death is greatly to be deplored, devised after his long experience on the St. Gothard his now well-known drill. As details of this have been published, and as they would be too technical for this evening's discourse, it will only be necessary to refer to them briefly. This drill is non-percussive, nor is it armed with diamond. It is a rotatory drill 3 inches in diameter with a pressure on the cutting points of 10 tons moving at slow speed, but capable of being acclerated at pleasure, and of being rapidly withdrawn.

The progress of each of the two faces during the month of April last has averaged 17 feet $3\frac{1}{2}$ inches per day, and is a remarkable corroboration of the speed estimated by the engineers four years ago. The estimate was as follows:—

1st year, the daily progress at each face would be ...	8·85 feet
2nd ,, ,, ,, ,, ,, ...	17·22 ,,
3rd ,, ,, ,, ,, ,, ...	19·18 ,,
4th ,, ,, ,, ,, ,, ...	21·32 ,,
5th ,, ,, ,, ,, ,, ...	31·16 ,,

The work is now in its second year, so that the estimated speed is being exceeded. In other words, the tunnel is being driven through granite at a higher speed than is attained in London clay.

It was at one time intended to sink a 20-inch bore-hole from the village of Berisal to the tunnel, a depth of some 2400 feet, for the purpose of delivering water at high-pressure for the works. This may still be done, but the meandering of the tool might result in the awkward dilemma of having to search for it, in solid rock, below ground.

The probable cost of the work now in hand will be about 2,000,000*l.*, and the time occupied in completing the tunnel ready for traffic is estimated to be $5\frac{1}{2}$ years, a penalty or a bonus, as the case may be, for delay or acceleration being fixed at 200*l.* a day.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The following is the text of the speech with which Prof. J. Mark Baldwin, professor of psychology in Princeton University, was presented for the degree of D.Sc. *honoris causa.* This is the first time the degree has been conferred in Oxford, it having been created only quite recently. The speech was written by Mr. A. C. Clark, of Queen's College, and Prof. Baldwin was presented by Prof. E. B. Elliot, F.R.S., in the absence of Prof. Love, F.R.S., who would in the ordinary course have officiated, being the occupant of the oldest scientific chair in the University :

Adest Jacobus Marcus Baldwin, Academiae de Princeton Graduatus, vir Psychologiae peritissimus. Cujus laudes ut brevissime complectar, primo Psychologiae Professor in Academia de Toronto creatus Psychologiae Experimentalis laboratorium, quod solum adhuc in Academiis Britannicis exstat, instituit, mox ad suam almam matrem reversus in Academia de Princeton Psychologiae Professor factus est. Libri etiam luculentissimi auctor est de ortu et incremento intellegentiae cum in infantibus tum in genere hominum universo, quem summa laude a viris doctis ubique ornatum Academia Havniensis numismate aureo donavit: idem ephemeridis praestantissimae apud Americanos res psychologicas tractantis diu editor, nunc grande Philosophiae et Psychologiae Abecedarium sub prelo nostro excudendum curat. Quo in labore doctissimi cujusque in hoc genere scriptoris opera utitur cum in America tum in Europa, quo in numero Praelector noster Wildianus dux est et fere signifer. Valde, nisi fallor, Academiae nostrae auram redolebit hoc volumen tot Oxoniensium sive sub nostro caelo, sive sub externo degentium, opera diligentia doctrina exquisita ornatum.

Quod vero primus Scientiae Doctor in Academia nostra creatus tantam in Psychologia laudem adeptus sit, felicissime profecto accidit, cum adhuc frigere apud nos hujus doctrinae studium externis videatur. Utinam hunc talem virum plurimi ejusdem laureae avidi longo ordine secuturi sint.

Illam vero insignem benevolentiam praetermittere non possum Academiae de Princeton, quae plurimos, qui in hac nostra Academia laude summa floreant ac floruerint, gradibus honoris causa conferendis libentissime auxerit. Cujus liberalitatis non immemor maximo cum gaudio ego hunc virum doctissimum, Academiae suae vivum exemplar, vobis ornandum trado.

