THURSDAY, MAY 26, 1898.

MODERN PHYSIOLOGY FROM THE CHEMICAL STANDPOINT.

Text-book of Physiology. Edited by E. A. Schäfer, LL.D., F.R.S. Vol. i. (Edinburgh and London: Young J. Pentland, 1898.)

UNDOUBTEDLY, as the editor remarks in his preface to the above work, there has been a great desire on the part of teachers of physiology in this country to obtain a complete text-book on their subject, written in English, somewhat similar to the classical Handbuch of Hermann. Prof. Schäfer, with the aid of some of the best-known physiologists in Britain at the present day, has succeeded in bringing out a work which, if one may judge from the first volume, is destined to supply more or less completely the want that has been so long felt. It is a text-book essentially intended for advanced students; and although all the parts are not treated with like fulness, still the fact remains undoubted that at present no text-book in English is so complete as this one. The first volume deals practically entirely with the subject from the chemical standpoint. The first two chapters, by Halliburton, on the chemical constituents of the body and food, and on the chemistry of the tissues and organs respectively, are praiseworthy in so far as they give a fairly full account of the subjects with which they deal. But, seeing that these chapters must contain from their very nature many of the points to be discussed afterwards under special chapters, it would have been better, perhaps, had they been slightly shorter and more interestingly written. Then, again, a number of errors have crept in that ought not to have appeared. For example, the statement that the sugars are designated according to the number of carbon atoms they contain is hardly correct, as one may see by taking one of the examples given in the book. Rhamnose, although it contains six carbon atoms, is not a hexose but a pentose, viz. a methyl-pentose $CH_3(CHOH)_4COH$. They are designated not by the number of carbon atoms they contain, but by the number of oxygen atoms they possess. Here and there careless methods of expression are used, especially in the case of the sugars. Levulose is a ketone of sorbite as well as mannite. The note at the foot of p. 6 is slightly vague in meaning. Of course, as the writer says, the letters *d*, *l*, *i* do not refer to the rotatory power of the sugars, but to their genetic relationship to a fixed aldo-hexose. The letters only agree with the rotatory power in the case of the natural aldo-hexoses. Small points here and there are vaguely expressed. There is absolutely no doubt that vitellin is not a globulin, but a nucleo-albumin. The statement that Kossel has described four nucleic acids corresponding to four separate nuclein bases is hardly correct. He merely surmised that there might be a nucleic acid furnishing on decomposition a single definite alloxur base, and he based this supposition upon his investigation of the nucleic acid obtained from the nuclein of the thymus gland, which he at first termed adenylic acid because he imagined that adenin only was obtained from its decomposition. This, of course, has been shown by Kossel himself to be incorrect. Up to the present no such nucleic acids have been prepared. Again, it is more than doubtful whether any genetic relationship exists between hæmatogen and hæmoglobin, as Bunge thought. The way in which the iron is bound in the former is absolutely different from that in the case of the latter. Again, there are points of the greatest interest that might have been put in a more interesting fashion; for example, the extremely important relationship between chitin and chondrin. The classification of the proteids which is given is not a particularly good one. There are too many repetitions, and the divisions into which the author has classed the different members are so scattered that it is difficult to grasp the subject at all well. There are many other points that would have been the better for a little fuller description, *e.g.* carnic acid (Siegfried) and the paired acids of glycuronic acid.

These articles have entailed undoubtedly a great deal of labour, and contain much that is interesting and difficult elsewhere to obtain, but they are hardly intended for students.

The part dealing with hæmoglobin and the principal products of its decomposition, by Gamgee, is exceedingly well written. It suffers, however, from its more or less one-sided character. Some of the more recent work—as, for example, the acids obtained from hæmatin—by Küster has been wholly disregarded. Through it all, however, the reader can easily perceive that it is a subject with which the writer is familiar.

The section on the blood, by Schäfer, is very well written.

The effect of acids on the reaction of the blood of herbivora might have been more clearly explained.

The proteids of the tissues in herbivora do not break down to furnish ammonia to neutralise the acid introduced, and hence the alkali of the blood is taken up with the result that mineral acids act as poisons in such a case.

The equation given on p. 157, showing the action of disodic phosphate in the transmission of CO_2 in the blood, is incorrect. It ought to be

$$Na_2HPO_4 + H_2CO_3 = NaH_2PO_4 + NaHCO_3.$$

Some reference might have been made to the important work done before Hürthle on the cholesterin esters in the blood; and it would also have been better if Nasse's work contradicting that done by Lépine on the absence of the glycolytic action of the blood in diabetes had been mentioned, as it is so important.

The recent work of Hammarsten on the coagulation of the blood might have been more fully referred to, as it was so carefully done, and the results obtained were so important. Many of the important points in Hammarsten's paper are referred to, but the source is not always acknowledged.

Diffusion, osmosis and filtration are treated of by Waymouth Reid in a very interesting chapter. This subject has been so much worked at in Germany within recent years, that the author would have no difficulty in gathering together and weaving into an interesting whole a number of facts scattered through the *Zeitschrift für physikalische Chemie* and Pfeffer's new text-book.

The chapter on the production and absorption of

lymph, by Starling, is short but good, and gives a succinct account of our present-day knowledge of this very interesting subject.

The next chapter, by Moore, on the chemistry of the digestive processes, must have entailed a large amount of labour, as the literature is overwhelming. It might have benefited by curtailment, and by the omission of such words as "flocky," "unsolvable," and some others. The mass of unproved details with which Kühne deluged physiology has been largely made use of. Those who wish to be able to criticise this work of Kühne might with advantage look up the original papers by Kühne and Chittenden and Neumeister. They will then perceive that a number of bodies there referred to depend for their separate and definite existence upon very insufficient data. The physiological chemist of a later date will smile when he reads of anti-albumid, anti-albumate, anti-albumose, and so on. A lot of details given in this paper might have been, perhaps, with advantage omitted, as after all they are only of use to those working at the subject, and later on will be merely of historical interest. Paijkull's work on the mucin of bile requires to be repeated. It is by no means certain that the mucin is a nucleo-proteid. This chapter, however, gives as good an account of the subject as any one could desire. It has been kept well up to date, including as it does such recent work as that of Nuttall and Thierfelder.

The chapter, by Langley, on the salivary glands is an excellent one, distinguished alike by its clearness and suggestiveness as well as its succinctness.

The mechanism of the secretion of gastric, pancreatic, and intestinal juices is discussed in an interesting way by Edkins, as is also the section on the secretion of bile, by Noël Paton.

The important chapter on the chemistry of the urine has been entrusted to Hopkins, who has succeeded, in the space at his disposal, in giving a most excellent account of the subject. Here, of course, an author must exercise the gift of selection, as, in order to be complete, one would require to give another Huppert and Thomas' Handbuch. It ought to have been noted that the Krüger and Wulff method for estimation of the nuclein bases and uric acid is not a trustworthy one, as other nitrogen-holding bodies are precipitated. The inorganic constituents of the urine have received but scant attention.

The chapters on the secretion of urine and on that of milk, by Starling and Schäfer respectively, are clearly written; as is also that on the secretion and absorption of the skin, by Waymouth Reid.

The chapter on the chemistry of respiration, by Pembrey, is a good one; as are also those on animal heat, by the same author, and on metabolism, by Schäfer.

It is a pity that in such a book as this there is not only a necessary repetition, but also a tendency to omission of certain facts because they fall under two headings. An example of this may be given. The relationship between leucocytosis and the excretion of uric acid and nuclein bases is referred to in the section dealing with the chemistry of the urine, and also in that on metabolism. The result has been that in neither is there a proper description of Horbaczewski's experiments, nor are the conclusions which Horbaczewski arrived at clearly defined.

The work of Sandmeyer, on the effect of giving pancreas by the stomach to dogs that have had their pancreas removed, has not been referred to. This volume closes with an exceedingly interesting account of the internal secretions of the ductless glands and their effects upon metabolism. As one would expect from the writer of this article, the supra-renal extracts have received a good deal of attention, a little of which might have been bestowed on the thyroid therapy.

The points which have been drawn attention to in this review as perhaps admitting of improvement are few in number. The book stands as a monument of industry care and thought on the part of the editor and his coadjutors. It is, without doubt, the best book that we at present possess in English on the subjects dealt with in the first volume of what will prove to be a text-book of the greatest advantage to all interested in the subject of physiology. Before the value of such a book can be accurately appraised, it must be read carefully and intelligently, and compared with the original papers from which all such books must be built up. Those working at a special department of the subject may think that there might have been some additions or omissions; but one must remember that the subject is such a huge one, and the mass of literature to be consulted so immense, that after all such a complete text-book for the scientific worker must always remain mainly as a stepping-stone between the ordinary smaller text-book and the original papers. It is the conscientious perusal of the latter that must always remain, if the slowest, still the surest way to gain a knowledge of that most fascinating subject, physiology.

T. H. MILROY.

VEGETABLE ORGANOGRAPHY.

Organographie der Pflanzen. By Dr. K. Goebel. Part i. With 130 figures in the text. Pp. ix + 232. (Jena: Gustav Fischer, 1898.)

IT is difficult to realise that this book is the work of the same author who wrote the now classical text-book of morphology. Later publications of Dr. Goebel's have been largely occupied with biological subjects, and he appears in the book before us to have abandoned the morphologist's standpoint, and assumed a physiological or, perhaps more correctly, a biological position. In making this change he admits that phyllogenetic speculations are, without doubt, more attractive than the investigation of the illusive causes, external or internal, which determine modifications of form; yet for him the recognition of the factors which bring about the unsymmetrical form of a leaf is of more importance than the construction of insubstantial theories of phyllogenetic development.

In the introduction the author further insists on the insufficiency of morphology, and quotes from Herbert Spencer to emphasise the fact that function and form are mutually interdependent. In the strict study of morphology the functions have been treated as something extraneous, and as having nothing at all to do with the characteristics of the organs.

The latter part of the introduction is devoted to a discussion of the two rival hypotheses as to the formation of the organs of plants, *e.g.* the theory of the

differentiation of indifferent rudiments and that of the metamorphosis of rudiments materially differing from one another. Dr. Goebel shows a strong bias in favour of the latter. Thus he says a foliage leaf is not a foliage leaf in the later stages of its development only, but the material constitution of its rudiment determines its development. Internal or external influences may, however, direct this development along other lines. To illustrate this point of view he describes the metamorphosis of the rudiment of a foliage leaf of a maple into a scale-leaf. But it must be confessed that although his arguments and illustrations are interesting, he fails to convince the reader that there are less difficulties in the way of the theory of metamorphosis, involving as it does some form of evolution in ontogeny, than are presented to the theory of differentiation, which in this case appears to be based on epigenesis. The indisputably indifferent nature of the cells forming the archesporial tissues and those in other positions in leaves, which are able to give rise to adventitious buds, are arguments in favour of the indifferent nature of all the leaf-cells, even in comparatively late stages of development. That no absolute material difference exists between the rudiments of different categories of organs is rendered probable by the absence of any definite demarcation between stem and leaf, as is shown by the example of Utricularia, which Dr. Goebel himself has investigated. Indeed in this direction Dr. Goebel goes further than the majority in maintaining that the vegetative body of Lemna is composed of branching leaves, and is not a leafless stem.

The purely morphological view, without regard to the functions of the organs considered, may often lead to misconception, and Dr. Goebel takes hairs as an example of this possibility. Thus according to him no sensible man would call a fern sporangium a "trichome"; for one cannot believe that either in the life-history of the individual, or of the race, that a sporangium arose by the metamorphosis of a hair. And yet the belief, which Dr. Goebel himself seems to share, that a stamen is a metamorphosed foliage leaf appears to rest on similar grounds, especially when viewed in the light of Bower's researches on spore-producing members.

Of great interest are those sections of the book dealing with the symmetry of organs and with the effect of light on dorsi-ventrality. The author finds that *Selaginella sanguinolenta* possesses leaves of two kinds, and is dorsi-ventral when subject to bright illumination; while if it is exposed to feeble light, it possesses leaves of one kind only and is radially symmetrical. The arrangement which is induced by the situation of the individual of this species, occurs normally on different parts of the same individual of other species. In these the individual is radially symmetrical in the lower portions of the stem, while the upper parts are anisophyllous. Furthermore, Dr. Goebel has been able to cause *S. helvetica*, which is normally anisophyllous, to considerably lessen the contrast between the two kinds of leaves by simple etiolation. Thus it appears that in some the adaptation is ontogenetic in its nature, and is brought about by the actual circumstances of the individual; in others it is inherited, and not materially affected by the immediate surroundings, although probably brought about by the relations of a succession of individuals to light.

In the succeeding section, on the difference between the structures of organs in the adult and early stages of development, there is much of interest. *Polysiphonia Benderi*, one of the most remarkable examples of this difference, has been already described by Dr. Goebel. In this alga the first stage resembles the adult in possessing a cylindrical thallus. This gives rise to one or more flat structures, which apply themselves to the surface of other algæ, and which are wholly different from both the first and final stages in appearance. Only before the formation of the reproductive organs are the adult cylindrical branches developed.

Passing on to the development of the higher plants, perhaps every one will not agree with the author in his view that the simpler form of the primary leaves of seedlings is due to an arrest of development. The existence of a more complicated form in some primary leaves than in those of the adult stages, must make one hesitate before accepting the theory of arrested development in every case, and may suggest that a similar reason for the difference between the leaves of the seedling and those of the adult exists both when the former are more simple and when they are more complex than those of the latter.

The section on vegetable teratology may be noted, as in it Dr. Goebel gives his support to Beyrinck's extension of Sachs' hypothesis, that the difference in form of plant organs is due to a difference of substance, and that changes in form are referable to alterations in the nutrition of the parts involved. Beyrinck's view is that galls are caused by such an alteration in the nutrition of the part in response to the stimulation by the gall-producing animal.

The last part of the book is devoted to a discussion of the influence of correlation and external stimuli on the form of plants. It is not behind the earlier parts in interest and wealth of example. Among the more important matters touched upon in this part are Lindemuth's experiments on the production of seeds in bulbous plants, Sachs' investigations on the relation of flower-production to light, and Lothelier's observations on the conversion of the spinous leaves of Ulex into flattened forms, in a moist atmosphere. Dr. Goebel doubts that this modification of spines due to moisture is of frequent occurrence, and believes that Lothelier observed isolated examples.

With confidence Dr. Goebel's book may be recommended to all who are interested in theoretical botany. It is full of suggestion and novelty, and its occasionally dogmatic style in no way lessens its tendency to arouse interest and discussion. H. H. D.

A GREAT NORTH ROAD.

A Northern Highway of the Tzar. By Aubyn Trevor-Battye. Pp. xiv + 256. (London: Archibald Constable and Co., 1898.)

MR. TREVOR-BATTYE gives in this book a very interesting account of his journey home from Kolguev, an island in the Arctic Ocean, on which he was for some time ice-bound.

The journey was undertaken in October, a time known

in Northern Russia as the Rasputnya season. Mr. Trevor-Battye describes the season as follows :—

"Rasputnya, as I have been since informed, means, literally, 'the separation of the roads,' but by some process of thought has now come to be the term for a fifth season, for the time which lies between autumn and winter; in short, for the month of October. It means in Northern Russia that the first frosts have thawed and the first snows melted; that the rivers are blocked with streams of broken ice, the morasses like a quagmire, the tracks, where any advance has been attempted upon old forest bog, a mixture of treacle and glue. Finally, it means, as I have said before, that no one dreams of trying to move until the country is sound and hard under the settled frost. During the whole of October the Government postal service is stopped, labour contracts are off, and the keepers of the stages are entirely freed from their usual obligation to supply the traveller with horses and sleighs."

Undertaking a journey at such a time seemed an act of madness, but it certainly was the means of getting an insight into the character of the North Russian peasant, and of seeing a side of it which might not have been revealed under ordinary circumstances. Their kindly good nature is striking, and throughout the journey, although at first objections were raised and the impossibility of accomplishing the various stages of the journey put forward, still some one was always found willing to supply horses and sleighs, and to accompany the travellers.

After crossing from Kolguev to the mainland, Mr. Trevor-Battye, together with his camp-man Thomas Hyland, and his old spaniel "Sailor," made their way across country to the small village of Askino, on the river Pechora. They were assisted in getting there by the Samoyeds, inhabitants of the *tundra* in the west. Askino is practically the only place where the Russians speak Samoyed, and where there is any apparent intercourse between the two races. At their next destination, Ust Tsilma, also on the Pechora, and which they reached by boat, the condition was quite changed; for on inquiry not one person could be found who spoke Samoyed, although the two places were only about 180 miles apart.

From Ust Tsilma the journey was continued overland, from *stantsyia* to *stantsyia*, which are log buildings put up by the Government at variable distances apart, and in charge of a *yamshstchik* (driver), who is bound to supply horses and conveyances to any travellers on production of a printed permission. The difficulties of getting conveyances, owing to Rasputnya, and the descriptions of the numerous adventures, especially those connected with crossing the ice-blocked rivers, are of great interest. Archangel was eventually reached, and the travellers considered their difficulties over. The sleigh drive to Vologda, a distance of about 700 miles, was accomplished without any difficulty, as the track was good. Having reached Vologda, the journey home was continued by rail.

The book gives us a good insight into the peasant life. The houses, or rather huts, occupied by the peasants are simple in the extreme, and consist generally of two rooms. In a prominent position in the front room there is always an *ikon*, before which lamps or candles are lighted. Attention is also drawn to the oven or *paitch*, which forms such a feature in these small buildings; and we are told that a characteristic proceeding of a *yamshstchik* on entering a house, "is to cross himself many times before the *ikon*, and the next to climb up to the oven top, from which simmering pulpit he holds forth on the events of the day."

Except for some references to birds and fishes, natural science does not form the same feature in the present book that it did in Mr. Trevor-Battye's previous one, "Ice-bound on Kolguev." This, however, is to be expected, for the journey had to be made with all possible speed. The book is written in a very instructive and pleasing style, and the map and illustrations by the author add much interest to it.

OUR BOOK SHELF.

Vorlesungen über Bacterien. Von Dr. Alfred Fischer, A.O. Professor der Botanik in Leipzig. Pp. 186. (Jena: Gustav Fischer, 1897.)

IT is sometimes alleged that bacteriology has suffered, as a pure science, from its association with medicine, since its pathological side has become disproportionately developed. This statement is certainly no longer justified, for the applications of the science to agricultural and manufacturing industries have been found almost as important to the farmer, the dairyman, and the chemist as they have been to the pathologist. Prof. Fischer's book is one which fills a distinct gap in bacteriological literature. Himself a botanist, he treats the subject from a broad and general standpoint. Without neglecting the pathogenic organisms he deals with them only, as it were, incidentally, and the book presents an admirable and judicial summary of the present state of knowledge of bacteriology in its widest and truest sense. It forms a valuable introduction to the subject from whatever point of view it is to be studied, since it affords a solid groundwork upon which more technical and special knowledge may afterwards be built.

