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British Scientific Instruments.

THE exhibition of British scientific instruments held under the auspices of the Physical Society and the Optical Society at the Imperial College of Science and Technology, of which a description was given in our columns last week, is a timely reminder of the importance of scientific instruments in the national economy. Modern civilisation is based, and must be increasingly dependent, on the extension of scientific knowledge and its applications to industry; and in these developments scientific instruments are an essential and predominant factor.

Of the part played by scientific instruments in the advancement of scientific knowledge there is no need to speak. The laboratories of the universities and kindred institutions where scientific research is prosecuted would be disabled were they without scientific instruments of the highest trustworthiness and precision. The variety and extent of the industrial purposes served by scientific instruments are so great that there is probably no important industry in the country which is not dependent on scientific instruments of one kind or another for the performance of its productive functions. Moreover, the field of application of scientific instruments is constantly widening; the uses of the microscope in the textile and steel industries, of the polarimeter in the sugar and essential oil industries, of the pyrometer in the metallurgical industry, and of X-rays in the iron and steel industries, are but a few of the many examples that could be cited to illustrate the invasion of scientific instruments into fields of industry in which they were at one time unknown. That the industries gain in sureness and accuracy and in a deeper and wider knowledge of the fundamental scientific principles involved is obvious. And the process continues and must continue. To-morrow new instruments will be devised and new uses found for old instruments.

Moreover, as was stated in the leading article published in NATURE of February 10, 1921, the scientific instrument industry, springing directly from the loins of science, and progressing as scientific knowledge widens, is one of the most highly skilled industries we have. Its expansion means a definite increase in the numbers of academic and technical scientific workers and of the most highly skilled artisans; and the national wealth, in any comprehensive conception of the term, must be enlarged by the increase of the numbers of such educated and skilled classes.

For these and other reasons a flourishing and efficient scientific instrument industry is vital to the nation, whether in peace or war. And, although it is obvious that the users of scientific instruments, whether in the industrial or academic domain, must not be prejudiced or hampered by being unable to obtain the best instruments, from whatever source, it would be a disaster of the first magnitude if British scientific instruments should not be produced equal to the best that the world has to offer.

If in some classes British scientific instruments fall somewhat below the standard of foreign instruments, in others they are unquestionably superior. It would be invidious to particularise minutely, but the following statement by the manager of a British firm of optical instrument makers, writing in the *Morning Post* of October 1 last, may be given in illustration :—

"In connection with the manufacture of optical instruments for research, a search has been made throughout the premier journals of the world devoted to physical science for the years 1910 to 1914. In each of them, in the Proceedings and Transactions of the Royal Society and in the *Philosophical Magazine* (Great Britain); in the *Physical Review* and the *Astrophysical Journal* (United States); in the *Comptes rendus* (France); and in the *Annalen der Physik* (Germany), there were without exception more references to instruments made by my firm here in London than to those of any other makers whatsoever. In the case of the *Annalen der Physik* there were 50 per cent. more references to my firm than to any other, the firm mentioned next in order of frequency being a well-known German one."

Facts like these are not so widely known, even among British scientific workers, as they should be.

A statement—originally, it may be, true in substance—is made that a certain type of foreign instrument is superior to any other; the statement grows to a legend and lives long after changes and developments have rendered it false or, at least, misleading; and the British instrument has to overcome much inertia of prejudice and fashion before it can secure the recognition which its merits deserve. It would be well if the leading scientific users of instruments would review from time to time their judgments of the quality and performance of instruments, so that improvements in British instruments may receive early recognition and the British manufacturer not be prejudiced by a belated preference for foreign instruments.

The present condition of the British scientific instrument industry is gravely compromised by the abnormal state of the international rates of exchange. Whatever legislative measures may be employed to help the industry over a difficult period, there can be no doubt that the most potent means of promoting the production of British scientific instruments equal to the best that the world can offer—a matter in which manufacturers and users are alike concerned—lies and must lie in an intensive and extensive application of scientific research to the fundamental scientific problems and the current technique of the industry. Other countries, notably Germany and America, we may be sure, will not neglect this. The leading British scientific instrument manufacturers have recognised the primary and paramount importance of scientific research. The British Scientific Instrument Research Association was founded in 1918, and its third annual report, which was reviewed in NATURE of November 17 last, gave ample evidence of the value to the industry of such an institution. It is true that, as is stated in the fifth annual report of the Committee of the Privy Council for Scientific and Industrial Research, "research cannot be expected to produce results at short and regular intervals"; but the Association has already produced results of immediate practical application and of economic benefit to the industry without losing sight of the fundamental researches, necessarily slower in coming to fruition, on which the progress of the industry must be based. Nor should it be overlooked that the co-operative research of the Association not only does not supersede, but stimulates and assists, the research work of individual firms which are members of the Association.

Moreover, where the Association, in view of its duty to the pressing needs of the industry, is unable to explore all the by-paths of pure scientific research that are opened out, arrangements have been made for extra-mural researches in the universities or kindred institutions for the prosecution of these relevant but more remote investigations. It must be remembered, too, that the Association, as the scientific centre of the industry, provides a needed *liaison* between the manufacturers and users of scientific instruments in this country, so that, on one hand, the manufacturers may be more fully informed of the needs of the users, and, on the other, the users may better appreciate the limitations imposed on manufacturers by the nature of materials and industrial conditions.

If the manufacturers will follow with patience and persistence the path of scientific research on which they have already made significant progress, there is every reason to hope that British scientific instruments generally will be, as many now are, supreme.

The History of Zeeman's Discovery, and its Reception in England.

Verhandeligen van Dr. P. Zeeman over Magneto-Optische Verschijnselen. Pp. xv + 341. (Leiden: Eduard Ijdo, 1921.)

TWENTY-FIVE years ago Dr. Zeeman, working at Leyden in the laboratory of Prof. Kamerlingh Onnes, achieved the epoch-making discovery which is now so abundantly familiar to physicists. Almost simultaneously he was appointed professor of physics at Amsterdam. To celebrate these events a volume of his collected papers, bearing on this branch of magneto-optics, has been published, under distinguished editorship, with a portrait and a few editorial notes and minor corrections.

This is the volume under review. It is a tribute to Prof. Zeeman from his friends and colleagues, on the occasion of the twenty-fifth anniversary of the announcement of his discovery to the Amsterdam Academy of Sciences on October 31 and November 28, 1896. It has an introduction in Dutch, dated October, 1921, which is signed by H. A. Lorentz, H. Kamerlingh Onnes, I. M. Graftdijk, J. J. Hallo, and H. R. Woltjer.