The speech delivered by Prof. Love on the occasion of the presentation of Prof. C. F. Chandler, of Columbia College, for the degree of D.Sc. *honoris causa*, was as follows :—

Adest Carolus Fredericus Chandler, chemiæ professor apud Americanos, cuius fama extra fines patriæ suæ iam dudum pervagata est. Hic apud suos litteris humanioribus primo imbutus, dein chemiæ deditus doctrinæ amplioris appetens ad Germanorum fontes accessit. Ibi doctissimi cuiusque viri, cum in Berolinensi Academia, tum in Gottingensi discipulus, Philosophiæ Doctor et Magister Artium apud Gottingenses creatus est. Ex hoc curriculo ad solum suum reversus in Academia de Schenectady primo vicarius erat Professoris optimi, Caroli Joy, dein hoc summo viro ad Academiam de Columbia avocato, ipse Professor factus septem annos de omni chemiæ genere, de agris lætificandis, de metallorum ratione, de geologia magnum discipulorum gregem praeclare docebat. Ita laudem insignem adeptus ipse Columbiam arcessitus, ubi scholæ metallorum novo exemplo instituendæ imprimis auctor erat, tres et triginta annos in omni rerum administratione florebat. Per hoc grande mortalis ævi spatium omne genus chemiæ felicissime tractavit: idem rude iam donatus a laboribus officiosis nondum recessit sed iuniorum studia adhuc informat. Neque hoc loco silendum arbitror quod huius precibus commoti fratres Havermeyeri, Novi Eboraci cives ornatissimi, aulam pulcherrimam, chemiæ sedem, ædificaverunt: Musæi etiam rebus omnibus, quæ ad chemiam pertinent, refertissimi ipse auctor est et conditor. Sex et viginti abhinc annos magna chemicorum frequentia ad Doctoris Priestly sepulchrum confluente, ut chemiæ inventorem rite salutarent et post centesimum iam annum scientiæ suæ natalem diem celebrarent, ipse conventus Præses erat: Societas autem chemicorum Americanorum, quæ ex illo coetu orta est, hunc bis Præsidem sæpe vice-Præsidem et curatorem habuit. Sodalicii etiam chemicorum, qui Novi Eboraci degunt, Præses est: hortorum etiam publicorum peritissimus Curator. Idem civitatis suæ personam gerens maximo medicorum conventui Havniæ interfuit, qui ab omni terrarum orbe missi de valetudine civium conservanda quærerent.

Dies mehercule me deficeret si doctissimi viri tot labores enumerare conarer. Illum consulunt populares sui de porcorum fibra unaquaque in quæstum convertenda, de silvis rei navalis causa conservandis, de veneno si quod in vino vel in cervisia delitescat detrahendo, de argentariorum chartulis imperviis aquæ et madori reddendis, de oleo e vivis fontibus scaturiente purgando, de plateis igneo vapore noctu illuminandis, de mercibus linteis candore eximio nivem superantibus, de omni re quæ ad utilitates, oblectamenta, lucrum denique civium pertinet.

Ut omittam honores quos Academia Gottingensis iuveni dedit, Doctor Medicinæ ab Academia Novi Eboraci, Litterarum etiam Doctor ab Academia sua Columbiensi factus est: neque solum domi clarus est, sed ubicunque terrarum viri docti, chemiæ dediti, inveniuntur, hunc sodaliciis et societatibus suis libentissime adsciverunt. Restat ut Academia nostra hoc summo viro in gremium suum accepto suas laudes augeat.

AT a meeting of the Council of the Birmingham University, held on Tuesday, the following letter, received from Lord Calthorpe by Mr. Chamberlain, was read :—"Dear Mr. Chamberlain,—My son and myself beg to offer to the University of Birmingham about twenty-five acres of land on the Bournebrook side of the Edgbaston estate as a site for the new scientific department of teaching and research which it is proposed to establish. There will of necessity be certain conditions, but these will occasion no difficulty.—Yours very truly, CALTHORPE."—It was proposed by the Vice-Chancellor, seconded by Sir James Smith, and unanimously resolved :—"That this Council desires to express to Lord Calthorpe and to the Hon. Walter Calthorpe its high appreciation of their generosity in offering to present twenty-five acres of land to the University of Birmingham as a site for the new scientific department. In gratefully accepting the offer, the Council recognises, not only the value of the gift, but the suitability of the site, which enables it to establish the new department in closer proximity to the centre of the city than would have been possible under any other circumstances."