The earlier chapters deal with morphology and with the intimate structure of bacteria—matters upon which Prof. Fischer's well-known researches on "plasmolysis" render him well qualified to speak. In the chapters on specificity and classification he shows himself no advocate of the extreme views on pleomorphism which have been advanced by some. In his remarks on classification he insists, with much justice, that strictly morphological characters must form the basis of generic distinctions, and that this matter lies within the province of the botanist alone. The classification which he proposes is a reasonable one, based largely on the character and distribution of the cilia, and the nature of the spores. The mode of life, and physiological properties of bacteria are next described, the chemistry of aërobiosis and anaërobiosis being fully dealt with; and two chapters are then devoted to the influence of physical and chemical agents, especially in relation to the problems of disinfection. The most fascinating part of the book will, however, be found in the sections devoted to the circulation of nitrogen and of carbonic acid in nature. The assimilation of free nitrogen by bacteria in the soil and in the nodules of Leguminosæ, and the decomposition and nitrification of proteids are set forth by the author with admirable clearness, and the same may be said of the various processes of fermentation with which he also deals. The last three chapters are devoted to pathogenic bacteria, and contain a short account of some of the more important species and their mode of action, with a sketch on serum-therapeutics and immunity. The writer is

throughout thoroughly impartial and judicial, and shows a healthy scepticism as regards theories unsupported by adequate fact. There can be no doubt that a translation into English of this admirable book would be of great assistance to all those students of bacteriology who are unable to read it in the original.

Lehrbuch der Entwicklungsgeschichte des Menschen. Von Dr. J. Kollmann, o.ö. Professor der Anatomie in Basel. Pp. xii + 658. (Jena: Gustav Fischer, 1898.)

THIS work appears to approach in method the ideal of an elementary text-book of science, since it gives a sound and well-balanced *résumé* of its subject to date, with references to authorities sufficient to place the student in direct touch with original description of detail. The pages of the book never pall, and in treatment and mode of expression it is one of the least "German" of German text-books with which we are familiar. It is illustrated by 386 excellent processed drawings, many of which are coloured, and where original these are very good and such as are likely to become popular. The investigations of His, of course, come in for a full share of recognition, and good use has been made of those of Keibel, Mall, Röse, Toldt, and others among recent workers. The book is divided into five leading sections. An introduction of sixteen pages is followed by portions dealing with the earlier stages of development ("Progenie" and "Blastogenie"), treated as far as is necessary comparatively. The fœtal membranes and progressive development of the human fœtus next come in for consideration; but the bulk of the work (405 pages) is of necessity devoted to a description of the development of systems and organs, and there is appended a twenty-page dissertation on heredity. Not the least pleasing feature of the book is its consummately artistic plan. Illustrations never obtrude themselves upon the margin nor overpower the text. In the placing of the figures, choice of their colour and descriptive letterpress, there are evidences of the bestowal of great care and forethought and of painstaking consideration of detail, which are alone a strong recommendation of the work. It is carefully written and non-pedantic, and should be deservedly popular.

Missouri Botanical Garden. Ninth Annual Report. Pp. 160. (St. Louis, Missouri: published by the Board of Trustees, 1898.)

ADMINISTRATIVE details occupy but a small part of this report, the chief contents being a collection of scientific papers and notes on interesting plants, illustrated by several half-tone plates. The results of the studies of the American Lemnaceæ occurring north of Mexico, by various botanists, are brought together by Mr. C. H. Thompson, and are combined with his own researches into a revision of the order. Mr. H. C. Irish contributes to the report a revision of the genus Capsicum, with especial reference to garden varieties. Mr. J. N. Rose describes five species of agaves which flowered in the Washington Botanic Garden in 1897, and were identified by him. One of these (*A. Washingtonensis*) appears to have been hitherto undescribed. Among the notes, Mr. William Trelease, the Director of the Gardens, records some interesting observations on Yuccas. He points out that *Yucca gigantea* is distinct from *Y. gloriosa* and *Y. Guatemalensis*—its nearest allies—and gives a figure of an Azorean specimen which is a good example of the species. With reference to the extent of the pollination of Yuccas by the Yucca moth, Mr. Trelease has now obtained information which proves the moth to be "the active agent in the pollination of Yuccas from Florida northward as far as fruit is set as a result of *Pronuba* activity, westward as far as southern California, and into the mountains of northern Mexico to the south."

LETTERS TO THE EDITOR

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Liquefaction of Hydrogen.

YOUR last issue contains a report of Prof. Dewar's remarkable achievement in the liquefaction of hydrogen and helium. In his account of it, which you quote, Prof. Dewar describes the apparatus employed as an enlarged plant of the same type as that used in his hydrogen-jet experiments discussed in his paper before the Chemical Society of December 19, 1895 (see *Proceedings*, No. 158), and in his lecture at the Royal Institution (see *Proceedings*, 1896), and illustrated in a figure printed with this lecture. An examination of that illustrative figure and of the description shows that the type of apparatus used involves an entirely new departure as compared with the methods of all who had liquefied air before 1895, including Prof. Dewar himself. The new self-intensive method then and now employed is a combination of the following four points: *a long tube conveying compressed gas, expansion of the compressed gas through a nozzle or throttle-valve, direct return of all the expanded gas over the tube of compressed gas, good interchange of temperatures between the compressed and expanded gas.* The new method embodying the above combination will be found fully described and illustrated in my patent, No. 10,165, 1895 (May 23). What is equally important historically: in November 1894, more than twelve months before Prof. Dewar first showed this new method in action, liquefying air, I had called, with an introduction, on his chief assistant, Mr. R. N. Lennox, at the Royal Institution, had there explained to him this self-intensive method, and had proposed it as a means of obtaining intensely low temperatures. By employing this method I was afterwards the first in this country to liquefy air and oxygen without employing other refrigerants. Since then, at the Royal Institution, where alone sufficient means are available for the prosecution of these researches, the same method has bridged over the space, impassable by former methods, between the temperature of liquid air and that of liquid hydrogen and helium, thus proving itself a new and valuable scientific instrument.

Under these circumstances I think that Prof. Dewar, seeing he was aware of the facts at the time of his account, ought not to have been content with eulogising the services of his assistant Mr. Lennox, but should also have given me credit for the invention of the method which has procured him so great a success. Although he has been easily able to find in old patents the separate elements which go to make up the new method—this can be done for any new invention—he has nowhere found, before the date of my communication to Mr. Lennox, that combination of the four points given above which is absolutely necessary to his apparatus for liquefying hydrogen.

The facts referred to above are stated and discussed in greater detail in a paper, to be printed shortly, which was read by me before the Society of Chemical Industry at Burlington House on the 2nd inst., with illustrative diagrams, and in letters by me to *Engineering* for April 15 and May 6. W. HAMPSON.

Concerning the Thermodynamic Correction for an Air-Thermometer.

IT is common in works on thermodynamics to give a formula for the thermodynamic correction applicable to an air-thermometer; the following is substantially the usual proof.

Accepting the current theory of the Joule-Thomson experiments, we may show that

$$t\frac{dv}{dt} - v = k\frac{\delta t}{\delta p},$$

where k is the specific heat at constant pressure measured dynamically. From this we obtain

$$t\frac{dv}{dt} = v + k\frac{\delta t}{\delta p}$$

and

$$t = \left(v + k\frac{\delta t}{\delta p}\right) \div \frac{dv}{dt}.$$

Thus t is seen to consist of two terms; the second term

$k\frac{\delta t}{\delta p} \div \frac{dv}{dt}$ is the smaller of the two, and we proceed to find its value. We have as a first approximation to the behaviour of gases,

$$pv = C(1 + \alpha T),$$

where T is the temperature centigrade on a gas-thermometer.

We therefore have, as approximate equations,

$$v = \frac{C}{p}\left(1 + \alpha T\right),$$

$$\frac{dv}{dT} = \frac{C\alpha}{p}.$$

We may further assume that $\frac{dv}{dt} = \frac{dv}{dT}$, since the degrees are practically equal on the two scales.

We therefore obtain, approximately,

$$v = \frac{C}{p}\left(1 + \alpha T\right),$$

$$\frac{dv}{dt} = \frac{C\alpha}{p}.$$

Using these approximate values, we have

$$k\frac{\delta t}{\delta p} \div \frac{dv}{dt} = \frac{kp}{C\alpha}\frac{\delta t}{\delta p}$$

$$= \frac{k}{C\alpha}\frac{\delta t}{\delta \log p},$$

and the equation for t becomes

$$t = v \div \frac{dv}{dt} + \frac{k}{C\alpha}\frac{\delta t}{\delta \log p}.$$

If now, further, we use the approximate values of v and $\frac{dv}{dt}$ in the term $v \div \frac{dv}{dt}$, we shall obtain

$$t = \frac{1}{\alpha} + T + \frac{k}{C\alpha}\frac{\delta t}{\delta \log p}.$$

This is the formula usually given.

This method of working appears to me to be incorrect, for the following reason:—

In the equation

$$t = \left(v + k\frac{\delta t}{\delta p}\right) \div \frac{dv}{dt}$$

there are two terms on the right-hand side, one of which, $k\frac{\delta t}{\delta p} \div \frac{dv}{dt}$, is small compared with the other. We may therefore neglect it as a first approximation, and we then obtain $\frac{v}{t}$ = function of p, in accordance with the laws of a perfect gas. If we wish to proceed to a closer approximation, we may use the perfect-gas laws as sufficiently good in the term $k\frac{\delta t}{\delta p} \div \frac{dv}{dt}$, because that is a small term, and the departure of the actual gas from the perfect gaseous laws will consequently in this term introduce only errors which depend on the squares of small quantities. But we are not at liberty to use the perfect gas laws in the remaining term $v \div \frac{dv}{dt}$, because it is *not* a small quantity, and we have therefore no guarantee that the use of such an approximation will not introduce errors of the first order of small quantities—that is to say, comparable with the term $k\frac{\delta t}{\delta p} \div \frac{dv}{dt}$ itself. With such errors introduced, the second approximation would not necessarily be better than the first.

The mistake in principle, which I have indicated, appears to be widespread, since it has crept into several of our well-known text-books. Thus the discussions given in Tait's "Heat" (pp. 338–339), in Baynes' "Thermodynamics" (pp. 126–127), and in Maxwell's "Heat" (pp. 211–214), all appear to me infected by this source of error. It is true that in these discussions the mistake is introduced more subtly, and is covered with a mass of symbols; whereas in the faulty investigation given above, I have purposely made the paralogism as glaring as possible. But *in substance* the mistake occurs in each of the discussions above named.

JOHN ROSE-INNES.

May 13.

Printer's Ink and Photographic Plates.

IN a paper on the action exerted by certain metals and other substances on a photographic plate, by Dr. W. J. Russell (*Proc. R.S.*, vol. lxi. p. 424), the author mentions that the *Westminster Gazette* is printed with an ink which readily acts on a photographic plate. The printed paper in some experiments is placed in contact with the photographic plate, in the dark, and after being left in contact for some time, in the dark, the plate is developed, and the printed letters come out clearly. Dr. Russell mentions the names of several periodicals the print of which acts on a sensitive plate. To these the following example of the same phenomenon may be added: a photographic plate wrapped up in an advertisement sheet of *Modern Society* on development showed the printed characters very clearly, the words reading from left to right, not being reversed, so that the action must have taken place through the thickness of the paper. This sample of the action of printer's ink on a photographic plate (the property of Mr. W. B. Croft) has been in the excellent physical laboratory museum at Winchester since 1892. The print is good and clear, and probably one of the earliest observed instances of the action of printer's ink on a photographic plate in the dark, in which the physical conditions were known and recorded.

F. J. JERVIS-SMITH.

Oxford, May 16.

Heavy Rainfalls.

I THINK it worthy of record that at a place called Nedunkeni, in the Northern Province of Ceylon, the rainfall on December 15–16, 1897 (24 hours), was 31·76 inches. The average annual rainfall of this place was 64·70, but in 1897 the amount totalled 121·85 inches.

The heaviest recorded rainfalls (as given in the "Encyclop. Britt.") are at Joyeuse, France, 31·17 inches in 22 hours; at Genoa, 30·00 inches in 26 hours; at Gibraltar, 33·00 inches in 26 hours; on the hills above Bombay, 24 inches in one night; and on the Khasia Hills, India, 30·00 inches on each of five successive days.

The rainfall in Ceylon, referred to above, is therefore notable. The greatest annual rainfall occurs, as is well known, on the Khasia Hills, with 600 inches. The wettest station in Ceylon is Padupola, in the Central Province, with 230·85 inches (mean of 26 years), the rainfall for last year being 243·07 inches.

C. DRIEBERG.

School of Agriculture, Colombo, Ceylon.

Hermaphroditism in the Apodidæ.

I AM not sure but that the tone of Prof. Lankester's demand, in NATURE of May 12, that I should "at once" withdraw my "assertions," or confirm them by "some evidence," would not have justified my ignoring it altogether. For those of your readers, however, who may be interested in this subject, may I say that I *have* produced "some evidence" (*Ann. and Mag. Nat. History*, xvii., 1896, plates xi. and xii.), and no counter evidence whatever has yet been forthcoming to shake my faith in the justness of my conclusions.

HENRY BERNARD.

Streatham, May 17.

MAGNETISM AND SUN-SPOTS.

WHEN Sir Edward Sabine was preparing his paper[1] "On Periodical Laws discoverable in the mean effects of the larger Magnetic Disturbances—No. ii.," in which he discussed the magnetic observations made at the temporarily established Colonial observatories at Toronto and Hobarton, he found that there existed at these places, in the years 1843 to 1848, a progressive increase in amount both of magnetic disturbance and in extent of diurnal range of the declination magnet, the values of diurnal range for the year 1843 having become in 1848 increased by some 40 per cent., the Toronto values for these years being 8′·90 and 12′·11 respectively, and the Hobarton values 7′·66 and 10′·63. This was an altogether unlooked-for result, one that engaged his special attention, such increase of value from year to year

[1] Read before the Royal Society, May 6, 1852.

in two quarters of the globe so widely separated as Toronto and Hobarton presumably indicating not simply a local effect, but one rather of cosmical character. He pointed out that as the sun must be recognised as at least the primary cause of all magnetic variations that conform to a law of local hours, as does the solar diurnal range, it seems not unreasonable to suppose that in the case of other magnetic variations we should look, in the first instance, to any periodical variation by which the sun is affected, to ascertain whether any coincidence of period or epoch is traceable. And he draws attention to the circumstance that, according to Schwabe's then recently-published table of frequency of solar spots, a minimum in number of spots occurred in 1843 and a maximum in 1848, with progressive increase in the intermediate years similar to that of the diurnal magnetic range during the same interval as shown by the Toronto and Hobarton observations. This led Sabine to infer the probable existence of a periodical variation in magnetism similar to that—one of about ten years—which Schwabe had detected in sun-spots from observations extending over a period of twenty-five years.

In the meantime another worker had been busy with the same subject. In *Poggendorff's Annalen* for December 1851 there appeared the well-known paper by Dr. Lamont, "on the ten-yearly period," in which he gave the following values of diurnal range of the declination magnet as observed at Munich.

1841 = 7′·82	1846 = 8′·81
1842 = 7′·08	1847 = 9′·55
1843 = 7′·15	1848 = 11′·15
1844 = 6′·61	1849 = 10′·64
1845 = 8′·13	1850 = 10′·44

Lamont considered that these numbers indicated a periodical variation, and from them he found by graphical construction that a minimum apparently occurred in 1843 and a maximum in 1848. He further discussed such older magnetic observations as were found to be available, and came to the following conclusion, which it may be interesting to give in his own words. "Die grösse der Declinations-Variationen hat eine zehnjährige Periode, so zwar, dass sie mit regelmässigen Uebergange fünf Jahre im Zunehmen, und fünf Jahre im Abnehmen begriffen ist."

Sabine became acquainted with Lamont's paper whilst writing his own, and quotes Lamont's figures from 1843 to 1848, showing how the Munich results confirmed those of Toronto and Hobarton. It would seem that Lamont and Sabine each independently suspected the existence of a periodical variation in diurnal magnetic range, which Lamont appears to have first distinctly formulated in the words quoted; whilst it was to Sabine that the suggestion that the periodical variation was one apparently concurrent with that of sun-spots was due. Lamont considered the variation to be so real that in any theory of the diurnal movement it could not be disregarded. Sabine more cautiously wrote: "As the physical agency by which the phenomena are produced is in both cases unknown to us, our only resource for distinguishing between accidental coincidence and causal connection seems to be *perseverance in observation*, until either the inferences from a possibly too limited induction are disproved, or until a more extensive induction has sufficed to establish the existence of a connection, although its precise nature may still be imperfectly understood." In a postscript to Sabine's paper (dated May 24, 1852) he gives a table of mean diurnal range of declination for Toronto and Hobarton from 1841 to 1851, which clearly shows, as do the Munich numbers, the minimum of 1843 and the maximum of 1848; and in 1856 he showed that at Toronto, from 1844 to 1848, there was a progressive increase in the amount of magnetic disturbance in all three elements of declination and horizontal and vertical force.

Considering that the periodical variation of diurnal range was found to exist in regions of the earth so far apart as Toronto, Hobarton and Munich, the results at the three places being distinctly corroborative, and, further, the circumstance that it appeared to be closely in accord with the established solar-spot variation, it seems to be matter for reflection as to how it happened that in some quarters the agreement between the magnetic and solar variations was thought to be only of apparent or accidental nature. Sir George Airy, in his paper[1] "On the Diurnal Inequalities of Terrestrial Magnetism," had occasion to give therein a list of the days of greater magnetic disturbance at Greenwich in the years 1841 to 1857, and he incidentally remarks that "there is no appearance of decennial cycle in their recurrence." But this is not surprising, for although magnetic disturbance does cluster about the epochs of maximum of sun-spots, it is on occasions by no means closely confined thereto, though nearly or quite absent at epochs of minimum of sun-spots. Thus the periodical variation, as regards the disturbance element, although existing, is not so distinctly traceable unless longer periods are examined, accompanying sun-spot maxima as disturbance does in a somewhat loose fashion as compared with the more regular increase and decrease of diurnal magnetic range with variation of sun-spot frequency. The behaviour of magnetic disturbance in this respect is indeed a matter that I am yet hoping to investigate more exactly.

Then, again, Lamont appears to have adopted for the diurnal magnetic range the difference between the positions of the magnet at 8h. in the morning and 1h. in the afternoon, as being the times of the greatest easterly and westerly deviation respectively. It is true that the positions of the magnet at these hours would not be likely to represent the extreme positions at Munich throughout the year, especially as regards the easterly deviation; still the diurnal range resulting from the employment of such fixed hours approximates in such degree to the true range for Munich, as very well serves clearly to bring out the decennial variation, of which indeed the good agreement between Lamont's and Sabine's results is of itself further proof, since the latter do depend on observations extending through the twenty-four hours of the day. From whatever cause, however, there were those in earlier days who doubted the existence of any real relation between magnetic and solar variations. The so-called decennial period, it may be here mentioned, seems to be more nearly an eleven-year period, this being about the mean value, although it is variable in length to the extent of several years.

