THURSDAY, JUNE 7, 1894.

HAGEN'S SYNOPSIS OF HIGHER MATHEMATICS.

Synopsis der Höheren Mathematik. Von Johann G. Hagen, S.J., Director der Sternwarte des Georgetown College, Washington, D.C. Erster Band: Arithmetische und algebraische Analyse. (Berlin: Felix L. Dames, 1891.)

THE author's object has been to give a bird's-eye view, or synopsis, of the whole range of higher mathematics; and this handsome volume of 398 pages is a first instalment. The work is not intended as a treatise, or to be merely a book of reference to which the mathematician may turn for his formulæ. It has a much more ambitious scope, and aims at presenting a general view of all branches of mathematics, methodically arranged and separated into a great number of sections, each of which contains a notice of the history of the subject to which it relates, followed by a series of numbered paragraphs giving the principal formulæ, with full references to the books and writings from which they are taken, and to which the reader must have recourse for further information.

The branches of mathematics treated of in the present volume may be classed under the four heads of Theory of Numbers, Theory of Series, Theory of Functions, and Theory of Equations. In this classification, however, an extended meaning must be given to these titles, for the functional branch includes determinants, invariants, and groups. Altogether there are twelve subject headings divided into 102 sections, each of which is further subdivided into separate articles when required. As an example of the mode of arrangement, we may take the Partition of Numbers. We first find a general sketch of the algebraical methods of Euler, Cayley, and Sylvester, with many of Euler's most interesting results; then we pass to partitions into figurate numbers and to quadratic forms, both treated in a similar manner.

It is evident that any near approach to absolute completeness could not be attained in such a comprehensive undertaking. No single person could read and digest the whole of mathematics as it exists in our day, and arrange and systematise it in a series of volumes. It might even be regarded as open to question whether so bold an enterprise could meet with any measure of success. But no one can look at this volume without admitting that the attempt has been well justified, and that, whatever its imperfections, we are indebted to the author for a most interesting and valuable work.

The critical reader naturally turns first to the subjects—or, rather, the portions of subjects—with which he is himself best acquainted, and it is not surprising if he should here find omissions; but, even in this extreme case, the sections in question can scarcely be read without advantage as well as interest. The true test of the utility of the work is afforded by an inspection of the sections relating to subjects which lie adjacent to, but not upon, the direct line of the reader's own studies; here he cannot fail to be impressed by the new matter which he will find set out before him.

The history, theorems, and references are grouped together in an attractive manner; a mathematician could not turn over the pages, even in the most casual manner, without being tempted to stop here and there and pore over some of the paragraphs. The historical introduction is always remarkably clear, and the formulæ are sufficiently explained to render them intelligible as they stand. Although the book is to some extent a cyclopædia, it is not unduly concise, nor is any attempt made to save space by the introduction of special abbreviations in the explanations or references.

As an illustration of the contents of the sections, we may take the paragraphs which relate to the number of prime numbers. We first find references to the proofs of the theorems that the number of primes is unlimited, and that every arithmetical progression, whose first term and difference have no common factor, must contain a prime. The next paragraph gives an account of Gauss's, Encke's, and Legendre's approximate formulæ for the numbers of primes between given limits, with references. Then we come to a *résumé* of Tchebicheff's memoir of 1851, with Sylvester's additions (1881), followed by a similar statement of Riemann's results (1859) and a reference to Meissel's methods of calculating the exact number of primes up to a given limit (1871). As another illustration, we may take the section relating to the harmonic series. First we find references to works or memoirs where special cases of harmonic series are treated at some length; then we come to the general summation by means of the semi-convergent series with Eulerian numbers as coefficients; and the section closes with an account of the history of Euler's constant. From this description it will be seen that the work, covering as it does all higher mathematics, is unique in its character. No other writer has attempted to deal systematically with any large field of mathematical research so fully and completely.

It seems to us that Mr. Hagen has very skilfully combined statements of results with references. It is difficult to avoid being too diffuse when formulæ have to be selected from an elaborate memoir; and it is difficult to render a mere body of references attractive. But in both these respects the author has been successful. The references are always accompanied by enough explanatory matter to render them interesting; in fact, unlike most mathematical quartos, every page of the book is "readable" in the ordinary sense of the word. The subdivision of the subjects into so many sections, though convenient for the user, must have added considerably to the labour of preparation, and increased the difficulty of arranging the references so as to avoid repetition.

A list of sixty-six treatises and twenty-one periodicals, which are referred to in the volume, is given at the end. This list, long as it is, might have been considerably extended, had more complete libraries been accessible to the author. As it is, the works consulted form a most excellent nucleus, which may be supplemented at some future time by the author or a successor. Had many more been included, we think the author's attempt must have failed, no matter what ability and perseverance he might have brought to his task. It is to be remembered that for such a compilation it is necessary to study the memoirs with some care in order to decide upon the results to be selected. No one who has not had experience of this kind of work can appreciate the labour involved; it is comparatively easy when the abstractor can confine himself to his own line of study, but when he has to get up fresh subjects for the purpose, the difficulty is enormously increased. It would be manifestly unfair to criticise a work of this kind on account of its deficiencies, or even its errors. Any competent mathematician who carries out such an undertaking is entitled to the thanks of his fellows for whatever he puts before them; and when he does his work well, as Mr. Hagen has done, he may be heartily congratulated upon a real service rendered to mathematical science.

The difficulty of dealing with the ever-increasing volume of journal literature is one which is common to all the sciences, but it is perhaps felt most acutely in mathematics, where the lines of research are so very numerous, and the workers in each are but few. The want of treatises has to some extent been supplied by the republication in a collected form of the scattered papers of many eminent mathematicians. The value of these complete editions cannot be exaggerated; but they necessarily aggravate the tendency to accumulate all discoveries upon the greatest names, and throw still further into the background the productions of the less distinguished writers. The paramount merit of classified indexes and books of an encyclopædic character is that they treat all papers with the same impartiality; and probably there are no works which do more for the advance of science than those which, like the present, have for their sole object to make available for general use the stores of more or less inaccessible knowledge which have been laboriously acquired and put on record. Perhaps, too, when Mr. Hagen has mapped out the whole territory of mathematics, there may be found some who will be willing to fill in certain regions on a larger scale than so comprehensive a plan has permitted to him.

A few words should be added with respect to the book itself. It is beautifully printed, the pages are large and handsome, and it is well indexed. The formulæ are so numerous, and the text is so conveniently divided into short and clear paragraphs, that the language will present no obstacle to anyone possessing the least acquaintance with German. It is intended that the complete work shall consist of four volumes, the second relating to geometry. If carried out in its entirety with the same care that has been bestowed upon the first volume, the whole work will form a splendid contribution to the history and progress of mathematics.

J. W. L. GLAISHER.

MICRO-CHEMISTRY.

A Manual of Micro-chemical Analysis. By Prof. H. Behrens. With an introductory chapter by Prof. John W. Judd. (London: Macmillan and Co., 1894.)

THE necessity of supplementing the microscopical examination of rocks and minerals by chemical tests led Dr. Boricky in 1877 to devise his method of micro-chemical analysis. He decomposed extremely minute particles of the substance to be examined on a glass slide, protected by a coating of Canada balsam, and examined the fluosilicates formed by the aid of the microscope. Since his time Prof. Streng, Dr. Haushofer, the author of the present manual, and others have devoted themselves to improving and extending micro-chemical methods. Although originally introduced for the purpose of enabling chemical tests to be applied to extremely small particles, it has been found that these methods have another and perhaps equally important claim to recognition. They often shorten the time required for a qualitative chemical examination. Thus Prof. Behrens tells us that a solution containing calcium, magnesium, zinc, manganese, cobalt, and nickel has been examined in forty minutes; and one containing silver, mercury, lead, bismuth, tin, antimony, and arsenic in an hour.

Up to the present time no general work on micro-chemical analysis has appeared in the English language, so that the manual before us fills a definite gap in our scientific literature. It is divided into three parts. The first treats of the general method and of the reactions at present employed in the identification of the different elements; the second, of the application of the method to the analytical examination of mixed compounds.

The apparatus required is of the simplest character. A microscope with magnifying powers of 50 and 200, a few microscopic slides, some capillary tubes, one or two platinum spoons, some platinum wire and foil, a burner giving a flame 5 mm. high, and a box of reagents, are almost all that is absolutely necessary. An idea of the scale on which the operations are conducted may be obtained from the fact that, in establishing the limits of the applicability of the several tests, the author worked with drops having a volume of one cubic millimeter. The conditions which determine the suitability of any particular reaction for micro-chemical work are obviously very different from those which govern ordinary qualitative analysis. It is much more important that the compounds formed should be easily recognisable, than that complete precipitation should be effected. The compounds by which elements are recognised under the microscope are therefore, as a rule, those which possess an appreciable though not very great solubility; for such compounds most readily form well characterised crystals.

It is in the selection of suitable reactions that Prof. Behrens has done so much to facilitate the application of micro-chemical methods. In describing these reactions he gives in each case the limit of sensibility in micro-milligrams, the precautions necessary to secure the result, and the circumstances under which the particular reaction is applicable. The work is illustrated with numerous figures representing the compounds relied upon for diagnostic purposes; but, as the author points out, the only way of acquiring facility in the identification of these compounds, as well as confidence in the method, is to go through the reactions and observe the results under the microscope.

The second part of the work treats of a systematic scheme of examination, and of the micro-chemical analysis of water, ores, rocks, alloys, and some combinations of rare elements. It must be admitted that it is at present quite impossible to formulate any general scheme at all comparable with those in use in ordinary analysis; and the chemist, unacquainted with what has been done by the aid of micro-chemical methods, would undoubtedly carry away a very unfavourable impression of them if he confined his attention to this part of the book. The following portions, which treat of the application of the method to ores, alloys, rocks, &c., are much more satisfactory, and contain information of great value to the metallurgist, petrologist, and others.

After all, micro-chemical analysis is only in its infancy, and, as the author points out, the present work will doubtless prove to be a mere outline compared with the manuals which will be published twenty years hence, "when the advantages of micro-chemical analysis will be understood everywhere, when its appliances will be fully developed, when difficulties have been surmounted, and obscurities have been cleared up." Meanwhile it is to be hoped that the publication of this small but extremely valuable little volume will have the effect of largely increasing the number of those who use micro-chemical methods in this country.

OUR BOOK SHELF.

Practical Botany for Beginners. By F. O. Bower. (Macmillan and Co., 1894.)

PROF. BOWER'S well-known "Practical Botany" has won for itself universal recognition as forming an indispensable adjunct to the botanical laboratory. But with its increasing popularity the size and scope of the volume also advanced, and at the present time, though it is invaluable to the student with sufficient time at his command, it is somewhat bulky for the large class of persons who, from various circumstances, require a more elementary acquaintance with the types they investigate.

It is for these that the "Practical Botany for Beginners" has been designed, and it will certainly prove of great service. Although the book is of smaller dimensions than the larger work just referred to, it is still conducted on the same lines. The text, so far as it goes, is for the most part similar, and the reduction in size is provided for by the use of smaller type, and by the omission of many subsidiary descriptions which had been introduced for purposes of comparison.

Like all good introductory books, it assumes no previous knowledge in the department to which it relates, and thus the student is enabled to begin really at the beginning. It will, however, be his own fault if he is not in possession of a very creditable amount of sound knowledge by the time he has worked through the volume. For those who are unable to go through the more extended course, a better book than the present one could not be recommended.

Simple Experiments for Science Teaching. By John A. Bower. (London: Society for Promoting Christian Knowledge, 1894.)

TEACHERS of science in elementary schools now live in halcyon days. Time was when books containing courses of experiments suitable for teaching the young idea the science of common things were hard to find, and they who desired to impart such instruction had to prepare their own sequence of lessons. But the examinations of the Science and Art Department and similar bodies have changed all that. There are now numerous primers for all branches of elementary science, some good, many indifferent, and a few bad. Teachers are no longer under the necessity of exercising the faculty of originality in devising experiments for class demonstration, for the work is done for them, and frequently done well, by the much-maligned text-book writer. Possibly the mental atrophy thus brought about is not desirable, but there is little doubt that the teaching has been benefited. Few of the courses of elementary science in our schools and colleges were truly scientific in character, and it is chiefly the text-book that has improved the old state of things by giving law and order to the chaos of experiments.

Mr. Bower's book deserves classification with those that help on the work of science. It consists of two hundred experiments fully illustrating the elementary "Physics and Chemistry" division in the code for evening continuation schools. The experiments are well graded, they are simple, they illustrate phenomena of every-day life, and most of them can be performed with the homeliest things. The pupil who sees the experiments will learn much; he who does them will obtain an excellent foundation in physical science. The book is nicely printed and sufficiently illustrated, and would be a very acceptable present for a boy fond of finding out some of the ways of nature.

LETTERS TO THE EDITOR.

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

The Teeth and Civilisation.

IN a letter to NATURE for May 17, on "The Teeth and Civilisation," the writer advances a theory to account for the great prevalence of decay of the teeth at the present day, and concludes that Dr. Wilberforce Smith's investigations show that "the ancients enjoyed a perfect set of teeth till advanced years, and modern savages enjoy the same blessing."

I have not had the opportunity of seeing Dr. Wilberforce Smith's communication, but the number of cases examined in this particular instance (ten Sioux Indians) would hardly be sufficient to draw any conclusions from; and even in these ten cases *all* the teeth were not examined. I think, however, it has been sufficiently proved by several careful investigations that caries of the teeth is not a purely modern disease, and is not entirely confined to civilised races. My father, in a communication to the Odontological Society in 1870, brought together the results of an inquiry extending over more than ten years, in which he examined over 2000 skulls, including all the available collections in Great Britain, and his conclusions as to the prevalence of dental caries differ very considerably from those of the writer of this letter.

Among thirty-six skulls of ancient Egyptians he found caries in fifteen (41·66 per cent.), in seventy-six Anglo-Saxon skulls he found twelve cases (15·78 per cent.), among 143 skulls of Romano-Britons there were 41 cases of caries (28·67 per cent.), while among 44 miscellaneous skulls of ancient Britons 20·45 per cent. showed carious teeth. Several other collections gave similar results.

Again, with regard to savage races—among the Tasmanians 27·7 per cent. of caries was found, among native Australians 20·45 per cent., among East African skulls 24·24 per cent, and among those of West African natives 27·96.

Similar results were obtained on the examination of skulls of many other races, but I think I have quoted figures sufficient to prove that caries is not confined to civilised races or to modern times.

It is quite comprehensible that excessive nerve strain, especially by affecting vascular supply, may lead to imperfect nutrition during the *development* of the teeth, and we know that the diseases of early childhood have a very marked effect upon tooth structure, indicated by the ridged and defective teeth so frequently seen, and it seems quite possible that too early stimulus of the brain in childhood may have a similar effect on forming teeth. It is very difficult, however, to understand how nerve strain can have any *direct* effect upon fully formed teeth, and we should, I think, look for the explanation of the cases referred to in some vitiated condition of the fluids of the mouth, caused by the depressed condition of health so common amongst hospital nurses.

There is little doubt that an open-air life and healthy surroundings encourage the formation of sound teeth in a sound body; but I cannot but think that the principal cause of caries must be looked for in the food. It is plainly shown by many investigators, and in the paper above referred to, that caries is rare among peoples who subsist principally upon animal food; the Esquimaux showed, among sixty-nine skulls, only two cases of caries, and the largest amount of disease was found among those races who lived upon a mixed or exclusively vegetable diet. These results are, of course, easily understood under the more accurate knowledge which we now possess of the immediate causes of dental caries.

As to the relative frequency with which different teeth are affected, I think statistics plainly show that it is the first molar tooth of the *lower* jaw which is most prone to decay of any tooth in the series, and most authorities consider the second lower molar as the next in order; with these two exceptions the upper are more frequently diseased than the lower teeth. This would, however, not affect the argument, as the lower molars are of course also supplied by the fifth nerve.

Structural defects, due to inherited weakness or imperfect nutrition *during the development of the teeth*, combined with the use of soft cooked food, which is long retained in contact with them, and is of a nature eminently suitable for fermentation, give us, I think, the principal factors of decay among civilised races.

While allowing the influence of nerve strain in early childhood, and as a factor in hereditary transmission of defective structure, I fail to see how it can influence teeth already formed. J. HOWARD MUMMERY.

May 27.

Centipedes and their Young.

REFERRING to Mr. Urich's letter in your issue of April 5, I send the following remarks, which no doubt will interest some of your readers. During my eight years' residence in Guiana, I have frequently had brought to the museum, centipedes of from 5–8 inches in length, carrying their young clasped by means of their legs to all parts of the under-side of the body, though generally the young have been clustered in dense masses rather than scattered. In their very early stages the young are closely clustered, and seem quite unable to clasp their parent in turn, but later they become very restless, and will be seen moving about independently, and when clustered by the action of the parent they are incessantly changing their position in the cluster. When the young are thus bunched together, the body of the parent is coiled upon itself at that part; and the contrast between a centipede in this position, and a scorpion carrying her young upon her back, just as a small opossum does, is a very marked one.

I had imagined that this habit of the centipedes was widely and generally known; and indeed Packard ("Guide to the Study of Insects," p. 674) remarks that "Wood also states that the female guards her young by lying on her side, and then coiling her body passes them along by a rapid cilia-like action of her feet, thus arranging them satisfactorily to herself." This is but a very terse description of what will be observed when one disturbs a centipede and the arrangement of her young about her body.

As remarked by Dalton ("History of British Guiana," vol. ii. p. 267), the centipedes "lay their eggs in clusters like little berries on the ground, and the female chooses an obscure place for this purpose, as under flower-pots, where she can remain until the eggs are hatched." Centipedes are not seldom met with in such obscure and uniformly moist places as under flower-pots and tubs, or boards and shingles, with their eggs clustered as described.

With regard to the disappearance of the young ones from the box forwarded from Trinidad to London, the most likely explanation is that they were eaten by the parent. If the parent centipede be kept with the young ones, and left unfed for a day or two, it will be observed to feed quite leisurely and greedily at times on its young. This I have witnessed directly in three separate cases where they had been kept unfed in a long glass jar in the museum. The most desirable food for centipedes in the tropics, I may incidentally remark, is the cockroach. J. J. QUELCH.

The Museum, British Guiana, May 10.

The Penetrative Power of Bullets.

I HAVE been stimulated by the recent trials of the bullet-proof cuirass, to try a few experiments on the subject. I will only mention one experiment, which I made this morning, assisted by several members of the junior scientific club here. It occurred to me that if the energy of the bullet could be made to act at rather a large angle to its line of flight, its penetrative power would be diminished. To effect this, I arranged a number of soft iron rods $\frac{1}{4}$-inch in diameter and 5 inches long, side by side and touching a piece of deal board; on these another layer was placed, so that one of the upper rods touched two of the under ones. A sheet of thin rubber $\frac{1}{16}$-inch thick, placed on this, separated it from a similar combination attached to it at right angles; and the whole formed the target. The rifle used was a Winchester, 22 bore, carrying a long bullet. At a distance of 20 feet the bullet penetrated 5 inches of hard pine with certainty; but when the bullet fired at the same distance hit my rod target, it failed to penetrate even the first layer, but only drove the upper rods aside nearly at right angles to the line of flight. The next experiments will be made with heavier materials and larger shot. Possibly a similar arrangement, but of large steel cylinders, might make a satisfactory barrier to the shot of big guns. FREDERICK J. SMITH.