THE Reports and Prospectuses of Technical Schools, which come under our notice from time to time, show unmistakably that increased provision is being made for practical work in science, and that teachers who have had the advantage of instruction in well-equipped laboratories are in charge of the work. The Municipal Science, Art, and Technical Schools of Plymouth is a case in point. These schools were erected by public subscription as a memorial of the Queen's Jubilee, and on their completion were handed over by the Jubilee Memorial Committee to the town. In the day school department the work is that of the Advanced Section of a "School of Science," that is to say, of a secondary school giving instruction in mathematics, mechanics, physical science, English subjects, French and drawing. There is a laboratory for practice in both chemistry and physics, and for manual instruction in woodwork. Both day and evening classes are held in many science subjects, and pupils whose elementary education is completed may take a two years' course of training in such subjects as will best fit them to become chemists, architects, civil, mechanical, or electrical engineers, or to engage in industrial work of any kind. The increase of institutions of this kind will be the salvation of our national welfare.

FROM the Northampton Institute, one of the youngest of the London Polytechnics, we have received a prospectus of courses in mechanical engineering, electrical engineering, and horological engineering which have just been introduced. The syllabuses of the courses are admirable, and, with the notes upon the objects and character of the work, they indicate that Dr. R. M. Walmsley, the principal, believes in the value of scientific instruction. Students who desire to take up these engineering courses must first show that they are capable of benefiting from it by passing an entrance examination. English and elementary mathematics are obligatory subjects, and we are glad to see that it is not proposed to make the latter a test of ability to perform mathematical gymnastics. The following extract from the prospectus is worth quoting :—"In 'Elementary Mathematics' the examination will aim at ascertaining the candidate's familiarity with simple arithmetical, algebraical and geometrical methods and their application so the solution of ordinary common-sense problems. In arithmetic this will include the use of decimals and abbreviated methods of calculation, with the usual problems of mensuration, including the volumes and surfaces of cylinders, spheres and right cones. In algebra the usual course as far as simple simultaneous equations will be included, but the more academic parts of the subject will not be required. The geometry will include the subjects treated in the first two books of Euclid, with some exercises in the accurate drawing of geometrical figures." The Institute has numerous laboratories and workshops for practical work in mechanics, engineering, metal and woodwork, electrical engineering, physics, electro-chemistry, metallurgy, and instrument making. The attention given to horological theory and mechanism, and horological technology, is a noteworthy characteristic. The courses of work in this as well as the other subjects show that sound instruction in the principles and practice of the chief branches of engineering can be obtained at the Institute.

SCIENTIFIC SERIALS.

American Journal of Science, July.—Energy of kathode rays, by W. G. Cady. This is a translation of a paper already published in the *Annalen der Physik*.—Volcanic rocks from Temisconata Lake, Quebec, by H. E. Gregory. The volcanic rocks consist of fine tuff and coarse amygdaloidal conglomerate or breccia. They are interbedded with Niagara sediments, and this helps to determine the time when widespread volcanic activity gave rise to the numerous small areas of tuffs and lavas in the Maine-Quebec region.—Interpretation of mineral analyses, and a criticism of recent articles on the constitution of tourmaline, by S. L. Penfield. It is safe to assume that the close approximation of atomic ratio to whole numbers constitutes the strongest argument that can be advanced in support of the excellence of an analysis and to correctness of the derived formula. The author criticises the formulæ proposed by Clarke and Tschermak, and maintains that it is definitely proved that the empirical formula of the tourmaline acid is $H_{20}B_2Si_4O_{21}$.—Carboniferous boulders from India, by B. K. Emerson. The author describes and illustrates some striated carboniferous boulders which remove the doubt as to the former existence of a carboniferous glacial period.—The statement of rock analyses, by H. S. Washington. The author proposes a regular system of stating the results of the chemical analysis of rocks. The oxides are to be enumerated in the following succession: SiO_2, Al_2O_3, Fe_2O, FeO, MgO, CaO, Na_2O, K_2O, H_2O, CO_2, and then the rarer oxides, also in definite succession. This will enable the geologist to classify the rocks in a purely chemical system and to pick them out at a glance. They can be advantageously entered upon a card catalogue.—A string alternator, by K. Honda and S. Shimizu. The authors describe a modification of Pupin's string interrupter by means of which a continuous battery current can be converted into an alternating current the frequency of which can be readily varied from 30 to 1000 per second.—Action of light on magnetism, by J. H. Hart. The author failed to obtain the demagnetisation of iron by light acting magnetically like an alternating current, until he adopted the expedient of depositing very fine iron films on glass. He then noticed a small but distinct difference in the magnetic state of the iron according to the plane of polarisation of the incident light.