When, in the year 1875, I was transferred at the Royal Observatory from the Astronomical to the Magnetical and Meteorological Department, I had then paid no particular attention to this question, and had an open mind thereon. But the daily examination of the photographic records after a time convinced me that change was in progress in the character of the records from year to year, such as even in this simple daily inspection of the records could not be well overlooked; and acting involuntarily on Sabine's principle of perseverance in observation, I came to the conclusion that it would be well to endeavour further to investigate the facts of observation, especially as the long series of Greenwich observations, made throughout on the same general plan and with instruments of the same kind, furnished so excellent an opportunity for applying an independent test of the reality or otherwise of the relation supposed to exist, which the late Dr. Wolf, of Zürich, had already done so much to establish. My first paper appeared in the *Philosophical Transactions* for the year 1880, and deals with the Greenwich observations from 1841 to 1877. This I have recently supplemented by a second paper, read before the Royal Society on March 10 of the

[1] Read before the Royal Society, April 23, 1863.

present year, which appears in the *Proceedings* of the Society. The results here employed extend from 1841 to 1896, a period of fifty-six years. The addition of the more recent observations is especially interesting as contrasting in some respects with the earlier portion, the

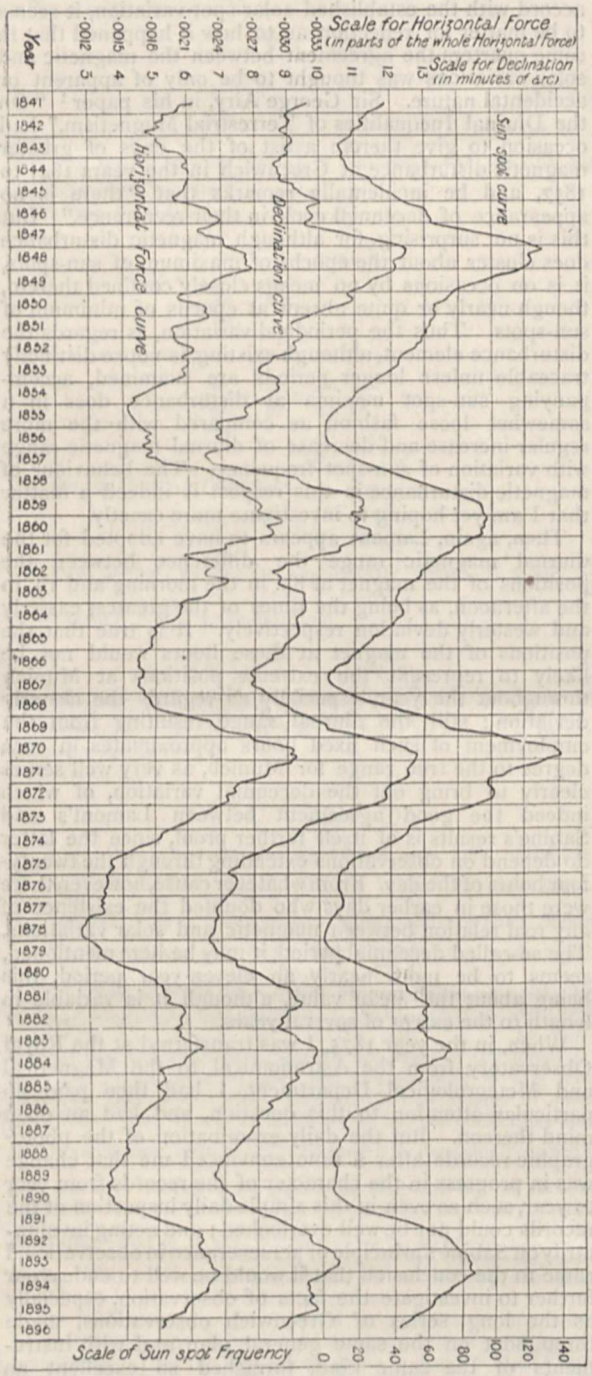

FIG. 1.—Smoothed curves of sun-spot frequency (Wolf), compared with corresponding curves showing the variation in diurnal range of the magnetic elements of declination and horizontal force from observations made at the Royal Observatory, Greenwich.

whole forming one continuous chain of evidence that much strengthens the argument for relation between the two classes of phenomena. The records of horizontal magnetic force, as well as those of declination, are employed. From 1841 to 1847 the results depend on eye observations made at intervals of two hours. In 1848 and afterwards, they depend on hourly tabulations from the photographic records. The mean diurnal range in each month is taken to represent (relatively to other months) the magnetic energy of the month. By the mean diurnal range of declination or horizontal force is to be understood the difference between the least and the greatest of the mean hourly values in each month.

In any graphical representation of unexplained phenomena it is important to give ready reference to the numerical data employed. Consequently in both papers complete tables of the elements used are either included, or indication given where such collected results can be found. The numbers for declination are in minutes of arc, those for horizontal force are in parts of the force, taken as unity. There being in the numbers a strongly marked annual period (the summer values being greater than those for winter), numbers that shall be free of annual inequality have (as explained in the paper) been prepared and used to construct the middle and lower curves of the diagram of collected curves. For sun-spot frequency the numbers published for so many years by Dr. Wolf, and since his death continued by his successor, Prof. Wolfer, have been employed. It is impossible to value too highly work of this kind, carried on for so many years on one fixed plan; such steady adherence to a definite method having many advantages. The monthly sun-spot numbers show considerable irregularities which Wolf smoothed by a process similar to that employed to free the magnetic numbers from the annual inequality, the resulting numbers being used for the upper curve of the diagram.

The collected curves show striking points of interest. The epochs of the extreme points of the curves are given in the following table:—

Table of Epochs of Magnetic and Sun-spot Minima and Maxima.

Reference No.	Phase.	Magnetic epochs. Declination.	Horizontal force.	Mean magnetic.	Sun-spot epoch.	Excess above sun-spot epoch. Declination.	Horizontal force.	Mean magnetic.
						y.	y.	y.
1	Minimum ...	1844·3	1842·9	1843·60	1843·5	+0·8	−0·6	+0·10
2	Maximum ...	1848·1	1849·0	1848·55	1848·1	0·0	+0·9	+0·45
3	Minimum ...	1857·2	1855·1	1856·15	1856·0	+1·2	−0·9	+0·15
4	Maximum ...	1860·6	1860·2	1860·40	1860·1	+0·5	+0·1	+0·30
5	Minimum ...	1867·5	1867·6	1867·55	1867·2	+0·3	+0·4	+0·35
6	Maximum ...	1870·8	1870·9	1870·85	1870·6	+0·2	+0·3	+0·25
7	Minimum ...	1879·0	1878·7	1878·85	1879·0	0·0	−0·3	−0·15
8	Maximum ...	1884·0	1883·8	1883·90	1884·0	0·0	−0·2	−0·10
9	Minimum ...	1889·5	1890·0	1889·75	1890·2	−0·7	−0·2	−0·45
10	Maximum ...	1893·5	1894·0	1893·75	1894·0	−0·5	0·0	−0·25
	Mean excess (five epochs of minimum)					+0·32	−0·32	0·00
	Mean excess (five epochs of maximum)					+0·04	+0·22	+0·13
	General mean excess					+0·18	−0·05	+0·06

The intervals between the successive mean magnetic epochs and the corresponding sun-spot epochs run, it will be seen, closely together. And if instead of successive intervals we take successive periods, as from No. 1 to No. 3, No. 2 to 4, &c., of the table, we have—

Length of Magnetic Period.

1–3	2–4	3–5	4–6	5–7	6–8	7–9	8–10
y.	y.	y.	y.	y.	y.	y.	y.
12·55	11·85	11·40	10·45	11·30	13·05	10·90	9·85

Length of Sun-spot Period.

y.	y.	y.	y.	y.	y.	y.	y.
12·50	12·00	11·20	10·50	11·80	13·40	11·20	10·00

Nos. 1 to 3, 3 to 5, &c., represent intervals between successive minimum epochs, and Nos. 2 to 4, 4 to 6, &c., intervals between successive maximum epochs. These are shown graphically in the annexed figure.

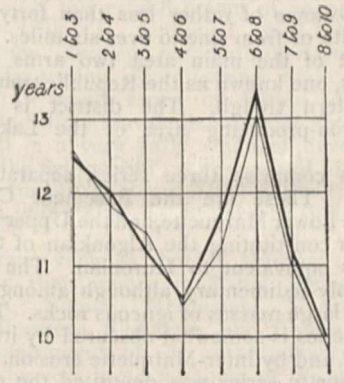

FIG. 2.—Length of sun-spot and magnetic periods compared. The thick line shows the variation in length of successive sun-spot periods, and the thin line that between successive magnetic periods. Odd numbers indicate periods from minimum to minimum, and even numbers periods from maximum to maximum.

Examining further the collected curves, it is seen that the several maximum points have at different epochs very different degrees of intensity. Arranged in order of intensity these are as follows :—

Order of Epochs.

Sun-spot curve ...	...	1870	1848	1860	1894	1884
Declination curve	...	1870	1848	1860	1894	1884
Horizontal force curve...		1870	1860	1848	1894	1884

The agreement is complete, excepting that in horizontal force the epochs 1848 and 1860 are transposed, although otherwise falling in with the order of the other curves.

The paper goes on to point out that—considering how the irregularities in the length of the sun-spot and magnetic periods, and also the order of epochs as regards elevation or depression of the maximum points of the curves, so entirely synchronise, and, further, the usually sharp rise from minimum to maximum and the more gradual fall again to minimum, a characteristic of all three curves—"there would appear to be no escape from the conclusion that such close correspondence, both in period and activity, indicates a more or less direct relation between the two phenomena, or otherwise the existence of some common cause producing both." Reference is also made to the question of the supposed lagging of the magnetic epoch, as referred to the sun-spot epoch, which the results presented do not appear much to confirm.

The paper concludes with an inquiry as to how far the practice of including in the Greenwich tabulation of magnetic elements all days (except those of extreme disturbance) may have affected the results presented, for which purpose diurnal ranges were deduced for the years 1889 to 1896 from five selected quiet days in each month —days free from magnetic disturbance—with result that the diurnal ranges so found show the same variation with sun-spots as do the diurnal ranges of the ordinary tabulation. WILLIAM ELLIS.

MONOGRAPHS OF THE UNITED STATES GEOLOGICAL SURVEY.

THE GLACIAL LAKE AGASSIZ.[1]

ONCE upon a time in North America the continental ice-sheet attained an area of about four million square miles, while its maximum thickness, in the central portion, was probably from one to two miles. It extended from the Atlantic to the Pacific, and from the northern United States to the Arctic Sea. During the closing stage of this glaciation there existed an immense lake, whose area is estimated to have been about 110,000 square miles ; a lake which extended 700 miles in length, and attained a width of 250 miles. Its maximum depth was 700 feet above the present level of Lake Winnipeg.

That the idea of the former existence of this great lake is no romance of modern days, no "glacial nightmare," is indicated by the fact that so long ago as 1823 the traces of it were recognised by Keating. Not, however, until 1879 was its present name applied to it in honour of Louis Agassiz.

Placed almost in the centre of North America, and occupying what is now part of the plain of the Red River and Lake Winnipeg, together with the Lake of the Woods and other smaller sheets of water, it lay for the most part in territory now Canadian, but a fifth part occurring within the United States. In the southern region, however, its ancient shore-lines have been more exactly explored. A very large part of its area in Canada, besides a considerable tract within its limits in northern Minnesota, is covered by forest, which makes it impracticable to trace there the beach-ridges and deltas, usually but a few feet high, the low escarpments of erosion, which range from 10 to 30 feet, and the other evidences of this lake, which in the prairie region could far more readily and definitely be followed.

It was evident that the scientific study of this interesting region should not be restricted by national geographical circumstances, and it is pleasing to note that arrangements were made between Director Powell (of the U.S. Geological Survey) and Director Selwyn (of the Canadian Survey), that the work of mapping the shores of Lake Agassiz should be continued by Mr. Upham through the prairie region of south-western Manitoba. Altogether this work comprises the results of field-observations carried on during six years.

Over the greater part of the old lacustrine area there is boulder clay from 100 to 300 feet thick. A series of terminal moraines marks the stages of retreat of the ice-sheet. For a while the lake gradually increased in size northwards, finding an outlet to the south in the "glacial" River Warren, whose channel was cut to a depth of 90 feet, and whose course is now occupied by Lakes Traverse and Big Stone and by the Minnesota River. As the ice-front retreated the lake was eventually drained by the natural slope of the land to the north-east, excepting in those areas which now form the lakes of Manitoba.

The steady uplifting of the area of Lake Agassiz, resulting from the unburdening of the land by the recession of the ice-sheet, gave to its beaches a northward ascent, and caused the several shores of its southern part to become double or multiple as they are traced northward.

The author gives a full and particular account of the beaches formed at different stages in the history of the lake, and discusses various earth-movements, some of which were independent of glaciation.

His work is by no means devoid of practical value. A chapter is devoted to artesian and common wells, and to the distribution and origin of certain saline waters ; and another chapter is given to the agricultural and material resources of the area.

[1] By Warren Upham. ("Monographs of the U.S. Geological Survey," vol. xxv. Pp. xxiv + 658 ; 38 maps, and 35 other illustrations.)

THE FLORA OF THE AMBOY CLAYS.[1]

This work, which was very nearly finished in 1890, by the late Dr. Newberry, was placed in the hands of Mr. Hollick in 1892. His task has not been unattended with difficulty, but he has carefully indicated his necessary alterations and additions.

The Amboy Clays take their name from Perth Amboy

[1] By John Strong Newberry. Edited by Arthur Hollick. ("Monographs of the U.S. Geological Survey," vol. xxvi. Pp. x + 137, with 58 plates.)

and South Amboy in New Jersey, where they form the local base of the Cretaceous group. The clays constitute an important item in the mineral resources of the State. The mollusca found in the Amboy Clays prove them to be of estuarine origin. Compared with European strata it seems probable that they may be regarded as Upper Cretaceous.

156 species of plants are described, and these include 8 ferns, 17 conifers, and 5 cycads, in addition to the many dicotyledonous angiosperms, and a few doubtful forms. No palms are recorded.

GEOLOGY OF THE DENVER BASIN IN COLORADO.[1]

In this work the authors describe an area of about one thousand square miles, in the centre of which stands the city of Denver in Colorado. Topographically the area itself forms a kind of basin, but geologically it has been found that the rocks of the Cretaceous system, which occur over a large part of the country, constitute a well-defined syncline which is named the Denver Basin.

The mountain range on the west comprises a crystalline complex of pre-Cambrian rocks, flanked by highly inclined rocks of the age of the Jura-Trias, and these are succeeded with apparent though deceptive conformity by Cretaceous deposits which assume a fairly horizontal position beneath Denver, and are uptilted slightly on the east so as to form the before-mentioned basin.

It is held that considerable portions of the crystalline nucleus of the Rocky Mountains constituted an archipelago of large islands in the Palæozoic seas. Within the area now described no outcrops of Lower Palæozoic rocks are found, but there is good reason to believe that they underlie the later sediments, and are concealed along the Archæan borders by the overlapping Mesozoic and later deposits.

The movements that took place at various intervals subsequently to the early Palæozoic times are briefly indicated. They are complex, and have variously affected the character and distribution of the strata. The present relations of the Jura-Trias and Cretaceous to the crystalline nucleus are not due to a simple vertical upward movement of that core: the structure has rather been produced by tangential compression, the effect of which was to produce a structure somewhat analogous to a vertical upthrust, but as a result of a horizontally rather than of a vertically acting force.

The strata referred to the Trias consist, curiously enough, of brilliant red conglomerates, sandstones and shales, with thin limestones and gypsums in the upper part. They are known as the Wyoming formation, and are overlaid by a series of freshwater marls—the Morrison formation—grouped as Jurassic. This group is also known as the Atlantosaurus clays, from its abundant reptilian remains.

The geology of these and of the succeeding Cretaceous, Tertiary and Pleistocene formations, is exhaustively treated, and there is a full account of the igneous rocks. In the chapter on Economic Geology, coal, fire-clays and other clays, building-stones, and artesian wells are dealt with. The coal occurs in the Laramie formation of the Cretaceous. A final chapter is devoted to Palæontology, including some account of the Cretaceous plants, by F. H. Knowlton; and of the Jurassic, Cretaceous, and Tertiary vertebrates, by Prof. O. C. Marsh.

The work is well illustrated with maps, sections and pictorial plates. The "spherical sundering in basalt" is well shown in Plate xiv. Among other plates we have restorations of the Jurassic *Brontosaurus*, *Stegosaurus*, *Camptosaurus*, *Laosaurus*, and *Ceratosaurus*; of Cretaceous Birds and Dinosaurs; of the Tertiary Mammals, *Brontops* and *Entelodon*; and of the Quaternary *Mastodon*.

[1] By S. F. Emmons, Whitman Cross, and G. H. Eldridge. ("Monographs of the U.S. Geological Survey," vol. xxvii. Pp. xvii + 556.)

THE MARQUETTE IRON-BEARING DISTRICT OF MICHIGAN.[1]

The Marquette district occupies an area extending from Marquette on Lake Superior westwards to Michigamme, a distance of rather less than forty miles, and with a breadth of from one to over six miles. From the western part of the main area two arms project for several miles, one known as the Republic trough and one as the Western trough. The district is the oldest important iron-producing area of the Lake Superior region.

The rocks comprise three series, separated by unconformities. These are the Basement Complex or Archæan, the Lower Marquette, and the Upper Marquette; the two latter constituting the Algonkian of the district, and perhaps equivalent to Huronian. The Marquette series is mainly sedimentary, although among the strata are included large masses of igneous rocks. The succession of the series is somewhat obscured by irregularities of deposition, and by inter-Marquette erosion. After the Upper Marquette series was deposited the district was folded, faulted and fractured in a complex fashion, with resultant profound metamorphism.

The greater iron-ore deposits occur in the Negaunee formation, which is from 1000 to 1500 feet thick, and occurs in the Lower Marquette series. Petrographically the formation comprises sideritic slate, ferruginous slate, ferruginous chert, jaspilite, and iron-ore. The ferruginous chert and jaspilite are frequently brecciated. The iron-ores resulted from the concentration of the iron-oxides through the agency of downward percolating waters. These concentration-bodies usually occur upon impervious basements in pitching troughs.

The various features connected with this iron-producing region are all worked out in great detail, and the memoir is beautifully illustrated with coloured plates of banded and brecciated rocks, and various pictorial views and sections. H. B. W.

[1] By C. R. Van Hise and W. S. Bayley, including a chapter on the Republic Trough, by H. Lloyd Smith. ("Monographs of the U.S. Geological Survey," vol. xxviii. Pp. xxvii + 608; 35 plates, and 27 other illustrations, together with large folio atlas of maps.)

ANTHROPOLOGY IN MADRAS.

WHEN recently on furlough in England, I was greatly interested in hunting up the facilities for the study of anthropology in London, and in the scheme for the establishment of a bureau of ethnology for the British Empire. And it has been suggested to me that it may interest those concerned in the development of anthropological research to know what is being done, in a mild way, in a remote possession of the Empire, the Madras Presidency, viz. the southern portion of the Indian peninsula. I add this geographical explanation, inasmuch as a friendly critic, in a recent review of my work, got hopelessly mixed between Madras and Bengal, reminding me of the story of the Viceroy-elect, who was overheard murmuring to himself, "Bombay in the west, Calcutta in the east, Madras in the south." Wide as is the area, and numerous as are the tribes, castes, and races included within my limited beat of 150,000 square miles, I have set myself the task, which must perforce occupy many years, of carrying out a detailed anthropological survey. This survey was, with the approval of the Madras Government, inaugurated in 1894. In that year, equipped with a set of anthropometric instruments obtained on loan from the Asiatic Society of Bengal, I commenced an investigation of the hill-tribes of the Nīlgiris, the Todas, Kotas, and Badagas, bringing down on myself the unofficial criticism that "anthropological research at high altitudes is eminently indicated when the thermometer registers 100° in Madras." From this modest beginning have resulted: (1) investigation of the

various classes which inhabit the city of Madras, during my residence at headquarters; (2) periodical tours to various parts of the Presidency, with a view to the study of the more important tribes and classes; (3) the publication of bulletins, wherein the results of my work are embodied; (4) the establishment of an anthropological laboratory (Fig. 1), equipped with the apparatus necessary for carrying out anthropometric research; apparatus for testing sight, hearing, vital capacity, hand-grip, &c.; a small series of Hindu, Muhammadan, Burmese and Sinhalese skulls; and an anthropomorphic series, still in a very early stage of development, but including the finger-print impressions of an Orang-utan; (5) a collection of photographs of native types, arranged in albums; (6) a series of lantern-slides for lecture purposes.