In commending this volume I would say that no one need be deterred from attending to it by reason of ignorance of the Dutch language: for our Dutch friends, with their well-known consideration, are polyglot in their publications, and there is plenty of English as well as French and German in the book.

The volume being mainly one of historical and permanent interest, it seems fitting to receive it with acclaim and to supplement it by an account of the reception and speedy appreciation of the discovery in England. For in a quarter of a century a new generation of physicists has arisen, many of them so intently occupied with their own admirable investigations that perhaps the origin of much of our present knowledge of Nature is liable to be submerged. Especially may they fail to realise the anticipations of the great theorists, which enabled a little seed-fact to fit immediately into its cranny and quickly to develop magnificent blossoms.

As to its reception here, the beginning was extremely modest, and may be narrated thus: On December 24, 1896, there appeared in NATURE, vol. 55, p. 192, the usual report of a meeting of the Royal Academy of Sciences of Amsterdam, and in a paragraph abstracting a number of other communications to that society the following sentence occurs:—

"Prof. Kamerlingh Onnes communicated two papers: (*a*) by Dr. Zeeman, on the influence of magnetisation on the nature of the light emitted by a substance. Pursuing a hint given by Faraday, several experiments were tried. The principle was this: the light of the electric arc, being sent through a heated tube containing sodium vapour, is analysed by a Rowland's grating. The tube is placed between the poles of an electro-magnet. When acted on by the magnet, a slight broadening of the two sodium lines is seen, tending to show that forced vibrations are produced in the atoms by the action of magnetism; (*b*) by Dr. J. Verschaffelt on capillary ascent," etc.

This sentence, included in a long paragraph, was probably the first announcement in England; but it was so inconspicuous that it could scarcely have attracted much attention, had not Sir Joseph Larmor, this year's Copley medallist, been on the look-out for an effect of this kind. He had previously perceived that such a result was necessary theoretically; a fact which is demonstrated by, among other things, the following passage reproduced on p. 203 of his book, "Æther and Matter":—

"Each absorption line say of sodium vapour in a magnetic field will thus be more or less widened, and its main position also slightly shifted but only to a higher order of small quantities: and the same will apply to each line in the emission spectrum."

Larmor had indeed gone on to calculate the amount of displacement or broadening to be expected, and had found the effect too small to be observed; for, like everyone else at that time, he considered that the radiating body must be an atom or part of an atom with an $e/m=10^4$. So directly Zeeman got an effect, and found that the e/m was really of the order 10^7, Larmor perceived that, not the whole atom, but the charge only—the electron part of the ion, or an electron itself—was a free radiator, and wrote to me suggesting that I should examine and confirm the result. In a week I had done so, with such appliances as were to hand; though not without sufficient difficulty to make me realise the naturalness of Faraday's failure to see anything—he being wholly unguided by theory—and to admire the skill of Zeeman in detecting the effect.

Prof. Zeeman must soon afterwards have communicated his observations to the Physical Society of Berlin; for in NATURE, vol. 55, p. 347, is a translation of a short paper by him, dated from Amsterdam and thanking Prof. K. Onnes for his interest in the work.

The first official notice in England occurs in the Proceedings of the Royal Society for February 11, 1897, when a note by me entitled "The Influence of a Magnetic Field on Radiation Frequency" was received and read on the same day. It gives an account of my repetition of Zeeman's experiment and directs attention to Prof. Lorentz's theory of it, together with his brilliant prediction about polarisation of the modified lines, and its experimental verification (see Proc. Roy. Soc., vol. 60, p. 513). It is followed, on p. 514, by a theoretical note by Sir Joseph Larmor, in which he emphasises the "electron" aspect of the matter, and its reciprocal relation to Faraday's first magneto-optic effect. He also directs attention to previous memoirs by Helmholtz in 1893, and by Lorentz in 1892 and 1895, especially the former; and he cites p. 813 of his own splendid Memoir in Phil. Trans., A, 1894.

I also communicated a much longer article to the *Electrician* for February 26, 1897, vol. 38, p. 568, under the heading, "The Latest Discovery in Physics": an article which I should like to reproduce here, for I venture to say that portions of it are worthy of reference by anyone interested in scientific history. The freedom with which we all spoke of electrons and their motions in those days rather surprises me, seeing that the unit charge was not isolated and clinched until 1899. But, of course, the theoretical work of Dr. Johnstone Stoney and others had long preceded this date.

There was no excuse for not fully understanding the main perturbations of spectrum lines when once the idea of electrons revolving like satellites in regular orbits, obedient to astronomical laws, had been grasped; for Dr. Johnstone Stoney's remarkable paper, entitled "On the Cause of Double Lines and of Equidistant Satellites in the Spectra of Gases," was in my possession. (It will be found in the Transactions of the Royal Dublin Society for 1891, vol. 4, Series II., pp. 563–608.)

But the difficulty was that at that date we all—

except perhaps Larmor and Lorentz—thought of an electron as of something attached to an atom, making it an ion, in accordance with Faraday's electrolytic ideas; and the notion of a free satellite electron, inside the boundary of an atom, was of later growth. In fact, it was a development largely brought about by Zeeman's discovery.

Parenthetically I may remark that there is some risk of Dr. Stoney's contributions to science being overlooked, partly because the Transactions of the Royal Dublin Society are not so readily accessible as some other publications, and partly because he expressed himself in terms and ways not always in accordance with ordinary custom. Let me put on record here, therefore, that, at that early date, 1891, he examined dynamically the problem of satellite electrons perturbed from a simple orbit by unknown forces. He deals with elliptic, apsidal, and precessional motions, with periodic changes in each, and clearly depicts the double and treble and quadruple lines which would result.

He is not dealing with perturbations excited by some definite outside physical cause, such as a magnetic field applied to the source, but with the normal series of lines observed by spectroscopists—Balmer, Kayser and Runge, etc.; and the inference he draws is that many of the known groups can be accounted for on the analogy of astronomical perturbations. The problem he set himself is thus worded (p. 569):—

"We shall accordingly, for the present, regard certain points in the molecules of the gas as acting dynamically on an æther capable of receiving and transmitting only transverse vibrations, and we have to inquire what motions of these points within the molecules would impart to the medium the oscillations which correspond to the observed lines in the spectrum."