Bollettino della Società Sismologica Italiana, vol. vi. 1900–1901, N. 1.—Rules and list of fellows (forty-three national and thirteen foreign).—Vesuvian notices (year 1899), by G. Mercalli. A monthly review of the condition of Vesuvius, with sections on the form and state of the crater, the end of the eruptive phase of 1895–1899, the lavic cupola of 1895–1899, the supposed endogenous elevation of the lavic cupola, and the fumaroles of the lavic cupola and fracture.—On the nature of seismic vibrations, by M. P. Rudski (in French). The author contends that superficial, and probably deep-seated, rocks are not isotropic media, and that earthquake waves consist of vibrations which are not entirely longitudinal or entirely transversal.—Notices of earthquakes recorded in Italy (January 1 to March 14, 1896), by A. Cancani, the most important being the Mexican earthquakes of January 14 and 25, the Greek earthquake of January 22, and distant earthquakes on January 6, 22, and March 7.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 17.—"The Circulation of the Surface Waters of the North Atlantic Ocean." By H. N. Dickson, B.Sc. Communicated by Sir John Murray, K.C.B., F.R.S.

In this paper an attempt is made to investigate the normal circulation of the surface waters of the Atlantic Ocean north of 40° N. lat., and its changes, by means of a series of synoptic charts showing the distribution of temperature and salinity over the area for each month of the two years 1896 and 1897.

The principal conclusions arrived at with reference to the circulation may be summed up as follows:—

(1) The surface waters along the whole of the eastern seaboard of North America north of (about) lat. 30° N., consisting partly of water brought from the equatorial currents by the Gulf Stream, and partly of water brought down by the Labrador current, are drifted eastward across the Atlantic towards south-western Europe, and banked up against the land outside the continental shelf. This continues all the year round, but it is strongest in summer, when the Atlantic anti-cyclone attains its greatest size and intensity; and the proportion of Gulf Stream water is greatest at that season.

(2) The drifts in the northern part of the Atlantic area are under the control of the cyclones crossing it. The circulation set up accordingly reaches its maximum intensity in winter, and almost dies out in summer. In winter the drifts tend to the south eastward from the mouth of Davis Strait, eastward in mid-Atlantic, and north-eastward in the eastern region. In spring and autumn the movement is more easterly over the whole distance, and a larger quantity of water from the Labrador stream is therefore carried eastward.

(3) The water banked up in the manner described in (1) escapes partly downwards, partly southwards, and partly northwards. It occupies the whole of the eastern basin of the North Atlantic, and to the north it extends westward to Davis Strait, being confined below 300 fathoms depth by the ridges connecting Europe, the Faeroes, Iceland, and Greenland. Above that level it escapes northward by a strong current through the Faeroe-Shetland Channel and between Faeroe and Iceland, and by the two branches of the Irminger stream, one west of Iceland the other west of Greenland.

(As it seems desirable that this northerly current should have a distinctive name, it might be well to call it the European stream, and its branches the Norwegian, Irminger, and Greenland streams respectively.)