A museum, such as that of Madras, the visitors to which sign their names in Tamil, Telugu, Kanarese, Malayalam, Nāgari, Hindustani, Mahrāti, Guzarāti, Bengāli, Burmese, Sinhalese, and Chinese, lends itself to the requirements of the anthropologist, as it is resorted to by very large numbers of the poorer classes, who, in return for a small fee, are ofttimes willing to lend their bodies for the purposes of anthropometry. And, nearly every morning, I am to be seen measuring Hindus or Muhammadans, amid an admiring crowd of native visitors (the females dressed in gaudy English piece-goods), in the surrounding corridor. Quite recently, when I was engaged in an inquiry into the Eurasian or half-breed community, the booking for places was almost as keen as on the occasion of a first night at the Lyceum, and the Sepoys of a native infantry regiment, quartered in Madras, entered heartily into the spirit of what they called the "Mujeum gymnashtik shparts," cheering the possessor of the biggest hand-grip, and chaffing those who came to grief over the spirometer. Anthropological research in the city of Madras, where the native community has become accustomed to the European, and discovered that, if his ways are peculiar, he is at any rate harmless, is all plain sailing. But, in the jungles and places remote from civilisation, one has to deal with simple-minded folk, unfamiliar with the eccentricities of the investigator, and suspicious of his motives. Well do I remember a native remarking at a pearl-fishery camp, "Mr. Thurston is a pleasant man, and it is a great pity he is so mad." The fact indicating insanity being that I used to sit outside my tent in the sun, at mid-day in the month of April, examining oyster after oyster in connection with the pearl-producing area.

The essential ingredients of a successful campaign in the wilds are tact, patience, 4-anna pieces, cheap cheerots, and, as a final resource, raw whiskey or brandy. The Paniyan women of the Wynaad, when I appeared in their midst, ran away, believing that I was going to have the finest specimens among them stuffed for the museum. Oh, that this were possible! The difficult problem of obtaining models from the living subject would then be disposed of. The Muppas of Malabar mistook me for a recruiting sergeant, bent on enlisting the strongest of them to fight against the Moplahs. An Irula of the Nīlgiris, who was "wanted" for some ancient offence relating to a forest elephant, refused to be measured on the plea that the height-measuring standard was the gallows. A mischievous rumour found credence among the Irulas that I had in my train a wizard Kurumba, who would bewitch their women and compel me to abduct them. The Malaiālis of the Shevaroys got it into their heads that I was about to annex their lands on behalf of the Crown, and transport them to the penal settlement in the Andaman islands; and one of them informed me that he would rather have his throat cut than be measured. On one occasion I casually photographed a group of Badagas in their bazaar, and, on the following day, a deputation waited on me with a petition to the effect that "we, the undersigned, beg to submit that your honour made 'botos' of us, and have paid us nothing. We, therefore, beg you to do this act of common justice." The deputation was made happy with a *pour boire*. Would that official deputations could be disposed of as easily!

Despite the trifling obstacles at the outset, confidence was eventually established with the various tribes just referred to, though not without a good deal of palavering and mild bribery, and a sufficient number of individuals for statistical purposes were investigated.

The main objects, which are systematically kept in sight during my wanderings, are:—

(1) To record at least the essential measurements of men, and (when they will permit) women.

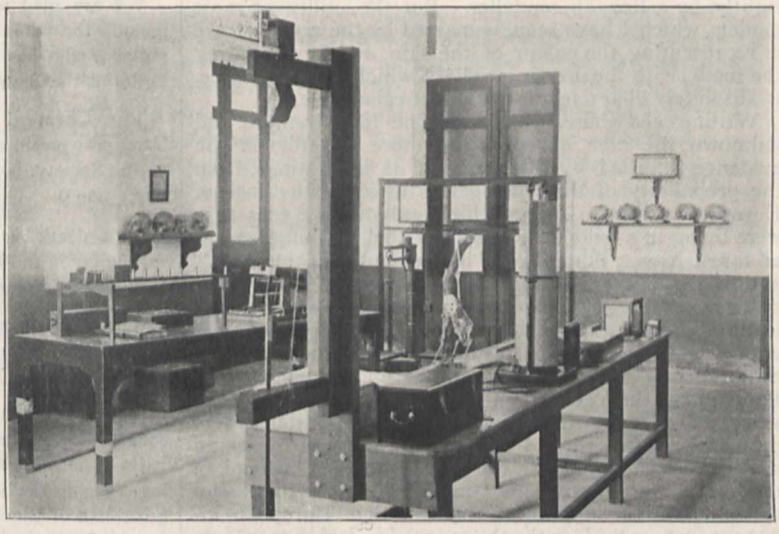

FIG. 1.—Anthropological Laboratory.

(2) To study the characteristics of external anatomy.

(3) To record "manners and customs," tattoo-marks, clothing, personal adornment, &c.

(4) To take photographs of typical individuals, dwelling-huts, &c.

(5) To acquire by purchase "specimens" illustrating clothing, jewellery, musical instruments, games, &c.

As a general rule the traveller, who makes collections in any branch of science, hands them over, as a gift or by purchase, to some national or provincial museum, and honours are divided; the museum securing the collection, and the collector being immortalised on a label or in a monograph. Possibly, with luck, a new species, or even genus, is named after him, and his reputation is enhanced in the family circle. Looking recently, on a depressing November day such as we in the East know not, at a collection of sponges which to the casual visitor possess no special attraction, exhibited in or by my name at the British Museum (Natural History), I recalled to mind the many pleasant hours spent in a dug-out (canoe) on the coral reefs, an attack by a saw-fish, and a severe sun-head. And the museum, whose destinies I have steered since 1885, teems with happy memories of

camp and jungle life; for, by the fortune of circumstances, it falls within my province not only to make collections, but to preside over their arrangement for exhibition. And the advantages of this dual function are self-evident: a tour concluded, the work of museum arrangement commences; and here one is met with an obvious difficulty at the outset. For two systems of arrangement are possible, each with much to be said both for and against it, and a selection of one or the other has to be made; for the material collected, and available space will not, as a rule, suffice for both. Either the collections may be arranged according to the nature of the exhibit, *e.g.* models of boats, sacrificial utensils, musical instruments, games, images, &c.; or each tribe or community may be represented in its various aspects, animal and social, in a single case or in adjacent cases. For myself, I give the preference to the latter system, mainly on the score of convenience and finality of arrangement. Very effective, I remember, in one of my galleries, were some life-size photographic transparencies of Andamanese heads, presented by Mr. Portman to the ethnological section of the Indian Museum, Calcutta, when I was in temporary charge thereof some years ago. So, too, were the models of the Andamanese, executed, if my memory serves me rightly, by a Bengāli modeller. But the utility of most models, which I have seen, is marred by the want of care in representing the colour of the skin, and in decorating the model with the proper jewellery, which, in many cases, is absolutely characteristic of a particular tribe.

Writing elsewhere, I said: "The more remote and unknown the race or tribe, the more valuable is the evidence afforded by the study of its institutions, from the probability of their being less mixed with those of European origin." Tribes which, only a few years ago, were living in a wild state, clad in a cool and simple garb of forest leaves, buried away in the depths of the jungle, and living, like pigs and bears, on roots, honey, and other forest produce, have now come under the domesticating, and sometimes detrimental influence of contact with Europeans, with a resulting modification of their conditions of life, morality, and even language. The Paniyans of the Wynaad and the Irulas, who inhabit the slopes of the Nīlgiris, now work regularly for daily wage on planters' estates; and I was lately shocked by seeing a Toda boy studying for the third standard, instead of tending the buffaloes of his "mand." Ample proof can be adduced in support of the fact that European influence, import-trade with other countries, and the struggle for existence, are bringing about a rapid change (sad from an ethnographic standpoint) among the natives of Southern India, both tame and wild. It has recently been said that "there will be plenty of money and people available for anthropological research when there are no more aborigines"; and it behoves our museums in Great Britain and its dependencies to waste no time in completing their anthropological collections.

I gathered from observation when in London (1) that man as a social and intellectual being is illustrated with the unavoidable want of proportion, when no systematic scheme for the regular expansion of the collections is at work at the British Museum, Bloomsbury; (2) that it is under contemplation to illustrate man and the varieties of the human family from a purely animal point of view at the British Museum (Natural History), South Kensington; (3) that skulls must be sought for at the Royal College of Surgeons, Lincoln's Inn Fields; (4) that lectures and anthropological literature are available to members at the Anthropological Institute, Hanover Square. To this must be added (5) Mr. Galton's laboratory. Surely a great want of centralisation, such as might well be remedied, is indicated here. And as I wandered, both in and out of the London season, through the deserted galleries of the Imperial Institute, I could not refrain from speculating whether, with a radical change of policy for good, this much-discussed building could not be converted into our great National Museum of Ethnology, where man shall be represented fully and in every aspect, and where those interested in ethnological research could find under one roof a skilled staff to appeal to in their amateur difficulties, collections, literature, lectures, and anthropological laboratory. For the great mass of visitors to popular museums, who come under the heading of sightseers, it is of primary importance that the exhibits should be attractive. And I feel convinced that, were an ethnological museum up to the high standard of the British Museum (Natural History) established, it would, when its reputation became known, be, like Madame Tussaud's, widely resorted to by the general public, and that, by an admixture of free and paying days, and by the charge of a small fee for examination in the laboratory, it might be made to a certain extent self-supporting, and not entail a great burthen of expenditure on the State.

EDGAR THURSTON
Madras Government Museum.

NOTES.

WE are glad to notice that the Queen's birthday honours include the name of Dr. John Murray, F.R.S., of *Challenger* renown, who has been appointed a Knight Commander of the Order of the Bath (K.C.B.).

THE Chemical Society's banquet to Lord Playfair and six other past presidents who have completed fifty years' fellowship of the Society, is to be held at the Hôtel Métropole on Thursday, June 9.

THE death is announced of M. Souillart, professor of astronomy in the University of Lille, and correspondant in the Section of Astronomy of the Paris Academy of Sciences.

THE Department of Science and Art has received information that the fifth International Congress of Hydrology, Climatology, and Geology will be opened at Liége on September 25.

THE eighty-first annual meeting of the Société helvétique des sciences naturelles will be held at Berne on August 1–3. This will be the sixth occasion upon which Berne has been the meeting-place of the Society. The reception will take place in the great hall of the Museum on the evening of Sunday, July 31. On the following day there will be a general meeting, a banquet, and a fête, and the sections will meet for the consideration of papers on August 2. The sections and their presidents are as follows:—Mathematics, astronomy and physics, MM. Graf, Huber, Sidler; chemistry, MM. de Kostanecki, Friedheim; botany, M. L. Fischer; zoology, M. Th. Studer; anthropology, M. Th. Studer; geology, mineralogy, petrography and palæontology, M. A. Baltzer; physical geography (comprising geodesy and meteorology), M. E. Brückner; anatomy and physiology, MM. Strasser and Kronecker; medical clinics, MM. Kocher, Müller, Sahli; hygiene and bacteriology, MM. Girard, Tavel; pharmacy and alimentation, M. Tschirch; veterinary science, M. Berdez; agriculture and sylviculture, M. Coaz.

AT the Royal Institution on Thursday, June 2, Dr. Edward E. Klein delivers the first of two lectures on "Modern Methods and their Achievements in Bacteriology," and on Saturday, June 4, Dr. Richard Caton begins a course of two lectures on "The Temples and Ritual of Asklepios at Epidaurus and Athens." The Friday evening discourse on June 3 is by Prof. W. M. Flinders Petrie, on "The Development of the Tomb in Egypt"; that on June 10 is by Lord Rayleigh, whose subject is "Some Experiments with the Telephone."

As the result of a bacteriological examination, Dr. Haffkine has reported that the recent sudden outbreak in Calcutta was due to true bubonic plague. A long and detailed statement of the facts referring to the outbreak, and the measures taken by the Government of Bengal to prevent its spread, is given in the *Pioneer Mail* of May 6. As a preventive measure, inoculation with the prophylactic virus prepared by Dr. Haffkine is recommended. It has been found that inoculation by this material prevents from 80 to 90 per cent. of deaths from plague, and reduces the plague from an epidemic form to the position of a sporadic disease. Surgeon-General Harvey was deputed by the Government of India last month to Bombay specially to examine the results of Dr. Haffkine's methods, and his report is stated to be generally favourable to the system of inoculation. The Government of Bengal have therefore decided to exempt from liability to segregation all families which have been entirely inoculated prior to the occurrence of any case of plague among them. Inoculation is not to be forced on the people, but if a member of a completely inoculated family is attacked by the plague, neither he nor his family will be liable to removal to a segregation camp.

AT the anniversary meeting of the Royal Geographical Society on Monday, the medals were presented as already announced (p. 38). In the course of his address, the President said that a very sympathetic reply had been received from the Prime Minister's private secretary to the appeal on behalf of a Government Antarctic expedition. A German expedition was being organised on a liberal scale, and funds were being collected throughout Germany for the purpose. Moreover there was reason to hope that the Norwegian Government might send out an expedition also, perhaps under the leadership of Dr. Nansen, to carry out exploration mainly on land. Meanwhile the Belgian expedition, under M. de Gerlache, had been actively engaged, and the expedition, liberally supported by Sir George Newnes, under Mr. Borchgrevink, was in an advanced state of preparation. After a brief reference to Mr. Jackson's account of the Jackson-Harmsworth expedition, to Lieutenant Peary's labours, and to those of Captain Sverdrup, Colonel Fielden, Mr. Pearson, Mr. Arnold Pike, and Sir Martin Conway, the President said that German and Swedish expeditions were in progress for Spitsbergen and Franz Josef Land. Germany was setting an admirable example in scientific exploration. Besides the Antarctic expedition referred to, the German Government had made a grant of 15,000*l.* for oceanic research, especially in the Atlantic and Indian oceans. In the North Atlantic much good work was done under the joint co-operation of the Swedish, Norwegian, German, and British Governments. He hoped that during the coming summer authentic and satisfactory information concerning the hazardous balloon expedition undertaken by M. Andrée would be received.

MR. BORCHGREVINK has given to a representative of Reuter's Agency some details of the arrangements for the Antarctic expedition which will shortly leave for Australia and South Victoria Land. He said that his ship, the *Southern Cross*, has been designed by the builder of the *Fram*, and has 10 feet of solid oak at her bows, and at her weakest point is 32 inches in thickness. Over all she is sheathed with 3 inches of American greenheart—a wood which never splits, and is very hard and slippery. The *Southern Cross* will fly the British flag, and will leave London in July. A pack of sixty-five Siberian sledge-dogs will be taken, and a number of sledges for the inland journey on the South Victorian continent. The object of the expedition is to explore South Victoria Land, and to investigate the seas and islands between there and Australia. Mr. Borchgrevink is taking with him stores for three years and a supply of carrier-pigeons.

INFORMATION of the death of Mr. Edward Wilson, F.G.S., who for the past fourteen years has been Curator of the Bristol Museum, has been received from Mr. F. W. Knocker, Sub-Curator of the Museum. Having a good general knowledge of zoology and botany, and an extensive acquaintance with geology, Mr. Wilson was admirably fitted for his position. His efforts to enrich the Museum were zealous and untiring, and he was engaged during the last month of his life in procuring a large collection of mammalian remains and some worked flints from the cavern-deposits of Uphill, near Weston-super-Mare. He had likewise arranged in the Museum a special students' collection of minerals, rocks and fossils, of which he prepared a separate catalogue, in addition to his numerous issues of the "Guide to the Bristol Museum." For many years prior to his removal to Bristol, Mr. Wilson had been a science teacher at Nottingham, and he was there led to pay particular attention to the Permian and Triassic strata, the Rhætic beds and the Lias, to our knowledge of which he made considerable additions in papers dating from 1868. In 1885 he published an important article on the Marlstone of Leicestershire as a source of iron. Later on he devoted himself more especially to the study of the Liassic Gasteropoda, on which subject he had become our chief authority. He was joint-author, with Mr. W. H. Hudleston, F.R.S., of a Catalogue of British Gasteropoda, 1892. More recently he has laboured in company with Mr. S. S. Buckman at the palæontology of Dundry Hill. A new Liassic Gasteropod was named *Wilsonia* in honour of Mr. Wilson, by Mr. Hudleston, and the Council of the Geological Society awarded to him in 1888 the Murchison Geological Fund. He died after a short illness on May 21, at the early age of forty-nine, and his loss will be widely felt by his many friends. All acquainted with him entertained the highest regard for his gentle unassuming character, as well as for his able and painstaking researches.

THE report of the Committee appointed by the Society of Arts to consider the causes of the deterioration of paper is printed in the current number (May 20) of the Society's *Journal*, and is here summarised. At the outset, the report points out that during the present century the paper-making industry has undergone many revolutionary changes. As an industry it has grown considerably, and to meet the requirements of the enormously increased production a quantity of new fibrous raw materials have been introduced and have taken their place in due course as indispensable staples. The more important of these, so far as concerns this country, are esparto, in the period 1860-70; "mechanical wood" or ground wood pulp, in 1870-80; the wood celluloses, in the period 1880-90. These substances differ in chemical composition from the celluloses obtained from cotton, flax and hemp, which were the exclusive staple raw materials for paper making up to this century; and although they are efficient substitutes in most respects, it must be admitted that time has not yet been able to pronounce a judgment upon the relative permanence of the papers made from them. There is more than a suspicion that many of them are very inferior in this important respect, and it has been the main purpose of the work of the Committee to sift the evidence upon which such suspicions have been engendered.

THE Committee referred to above have examined a number of books as evidence of "deterioration of paper"; some submitted by librarians in a condition of complete disintegration; some of their own selection exhibiting various grades of deterioration of the paper of which they are composed. They conclude on the evidence before them as follows:—As to the two tendencies to deterioration of papers these are marked (1) by disintegration, (2) by discoloration. They are independent effects, but may be concurrent. They are notably so in papers containing mechanical wood pulp. Actual disintegration has been brought

to light in papers of all grades; from those of the best quality as regards the fibrous materials of which they are composed, *i.e.* rag papers; also of course in those of lowest quality, *i.e.* containing mechanical wood pulp in large proportions. It is generally the result of chemical change of the fibres themselves. As to the causes determining such changes: in the case of the rag papers examined the effects appear to be due to acid bodies; the disintegration may be generally referred to acidity. In the case of mechanical wood pulp the effects are traceable to oxidation pure and simple; the disintegration is accompanied by a basic or alkaline reaction of the paper. Discoloration may be said also to affect all papers more or less, and without discussing minutely the chemistry of the changes, the evidence obtained certainly warrants the general conclusion that discoloration of ordinary cellulose papers (as distinguished from those containing mechanical wood pulp) under usual conditions of storage is proportional to the amount of rosin which they contain, or more generally to the rosin and the conditions employed for fixing it in the ordinary process of engine-sizing. The Committee have been desirous of bringing their investigations to a practical conclusion in specific terms, viz. by the suggestion of standards of quality. They limit their specific findings to the following, viz. (1) normal standard of quality for book papers required for publications of permanent value. For such papers they specify as follows:—Fibres: not less than 70 per cent. of fibres of the cotton, flax, and hemp class. Sizing: not more than 2 per cent. rosin, and finished with the normal acidity of pure alum. Loading: not more than 10 per cent. total mineral matter (ash).