Millard Engineering Laboratory, Oxford, June 1.

The Garhwal Landslip.

LET me point out that the paragraph on p. 109 of NATURE for May 21, stating that the landslip that had occurred in the Garhwal district in the Himalaya, blocking up the Bireh Ganga river, had burst, causing the loss of many lives, is erroneous. The catastrophe reported from India had reference to a locality in Kulu, and not to Garhwal, the two being several hundred miles apart.

An accurate description of the Garhwal landslip will, I hope, be shortly published in the Royal Geographical Society's journal. The obstruction is being carefully watched, and the water has not yet topped it. There is, I think, considerable reason to anticipate that no great destruction will be caused at this place, as the landslip is of such vast dimensions as to make it almost impossible that it should be carried away in a manner to give rise to a great and sudden flood. It is upwards of a mile in length and two-thirds of a mile wide, rising about 900 feet above the original level of the valley, and being largely composed of enormous masses of rock.

June 1. R. STRACHEY.

Research Work.

MAY I be allowed to suggest that it would be a great help to many interested in science if an authorised body, such as the British Association, were occasionally to indicate paths of research work in different branches of science, especially in physics and chemistry, which would offer a reasonable prospect of leading to useful results? Many, especially among those engaged in educational work away from London, have not the advantage of continued intercourse with the leaders of scientific thought which would give them the opportunity of forming a judgment themselves, and the fear of having been forestalled by others makes them hesitate to devote the time required for a sustained course of experimental research. Within the writer's experience, men whose judgment carries great weight do not individually feel inclined to give advice which they consider ought primarily to be devoted to the advancement of their own students. The advantages of a laboratory, of leisure time, and of a desire to add their quota to the stock of knowledge are not, by the wise, thrown away, but a great deal of energy, at present more or less dissipated, might be diverted into more useful channels if the above suggestion were carried out—offering each one the opportunity of choosing that particular line of research which most nearly satisfies the conditions in which he is placed. The idea might be still further developed by associating workers together for a common end, even at the risk of not being able to eliminate the personal factor. W. G. WOOLLCOMBE.

Birmingham, May 31.

A Daylight Meteor.

THE following account of a meteor, seen by me in full daylight, may be of interest to readers of NATURE. It was written a few hours after the meteor appeared.

While practising at cricket to-night (May 18), in splendid light, I observed at 7.58 (railway time) a very brilliant meteor cross the sky obliquely from a point considerably north of the zenith to the south-east. Its movement was very slow, and it shone with a brilliant intense white light, which was concentrated in itself, and did not leave a train behind it like the meteor of March 18, 1893, which I had also the good fortune to see.

It got gradually smaller and smaller, and just before disappearing broke up into three or four pear-shaped portions. During its course, although the massy head was always brilliantly white, the little tail varied in hue, crimson and a rich ultramarine blue being most noticeable.

I immediately timed it, and found that it was about 13 seconds in view, which I thought a very long time indeed.

From diagrams made on the same evening, it seems that the meteor moved from a point 40° from the zenith, and some 15° west of north to a point about 30° east of south at an altitude of 30°.

JAS. G. RICHMOND.

Muirkirk, Ayrshire, May 30.

P.S.—The *head* when first seen had an apparent diameter about $\frac{5}{8}$ that of the sun, and when last seen $\frac{3}{8}$ sun's diameter. It rolled across like a ball with a very short tail, until it broke up, when the distance from the head to the tail of the last pear-shaped portion was about $3\frac{1}{2}$ sun's diameter.

Iron Crows' Nests.

REFERRING to the note by Mr. McMillan, in your issue of May 3, it may be of interest to some of your readers to know that we have in this museum a crow's nest from Rangoon entirely made of iron wire such as is used in fastening the corks of aërated water bottles. The donor, Mr. Joseph Dawson, of the Public Works Department, Rangoon, stated in his letter at the time that "wire nests are hardly a novelty in this country, as they can always be obtained from high trees in the vicinity of aërated water factories." The nest in question has a piece of hoop-iron about three or four inches long woven into it; but with that exception it is entirely composed of the small wire, and is about a foot in diameter.

J. MACNAUGHT CAMPBELL.

Kelvingrove Museum, Glasgow, May 28.

THE REPORT OF THE COMMITTEE ON ARMY EXAMINATIONS.

IN the *Times* of Wednesday, 23rd ult., there was a brief account of the report lately presented to Parliament by the committee appointed in 1893 "to enquire into the entrance examinations (in non-military subjects) of candidates for commissions in the Army, and to advise whether any modification of the existing arrangements is desirable."

The syllabus of subjects and marks recommended by the committee is as follows:—

CLASS I.—(*All may be taken up.*)

	Marks.
1. Mathematics ...	3000
2. Geometrical Drawing...	1000
3. French or German ...	2000
4. English...	1000
5. Freehand Drawing ...	500

CLASS II.—(*Any three subjects may be taken up, but for Woolwich one of the three must be Chemistry and Heat.*)

	Marks.
1. Pure Mathematics ...	2000
2. Applied Mathematics...	2000
3. German or French, as alternating with the same group in Class I. ...	2000
4. Latin ...	2000
5. Greek ...	2000
6. English History ...	2000
7. Chemistry (inorganic) and Heat ...	2000
8. Electricity and Magnetism and Light ...	2000
9. Geography, Political and Physical, and Geology ...	2000
10. Biology...	2000

Certain recommendations as to the fusion of the Woolwich and Sandhurst examinations, the admission to the Army of Queen's cadets, Militia candidates, and University candidates are also made.

In regard to the question of marking for physical exercises and development, which has lately been strongly advocated, it is advised that these subjects should not be marked in these competitions. It seems to be thought, however, that though the physique of our officers has been *well maintained* under the competitive system, yet a small proportion of cadets have been admitted who were not quite up to the necessary standard, and it is recommended that the medical examination should be made somewhat more stringent.

The two changes of greatest importance which have been advised by the committee are, briefly, as follows—

(1) That an elementary knowledge of chemistry and heat shall be made practically obligatory for Woolwich.

(2) That Latin shall be transferred from Class I. to Class II.

There is also a minority report on certain points, viz., on the suggestion of a complete fusion of the competitions for Woolwich and Sandhurst, and on the proposal to transfer Latin to Class II. This is signed by three of the nine members of the committee, and one of these three also signs a separate note in which he dissents from the addition of geography to No. 9 of Class II., and of biology to Class II. as a new subject, and makes certain proposals to meet the special needs of Woolwich (which he admits) that would certainly fail to effect their proposed purpose.

On May 29, this report, and especially the two recommendations relating to science for Woolwich, and to Latin, were vehemently attacked by the *Times* in an article in which the report was denounced as such an one as "might have been framed by a committee of crammers," so far as their probable effect is concerned, rather than by a committee which is unanimous in subscribing to the principle laid down in 1869-70, that the examinations should be designed "with special reference to the curriculum adapted at the most advanced of our public schools, and with the express intention of enabling the competitors to come straight from one of those establishments to the examination-hall without having occasion to resort to any intermediate place of study." And again in a later paragraph, as a mere attempt by a portion of the committee to show themselves modern and advanced at all hazards by replacing the dead languages by the new sciences—Latin by chemistry—which latter subject is pronounced to be the most easy of all to cram in face of the statistics, produced by the Civil Service Commissioners and printed with the report, which show the subject to be above the average in discriminating power—that is to say, one in which teachers have not succeeded, by cramming or in any other way, in raising the marks of the least apt to or near the level of those of the more apt.

The *Times* has not hesitated to accuse the majority of the committee of disregarding the evidence before them, but has itself committed this fault. Its case is indeed mainly founded on such disregard of the facts. By coupling together two changes which stand upon entirely different footings it creates the impression, and is itself apparently under the impression, that the committee was divided on both the above proposals. Nothing is plainer in the reports than that this was not the case.

From the same cause, a reader would gather from the *Times* that science is recommended as an obligatory subject for all Army candidates, whereas nothing of the sort has been proposed.

Then it ignores the fact that the opinions of head masters as expressed to the committee were almost entirely in favour of giving more weight to science in the case of Woolwich candidates. And finally, it seeks to give weight to the opinions of the minority of the committee by putting aside the opinion of the present Director-General of Military Education as that of a person of little present importance on this question, by ignoring the high classical acquirements of Mr. Roby, who is a distinguished scholar and the author of a standard Latin grammar, and by dismissing Sir Henry Roscoe, with his great educational experience on the Scotch University Commission and on other occasions, as though he were an ordinary Member of Parliament with no special experience or weight on a question of this kind. All these facts combine to make it important that we should place the matter fully and in a true light before our readers.

In order to form a just judgment on the recommendations of the committee, it is necessary to do just that which the *Times* has not done. Each of the proposed changes must be considered on its own merits, in relation to the other subjects, to the needs of the various branches of the Service, and to the present teaching powers of the most advanced public schools.

We must first point out that the recommendation that chemistry and heat shall be required in future from all Woolwich candidates stands upon a footing which is in many respects different, and altogether independent of that upon which the other recommendation stands.

In the first place, this recommendation is adopted by every member of the committee except one. And even he, in his dissent, admits that for Woolwich some degree of further specialising is necessary, and makes a recommendation for the purpose of effecting it. Unfortunately his proposal would pretty certainly fail of its purpose; it is quite unsound, and was, we think rightly, not adopted by the rest of the committee.

Secondly, it is not advised that science should be made a compulsory subject for the Army in the same sense as that in which Latin has of late years been compulsory. It is not proposed to require it of all candidates, but only of those who are admitted to the scientific branches.

These, we need hardly point out, form only a minority of the whole. No one need be kept out of the Army through ignorance of science, and those who are really strong in other subjects will not even be kept out of the Artillery and Engineers by this regulation if it be adopted.

Thirdly, as what follows will show, science for Woolwich was strongly supported by most of the head masters who assisted the committee with their opinions. Thus, Dr. Percival, of Rugby, included obligatory science in a scheme of examination which he offered for consideration, and said that he thought any school which is worth considering would bring its candidates up to a very fair level in science before they entered Woolwich or Sandhurst; and explained that he meant not only the larger, but almost all schools.

The Rev. J. E. C. Welldon, of Harrow, included a branch of science in a list of obligatory subjects which he considered should enter into the education of every English gentleman.

Mr. Phillpotts, of Bedford, did not advise compulsory science, but he expressed a wish that the chemistry marks should be raised to 2500, which experience has shown in effect almost make this subject an obligatory one.

The head master of St. Paul's suggested in a letter that a branch of experimental science should be raised to Class I. with 2000 marks for Woolwich candidates.

The head master of Westward Ho wrote that he believed that nothing short of the inclusion of a science among "obligatory subjects" will bring about satisfactory results.

The head master of Loretto placed science on his optional list; but said that but for geography he is not sure if some power of practical work should not be placed among the necessary subjects, and stated that he longs to see practical chemistry introduced into the regular curriculum of schools.

Only two head masters said nothing in support of science subjects for Woolwich. And finally, Prof. Jebb has lately expressed to the Secretary of State for War his opinion that the scientific study and the linguistic studies should be put on an equal footing in respect to these examinations.

With this evidence before them, with complaints alike from schools and on the part of the Professor of Experimental Science at Woolwich, of a waste of time and power there in regard to science teaching, which makes itself felt even in Class I., and which is inevitable under the present system, and with ample testimony to the increasing importance of science to the scientific branches, could any impartial body of advisers have made a more reasonable and more modest recommendation than that which the Army Examinations Committee has made to Parliament?

As regards the influence this change would have upon the curriculum of our "most advanced public schools," and the possibility that it may drive boys from the schools to the crammer, which our contemporary seems greatly to fear, what we wonder would be said by Rugby, Cheltenham, Clifton, Marlborough, St. Paul's, or by Westward Ho, Malvern, Dover, and a score of other schools, if it were suggested to them that their appliances for and power of teaching science were inferior to those of the private tutors? It is notorious that the contrary is the case, that for long past the schools have held more than their own in these respects, and that the school of moderate size that is not now able to give good elementary instruction in chemistry and heat, is so far from being amongst our most advanced schools that it must be pronounced to be one that is unmistakably behind the times.

Finally, the selection of subjects made by the committee is not only a good one, but under the circumstances seems the best that could be made. It will not discourage either chemistry or physics entirely in the schools, and there are schools which prefer each of these branches; it is within the scope of the resources of all thoroughly efficient schools, which some other selections might not have been; and, above all, since it corresponds well with the elementary courses of instruction that have been in force at Woolwich, it will best avoid the loss of time there, which has been already alluded to, and will permit the cadets at once to proceed to those sciences of which they will need a technical and advanced knowledge, such as electricity and the chemistry of explosives, and for which more time and a better state of preparedness at entrance is said to be greatly wanted.

The recommendation to place Latin in Class II., as we have said, needs separate consideration. It must be admitted that there was a considerable body of evidence against it, and a division of opinion on the subject among the members of the committee. The question is one of great difficulty. It would have been impossible to retain compulsory Latin for Sandhurst without practically compelling it for Woolwich also. All who are experienced in these examinations will admit this. But to have retained it for Woolwich would have tended very greatly to limit the range of subjects taken by these cadets. It cannot be said that Latin is professionally an essential subject for Army candidates, as a few others are; and even the *Times* admits that possibly its study may not be "an ideal whetstone of the mind," whilst it is certain that a good many youths do not appear to gain much from it after boyhood is past. Its early introduction into education, and its retention up to a certain point, are, on the other hand, widely thought to be among the best features of the public school system. There is also a feeling that it serves as an excellent introduction to the study of languages, and doubtless it does so when well taught. But these facts, though they afford a strong reason for avoiding any step which would really be likely to prevent the teaching of Latin in the lower forms of public schools, seem to be an insufficient reason for compelling those who do not get on with the subject to continue to study it up to the age of eighteen or nineteen years, when by dropping it in reasonable time they might turn to some, for them, more profitable study. It is often forgotten that when all boys learnt Latin and Greek and little else, but few of them stayed at school so late as great numbers do at present, and that therefore there is less reason for resisting a change in this direction now than there would have been in the days mentioned by General Sir G. T. Chesney, when cadets might enter Woolwich at the age of fourteen or fifteen years.

On the whole, therefore, our feeling is that the recommendation of the majority on this point goes in the right direction. The general position of Latin in the schools will surely be sufficiently protected by the action of the universities, and hence its serious discouragement need not be greatly feared. We would ask, however, whether the objections of the dissentient members of the committee could not be met by a requirement that all candidates should take for one of their subjects from Class II. a language. This would distinctly protect linguistic studies in the schools, and so act distinctly in favour of Latin, without compelling all candidates to offer Latin, or handicapping any school which may prefer not to teach it in all its divisions. It has been said that the difficulty of Latin will prevent its being much adopted as a voluntary subject. Surely this must mean that too high a standard has been adopted for the circumstances of these candidates who cannot of course reach to the level of the higher classical forms. The Civil Service Commissioners should and could prevent any such unfairness as this from occurring, and therefore could prevent the subject from being killed, which surely all would regret.

RECENT ADDITIONS TO THE ZOOLOGICAL SOCIETY'S MENAGERIE.

ALTHOUGH it becomes more difficult year by year for the Zoological Society to add new objects to their collection of living animals, yet, as is shown by the annual reports read at the anniversary meetings, examples of a certain number of species which have not been "previously exhibited" are acquired every year. In 1892, as we are told in last year's report, specimens of 11 mammals, 20 birds, 14 reptiles, and one batrachian "referable to species not included in the last (eighth) edition of the 'List of Animals,'" were added to the series. In 1893, the numbers of novelties in the respective classes were hardly less numerous.

FIG. 1.—The Ounce or Snow-Leopard.

Some of the more noticeable among the recent additions we now propose to bring before the readers of this journal by illustrations drawn from the life by Mr. J. Smit, the principal artist employed by the Zoological Society.

(1) The Ounce or Snow-Leopard (*Felis uncia*).—The Society's lion-house always contains a good representative series of the larger species of cats (*Felis*), such as lions, tigers, pumas, leopards, and cheetahs. All do well in confinement, and probably live much longer in their cages in the Regent's Park than they would do in their native wilds, subject "to the struggle for existence." The jaguar is certainly less easy to obtain, and perhaps less suited to captivity than those already mentioned, but has always a place in the series. But the ounce, or "snow-leopard," as the Indian sportsmen call *Felis uncia*, is a much more difficult subject to deal with. In the first place, the snowy interior of Central Asia, where it lives, is by no means easy of access. In the second place, the animal when captured must "pass through the fire" of an Indian sea-port on its way home, and is not unlikely to succumb to such an ordeal. It was consequently, in spite of the exertions of their many Indian friends and correspondents, not until 1891 that the Zoological Society acquired their first specimen of the ounce. This, however, was a mere kitten, in feeble condition, and, notwithstanding the care lavished on it, did not live many weeks. But in the spring of the present year the Society were more fortunate, having received a fine young male of this animal from the Western Himalayas. It was originally captured, when quite small, by the retainers of Thakur Debi Chand, a native chieftain of Gundla, in Lahaul, in the Western Himalayas, and was sent as a present to Mrs. Mackay, of Dunbar House, Kullu. Mrs. Mackay made a complete pet of it, and brought it up most carefully by hand. It is now nearly full-grown, measuring upwards of six feet in length, and is in splendid health and condition.

FIG. 2.—The Cunning Bassaris.

In its native state the ounce is said to live amongst the rocks at an elevation of 9000 feet and upwards, on the borders of the snows in the Himalayas and Thibet. It preys upon the wild sheep and goats, and probably also upon the rodents that inhabit these inhospitable regions. In similar situations the ounce is said to be found throughout the higher districts of Central Asia, extending northwards to the Altai and to Amoor-land, and even, it is said by Schrenck, into the Island of Saghalin. But the story of the occurrence of the ounce in Asia Minor, credited by Mr. D. G. Elliot, who has figured this species in his "Monograph of the *Felidæ*," is, as has been subsequently shown, altogether apocryphal, the animal mistaken for the ounce in this district being simply a pale variety of the leopard (*Felis pardus*).

(2) The Cunning Bassaris (*Bassaris astuta*).—The racoons and their allies form a peculiar family of carnivora restricted to the New World with one special exception, *Ælurus* of the Himalayas. One of the most singular and interesting genera of this group is *Bassaris*, of Central America, of which two species are known, *B. astuta* of Texas, California, and Northern Mexico, and its southern representative, *B. sumichrasti* of Southern Mexico, Guatemala, and Costa Rica. It is the former of these two species of which an example has recently been acquired by the Zoological Society after a period of forty years, during which, so far as it is known, no bassaris has reached Europe alive.