The strength and volume of the European stream is liable to considerable variation, according to the form and position of the Atlantic anti-cyclone, which causes the amount of banked up water, and the proportions escaping northward and southward, to vary. It is also modified by the strength and direction of the surface drifts in its course. It is, however, always strongest in summer.

(4) The Norwegian stream is by far the largest branch of the European, and it traverses the Norwegian Sea and enters the Arctic Ocean. The warm water thus sent northward melts enormous quantities of ice, and the fresh water derived from the ice moves southward in autumn, chiefly in a wide surface current, between Iceland and Jan Mayen, which may entirely cover other parts of the Norwegian stream. Part of the surface water also comes southward through the Denmark Strait, but the amount is much smaller, probably chiefly because the melting of the ice is slower, and the channel is longer blocked.

The Greenland branch of the European current also causes melting of ice in Davis Strait, but the warm winds from the American continent and the water received from the land are probably more effective in increasing the volume of the Labrador current.

(5) The water from the melted ice is spread over the surface of the North Atlantic during late autumn and winter by the increasing drift circulation, and it is gradually absorbed by mixing with the underlying water.

(6) The circulation described is liable to extensive irregular variations, corresponding to variations in the atmospheric circulation.

May 31.—"Influence of the Temperature of Liquid Hydrogen on Bacteria." By Allan Macfadyen, M.D., and Sydney Rowland, M.A. Communicated by Lord Lister, P.R.S.

In a previous communication we have shown that the temperature of liquid air has no appreciable effect upon the vitality of micro-organisms, even when they were exposed to this temperature for one week (about −190° C.). (*Roy. Soc. Proc.*, February 1; *ibid.*, April 5.)

We have now been able to execute preliminary experiments projected in our last paper as to the effect of a temperature as low as that of liquid hydrogen on bacterial life. As the approximate temperature of the air may be taken as 300° absolute, and liquid air as 80° absolute, hydrogen as 21° absolute, the ratio of these temperatures roughly is respectively as 15 : 4 : 1. In other words, then, the temperature of liquid hydrogen is about one-quarter that of liquid air, just as that of liquid air is about one-quarter of that of the average mean temperature. In subjecting bacteria, therefore, to the temperature of liquid hydrogen, we place them under conditions which, in severity of temperature, are as far removed from those of liquid air as are those of liquid air from that of the average summer temperature. By the kindness of Prof. Dewar, the specimens of bacteria were cooled in liquid hydrogen at the Royal Institution. The following organisms were employed: *Bac. acidi lactici*, *B. typhosus*, *B. diphtheriae*, *Proteus vulgaris*, *B. anthracis*, *B. coli communis*, *Staphylococcus pyogenes aureus*, *Spirillum cholerae*, *B. phosphorescens*, *B. pyocyaneus*, a Sarcina and a yeast.

The above organisms in broth culture were sealed in thin glass tubes and introduced directly into liquid hydrogen contained in a vacuum jacketed vessel immersed in liquid air. Under these conditions they were exposed to a temperature of about -252 C. (21° absolute) for ten hours. At the end of the experiment the tubes were opened, and the contents examined microscopically and by culture. The results were entirely negative as regards any alteration in appearance or in vigour of growth of the micro-organisms. It would appear, therefore, that an exposure of ten hours to a temperature of about $-252°$ C. has no appreciable effect on the vitality of micro-organisms.

We hope to extend these observations on the influence of the temperature of liquid hydrogen on vital phenomena, and to make them the subject of a future communication, and to discuss their bearing upon problems of vitality.

June 21.—"On the Viscosity of Gases as affected by Temperature." By Lord Rayleigh, F.R.S.

A former paper[1] describes the apparatus by which I examined the influence of temperature upon the viscosity of argon and other gases. I have recently had the opportunity of testing, in the same way, an interesting sample of gas prepared by Prof. Dewar, being the residue, uncondensed by *liquid hydrogen*, from a large quantity collected at the Bath springs. As was to be expected,[2] it consists mainly of helium, as is evidenced by its spectrum when rendered luminous in a vacuum tube. A line, not visible from another helium tube, approximately in the position of D_5 (Neon) is also apparent.[3]

The result of the comparison of viscosities at about 100° C. and at the temperature of the room was to show that the temperature effect was the same as for *hydrogen*.