THE Röntgen Society has appointed a Committee to inquire into the alleged injuries produced by exposure to Röntgen radiation. In order to obtain accurate information, the committee has prepared a set of questions framed with a view of determining the cause or causes of the injuries received.

A NOTE in *Comptes rendus* (May 9) states that M. Mascart has received information that Prof. Leist has found at Kotchétovka, in the province of Kursk (Russia) a local magnetic pole; that is to say, a point where a dipping needle stands vertical. It is necessary to move twenty metres from this point to change the direction of the needle by 1°. The declination needle sets itself indifferently in any direction in the spot where this magnetic anomaly occurs.

M. VINCENT stated at a meeting of the Academy of Medicine, held on May 10 (says the *Lancet*), that he has found that French soldiers are on an average a hundred times more subject to typhoid fever than native soldiers—a singular observation, because this disease is in general serious when it attacks Arabs. The comparative exemption of the Arabs depends, in his opinion, neither on a previous attack nor on a slow acclimatisation consequent on residence in towns, but on a natural immunity comparable to the immunity of negroes against yellow fever, or of Algerian sheep against anthrax.

THE U.S. Weather Bureau has published in its *Bulletin* No. 21, an abstract of a report on solar and terrestrial magnetism in their relations to meteorology, by Prof. F. H. Bigelow, who has during the last six years devoted much time to the study of the fundamental principles of this important subject. It is stated in the introductory text that he is of opinion that the atmospheric conditions which culminate in the storms traversing the United States are in part dependent upon the solar energy that reaches the earth in the form of magnetic force, and that there are synchronous fluctuations in the pressures and temperatures of the north-western regions of the American continent in the neighbourhood of the magnetic pole. Prof. W. L. Moore, the chief of the Weather Bureau, is of opinion that while at this stage of the investigation the sequence of cause and effect is not shown with sufficient definiteness to justify the weather forecaster in attempting to apply these theories in predicting marked atmospheric disturbances, the paper will lead to discussion and result in further additions to our knowledge of magnetic science.

Petermann's Mittheilungen publishes a new map of the central highlands of northern German East Africa. Much new matter is introduced by the addition of the surveys made by Premier-Lieut. Werther on the so-called Irangi expedition during 1896 and 1897; the map itself is drawn by Dr. B. Hassenstein. A paper describing the main features of the country traversed by the expedition is appended by Lieut. Werther.

PROF. A. SUPAN contributes a careful analysis of the reports and statistics of trade in China for the year 1896 to *Petermann's Mittheilungen*. The results lead him to expect immense developments from the construction of railways, even within the next decade, and he believes the establishment of Germany at Kiaou-tschou will mark the beginning of a new era in the trade of that country.

WE have received the index to the first ten volumes of the *Mittheilungen von Forschungsreisenden und Gelehrten aus den Deutschen Schutzgebieten*. The index, which covers the years 1888 to 1897, is arranged under six separate headings, four of which are subdivided according to the different colonies. Dr. von Danckelman is the editor.

THE *Verhandlungen des naturhistorischen Vereins der preussischen Rheinlande* contains a long paper, by Herr R. Hundt, on the petrography and palæontology of the middle Devonian rocks of south-west Prussia. The geology of the *Lenneschiefer* beds is discussed in detail, and a comparison with the Calceola beds of the Eifel is based on the distribution of fossils of Calceola and Stringocephalus. A map of the region is appended.

A RECENTLY issued part of the *Proceedings* of the U.S. National Museum (vol. xx., No. 1134) contains an important contribution to our knowledge of the ornithology of the Philippine Islands, by Messrs. Worcester and Bourns. The first portion of this memoir consists of a complete list of the 526 birds as yet known to inhabit the various islands of the Philippine archipelago and of those of the adjoining group of Palawan in a tabular form, and shows their occurrence or absence in thirty-seven islands of the two series. Taking this list as a text, Mr. Worcester proceeds in the second portion to discuss the very interesting problems presented by the distribution of the birds in these islands. Each island is taken in order, a list of its known birds is given, and its relationships, as thus shown, are worked out. Mr. Worcester comes to the conclusion that Mr. Everett's view (*Proc. Zool. Soc.*, 1889) that Palawan and its satellites belong ornithologically to Borneo, and not to the Philippines, is amply confirmed by recent evidence. Turning to the Philippines proper, the author shows that the five "sub-provinces" into which Dr. Steere, in 1894, proposed to divide the Philippine area are not maintainable. Nor is Mr. Worcester better satisfied with Dr. Steere's deduction that each genus of Philippine birds is represented by a single species only in each island. The contrary is manifestly the case in many instances. The memoir is illustrated by a map and numerous diagrams, and is worthy of careful study by all who are interested in laws of geographical distribution.

ONE of the most important services performed by the Agricultural Experiment Stations found in almost every one of the United States, is the instruction of the farmer and the fruit-grower in the life-history of the animal and vegetable foes which destroy or injure his crops, and in the mode of combating them.

From the Cornell University Experiment Station, located at Ithaca, N.Y., we have received *Bulletin* No. 145, devoted to two important diseases of the pear, the "leaf-spot" (*Septoria piricola*), and the "leaf-blight" (*Entomosporium maculatum*), by Mr. B. M. Duggar, admirably illustrated; and from that for the University of Wisconsin *Bulletin* No. 65, on a bacterial rot of cabbage and allied plants (*Bacillus campestris*), by Mr. H. L. Russell, also well illustrated. These bulletins and the annual reports are sent free to all residents in the State on request. From the Michigan State Station we have also received *Bulletins* Nos. 151–153, containing a very large amount of practical information on the growth of vegetables and fruits suitable for cultivation in that State.

IN a recent article (March 17, p. 464) on the resources of the West India Islands, reference was made to the necessity for supplementing the staple products by the introduction of a variety of cultural industries which would increase the wealth of these Colonies. The obvious way to lead to such developments is to establish a department of economic botany, for the purpose of carrying out systematic experiments concerned with agricultural cultivation, wherever necessary, and to extend the equipment of existing botanic gardens so that proper attention can be given to the introduction of new plants. Mr. J. H. Hart, the Director of the Royal Botanic Gardens at Trinidad, in a lecture reprinted in the *Bulletin* of the Gardens, shows that many at present minor industries might be developed with profit in the Colony. He points out that Trinidad could grow enough mahogany and cedar to supply the markets of Great Britain, and if the island was simply a mahogany and cedar forest, it would be one of the richest of our colonial possessions. Yet no one plants cedar trees in the island, and no one plants mahogany. Jamaica exports logwood to the value of 300,000*l.* annually, but Trinidad, where logwood of the very finest quality can be grown, sends none to market. Rubber trees grow well in the Island, the trees in the Botanic Gardens yielding from four to six pounds of rubber per tree per annum, but they are not cultivated to any extent outside the Gardens. In addition to these potential crops, Mr. Hart enumerates fifty other products which could be successfully grown in Trinidad. His lecture shows the valuable assistance which botanic gardens are able to give to cultivators; and we are glad to see that the botanical department under his direction is to be extended, land having now been allotted for the purpose of establishing a section for economic and scientific work. The extension encourages the hope that the reproach, that "Trinidad has the wealth of the Straits Settlements going to waste," will soon be removed.

THE fifth and sixth Reports on the Yorkshire Carboniferous Flora, by Mr. Robert Kidston, are reprinted from the *Transactions* of the Yorkshire Naturalists' Union.

THE third edition of Mr. W. T. Lynn's little book on "Remarkable Eclipses" has just been issued by Mr. Edward Stanford. The book has been brought up to date by mention of the total solar eclipses of August 1896, and January last.

A SECOND edition of "Applied Bacteriology," by Messrs. T. H. Pearmain and C. G. Moor, has just been published by Messrs. Baillière, Tindall, and Cox. Several parts of the book have been enlarged and improved, and the whole has undergone revision. A short account of the bacteriology of sewage has been added. The volume provides students, medical officers of health, analysts and sanitarians with a good general survey of the science of bacteriology.

THE second part of Mr. W. P. Hiern's "Catalogue of the African Plants collected by Dr. Friedrich Welwitsch in 1853–61," comprising the natural orders of Dicotyledons from Combretaceæ to Rubiaceæ, has just been published by the Trustees of the British Museum (Natural History). Another publication which has just been issued from the Museum is a list of the types and figured specimens of fossil Cephalopoda in the collection, prepared by Mr. G. C. Crick.

THREE papers of interest to anthropologists appear in the *Proceedings* of the Royal Society of Tasmania (1897). One contains the results of measurements of the crania of Tasmanian aboriginals now in the Hobart Museum, compared with measurements of the skulls of Europeans, by Dr. A. H. Clarke and Mr. W. E. Harper. The authors do not attempt to draw conclusions as to the origin of the Tasmanian aboriginals, nor to define their characteristics; but the measurements of the skulls of an extinct race constitute a work of value to anthropologists. The two other anthropological papers in the *Proceedings* are by Mr. J. B. Walker; they contain a number of interesting notes on the Tasmanian aborigines, extracted from the journals of his father.

THE Rev. Prof. G. Henslow has in preparation a volume entitled "Medical Works of the Fourteenth Century," consisting of transcripts with notes from four MS. volumes contemporary with the works of Wiclif and Chaucer. These transcripts will furnish illustrations of the crude and quaint conceptions of the value of plants as drugs prevailing in the Middle Ages. The volume will also contain an alphabetical list of upwards of 700 medical and other plants mentioned in works of the fourteenth century, compiled and identified with their modern English and Latin equivalent names.

PROF. T. W. RICHARDS, of Harvard, whose name is already identified with the accurate determination of atomic weights, has recently published the results of a redetermination of the atomic weights of nickel and cobalt. The close approach to equality in the atomic weights of these elements has always given a special interest to any such redetermination, and this interest has been increased in recent times by the suggestion that the two elements are ordinarily associated with a third new element—"gnomium," which is not separated from them in the usual course of analysis. The evidence on which this suggestion was based by Krüss and Schmidt was subsequently rebutted by the work of Winkler; yet Winkler's own determinations of the atomic weight of cobalt by two different methods gave results which differed by 1 part in 200, viz. 59·82 and 59·52. Still later determinations by Hempel and Thiele, by three methods, gave respectively 58·99, 58·78 and 58·91. The method employed by Prof. Richards consisted in the preparation of the bromides of nickel and cobalt, and their analysis by means of pure silver nitrate. The greatest precautions were taken in order to obtain pure anhydrous materials, and the same methods of manipulation employed as in the previous case of the determination of the atomic weight of magnesium. The fourteen experiments with nickel bromide agree remarkably, the extreme differences being just over 1 part in 1000. Thirteen experiments with cobalt bromide show an equally good agreement. The numbers given finally are for nickel 58·69 and cobalt 58·99 (o=16). Prof. Richards, anticipating the criticism that his determinations are based on a single method, remarks that a series of carefully conducted determinations by a single reliable method have especial value in the case of nickel and cobalt, where hitherto accuracy has been sought by varying the methods rather than by securing constancy in the results attainable by any one of them. Prof. Richards concludes that discrepancies among previous determinations of the atomic weights of nickel and cobalt afford no evidence of the existence of the hypothetical gnomium, nor do his own observations in any way indicate the existence of such an element.

THE additions to the Zoological Society's Gardens during the past week include a Guinea Baboon (*Cynocephalus sphinx*, ♂) from West Africa, presented by Captain H. de la Cour Travers; a Vervet Monkey (*Cercopithecus lalandii*, ♂) from South Africa, presented by Mr. C. J. Barratt; a Common Raccoon (*Procyon lotor*) from North America, presented by Mr. A. D. Jenkins; a Reindeer (*Rangifer tarandus*, ♂) from Newfoundland, presented by the Hon. M. A. Bourke, H.M.S. *Cordelia*; a Common Guillemot (*Lomvia troile*), British, presented by Mr. Ernest Horne; a Seven-banded Snake (*Tropidonotus septemvittatus*) from North America, presented by Mr. James Meldrum; a Barbary Ape (*Macacus innus*, ♂) from North Africa, a Red-River Hog (*Potamochærus penicillatus*) from West Africa, a Beccaris Cassowary (*Casuarius beccarii*) from New Guinea, two Orange-winged Amazons (*Chrysotis amazonica*), two Blue-fronted Amazons (*Chrysotis æstiva*) from South America, deposited; a Leucoryx Antelope (*Oryx leucoryx*, ♂) from North Africa, purchased; a Red-winged Parrakeet (*Ptisles erythropterus*, ♀), a Long-billed Butcher-Crow (*Barita destructor*) from Australia, received in exchange; two Japanese Deer (*Cervus sika*, ♂ ♀), three Shaw's Gerbilles (*Gerbillus shawi*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN JUNE:—

June 3. 6h. 34m. to 9h. 25m. Transit of Jupiter's Sat. III.
4. 8h. Eastern elongation of Saturn's Sat. Japetus.
4. 8h. 10m. to 9h 11m. Occultation of A Ophiuchi (mag. 4·7) by the moon.
4. 15h. 43m. to 16h. 34m. Occultation of B.A.C. 5909 (mag. 6·2) by the moon.
5. 10h. 15m. to 11h. 22m. Occultation of λ Sagittarii (mag. 3·1) by the moon.
9. 11h. 31m. to 12h. 23m. Occultation of B.A.C. 7804 (mag 6·1) by the moon.
9. Saturn. Outer minor axis of outer ring, 18″·62.
10. 10h. 23m. to 13h. 16m. Transit of Jupiter's Sat. III.
12. 19h. Neptune in conjunction with the sun.
15. Venus. Illuminated portion of disc 0·853.
15. Mars. ,, ,, ,, 0·919.
15. Jupiter. Polar diameter, 34″·8.
15. Saturn. ,, ,, 17″·0.
17. 9h. 45m. to 11h. 23m. Transit of Jupiter's Sat. IV.
18. 10h. 59m. Minimum of β Persei (Algol).
23. 5h. Inferior conjunction of Saturn's Sat. Japetus.
29. Saturn. Outer minor axis of outer ring, 18″·33.

The transit of Jupiter's fourth satellite on June 17 is the only one visible during 1898.

BLURRING ABERRATION IN THE TELESCOPE. — Some time ago we referred in this journal (December 30, 1897, p. 200) to a communication by Prof. Schæberle which pointed out that the optical image of a celestial object, formed in the focus of a reflecting telescope of great angular aperture, is possessed of errors of definition which arise from a cause hitherto unrecognised by mathematical and practical opticians. The main results of this paper briefly summed up are as follows:—First, that the focal plans of a curved reflecting surface for parallel rays impinging thereon is situated upon the axis, half-way between the centre of curvature and the reflecting surface itself; and, second, that the plane of the image formed by each small patch of the converging surface tends to lie at right angles to the path of the focussed rays, so that the images formed from every minute portion of the reflecting surface, while their centres may coincide on the axis of the telescope, all tilt from the focal plane directly as the extreme of aperture is approached, or as the focal point is shifted from the axis. In the *Transactions* of the Astronomical and Physical Society of Toronto for 1897, Mr. J. R. Collins, in referring to Prof. Schæberle's paper, points out that it is possible to so proportion the curvatures of the reflecting surfaces of the Gregorian form of reflecting telescope (where the image is formed by the large reflector in front of the small concave mirror, and the light is thrown back to a focus on the axis through an opening in the centre of the large reflector to the eye-piece), as to completely correct the tilt and want of uniformity of dimensions of the components of the compound image, that it may reach the front of the eye-piece entirely freed from these defects. It may be remarked that the tilting of the image not only occurs in the case of the reflector, but in that of the refractor also, the effect in the latter case being twice as great as that in the former. In fact, the Schæberle aberration is a defect that exists in all forms or combinations of lenses, and must, therefore, be taken into account if we wish to attain maximum efficiency in definition.

PHOTOGRAPHY BY THE AURORA BOREALIS.—Mr. J. E. Turner, writing in *The Amateur Photographer* for May 6, describes a unique photograph which he has obtained. It seems that on April 15 Gourock was visited by a very vivid display of the aurora borealis, which lasted from 10 to midnight. The moon having set at 9.13 p.m. and not rising again until 4.5 a.m. the next morning, he thought it might be possible to get a photograph merely by the light of the aurora borealis, and he consequently exposed a plate towards the northern horizon, giving an exposure of only two minutes with f/8 and a Paget xxxxx. plate. The negative, when developed with a very weak pyro and ammonia developer for about one hour, came out well and showed clearly the nearest land that was three miles distant, together with the houses, which were clearly defined, besides numerous trees in the foreground. The photograph is reproduced in the above-named journal. It is not mentioned whether an impress of the aurora itself was obtained, but only the statement: "the stars also nearest the zenith are faintly seen, the light from the aurora, of course, obscuring them."

MR. TEBBUTT'S OBSERVATORY.—The Report of Mr. Tebbutt's Observatory at Windsor, New South Wales, for the year 1897, shows that the number of observations made is up to the standard of former years. The 8-inch equatorial was employed for observing occultations of stars by the moon, 134 phases being noted, and numerous minor planets. Perrine's comet was also diligently watched for several weeks, and many variable stars and phenomena of Jupiter's satellites observed. The meteorological observations have been as usual regularly made. Seven years' meteorological observations are now in hand, and will be soon published; and when this is completed, there will be a period of thirty-five years of published data which will be invaluable for investigating the local climate. In consequence of recent local legislation, Mr. Tebbutt writes: "A notice was sent to the Minister of Public Instruction on October 11 last, that it was intended at the close of the year to discontinue the meteorological department, and the hope was expressed that the Government would see fit to continue the work at its own expense. A reply was received stating that the work would be continued . . . at the Hawkesbury Agricultural College, about four miles west of the Observatory." Such an arrangement as this was evidently very satisfactory, for it would have been a crime to have suddenly broken the continuity of what must be valuable data for investigating the climatic conditions of New South Wales. "After due inquiry," as Mr. Tebbutt further states, "at the close of the year, it turned out, however, that provision had not been made for continuing the Windsor meteorological work in all its departments. It is proposed to continue at this observatory observations of the daily rainfall by the two gauges, and to secure the monthly maximum and minimum air temperatures." We hope that the Government will not be long in seeing that due attention must be paid to the question of meteorology in New South Wales, and that, after private enterprise has carried on the work for so many years, it becomes a duty to see that a breach in the continuity of the observations is not made through lack of funds.

SOME NEW STUDIES IN KATHODE AND RÖNTGEN RADIATIONS.[1]

THE researches of Crookes, Lenard, and Röntgen have given to man a new eye; they have, perhaps, also given to nature a new light; they have certainly given to science more than one new problem. A vacuum tube may appear but a simple piece of apparatus; but were we acquainted in their entirety with the secrets that it contains, we should know much at present utterly unknown, not only as regards electrical action, but also in reference to the fundamental constitution of matter, and the

[1] Abstract of Friday evening discourse delivered at the Royal Institution on February 4, by Alan A. Campbell Swinton.

true mechanism of energy. It is, in fact, for the reason that within the Crookes' radiant matter tube it is possible to deal, not as in every-day life with aggregates of matter, but perhaps individually with single molecules and single atoms floating apart in space, that so much attention is at present being devoted to this particular branch of physics.