To return from this digression. Whether on account of my article in the *Electrician*, or because I had written direct to Prof. Zeeman (probably for the latter reason), he sent me the MS. of a finished paper of his, giving the experimental details and also his version of Lorentz's theory developed on equations like those of the Foucault pendulum; and this paper I at once communicated to the *Phil. Mag.* for March, 1897 (vol. 43, p. 226), adding a brief footnote to say that I had verified the author's results so far as related to emission spectra and their polarisation. This memoir is now reproduced as the first in the volume of Zeeman's collected papers just issued, and it is printed in four languages—Dutch, English, French, and German; but the English and other versions contain an appendix, not in the original Dutch, giving an account of the attempts made long ago by Faraday, and likewise a theoretical anticipation by Prof. Tait in 1875 (an anticipation based on Kelvin's general theory of magneto-optic rotation), together with the record of a contemporary failure experimentally to detect any such effect. This appendix also removes from competition some apparently similar but not identical observations made by a M. Fievez.

It is of interest to find that in this remarkable and fundamental paper by Prof. Zeeman the possible effect of solar magnetism on the sun's radiation is indicated as a subject for inquiry—a development afterwards so brilliantly followed up by Prof. Hale.

In May, 1897, I communicated another note to the Royal Society (Proc. Roy. Soc., vol. 61, p. 413), in which details of the appearance of the lines are given, and the curious complexity of some of them; also, which surprised me, a difference between the behaviour of the components of the pair of sodium lines. The red cadmium line was also examined, and other spark spectra. The substance of this paper is reported in NATURE, vol. 56, p. 237. And in the same month (on May 19) I exhibited the effect at the Royal Society soirée, as appears from the following entry in the Year-book for 1897, p. 119:—

"*Demonstration of Zeeman's Discovery of the Broadening of Spectrum Lines by the Action of a Magnetic Field on the Source of Light. Exhibited by Prof. Oliver Lodge, F.R.S.*

"Sodium lines produced by an oxyhydrogen flame between the poles of a powerful magnet are examined by means of a Rowland concave grating (the one with which Mr. George Higgs photographed the solar spectrum), and can be seen to broaden whenever the magnet is excited. A nicol or other analyser shows that the light of changed refrangibility is polarised, as it would be if the source of radiation consisted of revolving electrified particles whose motion is accelerated or retarded by magnetic lines of force through the plane of motion.

"Recent Observations.—By reason of reversals, the usual appearance of each sodium line is as if it were doubled; the magnetic field makes it appear triple, or even quadruple. A nicol properly oriented removes the magnetic effect. D_1 shows it more sharply than D_2. The new lines intrude into the middle, after the fashion of Newton's rings."

It may seem from this that the observation of doublets and triplets, as indicated by the theory, was made by me; but that I disclaim, as appears in the volume under review, p. 101, since, though I saw something like the real effect, I did not apprehend it clearly as a pure precessional effect (akin to that which Dr. Johnstone Stoney had worked out long ago), and was inclined to suppose that the magnetic acceleration and retardation of frequency, acting on a random collection of molecules, would be likely to cause a confused broadening (see the *Electrician* of February 26, 1897, vol. 38, top of p. 569). I was still too much influenced by the idea of random atomic motions, instead of precise electronic orbits.[1] The real effect, as perceived in advance by Lorentz and realised clearly by Zeeman, was much sharper and more beautiful than that, and my suspicion of a more complex or mixed effect was unnecessary; the simple Lorentz theory served, just as cited in that same article of mine in the *Electrician* (except that I made a slip and gave a value for the perturbed frequency which I correct in the second following issue, p. 643 of the same vol. 38. Some remarks on e/m, interesting from an historical point of view, will also be found in that issue, and an extremely short formulation of the theory, thus: "Magnetised change of centripetal force, $eHr\omega = mrd\omega^2$, whence $d\omega = eH/2m$." Here also is the record of a temporary slip about the sign of the effect, made by Zeeman himself, for he at first announced that the radiating particle was a *positive* charge).

At the same time, a pure doubling or a tripling, characteristic of a truly circular or elliptic orbit perturbed by an apsidal or a precessional motion, is not the last word; for, though this is the standard of simplicity, each line in the spectrum is liable to have peculiarities of its own, depending on the nature of the electronic orbit which is magnetically perturbed; and hence there is found, not indeed mere broadening, but a quadrupling, sextupling, and other varieties of effect, such as are now well known, but which I confess surprised me when first I saw their indications.

In the *Phil. Mag.* for December, 1897, is an important theoretical paper by Sir Joseph Larmor, "On the Theory of Magnetic Influence on Spectra, and on the Radiation from Moving Ions." Towards the end of this paper he deduces his fundamental expression for radiative power, as proportional to square of charge and square of acceleration. Non-radiation from charges moving at uniform speed *seems* to be indicated—which would be very convenient in making unperturbed atoms permanent—but unfortunately centripetal acceleration seems equally destructive to their constitution, were it not for the modern device of quanta.

In this same volume of the *Phil. Mag.* (vol. 44, pp 55 and 255) are two additional papers by Zeeman, also reproduced in the book under review, constituting the real publication of the occurrence of definite doublets and triplets in the magnetic field; and they are followed in this book by another one giving metrical results obtained photographically.

Photographic records of the effect were, indeed, tried for by other experimenters, though without success (see NATURE, vol. 56, p. 420). In NATURE, vol. 57, p. 173, however, Thomas Preston reports complete success, in Dublin, with a fine grating belonging to the Royal University of Ireland, mounted in accordance with Rowland's geometrical-slide design. But on p. 192 of the same volume a meeting-report shows that Zeeman had exhibited specimens of similar photographs at the Amsterdam Academy a month earlier; and he was now able to apply the photographic method to the obtaining of more exact measurements, as mentioned in the *Phil. Mag.* for February, 1898, p. 197. See also Preston, p. 325 of the same volume (vol. 45), by whom a plate showing the various appearances with great distinctness is submitted. A few pages further on (p. 348) is a communication, which still further emphasises complexities and individual peculiarities in the magnetised lines, by Prof. Michelson, who here begins to apply to them his remarkably powerful "visibility" test, which was first elaborated in the *Phil. Mag.* for September, 1892 (vol. 34, p. 280), as a sequel to his earlier more theoretical paper in April, 1891, and is now employed with such skill and brilliant success at Passadena to measure the diameter of stars.

In further papers by Zeeman the spectrum of *iron* is specially examined, and a lack of symmetry detected in some of its lines. And presently the resolving power of the Michelson echelon is pressed into the service for the further examination of details, with results which are described and expounded through the remaining 200 pages of this interesting memorial volume.

The extreme importance of Zeeman's great discovery, and the admirable way in which he worked it out with the inspiring theoretical assistance of Prof. H. A. Lorentz—so that theory and experiment went hand in hand, as it is to be wished they did more often—may be allowed to justify and excuse this somewhat personal welcome of its twenty-fifth anniversary by an English physicist.