In the former paper the results were reduced so as to show to what power (n) of the absolute temperature the viscosity was proportional.

	n.	c.
Air	0·754	111·3
Oxygen	0·782	128·2
Hydrogen / Helium	0·681	72·2
Argon	0·815	150·2

Since practically only two points on the temperature curve were examined, the numbers obtained were of course of no avail to determine whether or no any power of the temperature was adequate to represent the complete curve. The question of the dependence of viscosity upon temperature has been studied by Sutherland,[4] on the basis of a theoretical argument which, if not absolutely rigorous, is still entitled to considerable weight. He deduces from a special form of the kinetic theory as the function of temperature to which the viscosity is proportional

$$\frac{\theta^{\frac{1}{2}}}{1 + c/\theta} \qquad \text{(1)},$$

c being some constant proper to the particular gas. The simple law $\theta^{\frac{1}{2}}$, appropriate to "hard spheres," here appears as the limiting form when θ is very great. In this case, the collisions are sensibly uninfluenced by the molecular forces which may act at distances exceeding that of impact. When, on the other hand, the temperature and the molecular velocities are lower, the mutual attraction of molecules which pass near one another increase the number of collisions, much as if the diameter of the spheres was increased. Sutherland finds a very good agreement between his formula (1) and the observations of Holman and others upon various gases.

If the law be assumed, my observations suffice to determine the values of c. They are shown in the table, and they agree well with the numbers for air and oxygen calculated by Sutherland from observations of Obermayer.

"Underground Temperature at Oxford in the Year 1899, as determined by Five Platinum Resistance Thermometers." By Arthur A. Rambaut, M.A., D.Sc., Radcliffe Observer. Communicated by E. H. Griffiths, F.R.S.

Royal Microscopical Society, June 20.—Mr. Carruthers, F.R.S., President, in the chair.—Mr. G. H. J. Rogers exhibited a modification of the Rousselet compressor, in which two thin indiarubber bands, sunk into grooves, were employed to keep the cover-glass in position, instead of having it cemented, the advantage claimed for this modification being the facility with which a broken cover-glass can be replaced.—Mr. Chas. Baker exhibited an achromatic substage condenser which was a modification of Zeiss's model of the Abbe condenser, the N.A. being 1·0, aplanatic cone 90°, lenses $\frac{7}{10}$-inch diameter, working distance $\frac{4}{10}$-inch. With the front lens removed the condenser is suitable for use with low-power objectives.—A short paper by Mr. E. B. Stringer, on a new projection eye-piece and an improved polarising eye-piece, was taken as read.—A paper by Miss Loraine Smith, on some new microscopic fungi, was also taken as read, the President giving a short *résumé* of it and expressing his opinion that the paper would be an important addition to our knowledge of microscopic fungi. Mr. Bennett said there was one special point with regards to parasitic fungi which might prove to be of considerable practical importance—he referred to the cultivation of fungus parasites on certain insects It had been proposed to do this on the Continent and in Australia and America, with a view of getting rid of insect pests—locusts and others; and if efforts in this direction were successful they might be the means of producing very beneficial and economic results.—The President then read a paper, and gave a lantern demonstration, on the structure of some palæozoic plants. He said the intelligent study of palæozoic plants was not yet a century old, for although their presence had long been noticed, they appear to have been regarded simply as freaks of nature. The importance of fossils was first recognised by Wm. Smith, who observed that strata could be identified by the organised fossils found in them. He published this important fact in 1816, and thus laid the basis of stratigraphical geology. The majority of fossil plants are found in the shales, and although the tissues had been converted into carbon, the form and venation of the leaves and occasionally the aspect of the fruits had been preserved. The most important information, however, had been obtained from specimens in which the tissues had been replaced by minerals dissolved in the strata enclosing them. He had arranged for the lantern sections of plants from the carboniferous system, but before exhibiting them he wished to point out to what group of plants they belonged. The cellular plants, with few exceptions, had been lost. Sir Wm. Dawson found specimens of a remarkable stem in the lower Devonian rocks of Canada, to which he gave the name of *Protaxites*. From a microscopic study of specimens he, the President, was led to publish a paper in the Society's *Journal* in 1872, in which he demonstrated that the stem was that of a cellular plant belonging to the Algæ, a view which was ultimately accepted by Sir Wm. Dawson. Fungal remains had been detected by Alder, and also by himself. The plants which had been certainly determined were vascular plants belonging to the Equisetaceæ, Filices, and Selaginellaceæ, among Cryptogams, and to the Coniferæ, groups which existed in the present flora of the globe, and were represented in the indigenous flora of Britain. The President proceeded to describe the principal characteristics of the fossil and existing forms of the four orders of plants referred to. In illustration of his remarks a number of preparations were shown on the screen.—Mr. Bennett wished to say a few words to elicit an opinion on a matter of great interest.