Every one is now acquainted with what has become the quite ordinary phenomenon of the kathode rays. These excite luminescence in the glass upon which they fall, and cast a sharp shadow of any obstacle interposed in their path. When the tube is suitably placed in a magnetic field the shadow rotates and becomes at the same time smaller, the magnetic field having thus the property of concentrating the rays, and at the same time giving them a twist. This concentration of the kathode rays by means of a magnetic field, which has been studied by Birkeland and by Fleming, can be employed to show the intensely heating effect and erosive properties of the rays. Indeed, by suspending a tube over one pole of a straight electro-magnet, and thus concentrating the rays to a point, it is possible by moving the tube or the magnet to actually engrave on the interior surface of the glass a figure of any desired form.

The more ordinary method of producing a concentrated kathode discharge is by employing as kathode a spherical aluminium cup, from the concave side of which the rays are given off normally to the surface. By employing two such cups, connected to the two secondary terminals of an induction coil supplied with alternating electric current, and giving at the secondary terminals a pressure of about 20,000 volts, the intense heating effect of the kathode rays can readily be shown by allowing them to fall upon a small fragment of quicklime. In this manner a brilliant and beautiful light is produced, and it is not at all improbable that it may eventually be found possible to obtain in this way, commercially and practically, high voltage electric lamps of much higher efficiency than the ordinary incandescent filament lamps, and possibly even rivalling arc lamps. In both these latter it is necessary that the incandescent substance should be a fairly good electrical conductor; whereas in the kathode ray lamp there is no such limitation, and consequently there is a much wider range of available refractory substances. It is also quite conceivable that in the future an electric furnace of this nature may be found of service in some of the more delicate of chemical investigations, where it is necessary to obtain in isolated substances exceedingly high temperatures. Indeed, already, Crookes and Moissan have employed this means for turning into graphite the surface of diamonds.

It is now becoming more and more generally believed that Sir William Crookes' original theory as to the nature of these kathode rays is correct. According to this theory they consist of material particles of residual gas, which, being similarly electrified by contact with the kathode, are violently repelled by the latter. This has been the view held for a long time by most English physicists, and the chief point of difference now appears to be whether these material particles are single atoms, single molecules, or larger aggregations of matter. This theory is supported by the erosive action of the rays, which are found after a short time to bore straight and very minute holes right through the block of quicklime in the kathode ray lamp. A model, consisting of a gilded pith ball suspended between two metal plates connected to a Wimshurst machine, may be used to roughly illustrate what is supposed to occur. The ball obtains an electrical charge from whichever plate it starts in contact with, and is violently repelled into contact with the other plate, and so on backwards and forwards. In a Crookes' tube, however, the velocity of the negative stream is undoubtedly much higher than that of the positive stream. This may be connected with the fact that the positive discharge is much more dispersive than the negative. Indeed, a tube while in action appears to be filled almost entirely with positively electrified atoms, while it is only behind the kathode and in the kathode stream itself that any negatively electrified atoms are to be found. It is, however, possible to show experimentally that something, at any rate, producing the same effect as a positive stream does exist at very high exhaustions. For this purpose a radiometer tube, as shown in Fig. 1, containing a small mill wheel with mica vanes, similar to those employed by Crookes, may be used. The wheel is mounted upon a sliding carrier, so that it can be moved bodily either out into the centre of the tube, when the kathode stream impinges directly upon the vanes, or back into an annex, when the vanes are quite outside the kathode line of fire. In the former position, as discovered by Crookes, the wheel rotates with great rapidity in a direction indicating an atomic stream from the kathode to the anode. In the latter position, with sufficiently high exhaustion, the wheel is found by the author always to rotate in an opposite direction, indicating a returning stream of atoms from the anode to the kathode, the anode stream passing outside of the kathode stream. As suggested by Prof. G. F. Fitzgerald, some action of this nature will perhaps explain the curious effects obtained by the author, and already noticed in NATURE for April 15, 1897, from which it appears that both the convergent and divergent cones of kathode rays in a focus tube are usually hollow, it seeming likely that if the supply of atoms to the active kathode surface is from all round the edge of the latter, the atoms may be all shot off again from the kathode in the form of a hollow cone, before they get further than a certain distance towards the centre.

Birkeland has shown that if a thin kathode stream, obtained by passing the rays from a flat kathode disc through a narrow slit in a piece of platinum serving as the anode, is deflected by a suitable magnetic field, it is split up into bundles of rays; and if allowed to fall upon the glass walls of the tube, it gives fluor-

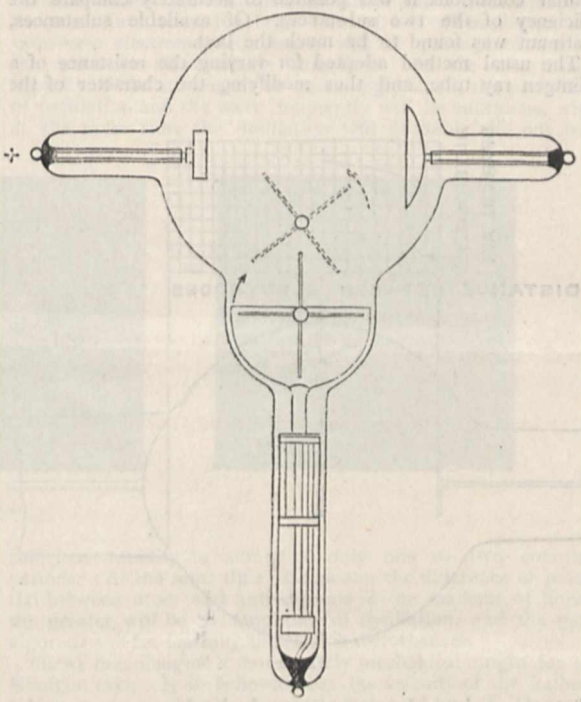

FIG. 1.

escent bands of alternate brightness and darkness. The author has been able to photograph these bands by simply binding a strip of sensitive photographic film round that part of the bulb upon which the bands are formed, and making a single discharge by a single break of the contact breaker of the induction coil. Further, by inserting between the glass and the photographic film a piece of very thin black paper, so placed as to cover only one half of the image, it is possible to obtain a photograph of the bands, one half of which is due to the visible fluorescent luminosity of the glass, and the other half to the invisible Röntgen rays. Photographs produced in this manner show that the Röntgen rays are also under these conditions given off in bands, which are co-terminous with the fluorescent bands, though photographically fainter than the latter. It is important to note that in the Röntgen ray photograph the greatest effect is always produced by the least deflected of the kathode-ray streams; that is to say, by that stream which is presumably travelling at the greatest velocity. Here we have a probable explanation of the existence of the bands, which are most likely due to the atoms of the kathode rays having from the first different velocities imparted to them, due to the oscillatory character of the induction coil discharge, and from their gathering into groups travelling at

different velocities, on the well-known principle that occasions the traffic in the street to form knots of maxima and minima, owing to the faster vehicles catching up the slower, and being impeded by them.

Passing on to the production of X-rays in tubes of the ordinary focus type, it is found that the particular material employed for the anti-kathode surface considerably affects the production of the Röntgen rays. This is a subject that was first investigated by Prof. Sylvanus Thompson, who found that the best absorbents were the best emitters of the Röntgen rays; in other words, that the best materials for the anti-kathode were metals of the highest atomic weight. If, as seems probable, the Röntgen rays are produced by the sudden removal of velocity from the kathode ray atoms by collision with the anti-kathode, this is in accordance with what would be expected, as substances of high atomic weight would obviously be the most efficient by reason of the greater inertia of their atoms. The author has made numerous experiments with various metals for the anti-kathode, comparing them in a tube in which the anti-kathode, made half of one metal and half of another, was movable. By jerking the tube, either half could be brought opposite the kathode, and put into use; so that under exactly similar conditions it was possible to accurately compare the efficiency of the two substances. Of available substances, platinum was found to be much the best.

The usual method adopted for varying the resistance of a Röntgen ray tube, and thus modifying the character of the

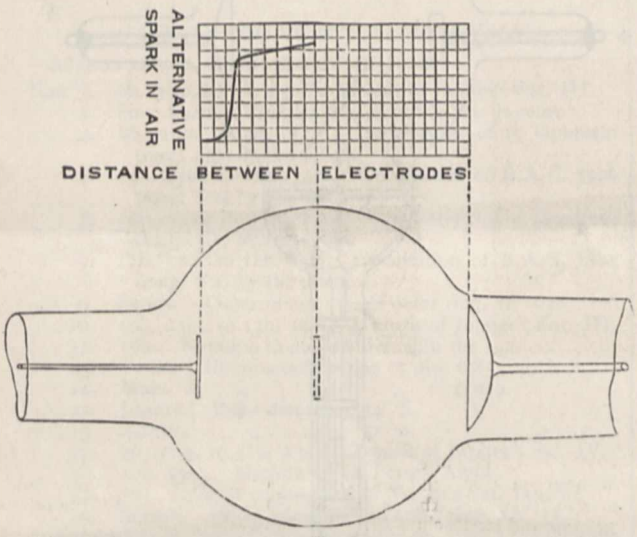

FIG. 2

Röntgen rays it produces, so as to obtain the exact penetrative quality that is desired, is by varying the vacuum. The higher the exhaustion the greater is the resistance in the passage of the discharge, the greater appears to be the velocity of the kathode stream, and the more penetrative are the Röntgen rays. This variation of the vacuum is usually effected by heating the tube, which has the effect of driving out into the interior molecules of the residual gas condensed or occluded upon the glass. Apart from this, however, it is suggested that very possibly the temperature of the contents of the tube and the consequent kinetic energy of the molecules, which is greater the higher the temperature, may in itself assist the passage of the discharge. The author has found other means of varying the resistance of the tube, and altering the character of the Röntgen rays that it generates, which do not depend upon either the degree of exhaustion or upon the temperature. According to one method the tube is fitted with two or more kathodes of different sizes, but all focussing upon the same anti-kathode. With such a tube it is found that the smaller the kathode the greater is the E.M.F. required to cause the electric discharge to pass through the tube, and the more penetrative are the Röntgen rays generated. Another method of effecting regulation consists in making the anti-kathode, which is also the anode, movable, and altering the distance between it and the kathode. Still another, in making the kathode movable, and altering its position relative to the glass walls of the tube. Some of the author's experiments in these directions have already been described in NATURE for April 29 and May 27, 1897. He has, however, now further studied the cause of these effects by means of a tube in which the positions of both anode and kathode can be altered independently by means of a magnetic adjustment. Fig. 2 shows a portion of this tube, and above it is drawn a curve representing, in terms of the alternative spark in air, the difference of potential required to cause a discharge to pass through the tube with varying positions of the anode. In the diagram the abscissæ represent the distance between anode (which also formed the anti-kathode) and the kathode, divided in tenths of an inch, while the ordinates represent also in tenths of an inch the length of the alternative sparks in air between two brass balls ¾ inch in diameter. Starting with the anode in its furthest position from the kathode, and moving it gradually towards the latter, it will be observed that at first there is a slight gradual increase in the length of the alternative spark. Then for the next small movement there is a very sudden increase, and after that a further gradual increase till the point marked in dotted lines is reached, which denotes the limit of travel that the anode was allowed. Similarly, Fig. 3 represents the effect of moving the kathode in the same tube, the anode being stationary in the position shown. Here, as will be seen, the less the distance between the kathode and anode the less is the length of the alternative spark. This distance in this case

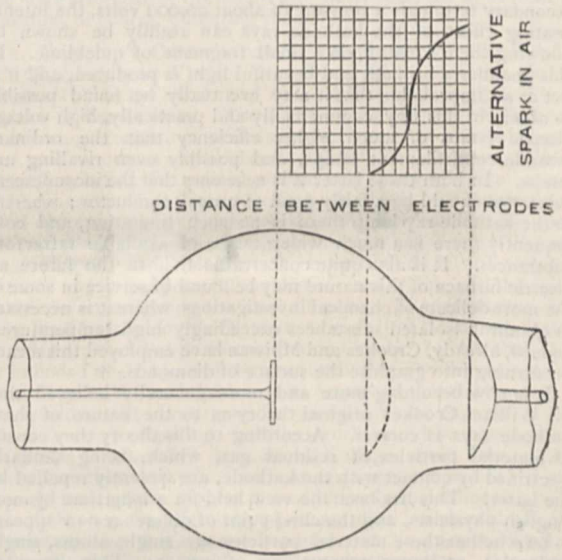

FIG. 3.

does not appear to be the determining factor, as it is more than counterbalanced by the more important factor of the position of the kathode relatively to the glass walls of the tube. Starting with the kathode as far away as possible from the anode, and moving it towards the latter, there is a gradual decrease in the length of the alternative spark to commence with, then a further, much more rapid decrease, as the kathode emerges from the annex, and a still further, but less sudden decrease, as the kathode is moved away from the glass walls out into the bulb. Now as to the effect upon the Röntgen rays, as it has been before remarked, the greater the resistance of the tube and the greater the E.M.F. necessary to cause a discharge to pass, the greater is the velocity of the atoms that form the kathode stream, and the more penetrative are the Röntgen rays produced. Further, so far as the movable kathode is concerned, the supply of atoms appears to be of great importance. If penetrative Röntgen rays are desired, the access of atoms to the kathode must be restricted. If only a few atoms can get to the kathode, these are projected at great velocity; if there is too ready access, the atoms crowd in upon the kathode, and the electrical charge of the latter is unable to throw them off with much speed. It is possible to restrict the supply of atoms to the kathode either by bringing the latter back into a recess or annex, as in the tube just shown, or by using a tube in which both kathode and anti-

kathode are fixed, but in which there is a movable conical glass shield which can be brought up from behind the kathode so as to impede the access of the atoms which, as we have seen, come in round the edges of the kathode, to any desired extent. This tube regulates just as did the adjustable kathode tube.

In order to produce sharply-defined Röntgen photographs, it is of course of the utmost importance that the rays should be given off from a very small area. The sharpness of definition varies considerably with different tubes, and a ready means of judging as to their quality in this respect is very useful.

The best and most accurate method is by means of pin-hole photography. Seeing that the Röntgen rays are not refracted, photography with a lens is, of course, out of the question; but with a pin-hole, very accurate and distinct images can be obtained. It is only necessary to place a sheet of lead, pierced by a pin-hole, near the tube, and then to examine the rays coming through the hole with a fluorescent screen, placed some way behind the lead sheet, in order to see exactly the size and shape of the active area of the anti-kathode; or, instead of the screen, a photographic plate may be employed and the effect recorded. Fig. 4 shows three pin-hole photographs of the anti-kathode taken in this way, giving the effect produced with three different distances between the kathode and anti-kathode. The largest figure is produced with the greatest distance, and *vice versâ*. It will be observed that, owing to the anti-kathode being placed obliquely to the kathode, the figures are all oblique, though somewhat imperfect, conic sections; further, that when the distance between kathode and anti-kathode is great, we have a section of the divergent cone giving a hollow ring with a central spot. The ring gets smaller and smaller, and finally

FIG. 4.

disappears as the distance between the electrodes is reduced, and the focus approaches the anti-kathode. It will also be noticed that where in the ring portion of the figures the kathode rays strike most normally—that is to say, at one of the two points of greatest curvature of each ellipse—the Röntgen rays are produced more actively than in the remaining portion where the kathode rays impinge on the anti-kathode more on the slant.

By some it is imagined that because the Röntgen rays are so very penetrating, therefore they are of the nature of an invisible light of great intensity, which, though not affecting the human retina, acts upon photographic plates very powerfully. This is quite erroneous, and, as a matter of fact, the photographic effect of Röntgen rays is relatively very feeble. The author has investigated this by exposing two photographic plates, respectively, to a very powerfully excited Röntgen-ray tube, screened by black paper to remove the visible luminosity, and to the light of a single standard candle. By adjusting the distances and exposures so as to obtain a precisely equal effect in both cases, he has found that the photographic power of the particular Röntgen-ray tube investigated was about one-sixtieth of one standard candle.

With regard to the true nature of the Röntgen rays, there have been many theories. There is the original suggestion of Röntgen himself, that they may possibly consist of longitudinal waves in the ether. Others have thought that they were possibly ether streams or vortices. There is a theory that they consist of moving material particles similar to the kathode rays. There is the more generally received doctrine, that they are simply exceedingly short transverse ether waves, similar in all respects to the waves of light, only so much shorter than the most ultra-violet waves hitherto known that they pass between the molecules of matter, and are consequently neither refracted nor easily absorbed or reflected by any media. Lastly, there is the theory, first suggested to the writer early in 1896 by Prof. George Forbes, and recently independently enunciated and elaborated by Sir George Stokes, which imagines them to be frequently but irregularly repeated, isolated, and independent disturbances or pulses of the ether, each pulse being similar, perhaps, to a single wave of light, and consisting of a single transverse wave or ripple, but the pulses following one another in no regular order, or at any regular frequency, as do the trains of vibration of ordinary light.

Then, again, there is the question of the mechanism by means of which the Röntgen rays are produced. They are generated by the impact of the kathode stream upon the anti-kathode, and it is now becoming more and more certain that the kathode stream consists of negatively charged atoms travelling at enormous velocity. If we accept this view, there are obviously several methods by which we may imagine the Röntgen rays being generated by the impact of the travelling atoms upon the anti-kathode. Each kathode-ray atom carries a negative charge, while the anti-kathode is positively charged, so that when the two come into contact an electrical discharge will take place between them. An electrical oscillation will thus take place in the atom just as in the brass balls of a Hertz oscillator, and transverse electromagnetic waves will be propagated through the ether in all available directions. As the electrostatic capacity of the atom must be exceedingly small, the periodicity of oscillation and the wave frequently will be enormous, while at the same time the oscillation will probably die out with sufficient rapidity to admit of only one or two complete periods. At the same time the greater the difference of potential between atom and anti-kathode at the moment of impact the greater will be the amplitude of oscillation, and the more vigorous and far-reaching the etheric disturbances.

Or we may imagine a more purely mechanical origin for the Röntgen rays. It is believed that the velocity of the kathode rays is enormous, being, as recently measured by J. J. Thomson, over 10,000 kilometres per second; and though Lodge, in his well-known endeavours to detect a movement of the ether by dragging a material body through it obtained only negative results, of course he could not possibly obtain any velocity at all comparable to this. Assuming that at the velocity of the kathode-ray atoms these do appreciably drag the ether with them, there may be some other effect produced, analogous to the atmospheric effect that is noted as the crack of a whip or a clap of the hands, as each atom hits the anti-kathode and rebounds.

Since this paper was written, the author's attention has been called to Prof. J. J. Thomson's suggestion in the *Philosophical Magazine* for February, that the Rontgen rays consist of very thin and intense electromagnetic pulses produced in the ether by the sudden stoppage by the anti-kathode of the electrified particles of the kathode stream.