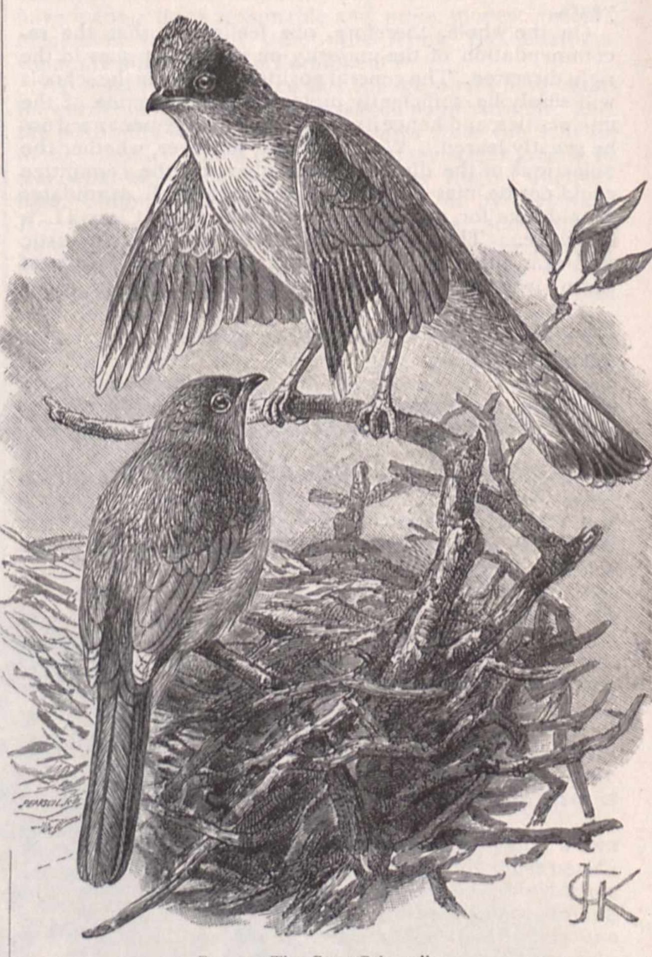


FIG. 3.—The Grey Coly-strike.

The cunning bassaris is of about the size of a small domestic cat, but more slender in form, and provided with a long cylindrical white tail, which is crossed by seven or eight distinct black rings, rendering it the most conspicuous feature of the animal. In a state of nature the bassaris lives among wooded rocks, but often takes up its abode close to houses, and proceeds to ravage the pigeons and poultry. The genus *Bassaris* was originally referred by systematists to the *Viverridæ*, but Sir William Flower's account of its anatomy, published in 1869 (*P.Z.S.* 1869, p. 31), has placed its correct systematic position among the *Procyonidæ* beyond question.

(3) The Grey Coly-strike (*Hypocolius ampelinus*).—For their living specimens of this rare and beautiful passerine bird, which will be found lodged in one of the large cages in the parrot-house, the Society are indebted to their excellent correspondent Mr. W. D. Cumming, of Fao, on the Persian Gulf. The coly-strike has obtained its name, together with its scientific appellation *Hypocolius*, from some fancied resemblance to the African colies (*Colius*), with which, however, it has really nothing to do, though the tints of its plumage exhibit some slight similarity to the above-mentioned form. But *Hypocolius* is a true passerine bird, probably belonging to the caterpillar-hunters (*Campophagidæ*), though this is by no means certain. It was first discovered by the French collector Botta, on the coast of Abyssinia, and described from his specimens by Bonaparte. The German naturalist Heuglin obtained examples of it in 1850 from Massowah,

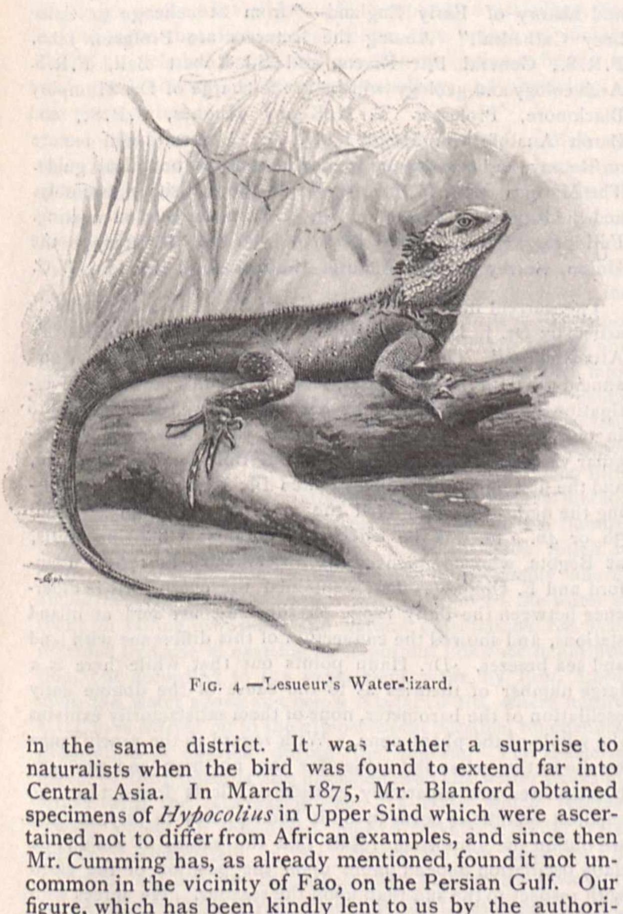


FIG. 4.—Lesueur's Water-lizard.

in the same district. It was rather a surprise to naturalists when the bird was found to extend far into Central Asia. In March 1875, Mr. Blanford obtained specimens of *Hypocolius* in Upper Sind which were ascertained not to differ from African examples, and since then Mr. Cumming has, as already mentioned, found it not uncommon in the vicinity of Fao, on the Persian Gulf. Our figure, which has been kindly lent to us by the authorities of the Zoological Society of London, represents both sexes of this bird during their attempts at nest-making in the Zoological Society's aviary.

(4) Lesueur's Water-lizard (*Physignathus lesueuri*).—Some very strange forms of Agamoid lizards are found in Australia, such as *Chlamydosaurus kingi* with its conspicuous frill, and *Moloch horridus* with its coat of spikes, pronounced by an American writer to be "one of the most repulsive creatures in nature"! The lizard which we now figure, though belonging to the same family, is, however, rather elegant in shape, and bright in colour. It is a member of the Agamoid genus *Physignathus*, of which seven species are recognised by Mr. Boulenger in his "Catalogue of Lizards." Of these four are inhabitants of Australia, whilst one comes from Timor Lant, and the remaining two are found in Cochin China and Siam. The name is taken from the bladder-like expansion of the lower angle of the jaw, which is very striking in these lizards.

In habits the *Physignathi* are said to be aquatic, inhabiting the trees on the margins of rivers, and swimming well with the aid furnished by the wide expansion of the horizontal fringes of scales on the sides of their long stout toes.

The Zoological Society's specimen of this lizard—so far as is known the first that has reached Europe alive—was received, along with other Australian reptiles, in exchange from the Australian Museum, Sydney.

NOTES.

PROF. ROBERTS-AUSTEN has been awarded, by the Société d'encouragement pour l'industrie Nationale of Paris, a prize of 2000 frs. for his recent researches on alloys, and more particularly for those which relate to the behaviour of metals and alloys at high temperatures and to their mechanical properties as influenced by small quantities of added elements.

AT the last general meeting of the Zoological Society, it was announced by the Council that they had resolved to bestow the silver medal of the Society on Mr. Henry Hamilton Johnson, C.B., H.B.M. Commissioner and Consul-General for British Central Africa, in acknowledgment of the efforts he had made to increase our knowledge of the zoology of British Central Africa.

WE regret to learn that the American journal *Science* has been discontinued owing to insufficiency of support. The first number appeared on February 9, 1883, and though the circulation, after fluctuating, has steadily increased during the last two years, the paper has never paid expenses.

THE Salters' Company have recently established in connection with the medical school of St. Thomas's Hospital a Research Fellowship in Experimental Pharmacology of the annual value of £100. The Fellow elected, who may hold the office for three years, will be required to devote himself to the study of the physiological action of drugs. The Salters' Company have also endowed a similar Research Fellowship in Chemistry in connection with the research laboratory of the Pharmaceutical Society, in order to provide for investigations on the chemical side of pharmacology.

THE Prince Jablonowski Society of Leipzig has just issued the subject for the mathematical competition of 1897. It is well known that the methods of integrating partial differential equations of the second and higher orders, due to Monge, Ampère, and Darboux, can only be applied to equations which have solutions in common with other equations, which solutions are not entirely dependent upon arbitrary constants. On the other hand, it follows from Lie's investigations of infinite groups that equations admitting of an infinite group of contact transformations have in general this relation of involution to other equations. The problem proposed by the Society is that of developing the methods of integration indicated, and to illustrate them by the most instructive and completely worked-out examples. The prize offered consists of 1000 marks (about £50). Full particulars are given in the annual report of the Society, 1894.

A LARGE number of pupils, friends, and colleagues of Prof. Bertrand, the Permanent Secretary of the Paris Academy of Sciences, met at the École Polytechnique on May 27, and presented him with a medal struck in commemoration of the jubilee of his service on the staff of the school. M. Maurice Lœwy, the President of the Academy of Sciences, presided over the meeting, and among those who assembled to do honour to Prof. Bertrand were General André, MM. Faye, Darboux, and Cornu, M. Gaston Boissier (the Administrator of the College de France), G. Perrot (the Director of the École Normale), M. Poincaré, and M. Mercadier (the Director of Studies at the École Polytechnique). "Un pays s'honore en honorant ses grands citoyens," says the *Revue Scientifique* in its report of the ceremony. This aphorism is borne in mind in France more than anywhere else. Bertrand has now been honoured by receiving the homage of his admirers and pupils, like Pasteur and Hermite before him. It is right that this regard should be expressed in the manner it has, for the mathematical sciences do not appeal to the generality; and the only recompense a student of them can hope for is a recognition of the scientific importance of his labours by fellow-workers. The meeting at the Polytechnic School, and the speeches that were made at it, must have made Prof. Bertrand feel that the consecration of his life to the search for truth has brought a reward worth working for.

THE death is announced of Geheimrath A. Kundt, Professor of Physics in Berlin University, and of Dr. K. W. Baur, Professor of Mathematics in the Stuttgart Technische Hochschule.

THE *British Medical Journal* states that Prof. Czerny has declined the offer of the Chair of Surgery in the University of Vienna, made to him by the Austrian Government. It is believed that the reason for his refusal to accept the succession of his old master, Billroth, is the inadequacy of the laboratory and teaching equipment in the Allgemeines Krankenhaus.

WE learn from *La Nature* that a company, formed some time ago for the purpose of constructing an electric railway on the Jungfrau, have asked permission to devote a sum of one hundred thousand francs to the erection of a geophysical observatory, and five thousand francs annually for its maintenance. The observatory would have an altitude of 4200 metres, and the projected line would put it into direct communication with the valley below.

ACCORDING to the *Zoologist* for June, a committee of English sportsmen and naturalists has been formed for the purpose of devising some scheme for the protection of South African mammals, chiefly giraffe, zebra, gland, gnu, koodoo, and other antelopes, several of which, owing to indiscriminate slaughter, are on the verge of extinction. To attain this desirable end it is proposed to enclose a suitable tract of country, of about one hundred thousand acres, with a wire fencing, strengthened by a strong live fence of thorn on the outside. It is hoped that the British South African Chartered Company may allow such an enclosure to be made in the district near Fort Salisbury, which has already been reserved for game by the Company. That such a scheme is feasible is shown by the success which has attended Mr. Austin Corbin's efforts to establish in New Hampshire, U.S.A., a similar game park to that suggested, covering an area of twenty-eight thousand acres. The description of the enclosing and stocking of this park, which follows the proposals of the new preservation society in the *Zoologist*, will do much to combat adverse criticism.

The aim of the National Home-Reading Union may be summed up in a short sentence—to render study attractive. A happy experience of four successive summers has proved to the council of the society that there is no other means by which this can be accomplished so effectively as by taking the student to the locality which most abundantly illustrates his work. We all know that geology can only be learned in the field: and, in like manner, the beginnings of history acquire an objective reality as one stands within the circle at Stonehenge. Botany, also is irresistibly interesting when the teacher accompanies his pupils through a wood or over a moor. The summer assemblies of the Union, which are open to all, whether members of the Union or not, will be held this year at Buxton, in Derbyshire, during the last week in June, and at Salisbury during the first week in July. The character of the scientific side of the meetings may be gathered from the following abridged list of lecturers and subjects. At Buxton the inaugural address will be given by the Ven. Archdeacon Farrar, and lectures will be delivered by the Rev. R. Harley, F.R.S., and others. The geological excursions will be conducted by Mr. J. C. Marr, F.R.S., who will lecture on "The Building of the Pennine Chain." Conferences upon various social and educational subjects have also been organised. The object of the meeting at Salisbury will be the study of the monuments with which the district abounds, illustrative of the archæology, art, and history of Early England—"from Stonehenge to Salisbury Cathedral." Among the lecturers are Professor Jebb, F.R.S., General Pitt Rivers, and Sir Robert Ball, F.R.S. Archæology and geology will be in the charge of Dr. Humphry Blackmore, Professor T. McKenny Hughes, F.R.S., and Baron Anatole von Hügel. Mr. A. C. Seward will lecture on Botany, and accompany the excursions as botanical guide. The Marquis of Bath will preside at the Salisbury assembly, and the Right Hon. W. Woodall, M.P., at the Buxton meeting. Full programmes can be obtained from the Secretary to the Union, Surrey House, Victoria Embankment, London, W.C.

THE current number of *Himmel und Erde* contains a valuable article by Dr. J. Hann, entitled "Ebb and Flow of the Earth's Atmosphere." The paper deals entirely with the diurnal and annual range of the barometer, and Dr. Hann's laborious investigations of these phenomena have frequently been referred to in our columns. It is more than 200 years ago since the regular variation of the barometer by day-time was first observed, and the first person who investigated the regular variation during the night-time, and fixed the morning minimum at about 3h. or 4h. a.m. was the celebrated botanist Cölestino Mutis, at Bogota, who commenced his observations in 1761. Blanford and F. Chambers first explained the characteristic difference between the daily range on the sea-coast and at inland stations, and showed the connection of this difference with land and sea breezes. Dr. Hann points out that while there is a large number of theories as to the cause of the double daily oscillation of the barometer, none of them satisfactorily explains the whole of the phenomena. With regard to the yearly range he shows that when the values for the northern and southern hemispheres are separately considered, it is found that the smallest quantities occur in both hemispheres in July, so that we obtain the important result that the values of the double daily oscillation depend more upon the position of the earth with respect to the sun than upon the seasons. He agrees with Lord Kelvin and others that the only means of eventually obtaining a satisfactory explanation of the subject will be by harmonic analysis, and by comparison of the variations at a large number of stations.

THE sixth annual report of the trustees of the Marine Biological Laboratory at Wood's Holl, Massachusetts, informs us that not only has the past season been very successful as far as the number of students and investigators and the quality of their work are concerned, but also that the condition of the finances is more satisfactory than at any time since the foundation of the laboratory. The fact that eighteen different colleges and universities now contribute annually to the support of tables in the laboratory is very encouraging, as showing a wide-spread interest in the laboratory as the summer working-place of both instructors and students interested in biology. It is the aid thus obtained from colleges and universities which, for the first time since its establishment, has rendered the laboratory self-supporting during the past season. The number of students and investigators occupying work-tables last summer was one hundred and eleven, this being the extreme limit of accommodation. There is every reason to believe that the number of applicants for places during the coming summer will considerably exceed the present capacity of the laboratory, and, unless the present building is enlarged, it will be impossible to accommodate them. The trustees hope that provision will be made for the increasing number of students. Further, they have to consider the question of the extension of the field of usefulness by the introduction of departments of biology not yet represented, and the development of those recently introduced into the institution. Such an extension implies an increase of working room, as well as an increase in the laboratory equipment. For the first time, the laboratory numbered last summer among its workers investigators in comparative pathology, and it is thought that, in the near future, this branch of biology should be included among the lines of investigation to be carried on in the laboratory, as are zoology, botany, and physiology at the present time.

A RECENT number of *Science* contains a short article on the employment of disease-causing microbes for the destruction of field mice and similar vermin, in which attention is called to a paper on this subject recently presented to the French Academy by M. Jean Danysz. The microbe employed in producing artificially a destructive epidemic amongst these troublesome vermin, is stated by the author to be very similar to the bacillus of duck cholera, but is not identical, for it is not pathogenic either to these birds or other fowls. Both Löffler and Lasar have discovered similar microbial enemies to field mice which have been used with marked success for the suppression of plagues of these animals, but so far in the United States they have been content to use poisoned grain or carbon bisulphide for this purpose; but Mr. Gerald M'Carthy's interesting little article will no doubt attract attention to this more novel method of dealing with such vermin. Another article in this number is on the self-purification of rivers, a subject upon which so much difference of opinion exists, that it invariably affords ample material for discussion. The aëration of the water of rivers in falling over dams and natural obstructions, has been regarded by some as exerting an important influence in purification, but according to the experiment made by Prof. Leeds upon the water above and below Niagara Falls, where natural aëration is carried on to the utmost extent possible, no chemical purification is effected during the process. The bacterial aspect of the subject is also discussed, and the writer closes his article with the observation that "a river which receives sewage should be considered unfit to serve as a public water supply." Fortunately in this country we are alive to this objection, but many of the largest cities in America invariably use sewage polluted river-water unpurified, resulting in severe epidemics of typhoid fever.

A PORT BLAIR correspondent of the Allahabad *Pioneer* announces the discovery of the remains of an elephant on South Sentinel, an islet about twenty miles from any other land. The remains were buried about nine inches below the surface, and since the yearly deposit of soil on the island must be very small, it is supposed that they are of very considerable age. It is, moreover, interesting to learn that the volcano on Barren Island is apparently entering upon a period of renewed activity.

THE Washington letter in the last number of the *Bulletin* of the American Geographical Society announces that the recent study of the observations on mountain summits in the neighbourhood of Mount St. Elias, shows that Mount Logan is the loftiest peak in North America with a height of 19,500 feet, thus being 1200 feet higher than Orizaba, and 1500 feet higher than Mount St. Elias itself.

THE June number of the *Geographical Journal* completes the third volume of the new form of the monthly publication of the Royal Geographical Society. It contains an exceptional range of geographical news, including the text of Mr. Littledale's paper on his recent journey across Central Asia, with a series of original maps and illustrations. Mr. Dolby Tyler contributes an account of his journey up the river Napo, perhaps the least known of all the tributaries of the Amazon. There is an excellent account of the primitive "Indians" of the region. Mr. Ravenstein, in a lightly written article on recent African books, incidentally calls attention to the immense flood of literature on that continent now appearing, his list including twenty-one works, all published within the last few months. Mr. H. Yule Oldham has a most readable account of the Manchester ship-canal, showing its peculiar geographical importance, and Mr. A. Montefiore gives a note on the geography of Franz-Josef Land.

THE *Scottish Geographical Magazine* for June contains the first part of an extremely valuable paper by Prof. Otto Pettersson, of Stockholm, on Swedish hydrographical work on the Baltic and North Seas. He uses *hydrographical* not in the ordinary English sense of a mere survey by soundings, but with the wider meaning of a physical and chemical examination of the water. This first part, indeed, is mainly chemical, detailing the processes employed for analysing the dissolved gases and determining the salinity and density of sea-water. The author's opinion that the use of hydrometers in marine research is nearly past, and that only determinations of density by weighing with apparatus similar to Sprengel's pyknometer can be held as sufficiently accurate, is not corroborated by the experience of most British oceanographers in whose hands the *Challenger*-type hydrometer has given most excellent results. The Edinburgh magazine sustains by this article the high reputation it has long held as the first English authority on oceanography, and it is to be congratulated on securing the first publication in any language usually read by scientific men outside Scandinavia of so original and able a treatise.