OLIVER LODGE.

[1] Incidentally and generally, it cannot be unknown, but it seems to be sometimes overlooked, that every *regularity* tends to evade the equipartition of energy difficulty: for Maxwell's proof requires the motions to be not only interchangeable, but also completely random.

The Kaiser Wilhelm Institute.

Festschrift der Kaiser Wilhelm Gesellschaft zur Förderung der Wissenschaften zu Ihrem zehnjährigen Jubiläum Dargebracht von ihren Instituten. Pp. iv+282. (Berlin: Julius Springer, 1921.) 100 marks.

THE Kaiser Wilhelm Gesellschaft zur Förderung der Wissenschaften owes its origin to the action of certain leading industrialists

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connected with the principal chemical establishments of Germany who were concerned as to the future of science, and more particularly of physical science, in that country. In their opinion the German university system no longer sufficed to meet modern requirements in regard to research in abstract science, and they suggested to the All Highest the creation of an institution which should be wholly and exclusively devoted to research, and should be staffed by men of proved capacity to undertake its successful prosecution. They so far succeeded in impressing the Emperor with their views that he in his turn suggested to his memorialists, and to others who sympathised with them, that they should themselves find the money needed to endow and equip the contemplated institution, and, by way of showing his practical interest in the project, he further indicated what amounts the several industrial concerns, or their representatives, might be expected to contribute.

The society was duly inaugurated with all the pomp and ceremony which usually characterised any function or enterprise with which William II. desired that his name should be specially associated, and the occasion was further made memorable by the address which the late Prof. Emil Fischer then delivered.

The institution thus established at Berlin-Dahlem has now been in existence for ten years, and it has been thought expedient by those connected with its working to celebrate its "zehnjährigen Jubiläum" by the publication of a "Festschrift." By us a jubilee is usually understood to mean the celebration of a period extending over fifty years, corresponding to the Grand Sabbatical Year of the Jews, although there has grown up a certain laxity in the use of the term which is frequently held to denote a season or occasion of public festivity, which may or may not recur at stated periods. What were the precise reasons in the minds of those responsible for the management of the institution which led them to direct public attention to it at this particular time can only be surmised, for there is nothing by way of preface or introduction to the "Festschrift" to inform us.

The celebration of a jubilee after so short an interval as ten years, during half of which time the work of the society was seriously disturbed and hindered by the war, has, when we have regard to the unsettled condition of Germany, somewhat the appearance of a political move. It will not be forgotten that it was at the Kaiser Wilhelm Institute "for the Promotion of Science" that Geheimrat Haber made his experiments on poison gas, prior to the Battle of Ypres, which initiated a mode of warfare which is to the everlasting discredit of the Germans. We are not aware that the present Government has shown itself inimical to the interests of science; unlike Coffinhal, it has never pronounced "La République n'a pas besoin de savants." On the contrary, Germany realises that she owes too much to science during the last half-century, and especially during the critical years of the war, for her to be unmindful of its benefits. Whatever form of government she may ultimately adopt, she is too much beholden to science to neglect its claims, and there is no reason to believe that these claims will be less adequately met by a republic than by a monarchy. At the same time, it cannot be doubted that the impoverishment of the country will react disastrously upon the position and prospects of all institutions which, like the Kaiser Wilhelm Society, are dependent upon public funds or private munificence.

Although we are prepared to welcome every sign of renewed scientific activity in Germany, it cannot be said with strict regard to truth that this "Festschrift" is in any sense epoch-making. There is certainly nothing jubilant about it. It is divided into two main portions, one of which, consisting of thirty-three short papers extending in all over 243 pages, deals with natural science; the other, consisting of four papers, is concerned with the science of history, and is comprised within eighteen pages. Of the natural science papers the greater number relate to relatively small points of bio-chemistry; the others are about equally divided between subjects of pure and applied chemistry and physical chemistry. Among the contributors are Abderhalden, "Zur Kenntniss von organischen Nahrungsstoffen mit spezifischer Wirkung"; Armbruster, "Tiere als Tierzüchter—Eine Erklärung ihres Sozialismus"; Einstein, "Eine einfache Anwendung des Newtonschen Gravitationgesetzes auf die Kugelförmigen Sternhaufen"; Haber, "Uber Wissenschaft und Wirtschaft"; Carl Neuberg (who edits the volume), "Uber den Zusammenhang der Gärungserscheinungen in der Natur"; Prandtl, "Neuere Einsichten in die Gesetze des Luftwiderstandes"; and Stock, "Die Chemie des Leichtflüchtigen." Many of the papers are short historical summaries of the present state of knowledge on the particular point dealt with. Some of them, in fact, read as if they were amplified excerpts from university courses of lectures. Others are simply *réchauffés* of work which has been published in detail elsewhere.

The papers on the science of history comprise one by von Harnack on "Die Apokalyptischen

Reiter," and—curious association—two short notices relating to the Emperor William I. These deal with the Frankfort Congress of 1863, and with episodes in 1870 at Ems, and at Sedan. The notes of the conversation with the French Ambassador Benedetti at the former place (July 13 and 15, 1870), and with Napoleon III. at the latter place (September 2, 1870), are of historical interest, and are among the few papers of permanent value contained in the book.

The price of the brochure, which is issued in paper covers, is stated to be 100 marks, which, considering the present value of German currency, is not excessive, however significant of Germany's financial straits. The book is admirably printed on excellent paper, and is suitably illustrated. It does credit, in fact, to the eminent firm by which it is published. The war and its consequences have evidently had no detrimental effect on the typographical excellence of book production in Germany.

Fish Preservation.

Fisheries—England and Wales. Ministry of Agriculture and Fisheries. Fishery Investigations: Series 1, Freshwater Fisheries and Miscellaneous. Vol. 2, No. 1, *The Methods of Fish Canning in England.* Pp. 25. (London: H.M. Stationery Office, 1921.) 2*s.* 6*d.* net.