1 *Roy. Soc. Proc.*, vol. lxvi. (1900), p. 68.

2 *Roy. Soc. Proc.*, vol. lix. (1896), p 207; vol. lx. (1896), p. 56.

3 I speak doubtfully, because to my eye the interval from D_1 to D_3 (helium) appeared about equal to that between D_3 and the line in question, whereas, according to the measurements of Ramsay and Travers (*Roy. Soc. Proc.*, vol. lxiii., 1898, p. 438), the wave-lengths are:

D_1	5895·0
D_2	5889·0
D_3	5875·9
D_5	5849·6

so that the above-mentioned intervals would be as 19·1 : 26·3 [*June* 23.—Subsequent observations with the aid of a scale showed that the intervals above spoken of were as 20 : 21. According to this the wave-length of the line seen, and supposed to correspond to D_5, would be about 5855 on Rowland's scale, where $D_1 = 5896·2$, $D_2 = 5890·7$, $D_3 = 5876·0$.] I may record that the refractivity of the gas now under discussion is 0·132 relatively to air.

4 *Phil. Mag.*, vol. xxxvi. (1893), p. 507.

He referred to the recent discovery of the mode of impregnation in some of the Cycadeæ by means of active spermatozoids, as in the case of vascular cryptogams. This seemed to suggest the question whether the gymnosperms were not more closely allied to the vascular cryptogams than was usually recognised. Did the evidence of palæontology favour the view that there was a closer affinity to the vascular cryptogams than to the higher section of flowering plants, the angiosperms?—The President said this question deserved careful consideration, but it should be remembered that in these strata they only saw four groups of plants, and that the coniferæ were found alongside the others, and were evidently living at the same period. Brogniart had shown the presence of pollen grains in the apical cavities of fruits which had been preserved in silex. It was not known how these spermatozoids were developed in Salisburia, but if they rendered pollen grains unnecessary, the presence of the pollen in these extinct fruits would be against the idea of including the gymnosperms with the cryptogams.—The President announced that the rooms of the Society would be closed from August 17 to September 17, and that the next ordinary meeting would be held on October 17.

PARIS.