THE current number of *Wiedemann's Annalen* contains a paper on the similarity between the after-glow of a Geissler tube and the first glow of solid bodies, by Carl Kirn. Herr H. F. Weber has shown that the first light which becomes visible when a solid body is heated, is not, as was supposed by Draper, dark red but grey, which shows itself spectroscopically as a band in the yellow-green. The researches of Stenger and Ebert on the limits of the visible light have shown that the phenomenon was caused by the different sensitiveness of the eye to the different colours, this sensitiveness being a maximum for that part of the spectrum where the band of grey light is first seen. The Geissler tube employed by the author exhibited, after an electric discharge had been passed through it, all the phenomena observed by Riess and Morren; the yellowish-white after-glow of the bulbs being visible for more than half a minute in a completely dark room. The light being observed with a spectroscope, it was found that, while the discharge was actually passing, the tube gave a line spectrum, the brightest lines coinciding with those of nitrogen and carbonic oxide. The feeble spectrum of the after-glow, however, is continuous, and at first occupies the entire space covered by the previously mentioned line spectrum, but it shrinks fairly quickly on either side into a band lying between wave-lengths of 555 and 495 $\mu\mu$, and this band vanishes more slowly, diminishing in breadth as it does so. The colour of this band does not appear to the eye to be the characteristic colour of this part of the spectrum, but a pale yellowish-grey, which becomes darker as extinction approaches. The position of the final glow corresponds almost exactly with the line E of the solar spectrum, and coincides closely with the region of greatest brightness in the ordinary solar spectrum. The whole phenomenon is thus seen to be the exact reverse of what is observed to take place when solid bodies begin to glow. Opinion is still divided as to the cause of the after-glow in Geissler tubes, but the author considers that the results of various researches seem to show that the phenomenon must be considered to be the result of chemical modification of the contents of the tube.

THE following excerpts from the Report for 1892 of the U.S. National Museum have lately been distributed by the Smithsonian Institution. "Japanese Wood-cutting and Wood-cut Printing," by Mr. T. Tokuno, edited and annotated by Mr. S. R. Koehler. Mr. Tokuno is the chief of the Bureau of Engraving and Printing Department at Tokio, and the information which he has given to the National Museum will be welcomed by all who are interested in the art of the wood-cutter and in the arts of Japan, more especially as his communication is believed to be the first authoritative statement on this subject made by a native of Japan thoroughly qualified for the task. "The Crump Burial Cave," discovered on the southern branch of the Warrior River, Alabama, is the subject of a paper by Mr. Frank Burns. The cave is about four hundred feet above the river, and in it were found a number of wooden coffins, indicating that the aborigines used it as a burial cave. In a note to the paper, Mr. T. Wilson, the curator of pre-historic anthropology in the Smithsonian Institution, points out that while this method of coffin burial was unusual, if not previously unknown in the United States, yet there are several instances of similar burials among the prehistoric peoples of other countries. Mr. Wilson has a paper on an extensive series of minute stone implements collected by Mr. A. C. Carlyle in the Vindhya hills or mountains in central and north-western India, and now in the National Museum. The implements are said to belong to the neolithic period, but Mr. Carlyle has also found others belonging to the palæolithic period in the same locality, and he believes that the evidence of the archæology of the district shows that there was no hiatus between the palæolithic and neolithic periods, and that the series of implements run from one period to another, their differences being accounted for by the general progress from the lower to the higher civilisation. "The Comparative Oology of North American Birds" is the subject of another excerpt. In this Dr. R. W. Schufeldt brings together a large amount of information of interest to ornithologists, and presents it in a manner which will greatly facilitate the study of the variations in the matter of form and colouration of the eggs of birds of different countries.

MESSRS. CASSELL AND CO. have commenced a new issue, in monthly parts, of Mr. W. F. Kirby's admirable and comprehensive work on "European Butterflies and Moths."

MR. C. F. JURITZ's report on work done in the Analytical Laboratory and Mineralogical Museum at the Cape of Good Hope, during 1893, has just been issued.

IT was a happy inspiration that led to the publication of the series of little books on "The Country Month by Month," by Mrs. J. A. Owen and Prof. G. S. Boulger. The June number of the series points out the beauties of nature in the same attractive style that distinguished previous volumes. Messrs. Bliss, Sands, and Foster are the publishers.

MR. A. F. CALVERT, the author of several works on Australia and its resources, has collected a number of facts and fancies with regard to "The Coolgardie Goldfield" in Western Australia, and his compilation has been published by Messrs. Simpkin, Marshall, and Co. The evidence adduced goes to show that the Coolgardie district is richly auriferous, and that the only great drawback to its development is the scarcity of water.

FOLLOWING the lead of other London Polytechnic Institutes, that at Battersea has started a journal—the *Battersea Polytechnic Review*. We hope that the new journal will not become merely a medium for recording cricket matches and social gatherings. Schemes of courses of study in various branches of science, art, and technology might be profitably included in its pages; and also lists of good books to read, and notes on recent work; while brief descriptions of the Polytechnics on the continent would create a spirit of emulation that would certainly help to develop the work of the Institute in the proper direction.

EACH of the papers in *Science Progress* is an important addition to scientific literature. The contributors to this monthly review of current investigations are always men in thorough touch with their subjects, and the result is that they summarise all that is worth knowing on the matters treated by them. The contents of the June number are as follows:—"Pure Yeast and its Relations to Brewing Operations," by Dr. A. K. Miller; "Electrosynthesis," by Dr. James Walker; "Glycogen," by Prof. W. D. Halliburton, F.R.S.; "Mesozoic and Kainozoic Geology in Europe," by Mr. Philip Lake; "The Localisation of Enzymes in Plants," by Prof. J. R. Green; and "Recent Additions to our Knowledge of the Ancient Sediments," by Mr. J. E. Marr, F.R.S.

THE additions to the Zoological Society's Gardens during the past week include a Two-Spotted Paradoxure (*Nandinia binotata*) from West Africa, presented by Mr. Joseph Wills; a Raccoon (*Procyon lotor*) from North America, presented by Mr. H. Burgess; a Grey Parrot (*Psittacus erithacus*) from West Africa, presented by Mrs. Lemming; two Goliath Beetles (*Goliathus druryi*) from West Africa, presented by Captain A. S. Mitchell; a White-handed Gibbon (*Hylobates lar*) from the Malay Peninsula; two Gazelles (*Gazella dorcas*, ♂ ♀) from Suakin, deposited; a Beech Marten (*Mustela foina*), a Pine Marten (*Mustela martes*), European, a Silky Bower Bird (*Ptilonorhynchus violaceus*), a Garrulous Honey-eater (*Myzanthe garrula*) from Australia, four Vinaceous Turtle Doves (*Turtur vinaceus*), four Cape Doves (*Œna capensis*) from Africa, a Timneh Parrot (*Psittacus timneh*) from Sierre Leone, two Stanley Cranes (*Tetrapteryx paradisea*) from South Africa, purchased; two Hamadryads (*Ophiophagus elaps*) from India, received in exchange.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL CONGRESSES AT UTRECHT AND VIENNA.—An astronomical congress will be held at Utrecht on Friday, the 10th, Saturday, the 11th, and Monday, the 13th of August. Notices of motion and other communications should be addressed to one of the committee before August 7. Dr. H. Gyldén, of Stockholm, will preside. Herren H. Seeliger, of Munich, and R. Lehmann-Filhés, of Berlin, are acting as secretaries.

The preparations for Section 2 (Astronomy) of the meeting of German men of science and physicians, to be held this year at Vienna, from Sept. 24 to 30, are under the direction of Prof. E. Weiss, Dr. J. Palisa, and Dr. J. Holetschek. Papers and subjects for demonstration should be announced to them at once, so as to form part of the provisional programme to be issued early in July. Intending exhibitors at the scientific exhibition, to be held in connection with the meeting, should write to the "Ausstellungs Comité der Naturforscher-versammlung, Wien., Universitat."

PROPOSED ASTRONOMICAL CONGRESS IN 1896.—At the end of a paper read at the last meeting of the Royal Astronomical Society, Dr. Gill propounded the following questions, which we reprint from the *Observatory*. (1) Whether, in the opinion of astronomers generally, steps should be taken for a more complete and harmonious organisation and partition of the astronomical world from the year 1900? (2) Are astronomers prepared to enter upon a preliminary study, discussion, and experiment on the practical methods by which the art of observation may be raised to a higher level of accuracy, and its results be derived and published in a more systematic and homogeneous system? (3) If these questions are answered in the affirmative, would it be desirable to hold an international astronomical congress, say in 1896, to discuss and make the necessary preliminary arrangements, and then let the definitive programme and partition of work be made at another general congress to be held in the year 1899?

THE LAW AND GREENWICH TIME.—Is there any legal authority for the use of Greenwich Time throughout Great Britain? The editors of the *Observatory* point out that in the Statutes (Definition of Time) Act 1880, 43 and 44 Vic. cap. 9, it is enacted that whenever any expression of time occurs in any Act of Parliament, deed, or any other legal instrument, the time referred to shall, unless it is otherwise specifically stated, be held in the case of Great Britain to be Greenwich Time, and in the case of Ireland, Dublin Time. It is remarked, however, that Sir James Stephen says, in the Larceny Act, "Criminal Law Digest," p. 247, sec. 3, in referring to the expression "of the clock":—"It may be worth while to observe that the expression 'nine of the clock,' 'six of the clock,' indicates *mean* as opposed to *solar* time; but a question might arise as to whether they mean local mean time or the mean time commonly observed at any given place. London time, or, as it is called, railway time, is now very generally observed, and there is a difference of more than twenty minutes between London and Cornwall. Local mean time is the natural meaning." In the case which led our contemporary to look up the matter, a defendant arrived at a court at the local (Carlisle) time appointed by the court to sit, but found that the court had met by Greenwich Time, and had decided against him. The difference of interpretation of the time appointed led to the granting of a new trial.

THE WORK OF HERTZ.[1]

THE untimely end of a young and brilliant career cannot fail to strike a note of sadness and awaken a chord of sympathy in the hearts of his friends and fellow-workers. Of men thus cut down in the early prime of their powers there will occur to us here the names of Fresnel, of Carnot, of Clifford, and now of Hertz. His was a strenuous and favoured youth; he was surrounded from his birth with all the influences that go to make an accomplished man of science—accomplished both on the experimental and on the mathematical side. The front rank of scientific workers is weaker by his death, which occurred on January 1 of the present year, the thirty-sixth of his life. Yet did he not go till he had effected an achievement which will hand his name down to posterity as the founder of an epoch in experimental physics.

In mathematical and speculative physics others had sown the seed. It was sown by Faraday, it was sown by Thomson and by Stokes, by Weber also doubtless, and by Helmholtz, but in this particular department it was sowed by none more fruitfully and plentifully than by Clerk Maxwell. Of the seed thus sown Hertz reaped the fruits. Through his experimental discovery, Germany awoke to the truth of Clerk Maxwell's theory of light, of light and electricity combined, and the able army of workers in that country (not forgetting some in Switzerland and France and Ireland) have done most of the gleaning after Hertz.

This is the work of Hertz which is best known; the work which brought him immediate fame. It is not always that public notice is so well justified. The popular instinct is generous and trustful, and it is apt to be misled. The scientific eminence accorded to a few energetic persons by the popular estimate is more or less amusing to those working in the same lines. In the case of Hertz no such mistake has been made. His name is not over well known, and his work is immensely greater in every way than that of several who have made more noise.

His best known discovery is by no means his only one. I have here a list of eighteen papers[1] contributed to German periodicals by him, in addition to the papers incorporated in his now well-known book on electric waves. I would like to suggest that it would be an act of tribute, useful to students in this country, if the Physical Society of London saw their way to translate and publish a collection of, at any rate, some of these papers.

Portrait Slide.

The portrait which I show is not a specially pleasing one. It is from a photograph taken by Mr. Yule, one of the band of foreign students who flocked to Hertz's laboratory at Bonn. It is excellent as a photograph, though it fails to represent Hertz at his best; perhaps because it was not taken till after the pharyngeal trouble had set in, which ultimately carried him off.

In closing these introductory and personal remarks, I should like to say that the enthusiastic admiration for Hertz's spirit and character, felt and expressed by students and workers who came into contact with him, is not easily to be exaggerated. Never was a man more painfully anxious to avoid wounding the susceptibilities of others; and he was accustomed to deprecate the prominence given to him by speakers and writers in this country, lest it might seem to exalt him unduly above other and elder workers among his own sensitive countrymen.

Speaking of the other great workers in physics in Germany, it is not out of place to record the sorrow with which we have heard of the recent death of Dr. August Kundt, Professor in the University of Berlin, successor of von Helmholtz in that capacity.

When I consented to discourse on the work of Hertz, my intention was to repeat some of his actual experiments, and especially to demonstrate his less known discoveries and observations. But the fascination exerted upon me by electric oscillation experiments, when I, too, was independently working at them in the spring of 1888,[2] resumed its hold; and my lecture will accordingly consist of experimental demonstrations of the outcome of Hertz's work rather than any precise repetition of portions of that work itself.

In case a minority of my audience are in the predicament of not knowing anything about the subject, a five minutes' explanatory prelude may be permitted, though time at present is very far from being "infinitely long."

[1] A Lecture delivered at the Royal Institution on Friday, June 1, by Prof. Oliver Lodge, F.R.S., ably assisted during both preparation and performance by Mr. Edward E. Robinson.

[1] *Hertz's Papers.*

1878-79. *Wied. Ann.*, 1880, vol. 10. p. 414. Experiments to establish an Upper Limit for the Kinetic Energy of Electric Flow.

1880. Inaugural Dissertation (Doctor Thesis) on Induction in Rotating Spheres.

1881. Vol. 13, *Wied. Ann.*, p. 266. On the Distribution of Electricity on the Surface of Moving Conductors.

1883. March. *Schlömilch Zeitschrift*, p. 125. On the Distribution of Pressures in an Elastic Circular Cylinder.

1881 (?) Crelle, vol. 92, p. 156. On the Contact of Solid Elastic Bodies.

1882. *Verhandlungen des Vereins des Gewerbfleisses* (Sonderabdruck). On the Contact of Solid Elastic Bodies and on Hardness.

1881. Vol. 14, *Wied. Ann.*, p. 581. Upper Limits for the Kinetic Energy of Moving Electricity.

1882. *Wied. Ann.*, vol. 17, p. 177. On the Evaporation of Liquids, especially of Quicksilver, in Air-Free Space, and on the Pressure of Mercury Vapour.

1883. *Wied. Ann.*, vol. 20, p. 279. On the Property of Benzine as an Insulator and as showing Elastic Reaction (Rückstandsbildner).

1882. *Verhandln. d. phys. Gesellschaft in Berlin*, p. 18. On a New Hygrometer.

1883. *Wied. Ann.*, vol. 19, p. 78. On an Appearance accompanying Electric Discharge.

1883. *Ib.*, vol. 19, p. 782. Experiments on Glow Discharge.

1883. *Zeitschrift für Instrumentenkunde.* Dynamometric Contrivance of Small Resistance and Infinitesimal Self-Induction.

1884. *Met. Zeitschrift*, November, December. Graphic Methods for the Determination of the Adiabatic Changes of Condition of Moist Air.

1884. *Wied. Ann.*, vol. 22, p. 449. On the Equilibrium of Floating Elastic Plates.

1884. *Ib.*, vol. 23. On the Connection between Maxwell's Electrodynamic Fundamental Equations and those of opposition Electrodynamics.

1885. *Ib.*, vol. 24, p. 114. On the Dimension of a Magnetic Pole in different Systems of Units.

1887-1889. Papers incorporated in his book, "Ausbreitung der Elektrischen Kraft," translated under the title of "Electric Waves."

1892. *Wied Ann.*, vol. 45, p. 28. On the Passage of Cathode Rays through thin Metal Sheets.

[2] *Phil. Mag.*, xxvi. pp. 229, 230, August 1888: or "Lightning Conductors and Lightning Guards" (Whittaker), pp. 104, 105; also *Proc. Roy. Soc.* vol. l. p. 27.

The simplest way will be for me hastily to summarise our knowledge of the subject before the era of Hertz.

Just as a pebble thrown into a pond excites surface ripples, which can heave up and down floating straws under which they pass, so a struck bell or tuning-fork emits energy into the air in the form of what are called sound waves; and this radiant energy is able to set up vibrations in other suitable elastic bodies.

If the body receiving them has its natural or free vibrations violently damped, so that when left to itself it speedily returns to rest, then it can respond feebly to notes of almost any pitch. This is the case with your ears and the tones of my voice. Tones must be exceedingly shrill before they cease to excite the ear at all.

If, on the other hand, the receiving body has a persistent period of vibration, continuing in motion long after it is left to itself, like another tuning-fork or bell for instance, then far more facility of response exists, but great accuracy of tuning is necessary if it is to be fully called out; for if the receiver is not thus accurately syntonised with the source, it fails more or less completely to resound.

Conversely, if the *source* is a persistent vibrator, correct tuning is essential, or it will destroy at one moment motion which it originated the previous moment. Whereas if it is a dead beat or strongly-damped excitor, almost anything will respond equally well or equally ill to it.

What I have said of sounding bodies is true of all vibrators in a medium competent to transmit waves. Now a sending telephone or a microphone, when spoken to, emits waves into the ether, and this radiant energy is likewise able to set up vibration in suitable bodies. But we have no delicate means of directly detecting these electrical or etherial waves, and if they are to produce a perceptible effect at a distance they must be confined, as by a speaking tube, prevented from spreading, and concentrated on the distant receiver.

This is the function of the telegraph wire; it is to the ether what a speaking-tube is to air. A metal wire in air (*in function*, not in details of analogy) is like a long hollow cavity surrounded by nearly rigid but slightly elastic walls.

Sphere charged from Electrophorus.

Furthermore, any conductor electrically charged or discharged with sufficient suddenness must emit electrical waves into the ether, because the charge given to it will not settle down instantly, but will surge to and fro several times first; and these surgings or electric oscillations must, according to Maxwell, start waves in the ether, because at the end of each half swing they cause electrostatic, and at the middle of each half wings they cause electromagnetic effects, and the rapid alternation from one of these modes of energy to the other constitutes etherial waves.[1] If a wire is handy they will run along it, and may be felt a long way off. If no wire exists they will spread out like sound from a bell, or light from a spark, and their intensity will decrease according to the inverse square of the distance.

Maxwell and his followers well knew that there would be such waves; they knew the rate at which they would go, they knew that they would go slower in glass and water than in air, they knew that they would curl round sharp edges, that they would be partly absorbed but mainly reflected by conductors, that if turned back upon themselves they would produce the phenomena of stationary waves, or interference, or nodes and loops; it was known how to calculate the length of such waves, and even how to produce them of any required or predetermined wave-length from 1000 miles to a foot. Other things were known about them which would take too long to enumerate: any homogeneous insulator would transmit them, would refract or concentrate them if it were of suitable shape, would reflect none of a particular mode of vibration at a certain angle, and so on, and so on.

All this was "known," I say, known with varying degrees of confidence, but by some known with as great confidence as, perhaps even more confidence than, is legitimate before the actuality of experimental verification.

[1] Strictly speaking, in the waves themselves there is no lag or difference of phase between the electric and the magnetic vibrations; the difference exists in emitter or absorber, but not in the transmitting medium. True radiation of energy does not begin till about a quarter wave-length from the source, and within that distance the initial quarter-period difference of phase is obliterated.