THE development of methods of preserving fish was a matter of national importance during the war, and the present account is founded on investigations started in that period. The fish used for canning are mostly surface-feeding and living fish, such as sprats (or bristling), sardines (or pilchards), tunny and bonito, herring and mackerel, the only other fish of any importance being the salmon caught in America on its migration to fresh water for breeding. Of British fish there is a great excess of herring in the normal fisheries, and, given suitable fishing gear, large quantities of sprats can also be obtained on all coasts. Mackerel are at times abundant, but there is little certainty of heavy catches year by year; pilchards are local to Cornwall, and the immature forms (sardines), so extensively tinned in France, Spain, and Portugal, are not caught in quantity. There was one British sprat cannery before the war, but herrings were put up at the great herring ports in oil or with tomato, the product being in some cases excellent. Excess sprats were generally used for manure, while herrings were salt-pickled and barrelled for export, the price being two or three for a penny. The latter is an "unspeakable" product, which has never found favour in this country, and fresh methods of preservation are urgently requisite for the utilisation of herrings as a cheap form of food. The markets, too, of Central and East Europe, which took most of this product, are disorganised, and it is doubtful whether they can ever be recreated, as there would seem to be a real improvement in Continental taste, brought about by the temporarily improved food conditions of the war.

The success of different kinds of fish as canned products depends largely on the fat which lies under the skin and between the muscles. Salmon is canned or frozen in air (dry frozen) on the Pacific coast almost immediately when caught, certainly before *rigor mortis* has set in; the same is, to some degree, true also of the Norwegian sprats (bristling), of which there are about eighty factories in operation. The difficulty in Great Britain is that no port has a herring or sprat season extending through more than three or four months, and a factory with modern appliances and trained packers cannot be run profitably for such a short season. The fish required at other times must be brought in by rail, and this doubles the cost, while the actual fish has passed through its *rigor* and is deteriorating. It would seem necessary to get the fish as fresh as possible and to discover some method of preservation in bulk for subsequent packing, the process being one which would in no wise alter its composition or flavour.

Experiments with brine freezing and subsequent cold storage are described, but difficulty was experienced in the caking of sprats into masses and the salting, due both to the small size of the fish and to an excessive cold-store temperature "just under 30° F." Both these difficulties might perhaps be got rid of, but the total cost of the actual freezing, storage, transport, etc., would probably average 3*d.* per lb., which only a first-rate product could bear. Unfortunately, British sprats, as at present caught, are shown to be by no means such a product, being indeed much inferior to the Norwegian. According to the tables, they varied in fat from 5 to 23 per cent., protein being 15 to 20 per cent., ash about 1·5 per cent., the rest being water, which, with fat, roughly forms 80·5 per cent. The problem is to catch sprats of the right composition for pickling. The English fish is winter and spring caught, while the Norwegian fishery is in summer and autumn. The reproductive cycle has doubtless something to do with the quality, but little is as yet known of the life-history of the English fish. The difference lies probably, not in the fat contents, but in other qualities, the winter fish being of inferior taste and texture. Clearly we must either continue to pack a second-rate product, or discover where our sprats go to in summer, invent methods of catching them, and finally adopt more "fastidious" methods of handling, all of which Dr. Johnstone clearly considers could be accomplished by further research. In contradistinction to the sprat our summer herring is said to be second to none.

After canning the flavour of the fish improves notably, the raw taste disappearing, the bones softening, and the flesh breaking easily; this is what is called "maturation," and the time required is from six months to as many years to give the best product. No suggestions or experiments to ascertain the cause of this proved satisfactory. It would not seem to be autolysis, for storage at a temperature of 37° C. did not hasten the process. Bacterial change is considered more likely, as spores can withstand a temperature of 150° C. if present in oil. Catalysis, however, cannot be ruled out, as the tin of the container is always to some degree dissolved. The whole question of "maturation" in respect to all canned foods is, as Dr. Johnstone says, "of huge practical importance—and of remarkable obscurity." It is certain that no commercial product can be stored for from three to six years and then sold cheaply.

The whole report is immature, in that the investigations were never made on a sufficient scale to be economically of value, and were prematurely closed down. It seems doubtful whether they can profitably be restarted until basal investigations, such as on the nitrogenous composition of the protein of fish in respect to phases of reproductive activity and to the formation of fat, are completed. On freezing and maturation the Food Investigation Board,[1] in the midst of other investigations, had been conducting researches for three years, but it is quite clear that there is plenty of room for less "directed" researches. Either the Fishery Boards should take up the whole problem, directly or through the Food Investigation Board, and vigorously prosecute it—even employing bounties if necessary—with a determination to create a new industry of value to an island nation, or drop it altogether. The Scottish Fishery Board made the export of salt herrings—in 1913 8,795,232 cwts. of value 5,331,042*l.*—a valuable British industry, by pursuing a consistent, steady policy through several decades. In the twentieth century Government officials seem to have little of the imagination required or to be afraid of the fluctuations of political affairs. They need not be, for surely these developments are national and not political, and such as "the man in the street"—and in the Commons—requires.

J. STANLEY GARDINER.

[1] See Report for 1920. (H.M. Stationery Office.) 1*s.*

Our Bookshelf.

The Microtomist's Vade-Mecum: A Handbook of the Methods of Microscopic Anatomy. By A. B. Lee. Eighth edition. Edited by Prof. J. B. Gatenby, with the collaboration of Prof. W. M. Bayliss and others. Pp. x+594. (London: J. and A. Churchill, 1921.) 28*s.* net.

THE new edition of this well-known work of reference has been completely revised by Prof. Gatenby, who has had the assistance of experts in various branches of microscopical technique, and the result is a volume which is practical, critical, and thoroughly up-to-date. Prof. W. M. Bayliss has rewritten the chapter on staining, and his concise account of the nature of staining and of differentiation gives a clear conception of the physico-chemical facts on which these processes are based. Dr. C. Da Fano has been responsible for the five chapters on neurological technique, which form 100 pages of the book and contain many suggestions drawn from his extensive experience. Dr. A. Drew has rewritten the section on Protozoa, which, in addition to the methods for fixation, staining, etc., gives an account of cultural methods for amœbæ; Dr. W. Cramer contributes a dozen pages on the micro-technique of fatty substances, including a useful summary of the methods to be employed in a complete histochemical investigation of fatty cell-inclusions; and Mr. J. T. Carter has revised the account of methods for the study of teeth and bone. The remainder of the work has been in Prof. Gatenby's hands, and the sections on fixation, chromatin, nucleoli, mitochondria, and the Golgi apparatus are especially noteworthy and helpful in suggestions; mention should also be made of the short account of methods of tissue culture *in vitro*, which, in the hands of Ross Harrison and his successors, have given such remarkable results. The last chapter has been written for the beginner and gives clear directions for carrying through the preparation of a whole mount of a Daphnia, for making sections of muscle or other tissue of a vertebrate, and for preparing a tadpole for serial sections.