Or, again, it is conceivable that the phenomenon is merely one of heating, and that the kathode stream atoms are, by impact with the anti-cathode, raised to such an enormous temperature, that they give off for a short space of time super-ultra-violet light. Taking a velocity for the atoms of 10^9 centimetres per second, as found by J. J. Thomson to be the minimum velocity of the kathode stream, and calculating the temperature to which a nitrogen atom would

be raised if, when travelling at this speed, it were instantly brought to rest and the whole of its energy converted into heat in the atom itself, we have the result that the rise in temperature is no less than the stupendous figure of approximately 50,000,000,000 degrees Centigrade. This is upon the assumption that the specific heat remains constant; but allowing for this, and even allowing for the merest fraction of the energy being converted into heat in the atom itself, there is obviously an ample margin to admit of a temperature being actually obtained enormously transcending anything of which man has any knowledge. Perhaps it may be objected that it is only when we come to deal with aggregations of atoms that we can speak of heat, and that a hot atom is a physical absurdity. If, however, we look upon heat as a rhythmic dance of the atoms, perhaps we may also contemplate the possibility of a single atom executing a *pas seul*, and giving pulses to the ether at each of its movements. In any case, this difficulty disappears if we imagine the travelling particles each to consist of an aggregation of atoms. The fact that substances of high atomic weight form the most efficient anti-kathodes, lends force to the suggestion that the Röntgen rays are produced in some way by the sudden removal of velocity from the atoms that form the kathode stream, owing to the collision of these latter with the comparatively stationary atoms of which the anti-kathode is composed; while the effect observed with the pin-hole photographs of the anti-kathode, in which, as has been seen, the kathode rays that strike the anti-kathode most normally are the most effective in producing Röntgen rays, is also in accordance with this view. At the same time, the fact that in Röntgen ray photographs of Birkeland's kathode ray spectrum it is always the least deflected ray that produced the greatest photographic action, goes to show that the higher the velocity of the kathode ray atoms the more effective these latter are in generating the Röntgen rays.

More than two years have now elapsed since the date of Röntgen's discovery, and nearly twenty years since the commencement of the researches of Crookes. Here, as always, we find that "Art is long, opportunity fleeting, experiment uncertain, judgment difficult." Thus wrote the Greek Hippocrates some twenty-three centuries ago, and time has not impaired the truth of the ancient aphorism.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The Junior Scientific Club met at the Museum on Wednesday, May 18. After private business, Rev. G. D. Allen exhibited his collection of European Cicindelidæ and Carabidæ. Mr. N. V. Sidgwick (Ch. Ch.) read a paper on "Tautomerism," which gave rise to a short discussion, and Dr. Gustav Mann gave an account of Miss L. Huie's further researches on changes produced in Drosera by feeding. The foods recently investigated include peptone, milk, globulin, and urea. The results previously obtained with egg albumin are confirmed by the three former foods, with important modifications. Urea acts as a poison.

CAMBRIDGE.—On June 15, honorary degrees are to be conferred on General Ferrero (Italian Ambassador), the Master of the Rolls, Mr. Leonard Courtney, Mr. James Bryce, Prof. Dicey, Sir Edward Poynter, Sir William Turner, F.R.S., the Master of Balliol, Mr. F. C. Penrose, F.R.S., Prof. S. R. Gardiner, Sir Henry Irving, and Mr. Charles Booth, author of the valuable inquiry into East-end life and poverty.

The honorary degree of M.A. is to be conferred also on Dr. Arthur Willey, Balfour student, for his excellent researches on *Nautilus*.

The General Board of Studies recommend the establishment of a University Lectureship in Chemical Physiology, but in view of the present state of the University finances the post will be without stipend from the Chest.

Dr. Joseph Griffiths has been appointed to the new Readership in Surgery, which takes the place of the suspended Professorship.

THE Report of the Council of the City and Guilds of London Institute upon the work of the Institute during last year has just been published. Before referring in detail to the several branches of the Institute's work, the Council point out that the percentage of expenditure on the teaching staff is 61·9 per cent. at the Central Technical College, and 58·2 per cent. at the Finsbury Technical College, while the average of fourteen University Colleges is 64·9 per cent. The comparison relieves the Council of any suspicion of excessive expenditure. The Research Fellowship at the Central Technical College, founded by the Leathersellers' Company during the mastership of Dr. W. H. Perkin, F.R.S., was awarded at the commencement of the summer term, with the sanction of the Company, to Mr. W. S. Gilles and Mr. F. F. Renwick, who were together engaged in investigating the oxidation products of the so-called artificial camphor. Dr. Williamson, the holder of the Salters' Company's Fellowship, has continued his investigations at the College on the actual composition of the wheat grain grown on Sir John B. Lawes's experimental farm at Rothamsted, and that of the Royal Agricultural Society at Woburn. A number of other investigations have been carried out in the engineering, physics, and chemical laboratories, and the results in many cases have been published in the technical and scientific journals. Prof. Ayrton rightly points out that the assignment of space for an electro-chemical laboratory merits attention in consequence of the rapidly growing importance of the electro-chemical industry. It is certainly time that a well-equipped laboratory was established to provide facilities for investigations in electro-chemistry.

SCIENTIFIC SERIALS.

American Journal of Science, April.—On the temperature coefficients of certain seasoned hard steel magnets, by Arthur Durward. The author examined the temperature coefficients of a large number of stout magnets seasoned according to the method of Barus and Strouhal. If the temperatures are plotted as abscissæ, and the percentage losses of magnetic moment as ordinates, the curves obtained show a slight concavity upwards in most cases, which implies that the loss of moment becomes accelerated at the higher temperatures. Some specimens show an anomalous behaviour, which can be traced to local softening of the steel, and a temperature coefficient considerably augmented in consequence.—The skull of Amphictis, by E. S. Riggs. Describes an almost complete skull in the Princeton collection from the phosphorites. It is unusually small, the length from the incisors to the condyles being ·074 m. The cranium is well expanded, showing a large and well-convoluted brain. The nasals are narrow and slender as in the civets. The genus forms a connecting link between the Mustelidæ and the Vineridæ, and supports Schlosser's theory as to their common origin.—New form of make and break, by C. T. Knipp. The ordinary form of make and break for a seconds pendulum consists of a platinum tip brushing through a mercury drop. This is subject to oxidation and other troubles. The author uses a simple spring device which is always in order, and gives a sharply defined tick for transmission. A T-shaped lever of thin sheet brass is attached to the pendulum. As it swings, each end alternately comes into contact with a fine steel spring. In the middle position, the springs are both in contact, and the circuit is established and transmits the signal.—Rhodolite, a new variety of garnet, by W. E. Hidden. During the past fifteen years there has been found from time to time, over a very limited area in western North Carolina, a variety of garnet called rose garnet. It is distinguished by the variety of its tints, by its transparency, and by its freedom from inclusions and other imperfections. Its specific gravity is 3·838. The ratio of MgO to FeO is almost exactly 2 : 1. The detailed formula is $2Mg_3Al_2(SiO_4)_3.Fe_3Al_2(SiO_4)_3$.

Bulletin of the American Mathematical Society, April.—The February meeting, in accordance with the rule lately set up by the Society, was an all-day one. This arrangement gives opportunity for not only scientific, but also social intercourse. There was a good attendance of members, and many papers were read.—The theorems of oscillation of Sturm and Klein (first paper), by Prof. Bôcher. The author states that Sturm's work (*Liouville's Journal*, 1836) has been regarded by some writers as not sufficiently rigorous, and that other methods must be substituted for his; for instance, the method of successive approximations recently employed by Picard for establishing some of the theorems. Prof. Bôcher considers that Sturm's work can be made perfectly rigorous without serious trouble and with no real modification of method. This is what

he proposes to do in the present paper ; in a subsequent paper he hopes to discuss the cases in which certain functions are discontinuous either within or at an extremity of the intervals within which they are considered. The paper was read at the December meeting, and within its limits appears to be a thorough discussion of the matter.—Another paper read at the December meeting is by C. L. Bouton, on some examples of differential invariants. It is founded on Lie's methods. The invariants are those occurring in projective transformations, and the treatment for the plane is given in full ; the method for the corresponding solid problem is sketched in, and the results given. In the author's opinion all the invariants are new.—Papers read at the February meeting are on an extension of Sylow's theorem, by Dr. G. A. Miller.—Note on the tetrahedroid, by Dr. J. L. Hutchinson. The writer points out the connection between a certain quartic surface, discussed by him in the *Annals of Mathematics* (vol. ii. p. 158), and the above-named surface.—Note on integrating factors, by P. Sarel.—Early history of Galois' theory of equations, by Prof. J. Pierpont. This is a very interesting bibliographical paper, which treats of (1) Galois' relations to Lagrange, and (2) how Galois' algebraic theories became public. Galois' estimate of his discoveries is thus stated : "J'ai fait des recherches qui arrêteront bien des savants dans les leurs."—Reviews follow of Love's theoretical mechanics, of Schell's tortuous curves, and of Page's differential equations.—There are a few slight notes, and the useful list of mathematical publications.

Wiedemann's Annalen der Physik und Chemie, No. 3.—Conductivities of electrolytes, by F. Kohlrausch, L. Holborn, and H. Diesselhorst. The authors point out that the modern advances in the measurement of temperatures and resistances have made it necessary to redetermine the conductivities of electrolytes in terms of the units now adopted. As standard electrolytes they take solutions of sulphuric acid of density 1·223, magnesium sulphate of density 1·190, and sodium chloride saturated at 18°. The resistance of 1 cc. as a cube is 0·7398, 0·04922, and 0·21605 in the three cases, which represent the maximum conductivities of those salts at the temperature mentioned.—The foundations of the electric unit of resistance, by W. Jaeger and K. Kahle. The authors describe the methods adopted in the Physikalisch-Technische Reichsanstalt for purifying the mercury and calibrating the tubes of standard resistances. The tubes must be filled in a vacuum. The resistances show a secular diminution of about 0·00003 ohms in five years.—Absorption and emission of steam and carbonic acid in the infra-red spectrum, by H. Rubens and E. Aschkinass. The infra-red rays separated out by five successive reflections at fluospar surfaces are absorbed by carbonic acid and water vapour in thick layers. Their wave-length is about 24 μ. Their absorption by the atmosphere accounts for their absence in the solar spectrum.—On the transparency of some liquids for rays of great wave-length, by the same authors. Water shows considerable absorption, but benzol is more transparent even than silver chloride.—On light nodes in a kathode ray bundle under the influence of a magnetic field, by E. Wiedemann and A. Wehnelt. When the lines of force are parallel to the axis of the tube, the kathode rays are twisted into a bundle having successive nodes. The phenomenon is completely in accordance with the projected-particle theory of kathode rays.—Visibility of Röntgen rays, by E. Dorn. Proves that the light effects seen are not due to an accommodation-strain or to electrical discharges in the neighbourhood of the observer's head.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 5.—"Observations on the Action of Anæsthetics on Vegetable and Animal Protoplasm." By J. B. Farmer, M.A., and A. D. Waller, M.D., F.R.S. Received March 9.

The object of the investigation was to observe simultaneously and comparatively the effects of certain anæsthetics (carbon dioxide, ether, and chloroform) upon vegetable and upon animal protoplasm.

Two gas chambers in series, through which anæsthetic and other vapours can be passed, contain : the first, a leaf of *Elodea Canadensis* under the microscope (× 300) ; the second, a sciatic nerve of *Rana temporaria* connected with an inductorium and galvanometer (or upon occasion a galvanograph).

The actual movements of chlorophyll bodies in a cell of the leaf were observed and measured by one observer, while the other took readings of the galvanometric deflections in response to excitation of the nerve. To establish comparison between the two classes of effects we took as measures :—the number of chlorophyll bodies that crossed a cobweb in the eye-piece during each successive minute, and the magnitude of galvanometric deflections at intervals of one minute, before, during, and after the action of the vapour. The number of bodies passing per minute gives measure of the rate of movement in the vegetable protoplasm, while the magnitude of successive galvanometric deflections gives measure of the mobility of the animal protoplasm.

The results obtained from a study of *Chara*, *Elodea*, and plasmodium of *Badhamia* were quite consistent, but owing to the greater ease in making a quantitative determination, *Elodea* was used for the more exact comparative experiments.

The action of carbon dioxide was to produce an initial slight acceleration, followed speedily by a complete cessation of movement. On disconnecting the CO_2 apparatus and aspirating air through the chamber the protoplasm, after the lapse of two or three minutes, began to show signs of recovery. Fitful movements of the granules first occurred, and then they soon resumed their processional motion around the cell ; at first very slowly. The movement rapidly became accelerated and considerably exceeded the normal rate. This acceleration was not of long duration, and was followed by a slowing down to the ordinary speed.

The results of experiments with chloroform and ether were also given.

May 12.—"On the Connection of Algebraic Functions with Automorphic Functions." By E. T. Whittaker, B.A., Fellow of Trinity College, Cambridge. Communicated by Prof. A. R. Forsyth, Sc.D., F.R.S.

If u and z are variables connected by an algebraic equation, they are, in general, multiform functions of each other ; the multiformity can be represented by a Riemann surface, to each point of which corresponds a pair of values of u and z.

Poincaré and Klein have proved that a variable t exists, of which u and z are uniform automorphic functions ; the existence-theorem, however, does not connect t analytically with u and z. When the genus (*genre*, *Geschlecht*) of the algebraic relation is zero or unity, t can be found by known methods ; the automorphic functions required are rational functions, and doubly periodic functions, in the two cases respectively. But no class of automorphic functions with simply connected fundamental polygons has been known hitherto, which is applicable to the uniformisation of algebraic functions whose genus is greater than unity.

The present memoir discusses a new class of groups of projective substitutions, such that the functions rational on a Riemann surface of any genus can be expressed as uniform automorphic functions of a group of this class. Groups are first considered which can be generated by a number of real substitutions of period two, whose double points are not on the real axis, and whose product in a definite order is the identical substitution. A method is given for dividing the plane into curvilinear polygons corresponding to such a group ; these polygons are simply-connected, and cover completely the half of the plane which is above the real axis. Sub-groups of these groups are found, whose genus is greater than unity, and which are appropriate for the uniformisation of any algebraic curves.

The sides of the polygons, into which the half-plane is divided, are formed of arcs of circles orthogonal to the real axis.

The analytical connection between the variables of the algebraic form and the uniformising variables is given by a differential equation of the third order. A certain number of the constants in this equation have to be determined by the condition that the group of substitutions associated with the equation leaves unchanged a certain circle. When any arbitrary values are given to these constants the solution of the differential equation is termed a quasi-uniformising variable. The properties of quasi-uniformising variables, and their relation to the uniformising variable, are discussed in the last section of the paper.

Physical Society, May 13.—Mr. Shelford Bidwell, President, in the chair.—A paper by Prof. W. E. Ayrton and Mr. T. Mather, on galvanometers, was read by Prof. Ayrton. It is a sequel to *Proc. Physical Soc.*, vol. x. p. 393,

and to *Phil. Mag.*, vol. xxx. p. 58. The authors suggest that in future the comparative sensitiveness of galvanometers should be expressed in terms of the number of millimetre scale-divisions per micro-ampere, when the observed image or "spot" is one metre from the mirror. Unit angular deflection is therefore 1/2000 of a radian. Further, for the periodic time, *i.e.* the time between two transits of the "spot" across some fixed point on the scale, in the *same* direction, the standard should be ten seconds. It is also proposed to reduce the factor of sensitiveness, as regards resistance, to the common basis of one ohm. The assumption is that, for a given galvanometer, the deflection per micro-ampere is proportional to the 2/5 power of the resistance of the windings. Tables accompanying the paper give complete data for a large number of galvanometers constructed during the past ten years, and it is possible to trace the improvements in sensitiveness throughout that time. The most sensitive galvanometers are the oscillographs, they have very short periods; the moving parts are small, the controlling fields very strong. They are designed to indicate the character of rapidly-varying currents. An oscillograph, as improved by Mr. Duddell, was exhibited; its period is 0·0001 sec., and its factor of sensitiveness, according to the authors' classification, is greater than any yet obtained. A distinction is drawn as to the use of the term "dead-beat." Maxwell applies it to galvanometers in which the motion is "aperiodic," *i.e.* to those in which the suspended system, before coming to rest, passes only *once* through the position of equilibrium. This meaning is retained; it is not to be confused with "quick-moving" or "short-period." A pendulum illustrating these distinctions was exhibited. As regards insulation of galvanometers and shunt-boxes, the authors now apply the "guard-wire" principle of Mr. W. A. Price. The instrument to be insulated is enclosed in a metal case provided with a terminal, to which one end of the windings is connected. The second end of the windings passes out through an ebonite bush-piece. This arrangement is said to nullify leakage and to prevent electro-static disturbance of the suspended system. In the second section of the paper, the authors calculate the limiting sensitiveness of galvanometers of the "Thomson" type. The investigation is based upon Prof. Schuster's B.A., 1894, paper; it takes into account the period of the suspended system, and the specific magnetisation of the needle. Lastly, the authors discuss the relative merits of long and short periods, *i.e.* the best "control," for galvanometers intended to indicate zero points in potentiometer operations. They conclude that if the control can be readily altered, and if the sensitiveness can be adjusted for the test, then, for rapidity of working, the "control" should be so adjusted that the sensitiveness is approximately two or three times greater than is absolutely needed for the desired accuracy. Prof. Threlfall thought the authors' method of comparing galvanometers very misleading. The results obtained in their comparison of the oscillograph (3,310,000), and the suspended-coil galvanometer (27) might be regarded as the *reductio ad absurdum* of the proposed system. The absurdity arose from the dissimilarity of the two instruments. Moreover, the proposed system ignored the fact that sensitiveness may be obtained by optical as well as by electro-magnetic means. Optical sensitiveness, owing to its greater stability, was to be preferred to electro-magnetic sensitiveness. The fundamental problem in the construction of galvanometers is an optical one; it is necessary to decide the mass and dimensions of the suspended parts so as to ensure (1) optical accuracy, and (2) electro-magnetic sensitiveness. Thus, to some extent, the weight of the mirror determines the thickness of the suspension. As an instance of what might be done by optical methods Prof. Threlfall referred to work done by himself and Mr. Brearley. (*Phil. Mag.*, 1896), in which it was possible to measure to $1{\cdot}48 \times 10^{-13}$ amperes, and, with special refinements, to 3×10^{-14} amperes. He had found that the best diameter for glass mirrors was 1·1 cms., with a weight just under 0·5 grammes. These were used with a scale at 276 cms., read by a microscope to 0·04 m.m. The course of the light was: lamp, large lens, small scale, mirror, eye-piece. The period was 25 secs., and the resistance 50,000 ohms. Even better results could be obtained by using mirrors of quartz or of blood-stone. Quartz is incomparably to be preferred to glass. Such figures indicated what could be done by optical sensitiveness, the sensitiveness that the authors ignored. It was pointed out by Prof. Threlfall that the controlling field for galvanometers of the "Thomson" type should be straight and uniform. This was best secured by using two magnets, one above and one below the needles. Prof. Perry said the authors had not asserted that a galvanometer with higher figure of merit, according to their classification, was *superior* to another of lower figure. It must be agreed that the figure they obtain is a very valuable datum for the comparison of instruments designed for similar purposes; for instance, in classifying those used by Prof. Threlfall. Mr. Duddell was to be congratulated on the extreme sensitiveness and small period of his oscillograph. Prof. Ayrton, referring to Prof. Threlfall's *reductio ad absurdum*, admitted that the criticism would carry some conviction if the two instruments were of different kinds; if, for instance, one possessed a suspended needle and the other a suspended coil. But the argument failed, because both instruments were of the suspended-coil type. In one of them Mr. Duddell had developed the advantages to be gained by reducing the air-gap. To form an opinion of electro-magnetic improvements in galvanometers it was necessary to reduce the results of all instruments to some system of classification. There was no objection, after that, to adding a good mirror, and reading by a good microscope.—The President proposed votes of thanks to the authors, and the meeting adjourned until May 27.