Hertz supplied the verification. He inserted suitable conductors in the path of such waves, conductors adapted for the occurrence in them of induced electric oscillations, and to the surprise of everyone, himself doubtless included, he found that the secondary electric surgings thus excited were strong enough to display themselves by minute electric sparks.

Syntonic Leyden Jars.

I shall show this in a form which requires great precision of tuning or syntony, both emitter and receiver being persistently vibrating things giving some thirty or forty swings before damping has a serious effect. I take two Leyden jars with circuits about a yard in diameter, and situated about two yards apart. I charge and discharge one jar, and observe that the surgings set up in the other can cause it to overflow if it is syntonised with the first.[1]

A closed circuit such as this is a feeble radiator and a feeble absorber, so it is not adapted for action at a distance. In fact, I doubt whether it will visibly act at a range beyond the $\frac{1}{4}\lambda$ at which true radiation of broken off energy occurs. If the coatings of the jar are separated to a greater distance, so that the dielectric is more exposed, it radiates better; because in true radiation the electrostatic and the magnetic energies are equal, whereas in a ring circuit the magnetic energy greatly predominates. By separating the coats of the jar as far as possible we get a typical Hertz oscillator, whose dielectric extends out into the room, and this radiates very powerfully.

Ordinary size Hertz Vibrator.

In consequence of its radiation of energy its vibrations are rapidly damped, and it only gives some three or four good strong swings. Hence it follows that it has a wide range of excitation, *i.e.* it can excite sparks in conductors barely at all in tune with it.

The two conditions, conspicuous energy of radiation and persistent vibration electrically produced, are at present incompatible. Whenever these two conditions coexist, considerable power or activity will of course be necessary in the source of energy. At present they only coexist in the sun and other stars, in the electric arc, and in furnaces.

Two Circular Vibrators sparking in sympathy.

The receiver Hertz used was chiefly a circular resonator, not a good absorber but a persistent vibrator, well adapted for picking up disturbances of precise and measurable wave-length. I find that the circular resonators can act as senders too; here is one exciting quite long sparks in a second one.

Electric Syntony—that was his discovery, but he did not stop there. He at once proceeded to apply his discovery to the verification of what had already been predicted about the waves, and by laborious and difficult interference experiments he ascertained that the previously calculated length of the waves was thoroughly borne out by fact. These interference experiments in free space are his greatest achievement.

He worked out every detail of the theory splendidly, separately analysing the electric and the magnetic oscillation—using language not always such as we should use now, but himself growing in theoretic insight through the medium of what would have been to most physicists a confusing maze of troublesome facts, and disentangling all their main relations most harmoniously.

Holtz Machine, A and B Sparks; Glass and Quartz Panes in Screen.

While Hertz was observing sparks such as these, the primary or exciting spark and the secondary or excited one, he observed as a bye-issue that the secondary spark occurred more easily if the light from the primary fell upon its knobs. He examined this new influence of light in many ways, and showed that although spark light and electric brush light were peculiarly effective, any source of light that gave very ultra-violet rays produced the same result.[2]

Wiedemann and Ebert, and a number of experimenters, have repeated and extended this discovery, proving that it is the cathode knob on which illumination takes effect; and Hall-

[1] See NATURE, vol. 41, p. 368; or J. J. Thomson, "Recent Researches," p. 395.

[2] The experiment shown in the lecture was on the lines of those described in my book, "Lightning Conductors," pp. 314 and 340; the connections being much as on p. 285, or as depicted in *Proc. Roy. Soc.*, vol. 50, p. 4.

wachs made the important observation, which Righi, Stoletow, Branly, and others have extended, that a freshly-polished zinc or other oxidisable surface, if charged negatively, is gradually discharged by ultra-violet light.

It is easy to fail in reproducing this experimental result if the right conditions are not satisfied; but if they are, it is absurdly easy, and the thing might have been observed nearly a century ago.

Zinc discharging Negative Electricity in Light; Gold Leaf Electroscope; Glass and Quartz Panes; Quartz Prism.

Take a piece of zinc, clean it with emery paper, connect it to a gold leaf electroscope, and expose it to an arc lamp. If charged positively nothing appears to happen, the action is very slow, but a negative charge leaks away in a few seconds if the light is bright. Any source of light rich in ultra-violet rays will do; the light from a spark is perhaps most powerful of all. A pane of glass cuts off all the action; so does atmospheric air in sufficient thickness (at any rate, town air), hence sunlight is not powerful. A pane of quartz transmits the action almost undiminished, but fluor-spar may be more transparent still. Condensing the arc rays with a quartz lens and analysing them with a quartz prism or reflexion grating, we find that the most effective part of the light is high up in the ultra-violet, surprisingly far beyond the limits of the visible spectrum.[1]

This is rather a digression, but I have taken some pains to show it properly because of the interest betrayed by Lord Kelvin in this matter, and the caution which he felt about accepting the results of the Continental experimenters too hastily.

It is clearly a chemical phenomenon, and I am disposed to express it as a modification of the Volta contact effect [2] with illumination.

Return now to the Hertz vibrator, or Leyden jar with its coatings well separated so that we can get into its electric as well as its magnetic field. Here is a great one, giving waves 30 metres long, radiating while it lasts with an activity of a hundred horse-power, and making ten million complete electric vibrations per second.

Large Hertz Vibrator in action; Abel's Fuse; Vacuum Tube; Strike an Arc.

Its great radiating power damps it down very rapidly, so that it does not make above two or three swings; but, nevertheless, each time it is excited, sparks can be drawn from most of the reasonably elongated conductors in this theatre.

A suitably situated gas-leak can be ignited by these induced sparks. An Abel's fuse connecting the water-pipes with the gas-pipes will blow off; vacuum tubes connected to nothing will glow (this fact has been familiar to all who have worked with Hertz waves since 1889); electric leads, if anywhere near each other, as they are in some incandescent lamp-holders, may spark across to each other, thus striking an arc and blowing their fuses.

This blowing of fuses by electric radiation frequently happened at Liverpool till the suspensions of the theatre lamps were altered.

The striking of an arc by the little reverberating sparks between two carbon points connected with the 100 volt mains I incidentally now demonstrate.

There are some who think that lightning flashes can do none of these secondary things. They are mistaken.

Specimens and Diagrams.

On the table are specimens of various emitters and receivers such as have been used by different people. The orthodox Hertz radiator of the dumb-bell type, and the orthodox Hertz receivers—a circular ring for interference experiments, because it is but little damped; and a straight wire for receiving at a distance, because it is a much better absorber. Beside these are the spheres and ellipsoids (or elliptical plates) which I have mainly used, because they are powerful radiators and absorbers, and because their theory has been worked out by Horace Lamb and J. J. Thomson. Also dumb-bells without air-gap, and many other shapes, the most recent of mine being the inside of a hollow cylinder with sparks at ends of a diameter; this last being a feeble radiator but a very persistent vibrator,[1] and therefore well adapted for interference and diffraction experiments. But indeed spheres can be made to vibrate longer than usual by putting them into copper hats or enclosures, in which an aperture of varying size can be made to let the waves out.

Many of these senders will do for receivers too, giving off sparks to other insulated bodies or to earth; but besides the Hertz type of receiver, many other detectors of radiation have been employed. Vacuum tubes can be used, either directly, or on the trigger principle, as by Zehnder,[2] the resonator spark precipitating a discharge from some other auxiliary battery or source of energy, and so making a feeble disturbance very visible. Explosives may be used for the same purpose, either in the form of mixed water-gases or in the form of an Abel's fuse. Fitzgerald found that a tremendously sensitive galvanometer could indicate that a feeble spark had passed, by reason of the consequent disturbance of electrical equilibrium which settled down again through the galvanometer.[3] This was the method he used in this theatre two years ago. Blyth used a one-sided electrometer, and young Bjerkness has greatly developed this method, abolishing the need for a spark, and making the electrometer metrical, integrating, and satisfactory.[4] With this detector many measurements have been made at Bonn, by Bjerkness, Yule, Barton, and others, on waves concentrated and kept from space-dissipation by guiding wires.

Mr. Boys has experimented on the mechanical force exerted by electrical surgings, and Hertz also made observations of the same kind.

Going back to older methods of detecting electrical radiation, we have, most important of all, a discovery made long before man existed, by a creature that developed a sensitive cavity on its skin; a creature which never so much as had a name to be remembered by (though perhaps we now call it trilobite). Then, in recent times, we recall the photographic plate and the thermopile, with its modification the radio-micrometer; also the so-called bolometer, or otherwise known Siemens' pyrometer, applied to astronomy by Langley; applied to the detection of electric waves in wires by Rubens and Ritter and Paalzow and Arons. The thermal junction was applied to the same purpose by D. E. Jones and others.

And, before all these, the late Mr. Gregory, of Cooper's Hill, made his singularly sensitive expansion meter, whereby waves in free space could be detected by the minute rise of temperature they caused in a platinum wire: a kind of early and sensitive form of Cardew voltmeter.

Going back to the physiological method of detecting surgings, Hertz tried the frog's-leg nerve and muscle preparation, which to the steadier types of electrical stimulus is so surpassingly sensitive, and to which we owe the discovery of current electricity. But he failed to get any result. Ritter has succeeded; but, in my experience, failure is the normal and proper result. Working with my colleague Prof. Gotch, at Liverpool, I too have tried the nerve muscle preparation of the frog, and we find that an excessively violent stimulus of a rapidly alternating character, if pure and unaccompanied by secondary actions,

[1] While preparing for the lecture it occurred to me to try, if possible, during the lecture itself, some new experiments on the effect of light on negatively charged bits of rock and ice, because if the effect is not limited to metals it must be important in connection with atmospheric electricity. When Mr. Branly coated an aluminium plate with an insulating varnish, he found that its charge was able to soak in and out of the varnish during illumination (*Comptes Rendus*, vol. 110, p. 898, 1890). Now, the mountain tops of a negatively charged earth are exposed to very ultra-violet rays, and the air is a dielectric in which quiet up-carrying and sudden downpour of electricity could go on in a manner not very unlike the well-known behaviour of water vapour; and this perhaps may be the reason, or one of the reasons, why it is not unusual to experience a thunderstorm after a few fine days. I have now tried these experiments on such geological fragments as were handy, and find that many of them discharge negative electricity under the action of a naked arc, especially from the side of the specimens which was somewhat dusty, but that when wet they discharge much less rapidly, and when positively charged hardly at all. Ice and garden soil discharge negative electrification too, under ultra-violet illumination, but not so quickly as limestone, mica schist, ferruginous quartz, clay, and some other specimens. Granite barely acts; it seems to insulate too well. The ice and soil were tried in their usual moist condition, but, even when thoroughly dry, soil discharges quite rapidly.

No rock tested was found to discharge as quickly as does a surface of perfectly bright metal such as iron, but many discharged much more quickly than ordinary dull iron, and rather more quickly than when the bright iron surface was thinly oiled or wetted with water.

To-day (June 5) I find that the leaves of a geranium discharge positive electrification five times as quickly as negative, under the action of an arc-light, and that glass cuts the effect off while quartz transmits it.

[2] See Brit. Assoc. Report, 1884, pp. 502, 519; or *Phil. Mag.* vol. 19, pp. 267, 352.

[1] J. J. Thomson, "Recent Researches," p. 344.

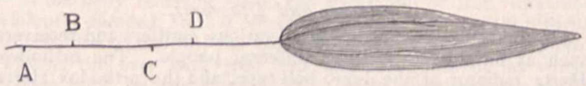
[2] *Wied. Ann.* 47, p. 77.

[3] Fitzgerald, NATURE, vol. 41, p. 295, and vol. 42, p. 172.

[4] *Wied. Ann.* 44, p. 74.

produces no effect,—no stimulating effect, that is, even though the voltage is so high that sparks are ready to jump between the needles in direct contact with the nerve.

All that such oscillations do, if continued, is to produce a temporary paralysis or fatigue of the nerve, so that it is unable to transmit the nerve impulses evoked by other stimuli, from which paralysis it recovers readily enough in course of time.



Experiment of Gotch and Lodge on the physiological effect of rapid pure electric alternations. Nerve and muscle preparation, with four needles or else non-polarisable electrodes applied to the nerve. C and D are the terminals of a rapidly alternating electric current from a conductor at zero potential, while A and B are the terminals of an ordinary very weak galvanic or induction coil stimulus only just sufficient to make the muscle twitch.

This has been expected from experiments on human beings; such experiments as Tesla's and those of d'Arsonval. But an entire animal is not at all a satisfactory instrument wherewith to attack the question; its nerves are so embedded in conducting tissues that it may easily be doubted whether the alternating type of stimulus ever reaches them at all. By dissecting out a nerve and muscle from a deceased frog, after the historic manner of physiologists, and applying the stimulus direct to the nerve, at the same time as some other well-known 1/100 h of a volt stimulus is applied to another part of the same nerve further from the muscle, it can be shown that rapid electric alternations, if entirely unaccompanied by static charge or by resultant algebraic electric transmission, evoke no excitatory response until they are so violent as to give rise to secondary effects such as heat or mechanical shock. Yet, notwithstanding this inaction, they gradually and slowly exert a paralysing or obstructive action on the portion of the nerve to which they are applied, so that the nerve impulse excited by the feeble just perceptible 1/100th volt stimulus above is gradually throttled on its way down to the muscle, and remains so throttled for a time varying from a few minutes to an hour after the cessation of the violence.

I had intended to exhibit this effect, which is very marked and definite, but it is impossible to show everything in the time at my disposal.

Air Gap and Electroscope, charged by Glass Rod and discharged by moderately distant Sphere excited by Coil.

Among trigger methods of detecting electric radiation, I have spoken of the Zehnder vacuum tubes; another method is one used by Boltzmann.[1] A pile of several hundred volts is on the verge of charging an electroscope through an air-gap just too wide to break down. Very slight electric surgings precipitate the discharge across the gap, and the leaves diverge. I show this in a modified and very simple form. On the cap of an electroscope is placed a highly-polished knob or rounded end, connected to the sole, and just not touching the cap. Such an electroscope overflows suddenly and completely with any gentle rise of potential. Bring excited glass near it, the leaves diverge gradually and then suddenly collapse, because the air space snaps; remove the glass, and they rediverge with negative electricity; the knob above the cap being then charged positively, and to the verge of sparking. In this condition any electrical waves, collected if weak by a foot or so of wire projecting from the cap, will discharge the electroscope by exciting surgings in the wire, and so breaking down the air-gap. The chief interest about this experiment seems to me the extremely definite dielectric strength of so infinitesimal an air space. Moreover, it is a detector for Hertz waves that might have been used last century; it might have been used by Benjamin Franklin.

For to excite them, no coil or anything complicated is necessary; it is sufficient to flick a metal sphere or cylinder with a silk handkerchief, and then discharge it with a well-polished knob. If it is not well-polished the discharge is comparatively gradual, and the vibrations are weak; the more polished are the sides of an air-gap the more sudden is the collapse, and the more vigorous the consequent radiation, especially the radiation of high frequency, the higher harmonics of the disturbance.

For delicate experiments it is sometimes well to repolish the knobs every hour or so. For metrical experiments it is often better to let the knobs get into a less efficient but more permanent state. This is true of all senders or radiators. For the generation of the, so to speak, "infra-red" Hertz waves any knobs will do, but to generate the "ultra-violet" high polish is essential.

Microphonic Detectors.

Receivers or detectors which for the present I temporarily call microphonic are liable to respond best to the more rapid vibrations. Their sensitiveness is to me surprising, though of course it does not approach the sensitiveness of the eye; at the same time, I am by no means sure that the eye differs from them in kind. It is these detectors that I wish specially to bring to your notice.

Prof. Minchin, whose long and patient work in connection with photoelectricity is now becoming known, and who has devised an instrument more sensitive to radiation than even Boys' radiomicrometer, in that it responds to the radiation of a star while the radio-micrometer does not, found some years ago that some of his light-excitable cells lost their sensitiveness capriciously on tapping; and later he found that they frequently regained it again while Mr. Gregory's Hertz-wave experiments were going on in the same room.

These "impulsion-cells," as he terms them, are troublesome things for ordinary persons to make and work with—at least I have never presumed to try—but in Mr. Minchin's hands they are surprisingly sensitive to electric waves.[1]

The sensitiveness of selenium to light is known to everyone, and Mr. Shelford Bidwell has made experiments on the variations of conductivity exhibited by a mixture of sulphur and carbon.

Nearly four years ago, M. Edouard Branly found that a burnished coat of porphyrised copper spread on glass diminished its resistance enormously, from some millions to some hundreds of ohms, when it was exposed to the neighbourhood, even the distant neighbourhood, of Leyden jar or coil sparks. He likewise found that a tube of metallic filings behaved similarly, but that this recovered its original resistance on shaking. Mr. Croft exhibited this fact recently at the Physical Society. Branly also made pastes and solid rods of filings in Canada balsam and in sulphur, and found them likewise sensitive.[2]

With me the matter arose somewhat differently, as an outcome of the air-gap detector employed with an electroscope by Boltzmann. For I had observed in 1889 that two knobs sufficiently close together, far too close to stand any voltage such as an electroscope can show, could, when a spark passed between them, actually cohere; conducting an ordinary bell-ringing current if a single voltaic cell was in circuit; and, if there was no such cell, exhibiting an electromotive force of their own sufficient to disturb a low resistance galvanometer vigorously, and sometimes requiring a faintly perceptible amount of force to detach them. The experiment was described to the Institution of Electrical Engineers,[3] and Prof. Hughes said he had observed the same thing.

Coherer in open, responding to Feeble Stimuli; Small Sphere, Gas-lighter, Distant Sphere, Electrophorus.

Well this arrangement, which I call a coherer, is the most astonishingly sensitive detector of Hertz waves. It differs from the actual air-gap in that the insulating film is not really insulating; the film breaks down not only much more easily, but also in a less discontinuous and more permanent manner than an air-gap. A tube of filings, being a series of bad contacts, clearly works on the same plan; and though a tube of filings is by no means so sensitive, yet it is in many respects easier to work with, and, except for very feeble stimuli, is more metrical. If the filings used are coarse, say turnings or borings, the tube approximates to a single coherer; if they are fine, it has a larger range of sensibility. In every case what these receivers feel are sudden jerks of current; smooth sinuous vibrations are ineffective. They seem to me to respond best to waves a few inches long, but doubtless that is determined chiefly by the dimensions of some conductor with which they happen to be associated.

Filings in open, responding to Sphere, to Electrophorus, to spark from Gold-leaf Electroscope.

I picture to myself the action as follows. Suppose two fairly clean pieces of metal in light contact—say two pieces of

1 *Wied. Ann.* 40, p. 399.

1 *Phil. Mag.* vol. 31, p. 223.
2 E. Branly, *Comptes Rendus*, vol. 111, p. 785; and vol. 112, p. 90.
3 *Journal Inst. E. E.*, 1890, vol. 19, pp. 352-4; or "Lightning Conductors and Lightning Guards" (Whittaker), pp. 382-4.

iron—connected to a single voltaic cell; a film of what may be called oxide intervenes between the surfaces, so that only an insignificant current is allowed to pass, because a volt or two is insufficient to break down the insulating film except perhaps at one or two atoms. If the film is not permitted to conduct at all, it is not very sensitive; the most sensitive condition is attained when an infinitesimal current passes, strong enough just to show on a moderate galvanometer.