Two recent methods for staining bacteria have been introduced to help those who may be doubtful whether certain bodies in tissue are or are not bacteria. Having gone so far, the editor might perhaps consider whether he could include in the next edition the methods for the study of spirochætes which zoologists nowadays frequently find it necessary to examine. Under Annelids a reference to the preparation and mounting of chætæ would also be a useful addition.

The editor and his collaborators are to be warmly congratulated on the production of this thoroughly sound and practical guide, useful alike to students and to research workers.

A French-English Dictionary for Chemists. By Dr. Austin M. Patterson. Pp. xvii + 384. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1921.) 18*s.* net.

THE present volume is a companion work to the author's "German-English Dictionary for Chemists," and is likely to meet with an equally favourable reception. A practical test, working through original papers in organic chemistry, inorganic chemistry, and technical (engineering) chemistry proved the usefulness of the dictionary; only on the engineering side were a few deficiencies found. Chemistry has several other sciences on its borders, and this is recognised practically by the inclusion of some biological and botanical terms. The addition of technical words from mathematics, geology, and engineering, with more words from physics, botany, biology, and medicine would widen the scope of the book without necessarily increasing its bulk. It is stated in the introduction that "words of the same or nearly the same spelling in the two languages are defined even when the meaning is exactly the same as in English." This appears to the reviewer as a defect; the space might be better utilised in the direction just indicated. Thus, taking a page (368) at random, out of seventy-eight words sixteen have identical spellings and meanings; of the remainder, twenty-one are practically the same, and the obvious translation is the correct one, such as *uniforme, unimoléculaire, uranyle, ultramicroscopique.*

Handbuch der Holzkonservierung. Edited by Ernst Troschel. Pp. xi + 540. (Berlin: Julius Springer, 1916.) In Germany, 18 marks; in England, 54 marks.

TWELVE authors, comprising engineers, architects, foresters, and professors, have produced this comprehensive text-book, which contains the result of the latest investigations until 1916, on the preservation of wood. The book is clearly written and well illustrated. It contains references to most of the literature that has been published on the subject, in English as well as in German, and frequently discusses processes and materials used in England, India, the United States, etc.

The matter is arranged as follows: After an introductory chapter on the structure, function, and growth of wood and its tissues, part 1 deals with the destruction of wood by fungi, animals, and other agents. Dry-rot caused by Merulius, Lenzites, and other fungi, and the numerous injuries due to insects and marine borers, are treated at considerable length. The second part discusses the methods that are actually employed in preserving wood. These are very numerous, and most attention is paid to the processes involving impregnation with antiseptics, applied with or without pressure. The materials and machinery used are described in detail. The history of the subject is illustrated by a list of all the substances that have been tried from 1700 to 1876, with the name of the inventor and mode of application in each case.

The third part is concerned with the care of wood put to use under various conditions, as in the open air, under water, inside houses, etc. The influence of moisture and the action of chemical preservatives on the strength and durability of timber are briefly treated, most reliance being placed on Janka's experiments at Mariabrunn. The fourth part is very practical, containing special articles by engineers on the problems connected with the maintenance and preservation of the wood used in mines, railways, telegraphs, docks, bridges, ships, houses, street-paving, etc. An appendix, pp. 498–540, gives a list, classified under forty headings, of the most important patents in connection with the preservation of wood that have been taken out in all civilised countries.

Liquid and Gaseous Fuels and the Part they Play in Modern Power Production By Prof. Vivian B. Lewes. Second edition. Revised and edited by John B. C. Kershaw. (The "Westminster" Series.) Pp. xiv + 353. (London: Constable and Co., Ltd., 1921.) 12*s.* 6*d.* net.

IN his revision of Prof. Lewes's work on liquid and gaseous fuels, Mr. Kershaw has adopted the plan, dictated in part, no doubt, by the need for economy, of inserting new matter in the form of footnotes collected at the end of each chapter. Thus when Prof. Lewes ventures upon a definition of an atom, we are referred to a footnote some five pages further on for more modern views on the subject; this becomes irritating. Substantial additions have been made to the first edition, which was reviewed in NATURE of December 5, 1907, p. 98, in the form of information relating to the manufacture and use of power alcohol, and in the appendices, which contain accounts of fuel oil burners and vertical continuous retorts for gas manufacture, as well as extracts of recent statistics of oil fuel burning.

The Fixation of Atmospheric Nitrogen. By Dr. Joseph Knox. (Chemical Monographs.) Second edition. Pp. vii + 124. (London: Gurney and Jackson, 1921.) 4*s.* net.

IN the revision of his useful little monograph Dr. Knox has added brief accounts of the Haber process and of ammonia oxidation. The statement in the preface that "comparatively little work of importance on the theoretical side has appeared since the first edition of this book was published" is scarcely justified, and the fact that, of the 169 references to the literature which are given, only about fifteen are of dates later than 1913 is not what one might expect. The account of the Serpek process, for example, is quite out of date, and no reference to Serpek's later publication is given. The book will no doubt prove as useful to students as the first edition, and is a readable introduction to a most important subject.

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.]*

Generalised Lines of Force.

LET me direct attention to a notable paper by Prof. E. T. Whittaker, in the Proceedings of the Royal Society of Edinburgh for November last.

It has often been discussed whether electric or magnetic lines of force were the more fundamental, and which might be regarded as the "cause" of the other; a discussion rather like the old controversy as to the direction of vibration in a polarised beam of light. Maxwell's theory satisfied the disputants by making both directions equally important.

In this paper Whittaker extends Faraday's theory of lines of force to electromagnetic activities in general, expressing the complex facts by aid of the space-time continuum of Minkowski, whereby any form of kinematics can be expressed as a sort of four-dimensional statics. The solenoids of Faraday are shown to be special cases of a more general kind of surfaces, called *calamoids,* which reduce to ordinary electric lines of force when the field is purely electrostatic, while they reduce to ordinary magnetic lines of force when the field is purely magnetic; so that the Faraday electric and magnetic lines are not two distinct and (as it were) rival things, but two limiting cases of the same thing. The essential solenoidal condition—strength inversely as cross-section—is retained if, instead of electric or magnetic force separately, the contra-variant $\sqrt{(E^2-H^2)}$ is employed, and if the cross-section is that of a calamoid.

Ordinary equipotential surfaces, whether electric or magnetic, are seen to be special cases of an "electro-potential" or "magneto-potential" [?ether-potential] surface, which reduces to one or other of them whenever the field becomes static. These electro-potential surfaces, in general, exist in the four-dimensional world of space-time; but when the field is static each surface is wholly contained within three-dimensional space, and is an ordinary equipotential surface.