Academy of Sciences, July 9.—M. Maurice Lévy in the chair.—Problem of permanent heating of a sphere by radiation, reduced to the simpler problem of heating the same sphere by contact, by M. J. Boussinesq.—Combustible gases of the atmosphere; sea air. Existence of free hydrogen in the atmosphere, by M. Armand Gautier. By way of completing his previous researches on the impurities in the air of towns, woods and mountains, the author now gives the results of experiments on sea air. In these experiments no carbon compounds could be detected in 100 litres of air, the amount present, if any, being less than 0·03 mgr. per 100 litres; hydrogen was still found, however, to the extent of 1·21 mgr. for the same volume. The amount of free hydrogen thus proved to be present in the air, 2 parts by volume in 10,000, is thus about two-thirds of the carbon dioxide normally present.—On two loci relating to the densities of the liquid and saturated vapour of carbonic acid, by M. E. H. Amagat. In remarking on a recent paper by MM. Cailetet and Mathias, the author points out that the conclusions drawn, although opposed to his own, are obtained from the same set of experimental data. The law of rectilineal diameters, although extremely useful when applied within certain limits, is not a mathematical but an empirical law, derived from experiment, and hence its use as rigidly true seems hardly justified.—The chemical constitution of steel; influence of tempering upon the state of combination of elements other than carbon, by MM. Carnot and Goutal. In manganiferous steels, the state of combination of the sulphur is not altered by tempering, and phosphorus behaves similarly. In steels containing arsenic, the latter is free if the cooling has been slow, tempered steels containing an arsenide of iron, probably Fe_2As.—M. Czerny was elected a Correspondent for the Section of Medicine and Surgery.—On the equations of motion of a wire in any co-ordinates whatever, by M. G. Floquet.—On certain linear partial differential equations of the second order, by M. C. Guichard.—On the instability of certain substitutions, by M. Levi-Civita.—Demonstration of the rotation of the earth by Foucault's experiment with a pendulum 1 metre long, by M. Alphonse Berget. The sensibility of the reading apparatus is increased by viewing the pointer carried by the pendulum in the field of a microscope furnished with cross-wires in the eyepiece. With a pendulum only 1 metre long, the deviation can be clearly observed after four seconds.—On the liquefaction of gaseous mixtures, by M. F. Caubet. The results of experiments upon mixtures of methyl chloride and sulphur dioxide are here given in the form of curves. Two of the curves have the form predicted from theoretical considerations by Gibbs and Konovalow; these experiments being the first to show these points.—On a new type of mercury pump, allowing of a good vacuum being attained rapidly, by MM. Berlemont and Jouard. A drawing of the pump is given, unaccompanied by any explanation. It is claimed for this pattern that it will work with 12 lbs. of mercury, gives a high vacuum automatically, is not easily broken, and contains neither taps nor rubber connections.—On an ammoniacal chromous sulphate, by M. Ch. Laurent. The salt described, which has the composition $Cr(NH_4)_2.(SO_4)_2+6H_2O$ is analogous to the double sulphate of iron and ammonia.—On the preparation of gentopicrine and glucoside from fresh gentian root, by MM. Em. Bourquelot and H. Hérissey. The fresh roots are treated with boiling alcohol as soon as possible after picking, in order to prevent the action of the oxydases of the plant upon the glucoside, 22 kilograms of root giving 250 grams of crystallised gentiopicrine.—Experimental parthenogenetic segmentation in Amphibia and Fish, by M. E. Bataillon. The chemical composition of the medium, in which the eggs are placed, has only a secondary effect. The serum of mammals, whether diphtheritic or not, behaves like an isotonic solution of a salt or sugar; it acts by its osmotic pressure.—Lœb's theory of the chemical fertilisation of the egg, by M. Viguer.—On the cytology of the Hymenomycetes, by M. René Maire.—The experimental origin of a new vegetable species, by M. Hugo de Vries.—Influence of experimental modifications of the organism upon the metabolism of sugar, by MM. A. Charrin and A. Guillemonat.—A new method of measuring stereognostic tactile sensibility, by MM. Ed. Toulouse and N. Vaschide.—Some new facts concerning the subterranean river at Padirac (Lot), by M. E. A. Martel. The work done in 1899 and 1900 has rendered accessible another 400 metres of this underground river.—Combination of the effects of synodic and tropical revolutions of the moon, by M. A. Poincaré.

NEW SOUTH WALES.

Royal Society, May 2.—W. M. Hamlet, President, in the chair.—Annual general meeting. Mr. W. M. Hamlet read an address upon the development of chemistry. Four words of Arabic or Egyptian source were taken as the text or frame work of this address, namely, alchemy, alkali, alkaloid and alcohol. Under the first came a brief review of the most prominent alchemists. The second afforded scope for the derivation of the word denoting the volatile alkali—the alkaline air—ammonia. In the case of the term alkaloid the researches of Fischer were referred to as showing the constitution of such alkaloids as theobromine and caffeine from structural formulæ of uric acid. Under the generic term, alcohol, the fermentation of other substances than those in use for the production of spirits of wine were dealt with. A vote of thanks was passed to the retiring president, and Prof. Liversidge, F.R.S., was installed as President for the ensuing year.

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