Now let the slightest surging occur, say by reason of a sphere being charged and discharged at a distance of forty yards, the film at once breaks down—perhaps not completely, that is a question of intensity—but permanently. As I imagine, more molecules get within each other's range, incipient cohesion sets in, and the momentary electric quiver acts as it were as a flux. It is a singular variety of electric welding. A stronger stimulus enables more molecules to hold on, the process is surprisingly metrical; and as far as I roughly know at present, the change of resistance is proportional to the energy of the electric radiation from a source of given frequency.

It is to be specially noted that the battery current is not needed to effect the cohesion, only to demonstrate it. The battery can be applied after the spark has occurred, and the resistance will be found changed as much as if the battery had been on all the time.

The incipient cohesion electrically caused can be mechanically destroyed. Sound vibrations, or any other feeble mechanical disturbances, such as scratches or taps, are well adapted to restore the contact to its original high-resistance sensitive condition. The more feeble the electrical disturbance the slighter is the corresponding mechanical stimulus needed for restoration. When working with the radiating sphere at a distance of forty yards out of window, I could not for this reason shout to my assistant, in order to cause him to press the key of the coil and make a spark, but I showed him a duster instead, this being a silent signal which had no disturbing effect on the coherer or tube of filings. I mention forty yards, because that was one of the first outdoor experiments; but I should think that something more like half a mile was nearer the limit of sensitiveness. However, this is a rash statement not at present verified. At forty yards the exciting spark could be distinctly heard, and it was interesting to watch the spot of light begin its long excursion and actually travel a distance of two or three inches before the sound arrived. This experiment proved definitely enough that the efficient cause travelled quicker than sound, and disposed completely of any sceptical doubts as to the sound-waves being perhaps the real cause of the phenomenon.

Invariably, when the receiver is in good condition, sound or other mechanical disturbance acts one way, viz. in the direction of increasing resistance, while electrical radiation or jerks act the other way, decreasing it. While getting the receiver into condition, or when it is getting out of order, vibrations and sometimes electric discharges act irregularly, and an occasional good shaking does the filings good.

I have taken rough measurements of the resistance, by the simple process of restoring the original galvanometer deflection by adding or removing resistance coils. A half-inch tube, eight inches long, of selected iron turnings, had a resistance of 2500 ohms in the sensitive state. A feeble stimulus, caused by a distant electrophorous spark, brought it down 400 ohms. A rather stronger one reduced it by 500 and 600, while a trace of spark given to a point of the circuit itself, ran it down 1400 ohms.

This is only to give an idea of the quantities. I have not yet done any seriously metrical experiments.

From the wall diagram which summarises the various detectors, and which was prepared a month or so ago, I see I have omitted selenium, a substance which in certain states is well known to behave to visible light as these other microphonic detectors behave to Hertz waves.

And I want to suggest that quite possibly the sensitiveness of the eye is of the same kind. As I am not a physiologist I cannot be seriously blamed for making wild and hazardous speculations in that region. I therefore wish to guess that some part of the retina is an electrical organ, say like that of some fishes, maintaining an electromotive force which is prevented from stimulating the nerves solely by an intervening layer of badly conducting material, or of conducting material with gaps in it; but that when light falls upon the retina these gaps become more or less conducting, and the nerves are stimulated.

I do not feel clear which part is taken by the rods and cones, and which part by the pigment cells; I must not try to make the hypothesis too definite at present.

If I had to make a demonstration model of the eye on these lines, I should arrange a little battery to excite a frog's nerve and muscle preparation through a circuit completed all except a layer of filings or a single bad contact. Such an arrangement would respond to Hertz waves. Or if I wanted actual light to act instead of grosser waves, I would use a layer of selenium.

But the bad contact and the Hertz waves are the most instructive, because we do not at present really know what the selenium is doing, any more than what the retina is doing.

And observe that (to my surprise I confess) the rough outline of a theory of vision thus suggested is in accordance with some of the principal views of the physiologist Hering. The sensation of light is due to the electrical stimulus; the sensation of black is due to the mechanical or tapping-back stimulus. Darkness is physiologically not the mere cessation of light. Both are positive sensations, and both stimuli are necessary; for until the filings are tapped back vision is persistent. In the eye model the period of mechanical tremor should be say $\frac{1}{10}$th second, so as to give the right amount of persistence of impression.

Eye Model with Electric Bell on Board.

No doubt in the eye the tapping back is done automatically by the tissues, so that it is always ready for a new impression, until fatigued. And by mounting an electric bell or other vibrator on the same board as a tube of filings, it is possible to arrange so that a feeble electric stimulus shall produce a feeble steady effect, a stronger stimulus a stronger effect, and so on, the tremor asserting its predominance and bringing the spot back whenever the electric stimulus ceases.

An electric bell thus close to the tube is, perhaps, not the best vibrator; clockwork might do better, because the bell contains in itself a jerky current, which produces one effect, and a mechanical vibration, which produces an opposite effect; hence the spot of light can hardly keep still. By lessening the vibration—say by detaching the bell from actual contact with the board, the electric jerks of the intermittent current drive the spot violently up the scale; mechanical tremor brings it down again.

You observe that the eye on this hypothesis is, in electrometer language, heterostatic. The energy of vision is supplied by the organism, the light only pulls a trigger. Whereas the organ of hearing is idiostatic. I might draw further analogies, about the effect of blows or disorder causing irregular conduction and stimulation, of the galvanometer in the one instrument, of the brain cells in the other.

A handy portable exciter of electric waves is one of the ordinary hand electric gas-lighters, containing a small revolving doubler—*i.e.*, an inductive or replenishing machine. A coherer can feel a gas-lighter across a lecture theatre. Minchin often used them for stimulating his impulsion cells. I find that, when held near, they act a little before the spark occurs, plainly because of the little incipient sparks at the brushes or tinfoil contacts inside. A Voss machine acts similarly, giving a small deflection while working up before it sparks.

And notice here that our model eye has a well-defined range of vision. It cannot see waves too long for it.

Holtz Sparks not exciting Tube: except by help of a polished knob.

The powerful disturbance caused by the violent flashes of a Wimshurst or Voss machine it is blind to. If the knobs of the machine are well polished, it will respond to some high harmonics, due to the vibrations in the terminal rods; and these are the vibrations to which it responds when excited by a coil. The coil should have knobs instead of points. Sparks from points or dirty knobs hardly excite the coherer at all. But hold a well-polished sphere or third knob between even the dirty knobs of a Voss machine, and the coherer responds at once to the surgings got up in it.

Electrophorous Lid and insulated Sphere.

Feeble short sparks again are often more powerful exciters than are strong long ones. I suppose because they are more sudden.

This is instructively shown with an electrophorous lid. Spark it to a knuckle, and it does very little. Spark it to a knob, and it works well. But now spark it to an insulated sphere, there is some effect. Discharge the sphere, and take a second spark, without recharging the lid. Do this several times; and at last, when the spark is inaudible, invisible, and otherwise imperceptible, the coherer some yards away responds more violently than ever, and the spot of light rushes from the scale.

If a coherer be attached by a side wire to the gas-pipes, and an electrophorous spark be given to either the gas-pipes or the water-pipes, or even to the hot-water system, in another room of the building, the coherer responds.

In fact when thus connected to gas-pipes, one day when I tried it, the spot of light could hardly keep five seconds still. Whether there was a distant thunderstorm, or whether it was only picking up telegraphic jerks, I do not know. The jerk of turning on or off an extra Swan lamp can affect it when sensitive. I hope to try for long-wave radiation from the sun, filtering out the ordinary well-known waves by a black-board or other sufficiently opaque substance.

We can easily see the detector respond to a distant source of radiation now, viz. to a 6-inch sphere placed in the library between coil knobs.

Portable Detector.

Also I exhibit a small complete detector made by my assistant Mr. Davies, which is quite portable and easily set up. The essentials are all in a copper cylinder three inches by two. A bit of wire a few inches long, pegged into it, helps it to collect waves. It is just conceivable that at some distant date, say by dint of inserting gold wires or powder in the retina, we may be enabled to see waves which at present we are blind to.

Observe how simple the production and detection of Hertz waves are now. An electrophorous or a frictional machine serves to excite them; a voltaic cell, a rough galvanometer, and a bad contact, serve to detect them. Indeed they might have been observed at the beginning of the century, before galvanometers were known. A frog's leg or an iodide of starch paper would do almost as well.

A bad contact was at one time regarded as a simple nuisance, because of the singularly uncertain and capricious character of the current transmitted by it. Hughes observed its sensitiveness to sound-waves, and it became the microphone. Now it turns out to be sensitive to electric waves, if it be made of any oxidisable metal (not of carbon), and we have an instrument which might be called a micro-something, but which, as it appears to act by cohesion, I call at present a coherer. Perhaps some of the capriciousness of an anathematised bad contact was sometimes due to the fact that it was responding to stray electric radiation.

The breaking down of cohesion by mechanical tremor is an ancient process, observed on a large scale by engineers in railway axles and girders; indeed, the cutting of small girders by persistent blows of hammer and chisel reminded me the other day of the tapping back of our cohering surfaces after they have been exposed to the welding effect of the electric jerk.

Put Copper Hat over Tube. Shut up everything in Box completely.

If a coherer is shut up in a complete metal enclosure, waves cannot get at it, but if wires are led from it to an outside ordinary galvanometer, it remains nearly as sensitive as it was before (nearly, not quite), for the circuit picks up the waves, and they run along the insulated wires into the closed box. To screen it effectively it is necessary to enclose battery and galvanometer and every bit of wire connection; the only thing that may be left outside is the needle of the galvanometer. Accordingly here we have a compact arrangement of battery and coil and coherer, all shut up in a copper box. The coil is fixed against the side of the box at such height that it can act conveniently on an outside suspended compass needle. The slow action of the coil has no difficulty in getting through copper, as everyone knows; only a perfect conductor could screen off that, but the Hertz waves are effectively kept out by sheet copper.

Chink; Round Hole; Protruding Wire.

It must be said, however, that the box must be exceedingly well closed for the screening to be perfect. The very narrowest chink permits their entrance, and at one time I thought I should have to solder a lid on before they could be kept entirely out. Clamping a copper lid on to a flange in six places was not enough. But by the use of pads of tinfoil, chinks can be avoided, and the inside of the box becomes then electrically dark.

If even an inch of the circuit protrudes, it at once becomes slightly sensitive again; and if a single branch wire protrudes through the box, provided it is insulated where it passes through, the waves will utilise it as a speaking tube, and run blithely in. And this whether the wire be connected to anything inside or not, though it acts more strongly when connected.

Receiver Hat and Metal Tube for Connecting Wires.

If wires are to be taken out of the box to a coherer in some other enclosure, they must be enclosed in a metal tube, and this tube must be well connected with the metal of both enclosures, if nothing is to get in but what is wanted.

Similarly, when definite radiation is desired, it is well to put the radiator in a copper hat, open in only one direction. And in order to guard against reflected and collateral surgings running along the wires which pass outside to the coil and battery, as they are liable to do, I am accustomed to put all these things in a packing case lined with tinfoil, to the outside of which the sending hat is fixed, and to pull the key of the primary exciting circuit by a string from outside.

Sender in Hat and Box, with Lid (adjustable) clamped on.

Even then, with the lid of the hat well clamped on, something gets out, but it is not enough to cause serious disturbance of qualitative results. The sender must evidently be thought of as emitting a momentary blaze of light which escapes through every chink. Or, indeed, since the waves are some inches long, the difficulty of keeping them out of an enclosure may be likened to the difficulty of excluding sound; though the difficulty is not quite so great as that, since a reasonable thickness of metal is really opaque. I fancied once or twice I detected a trace of transparency in such metal sheets as ordinary tinplate, but unnoticed chinks elsewhere may have deceived me. It is a thing easy to make sure of as soon as I have more time.

One thing in this connection is noticeable, and that is how little radiation gets either in or out of a small round hole. A narrow long chink in the receiver box lets in a lot; a round hole the size of a shilling lets in hardly any, unless indeed a bit of insulated wire protrudes through it like a collecting ear-trumpet.

Gas-lighter with Tinfoil.

It may be asked how the waves get out of the metal tube of an electric gas-lighter. But they do not; they get out through the handle, which being of ebonite is transparent. Wrap up the handle tightly in tinfoil, and a gas-lighter is powerless.

Optical Experiments.

And now in conclusion I will show some of the ordinary optical experiments with Hertz waves, using as source either one of two devices: either a 6-inch sphere with sparks to ends of a diameter, an arrangement which emits 9-inch waves, but of so dead-beat a character that it is wise to enclose it in a copper hat to prolong them, and send them out in the desired direction; or else a 2-inch hollow cylinder with spark knobs at ends of an internal diameter. This last emits 3-inch waves of a very fairly persistent character, but with nothing like the intensity of one of the outside radiators.

As receiver there is no need to use anything sensitive, so I employ a glass tube full of coarse iron filings, put at the back of a copper hat with its mouth turned well askew to the source, which is put outside the door at a distance of some yards, so that only a little direct radiation can reach the tube. Sometimes the tube is put lengthways in the hat instead of crossways, which makes it less sensitive, and has also the advantage of doing away with the polarising or rather analysing power of a crossway tube.

Various Apertures in Lid.

The radiation from the sphere is still too strong, but it can be stopped down by a diaphragm plate with holes in it of varying size clamped on the sending hat.

Reflecting Plate, Wet Cloth, Glass Plate.

Having thus reduced the excursion of the spot of light to a foot or so, a metal plate is held as reflector, and at once the spot travels a couple of yards. A wet cloth reflects something, but a thin glass plate, if dry, reflects next to nothing, being, as is well known, too thin to give anything but "the black spot." I have fancied that it reflects something of the 3-inch waves.

Refracting Prism and Lens.

A block of paraffin about a cubic foot in volume is cast into the shape of a prism with angles 75°, 60°, and 45°. Using the large angle, the rays are refracted into the receiving hat, and produce an effect much larger than when the prism is removed.

An ordinary 9-inch glass lens is next placed near the source, and by means of the light of a taper it is focussed between source and receiver. The lens is seen to increase the effect.

Arago Disk, Grating and Zone-plate.

The lens helps us to set correctly an 18-inch circular copper disk in position for showing the bright diffraction spot. Removing the disk, the effect is much the same as when it was present. Add the lens, and the effect is greater. With a diffraction grating of copper strips two inches broad and two inches apart, I have not yet succeeded in getting good results. It is difficult to get sharp nodes and interference effects with these sensitive detectors in a room. I expect to do better when I can try out-of-doors, away from so many reflecting surfaces; indoors it is like trying delicate optical experiments in a small whitewashed chamber well supplied with looking-glasses; nor have I ever succeeded in getting clear concentration with this zone-plate having Newton rings fixed to it in tinfoil. But really there is nothing of much interest now in diffraction effects except the demonstration of the waves and the measure of their length. There was immense interest in Hertz's time, because then the wave character of the radiation had to be proved; but every possible kind of wave must give interference and diffraction effects, and their theory is, so to say, worked out. More interest attaches to polarisation, double refraction, and dispersion experiments.

Polarising and Analysing Grids.

Polarisation experiments are easy enough. Radiation from a sphere is already strongly polarised, and the tube acts as a partial analyser, responding much more vigorously when its length is parallel to the line of sparks than when they are crossed; but a convenient extra polariser is a grid of wires something like what was used by Hertz, only on a much smaller scale; say an 18-inch octagonal frame of copper strip with a harp of parallel copper wires. The spark-line of the radiator being set at 45°, a vertical grid placed over receiver reduces the deflection to about one-half, and a crossed grid over the source reduces it to nearly nothing.

Rotating either grid a little rapidly increases the effect, which becomes a maximum when they are parallel. The interposition of a third grid, with its wires at 45° between two crossed grids, restores some of the obliterated effect.

Radiation reflected from a grid is strongly polarised, in a plane normal of course to that of the radiation which gets through it. They are thus analogous in their effect to Nicols, or to a pile of plates.

The electric vibrations which get through these grids are at right angles to the wires. Vibrations parallel to the wires are reflected or absorbed.

Reflecting Prism.

To demonstrate that the so-called plane of polarisation of the transmitted radiation is at right angle to the electric vibration,[1] *i.e.* that the wires of the grid are parallel to it, I use the same paraffin prism as before, but this time I use its largest face as a reflector, and set it at something near the polarising angle. When the line of wires is parallel to the plane of incidence, in which case the electric vibrations are perpendicular to the plane of incidence, plenty of radiation is reflected by the paraffin face. Turning the grid so that the electric vibrations are in the plane of incidence, we find that the paraffin surface set at the proper angle is able to reflect hardly anything. In other words, the vibrations contemplated by Fresnel are the electric vibrations; those dealt with by McCullagh are the magnetic ones.

Thus are some of the surmises of genius verified and made obvious to the wayfaring man.

[1] *c.f.* Trouton, in NATURE, vol. 39, p. 393; and many other optical experiments by Mr. Trouton, vol. 40, p. 398.

THE REPORT OF THE ASTRONOMER ROYAL.

AT the annual visitation of the Royal Observatory, Greenwich, on Saturday last, the Astronomer Royal presented his report of the progress made from May 11, 1893, to May 10 of this year. We take from it the following information:—

It appears that the average number of transits observed was no less than 31 each day, or if Sundays are excluded, 36. As an instance of the number of observations which were made under very favourable conditions, it may be mentioned that on three consecutive days in February no fewer than 458 transits and 460 zenith distances were observed.

A new universal transit-circle or altazimuth is being constructed by Messrs. Troughton and Simms, and satisfactory progress has been made towards completion. All the heavy portions of the instrument, including the rotating and reversing gear, are made, and have been put together, the object glasses for the instrument and collimators are practically finished, as well as the eye end with its micrometers, and the circles, microscopes, &c., are in hand.

As previously noted in our astronomical column, a valuable gift has been made to the Observatory by Sir Henry Thompson, who has generously offered a sum of £5000 to provide a large photographic telescope with accessories, which would serve as the complement of the 28-inch visual telescope just completed. This munificent offer was readily accepted by the Admiralty, and after careful consideration and discussion, a photographic telescope of 26 inches aperture and 22 feet 6 inches focal length, equatorially mounted, was ordered of Sir H. Grubb on May 5, the instrument to be completed in eighteen months. This telescope will be of exactly double the dimensions (aperture and focal length) of the astrographic equatorial which has proved so successful, and it will be mounted on a very firm stand which will allow of complete circumpolar motion without the necessity for reversal on the meridian, which has been felt as a drawback in the astrographic equatorial. It will be erected on the central tower of the new Physical Observatory, under the 30 feet dome which is shortly to be placed there, and will carry the 12¾-inch Merz refractor as a guiding telescope and the Thompson 9-inch photoheliograph. It will thus be mounted under very favourable conditions for work, and will be in every respect a most effective instrument.

The new 28-inch refractor has been brought into working order after much time spent in the erection of the instrument, in the adjustment of the object glass, and in the provision of various fittings at the eye end. The adjustments were finished by October 1, when, under good atmospheric conditions, the definition was found to be very fine. Since then the object glass has been tested on various objects with very satisfactory results. A sketch of Jupiter and some measures of double stars have been made, and the colour correction of the object glass has been determined on stars by readings for focus at different parts of the spectrum.