The property of the Faraday lines of force, that they are everywhere perpendicular to the equipotential surfaces, is shown to be a case of the more general theorem that the calamoids are everywhere "half-orthogonal" to the electropotential surfaces; (half-orthogonality being the four-dimensional analogue of three-dimensional perpendicularity).

In electrostatics, the total strength of all the Faraday tubes which issue from a closed surface containing no electric charge is zero; similarly, in general radiation-fields, the total strength of all the calamoids which cross a closed surface is zero. This theorem provides an intuitive geometrical integration of the Maxwell-Lorentz equations of the electromagnetic field.

There are also elaborated generalised "divergence" and "curl" theorems, with a certain kind of absoluteness about them, since they are independent of the motion of any observer.

For much fuller and more trustworthy information Prof. Whittaker's paper must be referred to. He said something about it in Section A at the recent meeting of the British Association in Edinburgh, but I, for one, did not understand his meaning then, in the rush of Sectional procedure. The object of the present summary is merely to direct early attention to a paper which cannot be long overlooked.

December 28. OLIVER LODGE.

Units in Aeronautics.

WRITE the usual formula in aeronautics,

$$\frac{R}{S}=23\cdot7\left(\frac{V}{100}\right)^2, \text{ lb/ft}^2,$$

in the Hospitalier notation, and the practical airman recognises that the resistance R, lb, over a surface S, ft², is at the rate 23·7 lb/ft² at a normal velocity of 100 f/s; and so on for any other velocity V, on the law of the square.

The airman pays no heed to any units except his foot and pound, and he has no use for any of the elaborate explanations of Mr. A. R. Low.

The factor 23·7 will be the result of experiment in the air-channel, reduced for air of standard conditions of barometer and thermometer on the ground.

But the air density is never measured in any of these experiments, and it is doubtful if the measurement has ever been carried out in any aeronautical laboratory.

In the early history of the Royal Society "weighing the air" was a favourite research. Charles II. bet Buckingham fifty guineas to one he would demonstrate the compression of air in his hollow walking-cane; but the other story of the fish in a bucket of water cannot be traced further back than Whateley, who is supposed to have invented it.

The air density arises in the formula of the treatise on aerodynamics on the idea that the formula is the expression of Newton's assumption that the resistance is due to the impact of inelastic air particles, as if air could be treated as a cloud of dust; and then at an air density w, lb/ft³, or better for calculation in thermo-aerodynamics, at a specific volume the reciprocal $C=1/w$, ft³/lb, Newton's formula becomes

$$\frac{R}{S}=w\frac{V^2}{g}=\frac{V^2}{gC}, \text{ lb/ft}^2; \text{ or } \frac{R}{S}=2wh,\ h=\frac{V^2}{2g}.$$

In this treatment the Equation of Continuity is ignored; the air particles should stop dead and fall down in a heap at the foot of the aeroplane, to be swept up as dust.

Thus the mysterious factor 0·00237 of the treatise on aerodynamics is the equivalent of w/g, and with $g=32\cdot2$, f/s², this makes $w=0\cdot0763$, lb/ft³, $C=13\cdot1$, ft³/lb, so that this standard air bulks 13 cubic feet to the pound, in round numbers.

Another way of expressing the law is to write it in the equivalent form

$$\frac{R}{S}=\left(\frac{V}{H}\right)^2, \text{ lb/ft}^2,$$

so that H is the velocity at which normal resistance is 1 lb per square foot; then on the figures above $H=20\cdot5$ f/s, and this may be replaced by 20 in round numbers for practical calculation, making

$$\frac{R}{S}=25\left(\frac{V}{100}\right)^2.$$

Flying over the ocean the velocity would be expressed in knots, K, and with 12 knots the equivalent of 20 f/s the formula is

$$\frac{R}{S}=\left(\frac{V}{20}\right)^2=\left(\frac{K}{12}\right)^2, \text{ lb/ft}^2;$$

simple numbers easily remembered.

In all these calculations Perry's dictum must be respected: that the accuracy of a formula is only the accuracy of its most inaccurate part.

Here the index 2 of the velocity, adopted for simplicity of calculation, is the part most subject to doubt, and then at this rate of the quadratic law the above numbers, 23·7, 24, and 25, are all equally suitable; their discrepancy is wiped out by small variation of air density or height of flight.

The practical airman will pay no heed to Mr. A. R. Low's elaborate explanation of the units employed in absolute measure (NATURE, January 5, p. 12). He has no use for poundal or slug units—fearful traps for the unwary and cause of great confusion of thought—and with the conceit to imagine they will pass current in the whole cosmos. But the rigour claimed for them is beginning to crack and show flaws under the merciless scrutiny of the new relativity.

Mr. Low is here coming to the rescue of the unhappy examinee, at the mercy of the whim of the examiner's text-book, and of the rigour demanded for the language employed there, ignored by the practical airman.

Divergence of language is never to disappear, as it seems, between science and engineering. The engineer refuses to budge when he finds he can arrive at a correct result in practice, and he ignores the rigour prescribed in the examiner's text-book as something to be thrown at the head of the examinee in his *conquête des diplômes*. G. GREENHILL.

Staple Inn, January 9.

Space and Æther.

THE relation of space and æther has been a subject of controversy. Three-dimensional absolute space has been regarded, before Einstein, as filled with a substantial æther. It is unnecessary to conceive the four-dimensional space-time of the relativists as so filled. If space-time is empty, is space also empty?

It seems to me that the crux of the difficulty is a wrong assumption that space-time is four-dimensional. Space-time is neither four-dimensional nor three-dimensional, but is two-dimensional. The orthodox analysis of the objective world down to the three fundamental entities of matter, space, and time has been incomplete. That which we call space also involves time. That which we call matter also involves both space and time. Thus what we call matter, space, and time should further be analysed as matter-space-time, space-time, and time where matter, space, and time with their new signification are fundamental entities. It is in this new sense that I shall use them hereafter.

Æther is the synthesis of space-times. It is matter-space-time. A synthesis is a petrified motion. We do not perceive the motion of æther because it is petrified. The motion in a space-time is independent of motion from space-time to space-time along the string that is æther. The so-called velocity of æther is not a change of space, but a change of matter.

Æther, being matter-space-time, partakes of the nature of all three. It has the density of matter, the rigidity of space, and the motion of time.

Æther is matter-space-time of no mind. The synthesis of matter-space-times of observing minds may be called hyper-æther—filling an absolute four-dimensional universe. Relatively to matter, æther is absolute. Relatively to mind, hyper-æther is absolute. The real is neither relative nor absolute, but is relatively absolute.