Chemical Society, May 5.—Prof. Dewar, President, in the chair.—The following papers were read:—The action of hydrogen peroxide on carbohydrates in the presence of iron, by C. F. Cross, E. J. Bevan, and C. Smith. The authors show that the presence of iron salts is necessary to cause the oxidation of hexoses and cane-sugar by hydrogen peroxide; the hydrogen peroxide causes a constitutional change in the hexose molecule yielding products containing the group C(OH) : C(OH). Dicarboxylic acids are produced as the result of secondary reactions.—Note on the oxidation of certain acids in presence of iron, by H. J. H. Fenton.—Properties and relationships of dihydroxytartaric acid. Part ii. Metallic salts, by H. J. H. Fenton. The salts of dihydroxytartaric acid with the alkali metals are now described.—The affinity-constants of dihydroxymaleic, dihydroxyfumaric, dihydroxytartaric and tartronic acids, by S. Skinner. On comparing the affinity constants of maleic, malonic, succinic, fumaric, tartaric, dihydroxymaleic, dihydroxyfumaric, dihydroxytartaric and tartronic acids, it appears that the affinity constant increases on introducing hydroxyl groups, and is greater for the lower members of the series of dibasic acids; the unsaturated acids have larger affinity constants than their saturated isologues.—Note on the enolic and ketonic forms of ethylic acetoacetate, by R. S. Morrell and J. M. Crofts.—The resolution of tetrahydropapaverine into its optically active components, by W. J. Pope and S. J. Peachey. The constitution which Goldschmeidt has attributed to papaverine indicates that tetrahydropapaverine has the constitution

$$\begin{array}{llll} (OMe)C.CH : C.CH_2.CH.CH_2.CH : CH.C(OMe) \\ \quad\| \quad\quad | \quad\quad | \quad\quad | \quad\quad \| \\ (OMe)C.CH : C.CH_2.NH \quad\quad CH : CH.C(OMe) \end{array}$$

The authors confirm Goldschmeidt's constitution for papaverine by showing that the tetrahydro-derivative is racemic, and have isolated the dextro- and lævo-isomerides by means of their salts with dextrobromocamphorsulphonic acid.—Molecular weights of permanganates, perchlorates, and periodates in solution, by J. M. Crofts. Molecular weight determinations of permanganates, perchlorates and periodates in fused Glauber's salt indicates that these salts have the molecular composition $M'MnO_4$, $M'ClO_4$ and $M'IO_4$.—The action of chlorine on pyridine, by W. J. Sell and F. W. Dootson. Amongst other products an addition compound of pyridine and chlorine is formed during the action of the latter upon the former.—The oxidation of paranitrotoluenesulphonic acid to dinitrostilbenedisulphonic acid and to paranitrobenzaldehydorthosulphonic acid, by R. Herz and W. H. Bentley.—Determination of molecular weights: modification of Landsberger's boiling-point method, by J. Walker and J. S. Lumsden.

Royal Microscopical Society, April 20.—Mr. E. M. Nelson, President, in the chair.—Mr. Rousselet exhibited and described a metal lamp chimney made by Mr. Pillischer, and having two openings to carry white and tinted glass.—The President exhibited and described a new monochromatic light screen trough of American invention.—Mr. H. G. Madan read a paper "On some organic substances of high refractivity available for mounting specimens for examination under the microscope." Mr. White asked if these media were suitable for histological work. Mr. Madan said piperine and quinodine had been found

harmless, monobromonaphthaline and phenylthiocarbimide were not likely to injure even delicate tissues, but he thought the mixture of metacinnamene and phenylthiocarbimide approached most nearly to balsam in permanency and neutrality. Dr. Dallinger said he had specimens mounted in nearly every medium which had been mentioned, but at the present time only one of these slides was in good condition; nevertheless, it was most important that such media should be available. The President referred to a table of coefficients which he had worked out to show the comparison of the refractive indices and dispersive powers of these new media with those of some well-known glasses.—Mr. Morland exhibited about three dozen slides of diatoms.—Mr. J. J. Vezey read a short note by Mr. E. B. Stringer, supplementary to his paper on photomicrography which was read at the meeting of the Society in December last.

Mathematical Society, May 12.—Prof. Elliott, F.R.S., President, in the chair.—Mr. A. E. H. Love, F.R.S., gave an account of some fundamental properties of manifolds.—Lieut.-Colonel Cunningham, R.E., communicated a description of "the 77 squares puzzle," by Major Turton, R.E., and exhibited a cardboard specimen of the puzzle. He also reported that the *complete* factorisation of the numbers $N = 3^n + 1$, where $n = 6\nu + 3$, had now been effected by the joint work of Mr. C. E. Bickmore and himself for the following values of n (51, 57, 69, 75, 81, 93 in part, 99, 105), thus *completing* the factorisation of these numbers up to $n = 105$ (except 93 in part), those from $n = 3$ to 45, 63, 87 being previously known. These numbers include several high primes of 9, 10, 11 figures.—The President communicated a paper, by Mr. H. G. Dawson, on the numerical values of $\int_0^h e^{t^2} dx$; and one by Prof. H. Lamb, F.R.S., on the reflection and transmission of electric waves by a metallic grating. Impromptu remarks were made by the President (in connection with the figure of Pascal's theorem) and by Mr. F. S. Macaulay.

Zoological Society, May 17.—W. T. Blanford, F.R.S., Vice-President, in the chair.—Mr. Oldfield Thomas read a paper on a small collection of Mammals from Nyasaland that had been presented to the British Museum by Mr. Alfred Sharpe, C.B. Sixteen species were enumerated, mostly from North Nyasaland. Among them was a new antelope from Urori, coloured like *Cephalophus æquatorialis*, but with horns in the female, as in *C. monticola*.—A communication was read from Dr. A. G. Butler on a collection of Lepidoptera lately made in British East Africa by Mr. C. S. Betton. It contained examples of 123 species of butterflies and of 111 species of moths. Among the moths were forms which were referred to five new genera, viz. *Bettonia*, *Aclonophlebia*, *Trotonotus*, *Hameopis*, *Lembopteris*, and *Metaculasta*. Besides these new genera thirty new species were characterised in this paper.—Mr. F. E. Beddard, F.R.S., communicated a paper by Miss Sophie M. Fedarb on some earthworms from India. Four species were treated of in this paper, of which the following three were described as new:—*Perichæta cupulifera*, *P. crescentica*, and *Dichogaster parvus*.—Mr. W. E. de Winton described a new rodent of the family Anomaluridæ from the Benito River, French Congo, which was referred to a new genus *Aëthurus*, differing from both *Anomalurus* and *Idiurus* in not having any expanded flying-membranes, but resembling the former in the formation of the tail, and being more like the latter in the form of the skull. The species, proposed to be named *Aëthurus glirinus* was of the same size as *Anomalurus batesi*, grey in colour, with a black bushy tail and a thickening of the skin of the lower leg, in which are set jet-black, club-shaped hairs forming anklets.—A communication was read from Mr. Stanley S. Flower, in which he pointed out that the gecko from Penang described by Stoliczka as *Cyrtodactylus affinis* and that described by himself under the name of *Gonatodes penangensis* were identical, and that the proper appellation of the species would be *Gonatodes affinis*.

Royal Meteorological Society, May 19.—F. C. Bayard, President, in the chair.—Mr. R. H. Scott, F.R.S., read a paper on the frequency of rainy days in the British Islands. He had taken the number of rainy days in each month at forty stations for the twenty years 1876-95, and then divided that number by the total number of days in the month, and so ascertained the resulting percentage. The greatest excess of frequency is always on the extreme north and west coasts. June is the month with the least number of rainy days, but in July the summer maximum of rain occurs, bringing the well-known Lammas floods. In October the weather becomes decidedly showery, and the distribution begins to assume its winter type. November is the month with the greatest frequency of rainy days.—Mr. F. J. Brodie read a paper on the abnormal weather of January last, which was one of the most remarkable winter months on record. The month was singularly dry, with an absence of snow or sleet—a somewhat unusual feature in January even for any individual station, but far more remarkable as applying to the country as a whole. The special feature, however, was the striking absence of severe frost, the frequent prevalence of unusually mild weather, and as a result the abnormal warmth of the month, especially in the more northern parts of the kingdom. The mean temperature was generally over the whole country about 5° above the average, while at many places situated in the more northern parts of the kingdom it was more than 6° above the average. The atmospheric pressure throughout the month was also very high, the mean being from two to three tenths of an inch above the average.

CAMBRIDGE.

Philosophical Society, May 2.—Mr. F. Darwin, President, in the chair.—On the theory of order, by Mr. E. T. Dixon. All the theorems of non-metrical (projective) geometry depend solely on the conception of "order" so defined as to be independent of the idea of "before or after," which belongs only to time. It follows from this definition that no "order" can be ascribed to less than four units in any uniform group: and this is why less than four points have no "projective relation" or an harmonic ratio. The paper further discusses the way in which numbers (or coordinates) may be assigned to the units of a group for purposes of analysis, with or without a system of "unique" lines having already been determined.—On the representation of a function, by Mr. H. F. Baker.—On the total eclipse of the sun, January 22, 1898, by Mr. H. F. Newall. A general account was given of the observations made during the recent eclipse, and photographs were exhibited, showing: (1) the general appearance of the corona; (2) the spectrum of the sun's limb as photographed with prismatic cameras by Sir Norman Lockyer's party, and by Mr. Evershed; (3) the spectrum of the sun's limb as photographed with a slit spectroscope.—Captain E. H. Hills, R.E., exhibited and described the photographs obtained by him of the spectrum of the corona, and also the two series of photographs of the spectrum of the sun's limb at the beginning and end of totality.

PARIS.

Academy of Sciences, May 16.—M. Wolf in the chair.—The Secretary announced to the Academy the loss it had sustained by the death of M. Souillart, Correspondant in the Section of Astronomy.—On the impossibility of certain series of groups of points on an algebraic surface, by M. Émile Picard.—On some causes of uncertainty in the exact estimation of carbonic acid and of water vapour, diluted with large volumes of air or inert gases, by M. Armand Gautier. It is shown that potash, even when spread over long columns of glass beads, is incapable of removing the last traces of carbon dioxide from air. This, however, is readily accomplished by the use of a U-tube containing moistened baryta. The increase of weight of a phosphoric anhydride tube after passing through it large volumes of air dried over sulphuric acid was also determined, the amount being of the order of 0·4 mgr. for 100 litres of air. An attempt was made to estimate the maximum amount of sulphuric acid vapour carried away by 100 litres of air, and the conclusion drawn that at ordinary temperatures the vapour pressure of sulphuric acid in air must be less than one twenty-millionth.—On an absolute actinometer, by M. A. Crova. The instrument described is a modification of those proposed by M. Knut-Angström and M. Chwolson, consisting of a thin disc of pure copper, suitably protected from accidental radiations, and placed normally to the sun's rays, the temperature being measured by the resistance of a thin constantin wire.—Agglutination of the bacillus of true tuberculosis, by M. S. Arloing. Certain serums have the power of causing the bacilli of true human tuberculosis to cohere. An attempt will be made to see whether this property can be applied to the diagnosis of tuberculosis in man, analogous to the method now used for typhoid fever.—On the development of the disturbance function, by M. Adrien Féraud.—On the quadratic and rational correspondence of two plane figures, and on a remarkable substitution, by M. Ernest

Duporcq.—On the Hamiltonian groups, by M. G. A. Miller.—On the liquefaction of hydrogen and of helium, by M. James Dewar (see NATURE, p. 55.) On a Crookes' tube which can be revivified by osmosis, by M. P. Villard. A platinum tube is fixed to one end of the glass part of a Crookes' tube. When after repeated use the resistance of the tube becomes too high, the platinum tube is heated with a Bunsen burner, the hydrogen of the flame penetrates the tube, and in two or three seconds the tube is fit for use again.—On a property of fluorescent screens, by M. P. Villard. If an object is placed between the Crookes' tube and the screen, the latter illuminated for some time, and then the object removed, it is found that those parts of the screen previously protected by the interposed object are more luminous than the others.—On the molecular weights of the easily liquefiable gases, by M. Daniel Berthelot. Starting with the theorem that the molecular weights of gases are proportional to their limiting densities when the pressure is infinitely small, from the experiments of M. Leduc, the true density ratios of oxygen, carbon droxide, nitrous oxide, hydrochloric acid, acetylene, phosphoretted hydrogen, and sulphur dioxide are determined, the precision being, in the opinion of the author, equal to that obtained by the best chemical methods.—On the preparation and properties of anhydrous beryllium fluoride, and the oxyfluoride of beryllium, by M. P. Lebeau. The product obtained by drying in air the substance given by the solution of beryllium hydrate in hydrofluoric acid is an oxyfluoride, $5BeF_2.2BeO$, and the anhydrous fluoride cannot be obtained in this way. The latter, however, can be obtained in the pure state if the drying be conducted in a stream of gaseous hydrogen fluoride.—On a method of preparing potassium carbonyl-ferrocyanide synthetically, by M. J. A. Muller. Potassium ferrocyanide, heating in closed vessels with carbonic oxide at 130°, gives in less than forty-eight hours 90 per cent. of the theoretical yield of $K_3Fe(CN)_5CO$.—On a new unsaturated tertiary alcohol, dimethylheptenol, by M. Ph. Barbier.—Ethanepyrocatechol and its derivatives, by M. Ch. Moureu.—On the presence of the common eel in the open sea, by M. Léon Vaillant. The eel was found in the stomach of a sperm whale, and is of interest in furnishing an undoubted proof that the eel descends to the sea.—On the development of *Alpheus minor*, by M. H. Coutière.—Origin of the structure of lenticels, by M. Henri Devaux. The observations given show that the lenticel is a small region continually accommodating itself to the conditions of external moisture.—On the origin of the thallus of the Cutleriaceæ, by M. C. Sauvageau.—On the *Septoria graminum*, destroying the leaves of wheat, by M. L. Mangin.—Insertion of the base of the nerve fibre on the limiting margin of an adult nerve axis, in the form of a continuous epithelial sheet, by M. J. Renaut.—Some micro-organisms of soured wines, by MM. F. Bordas, Joulin and de Raczkowski.—Some periscopic glasses, by M. Ostwalt.—Variations in the pressure and horizontal components of the wind governed by the moon. Discussion of the formulæ: generation of depressions, by M. A. Poincaré.—Earthquakes of May 6, 1898, documents by M. Jullien of Chambéry, M. Guerby of Annecy, M. André of Saint-Genis-Laval, and M. Soret of Geneva, communicated by M. Mascart.

DIARY OF SOCIETIES.

THURSDAY, MAY 26.

ROYAL SOCIETY, at 4.30.—On the Cytological Features of Fertilisation and Related Phenomena in *Pinus silvestris L.*: V. H. Blackman.—The Skeleton and Classification of the Calcareous Sponges: G. P. Bidder.—On Surfusion in Metals and Alloys: Prof. Roberts-Austen, F.R.S.—Note on the Complete Scheme of Electrodynamic Equations of a Moving Material Medium, and on Electrostriction: Dr. J. Larmor, F.R.S.—Aluminium as an Electrode in Cells for Direct and Alternate Currents: E. Wilson.—Contributions to the Study of "Flicker": T. C. Porter.—On the Kathode Fall in Gases: Dr. Capstick.

ROYAL INSTITUTION, at 3.—Heat: Lord Rayleigh.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—The Design of Electric Railway Motors for Rapid Acceleration: Prof. Charles A. Carus-Wilson.

FRIDAY, MAY 27.

ROYAL INSTITUTION, at 9.—Sir Stamford Raffles and the Malay States: Lieut.-General the Hon. Sir Andrew Clarke.

PHYSICAL SOCIETY, at 5.—A Simple Interference Method of Reducing Prismatic Spectra: Mr. Edser and Mr. Butler.—Some further Experiments on the Circulation of the Residual Gaseous Matter in Crookes' Tubes: Campbell Swinton.

SATURDAY, MAY 28.

ROYAL INSTITUTION, at 3.—The Biology of Spring: J. Arthur Thomson.

GEOLOGISTS' ASSOCIATION (Liverpool Street Station, G.E.R.), at 11 45.—Long Excursion to Aldeburgh and Westleton. Directors: W. Whitaker, F.R.S., F. W. Harmer, and E. P. Ridley.

WEDNESDAY, JUNE 1.

ENTOMOLOGICAL SOCIETY, at 8.—The Lepidoptera Heterocera of China and Japan: J. H. Leech.—The Moths of the Lesser Antilles; Sir Geo. F. Hampson, Bart.

THURSDAY, JUNE 2.

ROYAL INSTITUTION, at 3.—Modern Methods and their Achievements in Bacteriology: Dr. E. E. Klein.

LINNEAN SOCIETY, at 8.—Notes on some Lories: Prof. St. George Mivart, F.R.S.—A Revision of the Genus Symblepharis: E. J. Salmon.—On the Food of the Uropoda: Surgeon-Captain H. A. Cummins.

CHEMICAL SOCIETY, at 8.—The Action of Ether on Organic Acids and on Carbohydrates in Presence of Hydrogen Bromide: H. J. H. Fenton and Mildred Gostling.

FRIDAY, JUNE 3.

ROYAL INSTITUTION, at 9.—The Development of the Tomb in Egypt: Prof. W. M. Flinders Petrie.

GEOLOGISTS' ASSOCIATION, at 8.—Fossil Sharks and Skates, with special reference to those of the Eocene Period: A. Smith Woodward.

SATURDAY, JUNE 4.

ROYAL INSTITUTION, at 3.—The Temples and Ritual of Asklepios at Epidaurus and Athens: Dr. R. Caton.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Electro-Dynamics: Prof. C. A. Carus-Wilson (Longmans).—Bulletin of Miscellaneous Information, 1897 (Darling).—The Scientific Memoirs of Thomas Henry Huxley, edited by Profs. M. Foster and E. Ray Lankester, Vol. 1 (Macmillan).—Creation Records discovered in Egypt: G. St. Clair (Nutt).—Catalogue of the African Plants collected by Dr. F. Welwitsch in 1853–61: W. P. Hiern, Part 2 (British Museum).—List of the Types and Figured Specimens of Fossil Cephalopoda in the British Museum (Natural History): G. C. Crick (British Museum).—Elements of Descriptive Astronomy: Prof. H. A. Howe (Philip).—Manual Training: Woodwork: G. Ricks (Macmillan).—A Simplified Euclid Book I.: W. W. Cheriton (Rivingtons).—Syllabus der Pflanzenfamilien: Dr. A. Engler, Zweite, umgearbeitete Ausgabe (Berlin, Borntraeger).—Die Vegetation der Erde, II. Grundzüge der Pflanzenverbreitung in der Karpethen: F. Pax, I. Band (Leipzig, Engelmann).

PAMPHLETS.—Per la Storia della Meteorologia in Italia: P. G. Boffito (Torino).—Essai sur la Théorie des Machines Électriques a Influence: Prof. V. Schaffers (Paris, Gauthier-Villars).—Versuch einer Darstellung der Empfindungen: W. Przibram (Wien, Hölder).

SERIALS.—Journal of the Chemical Society, May (Gurney).—Zoologist, May (West).—Himmel und Erde, Mai (Berlin).—History of Mankind: F. Ratzel, translated, Part 26 (Macmillan).—Bulletin de l'Académie Royale des Sciences, &c., de Belgique, 1898, No. 4 (Bruxelles).—Memoirs and Proceedings of the Manchester Literary and Philosophical Society, Vol. 42, Part 2 (Manchester).—L'Anthropologie, Tome ix. No. 2 (Paris).—Monthly Weather Review, February, (Washington).

CONTENTS.