The object glass has also been tried in the photographic position, with the crown lens reversed and the lenses separated on the plan proposed by Sir G. G. Stokes. The determination of the best distance between the lenses and the exact adjustment of the crown lens for tilt and centering relatively to the flint has necessarily taken a long time, as small modifications were required in the cells and special contrivances had to be devised for the delicate adjustment of the heavy crown cell and lens. A large number of photographs have been taken at different distances inside and outside of the focus corresponding to different positions of the crown lens, and affording interesting information which will be useful in connection with the Thompson 26-inch photographic telescope.

With the astrographic equatorial, 923 plates, with a total of 2143 exposures, were taken on 183 nights in the year ending May 10. Of these 181 were rejected, owing to photographic defects, mechanical injury, mistakes in setting, the plate being wrongly placed in the carrier, failure in clock driving, and interference by cloud. The following statement shows the progress made with the photographic mapping of the heavens in the year covered by the report:—

	No. of Photos taken.	Successf Plates
Astrographic chart (exposure 40m.) ...	280	220
Plates for catalogue (exposures 6m., 3m. and 20s.)	508	387
Number of fields photographed for the chart		200
Number of fields photographed for the catalogue		367
Total number of fields photographed since the commencement of the work for the chart		333
Total number of fields photographed since the commencement of the work for the catalogue		610

To test the optical photographic distortion up to considerable distances from the centre, seven plates with the Pleiades photographed in the four corners have been measured. It appears that the distortion is practically insensible up to 60′ from the centre, and is still small up to 80′, but is not quite the same in the four corners of the plate. On examination, the character of the images in the four corners was also found to vary slightly, the coma being slightly inwards in one corner and outwards in another. The perpendicularity of the plate and object glass to the optic axis were examined and found to be satisfactory.

SOLAR OBSERVATIONS.

Observations of the sun have shown that the solar activity was fully maintained throughout the whole of 1893, the mean daily spotted area for the year being considerably in excess of that for 1892. The great spot of 1892 February still remains the largest hitherto seen in the present cycle, but in 1893 August a very fine group attained dimensions but little inferior, and the groups of 1893 November and 1894 February were very large. The characteristic of the year was, however, rather the great number of groups visible at the same time than the extent of any one of them. Thus in August and December 1893 as many as 16 or 18 distinct groups of spots were seen on the disk at the same time.

MAGNETIC OBSERVATIONS.

The variations of magnetic declination, horizontal force and vertical force, and of earth currents were registered photographically, and accompanying eye observations of absolute declination, horizontal force and dip were made as in former years. The period was one of much less magnetic activity than last year, but there was a large increase occurring in 1894 February, at the time of the great sun-spot. Copies of the magnetic and earth current registers during the disturbances of February 20–March 1 and March 30–April 1, have been supplied to Mr. Preece for discussion in connection with disturbances on the telegraph lines.

METEOROLOGICAL OBSERVATIONS.

Meteorological observations have been made as usual. The reductions show that the mean temperature of the year 1893 was 51°·1, being 1°·6 above the average for the 50 years 1841–1890.

During the twelve months ending 1894 April 30, the highest air temperature in the shade exceeded 80° on 28 days. It was 91°·0 on June 19, 93°·0 on August 16, 94°·2 on August 17, and 95°·1 on August 18. In the 53 years since 1841 higher temperatures have been recorded only twice previously (on both occasions in July). The lowest was 12°·8 on January 5, the maximum on that day being only 19°·0 and the mean daily temperature 15°·9. The mean temperature on August 18 was 79°·6, being the highest mean value recorded in August since 1841. The mean temperature of January 5 was lower than any previously recorded since 1841, with two exceptions. The mean monthly temperature was above the average in all months excepting September, November, and January 1894. In May it was 4°·6, in August 3°·9, in March 2°·7, and in April 3°·8, above the average. In November it was 1°·5 below the average.

The number of hours of bright sunshine recorded during 1893 by the Campbell-Stokes sunshine instrument was 1454, the greatest number on record since the commencement of the registration in 1877. This is 171 hours above the average of the preceding 16 years, after allowance is made for the small difference of indication of the Campbell and Campbell-Stokes instruments. The aggregate number of hours during which the sun was above the horizon was 4454, so that the mean proportion of sunshine for the year was 0·326, constant sunshine being represented by 1.

The rainfall for 1893 was 20·1 inches, being 4·4 inches below the average of the 50 years 1841–1890. From March 1 to September 30 (the period of the great drought) the rainfall amounted to only 7·77 inches, while the average for the 50 years 1841–90 for those months is 14·22 inches.

The mean amount of cloud for the year on the scale 0–10 was 5·75. The average amount as determined by Mr. Ellis (*Quarterly Journal Royal Meteorological Society*, vol. xiv.) from 70 years' observations is 6·75.

The outlook as regards instruments and accommodation for them is stated to be fairly satisfactory; but the fact that four vacancies in a staff of twelve persons have occurred during the fiscal year has necessarily caused serious disorganisation of the work, and greatly handicaps progress.

SCIENCE IN THE MAGAZINES.

THERE are few articles of scientific import in the magazines received by us. By this we do not mean to say that science is unrepresented in magazine literature for June, but that the articles, while affording an excellent pabulum for the omnivorous reader, lack originality of thought. They are, in fact, more descriptive than suggestive. "In the year 1887" (writes Mr. Edison, as an introductory note to an article by Antonia and W. K. L. Dickson in the *Century*) "the idea occurred to me that it was possible to devise an instrument which should do for the eye what the phonograph does for the ear, and that by a combination of the two all motion and sound could be recorded and reproduced simultaneously." The development of this idea, and its practical realisation, are well described by the authors of the article on Edison's kineto-phonograph—this being the comprehensive term given to the invention that is able to record and give back the impressions to the eye as well as to the ear. Muybridge, Marey, Boys, and others have shown what can be done in the way of instantaneous photography, but the plan used by Edison to obtain pictures of movable objects appears to differ from any previously used. After many trials, a highly sensitised strip of celluloid one and a-half inches wide has been adopted for the production of negatives, each strip being perforated on the outer edge. "These perforations occur at close and regular intervals, in order to enable the teeth of a locking-device to hold the film steady in the nine-tenths of the one forty-sixth part of a second, when a shutter opens rapidly and admits a beam of light, causing an image of phase in the movement of the subject. The film is then jerked forward in the remaining one-tenth of the forty-sixth part of a second, and held at rest while the shutter has again made its round, admitting another circle of light, and so on until forty-six impressions are taken a second, or 2760 a minute. This speed yields 165,600 pictures in an hour, an amount amply sufficient for an evening's entertainment, when unreeled before the eye. . . . The advantage of this system over a continuous band, and of a slotted shutter forging widely ahead of the film, would be this, that in one case only the fractional degree of light comprised in the 1720th part of a second is allowed to penetrate to the film, at a complete sacrifice of all detail, whereas in the present system of stopping and starting, each picture gets one-hundredth part of a second's exposure with a lens but slightly stopped down—time amply sufficient, as any photograper knows, for the attainment of excellent detail even in an ordinarily good light." The perforations in the film, referred to in the foregoing, are of assistance in establishing harmonious relations between the kinetoscope and phonograph, in making the action recorded by the one suit the word imprinted upon the other. Several reproductions of series of pictures obtained by the kinetograph accompany the article. In order that the subjects leaving their "passing moods" upon the kinetograph film may be brilliantly illuminated, a new kind of studio has been constructed. The building is pivoted at the centre, and is capable of being rotated so as to present any desired aspect to the sun. Another article in the *Century*, entitled "Field Notes," by Mr. John Burroughs, contains some interesting notes on the habits of a few common animals. This kind of contribution is very common in the magazines. "The Dog," by Mr. N. S. Shaler, and "American Game Fishes," by Mr. L. M. Yale, both in *Scribner*, belong to this anecdotal class.

Cassell's Family Magazine contains an article by Mr. J. Munro on "How I discovered the North Pole." The story is, of course, purely imaginary, but the idea upon which it is based might be developed for preliminary geographical exploration. A number of balloons are supposed to have been set free in high north latitudes, each provided with magazine cameras stocked with plates and having long-distance lenses of various focal lengths. Exposures were automatically made at regular intervals by means of clockwork, so that when the balloons were captured, they contained photographs of the tracks above which they had passed. Each balloon also carried a gyroscope mounted in such a manner that when its axis of rotation became vertical—that is, when the balloon containing it was exactly over the North Pole, cameras were brought into action and photographs taken of the earth below.

"The Spring of the Year," in *Longman's*, is an inspiring article written by Richard Jefferies, and found by Mrs. Jefferies among the MSS. left by him. Mr. A. Morgan retails some second-hand information on "Celestial Photography" in the same magazine. In *Good Words* Sir Robert Ball gives the second of a series of articles on "The Great Astronomers," the subject of his biographical sketch being Kepler. E. M. Caillard founds an excellent article on "Matter," and manages to impart clear and accurate notions on the universal properties of extension, inertia, unity, indestructibility and structure.

We note in *Chambers's Journal* "The Science of Colouring in Animals," "The Sargasso Sea," "Spiders and their Habits," and "The Identification of Habitual Criminals." Mr. A. Binet's "Mechanism of Thought," in the *Fortnightly*, is chiefly concerned with psychology and hypnotism. Honour is done to the late Prof. Robertson Smith by Mr. J. G. Frazer in the same magazine. Prof. Victor Horsley replies in the *Humanitarian* to the paper on vivisection contributed by Bishop Barry to the April number. The seventh of Mr. Phil Robinson's articles on "The Zoo Revisited," in the *English Illustrated*, deals with the animals in the "Small Cats' House." In the same magazine, Mr. W. B. Tegetmeier briefly describes the scope of his forthcoming book on horses, asses, and zebras. The May number of the *Nautical Magazine* contains an article in which Capt. Wilson Barker points to the study of "Natural History" (a term used to cover the ground of physiography) as a recreation for sailors.

In addition to the magazines mentioned in the foregoing, we have received the *Contemporary* and *National* reviews.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Provost of King's, Mr. A. Austen Leigh, has been re-elected Vice-Chancellor for the ensuing year.

St. John's College has carried off both the Smith's prizes this year; the winners are Mr. S. S. Hough and Mr. H. C. Pocklington, third and bracketed fourth Wranglers respectively in 1892, and first class in Part II. of the Mathematical Tripos, 1893.

Candidates for the University Lectureship in Invertebrate Morphology, vacated by Prof. Hickson, are requested to send their names to the Vice-Chancellor by June 9. The stipend is £50 a year.

Prof. Foster has been re-appointed a Manager of the Balfour Studentship Fund for the ensuing five years.

Mr. J. J. Lister, of St. John's, is to occupy the University's table at the Plymouth Biological Laboratory this summer.

The first examination for Diplomas in Agricultural Science will be held on July 2. Candidates are to send their names and fees to the Registrary by June 13.

The next examination for Diplomas in Public Health will begin on October 2. The names of candidates, with their certificates, are to be sent to the Registrary by September 18.

Sir G. G. Stokes, Dr. Sandys, and Prof. Robinson, are to represent the University at the Bi-centenary Festival of the University of Halle, to be held next August.

The following Examiners have been nominated by the Special Board for Medicine:—In Medicine, Dr. W. H. Dickinson, Dr. J. K. Fowler, Dr. L. Humphry, Dr. J. F. Payne; in Midwifery, Dr. W. S. A. Griffith, Dr. J. Phillips; in Surgery, Mr. H. H. Clutton, Mr. F. Treves, Mr. H. Marsh, Mr. W. H. Bennett.

Mr. H. Woods, of St. John's College, has been appointed an Elector to the Harkness Scholarship in Geology and Palæontology.

SCIENTIFIC SERIALS.

American Meteorological Journal, May.—The principal article is "Meteorology and Geodesy," by Prof. C. Abbe. It contains tables showing the variations in the force of gravity over the North American continent and the Atlantic ocean and their effect on the mercurial barometer. The author points out that there is a local attraction of gravitation that is less over the continents than over the oceans, and probably, on the average, less in the northern than in the southern atmosphere; these differences must be allowed for, in combination with the effects due to the density of the atmosphere and to centrifugal force. The principal resistance to the motion of the atmosphere originates in the connective processes that force stagnant air to mix with air in motion; this convective friction is quite independent of viscosity, which has been generally introduced into the formulæ for atmospheric motion, and it is much more effective. The most important subject for the meteorologist to study is these convective mixtures and the resistances or accelerations that result therefrom. The author considers it unnecessary to take up the minute irregularities treated of in this paper, until after the study above referred to has explained the larger part of the irregularities of atmospheric motions. The same journal contains some very useful suggestions by Prof. Abbe, on the various meteorological problems that might be taken up by mathematical students.

Bulletin de la Société des Naturalistes de Moscou, 1893, Nos. 2 and 3.—On the copulation organs of the males of the genera *Crosica, Melecta, Pseudomelecta*, &c., by General O. Radoczkowsky (in French, with four plates)—Contribution to the pathologic evolution of the nervous system, by Mme. O. V. Leonova, being a description of a complicated case of total anencephaly in a human embryo.—A case of seeming hermaphroditism with *Perca fluviatilis*, by N. Iwanzoff.—The Tithonian deposits of Theodosia, Crimea, by O. Retowski (in German, with six plates). This elaborate monograph contains the description of sixty-five fossil species from those little-known beds—no less than thirty-one species and one genus being new.—Palæontological data for the vertical subdivision of the Sarmathian deposits of South Russia, by A. P. Ivanoff (in Russian, summed up in French). The following five zones are distinguished:—(1) Zone of *Cerithium mitrale, mediterraneum*, and *rubiginosum*; (2) *C. disjunctum* and *mitrale*; (3) *C. nodosoplicatum, disjunctum*, and *mitrale*; (4) *C. rubiginosum, nodosoplicatum, disjunctum, mitrale*, var. *bicostata*, and *nympha*; (5) *C. mitrale*, var. *bijuga*; and (6) *C. disjunctum*. The beds overlying the above are characterised by the absence of *Cerithes*, and the appearance, for the first time, of *Trochus podolicus*, and a great development of *Mactra ponderosa*. The uppermost layers of the series contain no *Trochus podolicus*, while other species of *Trochus* and *Turbo* appear in great numbers.—The birds of Moscow, by Th. Lorenz, continued.—Note on J. D. Chersky, with a complete list of his works, by A. Iwanowski.—On a new species, *Parus transcaspius*, by N. Zaroudnoi (in French).

Memoirs of the Kazan Society of Naturalists, vol. xxvi. Nos. 4, 5, and 6.—On the theory of the root-force in the plant, by Dr. Alexis Horvath. The manometric measurements of the author prove the existence of a rarefaction within the plant, and he therefore considers the vessel of a plant as a tube, in which we should have a succession of drops of a liquid, separated from each other by bulbs of air. The heating of the gas and its expansion acts in the tube as the piston of an aspirating pump.—On the consequences of the decapitation of the plant on some of its organs, by W. Rothert.—On the supply of water to Kazan, by Prof. Stscherbakoff.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, April 19.—"On Variations observed in the Spectra of Carbon Electrodes, and on the Influence of one Substance on the Spectrum of Another." By W. N. Hartley, F.R.S.

Certain "lines" in Hartley and Adeney's spectrum of carbon are attributed to cyanogen in a recent paper by Eder and Valenta.[1] These lines are not produced by cyanides such as potassium cyanide or mercuric cyanide. Graphite electrodes immersed in solutions show beautiful groups of lines which coincide with the edges of certain bands in spectra of the flame of burning cyanogen. These bands can be recognised in the groups iii. and iv. on the spectra photographed by Kayser and Runge.

The origin of these coincident portions of spectra, namely, from the combustion of cyanogen and from carbon electrodes in saline solutions, taken in conjunction with the fact that they are not rendered by cyanides, makes it doubtful whether the cyanogen spectrum is not due to elementary carbon, as first advocated by Marshall Watts. There are other facts and circumstances which somewhat support this doubt. First, variations have been observed in the spectrum of carbon which cannot be easily accounted for. Secondly, the effect of one substance on

[1] "Line Spectrum of Elementary Carbon and the Ultra-violet Spark Spectrum of Wet and Dry Wood Charcoal" (Vienna: "Akad Wiss. Denkschriften," vol. 60, 1893).

the spectrum of another, which I have recently observed, not only strengthens weak lines, but in certain cases brings a new series of lines into view. Thirdly, the spectra of mixed vapours have been shown to be different from the spectra of the substances by themselves (Liveing and Dewar, "Roy. Soc. Proc.," vol. xxxiv. p. 428); and, fourthly, the influence of the strong lines of an element on adjacent weaker lines of another substance is to strengthen the weaker lines in some cases, but almost to obliterate them in others.

Variations in the spectrum of carbon as observed in different circumstances have been carefully examined and described. In order to test the probability of the carbon and nitrogen spectra being subject to variations when the two elements are together in the spark or flame, it is necessary to consider the effect of one spectrum on another when the two are produced simultaneously from quite different materials.

In the oxyhydrogen flame the water-vapour lines are prominent, but only two groups are visible in the spectrum under normal conditions, and with an exposure of half an hour. If, however, some sulphur be burnt in the flame, the conditions being otherwise unchanged, then the spectrum, in addition to a band of continuous rays and flutings characteristic of sulphur vapour, shows the water-vapour lines wonderfully strong, with groups extending beyond those portions of the spectrum usually photographed, and not only are the lines distinct, but dense, as if their radiating power or the chemical action of their radiations was greatly increased. This does not arise from the continuous spectrum merely overlapping and apparently strengthening the water-vapour lines, since new groups of lines came into view which were too feeble to be visible on the other photographs. Sulphur is not the only substance which affects this spectrum; for instance, the banded spectrum of magnesia and the spectrum of lime also appear to intensify it.

It is probable that something similar takes place with regard to carbon; we know that the spectrum is modified by the surrounding nitrogen of the atmosphere, and the rays of carbon increase the intensity of the nitrogen rays adjacent to the carbon lines, the effect being increased in the case of the spark by a saturated solution of zinc or calcium chloride.

The facts here set forth certainly favour the view that the lines in Hartley and Adeney's spectrum of carbon are the lines of the element and not merely the edges of cyanogen bands. Finally, the carbon spectra of Eder and Valenta differs from that published in the *Journal* of the Chemical Society, vol. xli. p. 91; the graphite spectrum, No. 10, on plate ii., yields neither the group III. nor group IV. of cyanogen as depicted in spectrum No. 4 of the photogravure plate illustrating Eder and Valenta's paper.

"Experimental Determination of Poisson's Ratio." By C. E. Stromeyer.

The experiments with which this paper deals were carried out between the years 1883 and 1886 by Prof. Kennedy and the author, with an instrument which the latter had originally designed for measuring local strains in metal structures, but which proved itself to be so exceedingly sensitive that it was capable of being applied to the measuring of the cross contraction of test pieces while these were subjected to a longitudinal pull, thus providing the means for measuring Poisson's ratio direct.

The conclusions drawn from the experiments with nineteen samples are:—

(1) That Poisson's ratio is not a constant value for all materials.

(2) That mechanical treatment (cold rolling and annealing) of the metal alter it.

(3) That Poisson's ratio is sometimes a function of the stress.

(4) That Poisson's ratio, as found by direct measurement, is not the same as that found by comparing torsion and tension experiments.

May 24.—"Some Voltaic Combinations with Fused Electrolytes and Gaseous Depolariser." By. J. W. Swan.

In this paper are described several voltaic combinations in which fused electrolytes and a gaseous depolariser were used. The electrodes were the same in all the experiments, viz. lead in a fused state as the positive, and carbon as the negative. The electrolyte used in the first experiments was a fused mixture of KCl,NaCl, but this was changed for one of $PbCl_2$. The depolarising gas used in all the experiments was chlorine, and was so applied as to chemically act on the electrolytic products formed at the carbon pole. Several methods of applying the gas were employed: by forcing the gas through porous carbon, by making the carbon pole tubular and feeding the chlorine through it, and by nearly wholly surrounding the carbon pole by an atmosphere of chlorine.

The condition found to be most necessary for successful depolarisation was *to alternately expose the carbon pole to the action of the gas and electrolyte in rapid succession.* During the electrolytic action, the lead dissolves as chloride of lead, and lead is deposited on the carbon pole, but is immediately reconverted to chloride by the action of the chlorine gas. The theoretical E.M.F. corresponding to the union of Pb and Cl_2 is 1·7942 volts, the highest obtained was 1·40 volts, this lower E.M.F. was probably due to the incomplete solution of the lead at the carbon electrode.

A noticeable feature of this kind of cell is the very low internal resistance, which makes it possible to obtain a large current density with comparatively small electrodes. In one of the experiments a current of 1·0 ampère was given with an area of the carbon of 10 to 12 sq. cm. It was also observed that the internal resistance, and at the same time the polarisation, *decrease*, when the electrical output *increases*, and that the cell gave an almost constant effect. The best results were obtained with small cells, the action of the chlorine being then more effective than when larger cells were employed. Experiments were also made with oxygen as a depolariser, but a description of them is left for a future paper.

Physical Society, May 25.—Prof. A. W. Rücker, F.R.S., President, in the chair.—Prof. W. Ramsay, F.R.S., read a paper on the passage of hydrogen through a palladium septum, and the pressure which it produces. After referring to the analogy between osmotic pressure of solutions, and the behaviour of hydrogen and palladium, the author described the apparatus he had used in his experiments, and showed it in operation. A vertical platinum tube provided with a palladium cap is enclosed within a glass vessel through which hydrogen or other gases may be passed, and outside the glass vessel is a vapour jacket, by means of which a constant temperature can be maintained. The lower end of the platinum tube communicates through a graduated capillary tube, with adjustable manometer, which enables the volume of the enclosed gas to be kept constant. Great precautions were taken for ensuring purity and dryness of the gases used. After filling the palladium and platinum tube with dry nitrogen at atmospheric pressure and the desired temperature, hydrogen was passed through the glass vessel. Some of the hydrogen permeated the palladium walls, thus increasing the pressure inside. After some time (usually an hour or so) the pressure attained a steady value, and the total increase was then observed. Experiments were made with air, nitrogen, nitric oxide, nitrous oxide, carbon dioxide, carbon monoxide, and cyanogen in the palladium tube, and in some cases the hydrogen was diluted with nitrogen. In all cases the maximum pressure of the hydrogen within the tube was less than that of the hydrogen outside the tube, as will be seen from the following table, which shows the ratio of these pressures under various conditions:—

Gas originally inside tube.	Gas passed outside tube.	Temp.	Ratio $\frac{\text{Internal hydrogen pressure}}{\text{External hydrogen pressure}}$
Nitrogen	Hydrogen	280 C.	0·9053
,,	,,	335	0·8984
,,	,, 50°/o (rest N)	,,	0·9362
,,	,, 25 ,, ,,	,,	0·9344
Carbon Dioxide	Hydrogen	280	0·9621
,, Monoxide	,,	,,	0·9545
Cyanogen	,,	,,	0·9693

After the palladium had been used once or twice it became coated with mercury (vapourised from the manometer), and lost its permeable properties. It was found necessary to heat the tube to remove the mercury, and then dissolve off the oxide of palladium thus produced, after each experiment. The permeable nature of palladium was found to depend greatly on the temperature, for at 232° C. the passage of hydrogen was so slow that the internal pressure was still rising after ten days; at 330° the passage was very rapid. An attempt to use the apparatus for giving a continuous indication of the amount of hydrogen in coal-gas failed because the palladium did not retain its activity sufficiently long. Other experiments showed that nickel is impervious to carbon monoxide. In the latter portion of the paper the author discusses the various "so-called" explanations which have been given of the phenomena, but finds none satisfactory. Experiments on the absorption of gases by platinum and other metals are in progress with a view to the further elucidation of the subject. Mr. Mond thought the fact that rise of temperature accelerates diffusion, tended to confirm Graham's view that the gases pass through openings in the solid, for increase of temperature would widen any pores which might exist in the metal. The President inquired whether the author's argument against the possibility of palladium hydride condensing in the pores of the metal, because of its being unstable at the temperatures employed, would be affected by the fact of water being capable of existing in contact with glass at temperatures much above boiling point. In reply Prof. Ramsay said the President's suggestion might be true, but if so another condition must be fulfilled, viz. that the hydrogen molecules must be split up into the atomic or *nascent* state.—A paper on the relations of pressure, volume, and temperature of rarefied gases, by Prof. W. Ramsay, F.R.S., and Mr. E. C. C. Baly, was read by the latter. In the first part of the paper a historical summary of previous researches on the subject is given, and the chief sources of error pointed out. The method employed by the authors was to have two McLeod gauges connected with a pump, and arranged so that both could be trapped under exactly the same pressure. One of the gauges was surrounded by a vapour jacket at about 130 C., whilst the other was cold at about 13° C. After both were trapped, the hot gauge was allowed to cool and the readings of both taken. From these observations the coefficient of expansion of the gas used could be calculated. The experiments also served as tests of the reliability of the McLeod gauge under different conditions. For air and carbon dioxide the gauges proved quite unreliable, whilst for hydrogen they were very satisfactory. With carbon dioxide the surface condensation was so large as to make the observations worthless, but hydrogen suffered no condensation between pressures of 650 mm. and 0·000076 mm. Great difficulty was experienced in filling the gauges with pure hydrogen, but when accomplished the expansion was found to be normal ($\frac{1}{273}$) down to 0·4 mm. pressure, and diminished to $\frac{1}{300}$ at 0·07 mm. Oxygen, however, gave a coefficient of $\frac{1}{261}$ at 5 mm. pressure, $\frac{1}{250}$ at 2·5 mm., and $\frac{1}{233}$ at 1·4 mm. At 0·7 mm. its behaviour was most erratic, there being as much as fifteen times the amount of gas trapped in the gauge at one time as at another. This confirms C. Bohr's observations on the anomalous behaviour of oxygen about this pressure. For nitrogen the values of the coefficients found were $\frac{1}{300}$ at 5 mm., $\frac{1}{304}$ at 1·1 mm., and $\frac{1}{342}$ at 0·6 mm. At small pressures the elasticities of hydrogen, nitrogen, carbon dioxide and air increase with decrease of pressure, but in oxygen the reverse holds. Examining the consequences of this increase of elasticity in the light of the kinetic theory of gases the authors point out that it means an increase of internal energy, and suggest that this may be the the cause of phosphorescence in high vacua. The President announced that the discussion on the last paper would be taken at the next meeting, after proofs had been distributed to members.

Chemical Society, May 3.—Dr. Armstrong, President, in the chair.—The following papers were read.—The structure and chemistry of the cyanogen flame, by A. Smithells and F. Dent. The flame of cyanogen burning in air consists of an inner cone of a peach-blossom tint surrounded by a blue-grey mantle. With a small air-supply the only products of combustion in the interconal gases are carbon monoxide and nitrogen with small proportions of nitrogen oxides and carbonic anhydride; the quantity of the latter constituent increases as the air-supply increases. On igniting dry cyanogen—the flame being fed with dry air—and separating the two cones in the usual way, the outer cone becomes extinguished; this agrees with Dixon's observation that a mixture of dry carbon monoxide and air is not explosive.—The results of measurements of the freezing points of dilute solutions, by H. C. Jones. The author defends his work from Pickering's recent criticisms, and attacks Pickering's method of plotting the results of freezing point determinations.—The conditions in which carbon exists in steel, by J. O. Arnold and A. A. Read. The authors confirm the existence in steel of a carbide having the composition Fe_3C; it is isolated as a greyish-black powder from normal steel, and as bright silvery plates from well-annealed steel. A highly manganiferous steel contained a double carbide of the composition $Fe_7Mn C_3$.—The "cis" and "trans" modifications of tetramethylenedicarboxylic acid (1 : 2) and pentamethylenedicarboxylic acid (1 : 2), by W. H. Perkin, junr.—Hexamethylenedibromide, $BrCH_2 . CH_2 . CH_2 . CH_2 . CH_2 . CH_2 Br$, by E. Haworth and W. H. Perkin, junr. The authors have prepared chloromethoxypropane, $Cl (CH_2)_3 OMe$; this, when treated with potassium in benzene solution, yields a substance of the composition $MeO (CH_2)_6 OMe$, which is converted into hexamethylenedibromide on heating with hydrobromic acid.—α-Hydrindone and its derivatives, by F. S. Kipping.

Linnean Society, May 24.—Anniversary meeting.—Prof. Stewart, President, in the chair.—The Treasurer presented his annual report duly audited, and the Secretary having announced the elections and deaths during the past twelve months, the usual ballot took place for new members of Council, when the following were elected in the place of those retiring:—Dr. John Anderson, F.R.S., C. B. Clarke, F.R.S., Prof. J. Reynolds Green, Arthur Lister, and Albert D. Michael. On a ballot taking place for the elections of President and officers, Mr. Charles Baron Clarke, F.R.S., was elected President, and the officers were re-elected. The Librarian's report having been read, and certain formal business disposed of, the retiring President delivered his annual address, taking for his subject "The Locomotion of Animals, with special reference to the Crustacea." On the motion of Dr. D. H. Scott, seconded by Mr. Howard Saunders, a unanimous vote of thanks was accorded to the President for his able address, with a request that he would allow it to be printed.—The Society's gold medal was then formally awarded to Prof. Ernst Haeckel, of Jena, and was received on his behalf by Mr. W. Percy Sladen, who read a long and excellent letter of acknowledgment and thanks, which was prefaced by an expression of the writer's regret at his inability to come to England to receive the medal in person.

CAMBRIDGE.

Philosophical Society, May 14.—The Master of Downing College, Vice-President, in the chair.—Mr. S. J. Hickson exhibited a specimen of *Chelifer* from Celebes, showing a remarkable sense-organ on the coxæ of the last legs.—Mr. A E. Shipley read a note on *Filaria immitis*.—On variations in the larva of *Asterina gibbosa*, by Mr. E. W. MacBride. The larva of *Asterina gibbosa* when fully developed possesses five cœlomic cavities, a median anterior and two pairs of posterior cavities, which suggest a comparison with the similarly srranged spaces in the *Balanoglossus* larva, a suggestion which derives further support from the fact that in both cases the anterior cavity opens to the exterior by a pore situated on the left side, called the madreporic pore, in the *Asterina* larva. Two cases of a similar pore on the right side were recorded, but the variations described chiefly concern the more anteriorly situated of the paired cavities. The left of these forms the water vascular system of the adult. In one instance a pore was observed leading from it directly to the exterior, recalling the collar pore of *Balanoglossus*. The right usually remains rudimentary, but several instances are described of its presenting in greater or less degree the features normally exhibited by its fellow on the left. These variations are to be interpreted, taking into consideration the bilateral symmetry of Echinoderm larvæ, as atavisms.—On a new method of preparing culture media, by Dr. Lorrain Smith. The author described a method for preparing media suitable for the cultivation of bacteria. The principle of the method consists in the addition of a small percentage of alkali to fluids which contain proteid such as egg-white and serum of blood. The fluid is then heated to the boiling-point or over it in the autoclave. By this means it is converted into a clear transparent jelly. It is then a medium suitable for the growth of a large variety of germs.

PARIS.

Academy of Sciences, May 28.—M. Lœwy in the chair.—Observations of Brooks' comet, 1893, 6 (October 16, 1893), and of Wolf's planet (AX, 1894), made with the great equatorial of Bordeaux Observatory, by MM. G. Rayet, L. Picart, and F. Courty. Note by M. G. Rayet.—On solar faculæ, by Prof. George E. Hale. A rejoinder to some remarks by M. Deslandres on a paper published by the author in *Knowledge*.—Observations of the sun made at Lyons Observatory during the first quarter of 1894, by M. J. Guillaume. From the observations quoted, March shows a decided minimum of spot surface more marked than the minimum of November 1893; the maximum for spots was in August 1893, and for faculæ in May of the same year.—On four related solutions of the problem of the transformation relative to the elliptic function of the second order, by M. F. de Salvert.—On the limitation of degree for the algebraical integrals of the differential equation of the first order, by M. Autonne.—On the properties of groups of substitutions of which the order is equal to a given number, by M. E. Maillet.—On the integration of partial equations of the second order with two independent variables, by M. J. Beudon.—On uniform integrals of partial differential equations of the first order and *genre zéro*, by M. Petrovitch.—Variation of the surface tension with the temperature, by M. H. Pellatt. A mathematical paper leading to the conclusion that the surface tension is a linear function of the absolute temperature.—On the capacity of the capillary electrometer, and on the initial capacity of mercury, by M. E. Bouty.—Method for the direct measurement of electromotive forces in absolute value, by M. C. Limb. The method depends on the direct comparison of the unknown electromotive force with an induced electromotive force in a case where the latter may be calculated.—*Résumé* of meteorological observations made at Joal (Senegal) by the mission sent by the Bureau des Longitudes to observe the total eclipse of the sun on April 16, 1893. A note by M. G. Bigourdan.—On the detection of hydrochloric acid, by MM. A. Villiers and M. Fayolle.—A comparative study of the nitrobenzoic acids, by M. Oechsner de Coninck. The reactions of these acids with aqua regia, dilute chromic acid, dilute hydrochloric acid, dilute nitric acid, dilute alcohol, and acetone have been further studied. Just as was found for their physical properties, two of these acids yield similar reactions, and differ from the third.—On the constitution of licareol, by MM. Ph. Barbier and L. Bouveault. The formula adopted now for licareol is the following:—

$$CH_3 . C(CH_3) : CH . CH_2 . CH(CH_2OH) . C(CH_3) : CH_2.$$

Athough licareol has given nearly the same products of oxidation as geraniol, the corresponding aldehydes appear to be different, as they give compounds with para-amidophenol having different melting points. Licareol is active, geraniol is inactive, and may possibly be a racemic form of the alcohol.—On the melting points of some phenols and their benzoates, by MM. A. Béhal and E. Choay. A tabular statement.—On the rectification of alcohol, by M. E. Sorel—On the latex of the lacquer-tree, by M. G. Bertrand. The mechanism of the production of lacquer from the exudation from trees of the *Rhus* genus is demonstrated. It is shown that the oxidation of the substance *laccol* only produces the characteristic black insoluble lacquer in the presence of a diastase termed by the author *laccase*.—On parthenogenesis in the Sarcoptidæ. A note by M. E. Trouessart.—On the development of excretory organs in *Amphiuma*, by M. Herbert Haviland Field.—Utilisation of vintage *marcs*, by M. A Muntz. The wine retained by the *marc* is displaced mechanically by water in special cylindrical vessels, and yields a good quality wine practically undiluted. The residual *marc* after treatment is utilised as cattle food.

AMSTERDAM.

Royal Academy of Sciences, April 21.—Prof. van de Sande Bakhuyzen in the chair.—Prof. Schoute made a communication on the regular sections and projections of the hekatomkosædroid (Z^{120}) and the hexakosicœdroid (Z^{600}). The chief results can be gathered from the following table:—

Projections of	Z^{600}	*v*	42	52	56	44	*f*	Z^{120}
		e	120	130	150	120	*e*	
		f	80	80	96	78	*v*	Sections of
	Z^{120}	*v*	158	180	160	80		
		e	240	282	250	120	*e*	Z^{600}
		f	84	104	92	42	*v*	

The four columns of the above represent at the same time the number of vertices, edges and faces of the projections of Z^{600} and Z^{120}, and the number of faces, edges and vertices of the sections of Z^{120} and Z^{600}.—Prof. Kamerlingh Onnes communicated the results of measurements made by Dr. Zeeman in the Leyden laboratory, of the reflection of polarised light on the pole of a magnetised nickel mirror. The so-called null rotation changes its sign at the incidence of 26°, in accordance with Goldhammer's theory. Drude's theory gives a value of 60°.

BOOKS AND SERIALS RECEIVED.

BOOKS.—The Frog: Prof. A. Milnes Marshall, 5th edition (Manchester, Cornish).—Walks in Belgium—the Old Flemish Towns and the Ardennes: edited by P. Lindley (30 Fleet Street).—A Handbook to the Marsupialia and Monotremata: R. Lydekker (W. H. Allen).—A Handbook to the Birds of Great Britain: Dr. R. B. Sharpe, vol. 1 (W. H. Allen).—Flore de France: A. Acloque (Paris, Baillière).—The Camel, its Uses and Management: Major A. G. Leonard (Longmans).—The Country Month by Month: J. A. Owen and Prof. Boulger, June (Bliss).—Elementi di Fiscia: Prof. A. Roiti, vol. 2 (Firenze, Monnier).—An Introduction to the Study of Metallurgy: Prof. W. C. Roberts-Austen, 3rd edition (Griffin).—Électricité Appliquée a la Marine: P. Minel (Paris, Gauthier-Villars).—Étude Expérimentale Dynamique d'une Machine a Vapeur: V. Dwelshauvers-Dery (Paris, Gauthier-Villars).

SERIALS.—English Illustrated Magazine, June (London).—Zeitschrift für Physikalische Chemie, xiv. Band, 1 Heft (Leipzig, Engelmann).—Brain, Part 65 (Macmillan)—Natural History of Plants: Kerner and Oliver, Part 2 (Blackie).—Natural Science, June (Macmillan).—Longman's Magazine, June (Longmans).—Chambers's Journal, June (Chambers).—Good Words, June (Isbister).—Sunday Magazine, June (Isbister).—Beiträge zur Methodik der Erdkunde, Heft 1 (Halle a S.).—Humanitarian, June (Sonnenschein).—Century Magazine, June (Unwin).—Cassell's Magazine, June (Cassell).—Report of the Marlborough College Natural History Society, No. 42 (Marlborough).—Transactions of the Linnean Society of London, 2nd series, Zoology, Vol. vi. Part 2: The Subterranean Crustacea of New Zealand: Dr. C. Chilton (Taylor and Francis).—National Review, June (Allen).—Contemporary Review, June (Isbister).—European Butterflies and Moths: W. F. Kirby, Part 1 (Cassell).—Geographical Journal, June (Stanford).—Bulletin de l'Académie Royale des Sciences de Belgique, No. 4, tome 27 (Bruxelles).—Journal of Botany, June (West).—Fortnightly Review, June (Chapman).—Geological Magazine, June (K. Paul).—Encyklopædie der Naturwissenschaften, Erste Abthg., 68 Liefg.; Zweite Abthg., 77 to 82 Liefg.; Dritte Abthg., 16 to 21 Liefg. (Breslau, Trewendt).—Science Progress, June (Scientific Press, Ltd.).—Michigan State Agricultural College, Experiment Station, Bulletins 107-110 (Michigan).—Bulletin of the New York Mathematical Society, Vol. 3, No. 8 (New York, Macmillan).

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