Einstein found that space-time was four-dimensional and that the universe was four-dimensional, and therefore argued that space-time was the universe. Therein lies his fallacy. His space-time is the two-dimensional section of a four-dimensional universe. There are two factors in evolution: persistence of identity and change of structure. As space-time is two-dimensional, its identity persists in the evolution from a three- to a four-dimensional universe. And as the world character changes, the internal structure of space-time changes. Einsteinian relativity is an anarchy. It marks a process of revolution, but does not attain a new position of stability.

Logic is not absolute, but is relative. The laws of logic of an absolute three-dimensional world are not the same as those of an absolute four-dimensional world. To study an absolute four-dimensional world we need a new logic, a new arithmetic, a new geometry, a new mechanics, and also a new science dealing not only with time as arithmetic does, not only with space as geometry does, not only with matter as mechanics does, but also with mind. On the recognition that time, space, matter, and mind contribute each a dimension to the universe I have been able to base an analytical geometry of the universe.

Space, in the sense of the arena of the three-dimensional universe, is matter-space-time, and may be regarded as filled with æther. The Euclido-Newtonian space-time and the Einsteinian space-time are non-material. But the latter is a stage of travail for the evolution of the former into a space-time with a new internal structure. The claim of the relativists to have demolished Euclid and Newton argues a want of the sense of historic perspective. Man does not progress by demolishing, but by building on, his past.

S. V. RAMAMURTY.

Trinity College, Cambridge, January 5.

Anisotropy of Molecules.

DIRECT evidence that the molecules of gases are not spherically symmetrical and are anisotropic in their properties is furnished by the recent experiments of Lord Rayleigh, who has shown that the light scattered by molecules is, in general, not completely polarised when observed in a direction transverse to the pencil of light traversing the gas. The method used by Rayleigh, and by those who have repeated the experiments establishing this effect is a photographic one, the track of the primary beam of light as viewed through a suitably oriented prism of Iceland spar being recorded on a plate with long exposures. In view of the great interest of the phenomenon, it occurred to the present writer that it would be worth while to attempt direct *visual* observation and measurement of its magnitude. The chief obstacle is, of course, the extreme feebleness of the unpolarised part of the transversely scattered light. This has, however, been successfully overcome. By using the strongest possible illumination (sunlight), securing a perfectly black background, and very carefully screening the eye from extraneous light, it has been found possible to detect with dust-free air at atmospheric pressure the non-extinction of the track as seen through a nicol at any orientation. With carbon dioxide the effect is quite conspicuous, and visual determinations of its magnitude have been successfully made by Mr. K. R. Ramanathan working in the present writer's laboratory.

A very interesting question arises whether it is possible to establish the same effect by observations on the polarisation of skylight. As is well known, there is a marked defect in the polarisation of skylight in a direction removed 90° from the sun, which is, however, in the main, due to dust and condensed water-vapour in the atmosphere and the diffuse lighting up of the sky by self-illumination and by reflection from the earth's surface. It occurred to me that the elimination of the effects due to these disturbing factors does not present insuperable difficulties. The reflecting power of landscape (about 0·08 when covered by vegetation) is known, and its effect is therefore calculable. Dust and low-lying mists may be practically eliminated by making the observations on a bright, clear day at a high-level station, and the self-illumination of the sky under the same conditions is very small *in respect of wave-lengths near the extreme red end of the spectrum.* The residual effect of self-illumination in these circumstances may be computed with sufficient accuracy by the method used by L. V. King (Phil. Trans. Roy. Soc., A, vol. 212, 1913), the uncertainties due to the neglect of the curvature of the earth and other simplifying assumptions in the calculation being then of little importance.

In order to obtain material for testing these ideas I made observations on the forenoon of December 4 last from the summit of Mount Dodabetta, in the Nilgiris (8750 ft. above sea-level), the sky at the time appearing beautifully clear, free from cirrus clouds, and almost completely black when seen through a deep red filter. The weaker component of polarisation was found to have 13 per cent. of the intensity of the stronger component. Diffuse illumination of the sky is capable of explaining only a part of this, a weaker component of about 8 per cent. intensity being indicated by the calculations. The residual 5 per cent. must therefore be ascribed to molecular anisotropy, and this is in agreement with the laboratory determinations of Rayleigh.

Observations on the molecular scattering of light in *liquids* made by the writer also show an imperfect polarisation attributable to anisotropy. Experiments in the same direction on the atomic scattering of light in crystals are being made, and an attempt is also in progress to discover the existence of an effect indicated by Sir J. J. Thomson's theory (*Phil. Mag.*, October, 1920), namely, the dependence of the results on the frequency of the scattered radiation.

C. V. RAMAN.

210 Bowbazaar Street, Calcutta, December 19.

The Resonance Theory of Hearing.

MAY I reply to Dr. Perrett's letter (NATURE, December 29 last), in which he makes the objection to the resonance hypothesis that it does not explain how we perceive when there are two tones of the same pitch sounding simultaneously?

It seems to me that Dr. Perrett has made two slight errors:—

(1) There must be, he writes, one result, unique and without alternative, when the tracing of the combined wave-form of any two notes of the same frequency is submitted to Fourier analysis.

But surely this cannot be true; for example, if in one case the two tones are 256 vibrations per sec. from an oboe and a flute simultaneously sounded, the relative amplitudes of the overtones found by Fourier analysis would be quite different from those found for the same tone sounded simultaneously on a violin and a cornet. Not only would the amplitudes of the overtones differ in the two cases relatively to the fundamentals, but they would differ also relatively to one another.

(2) Dr. Perrett proceeds: "If the ear acts as a kind of practical Fourier's theorem, it can perceive only one fundamental tone. But we invariably judge of the pitch of a note by its fundamental tone. If, then, we hear at the same time two notes of pitch *n*, the ear must be able to perceive also at the same time two fundamental tones of frequency *n*—that is to say, it must be able to perform an analysis which is not in accordance with Fourier's theorem."

Surely Dr. Perrett has omitted in the above reasoning to take into account the existence of beats, overtones, and phases. If these did not exist, and if the ear could still tell whether one or more than one instrument were contributing to a tone, then the resonance theory would have met with a serious difficulty. But overtones do exist, and they are known to differ for different instruments, also for one instrument in different circumstances, *e.g.* the human voice when sounding various vowels. The resonance theory, in that it explains the perception of overtones, even when their intensity compared with the fundamental is small, also explains how we can tell whether two different instruments are contributing to a tone or one only. But there are other clues; for besides that given by overtones, which in accordance with the resonance hypothesis the ear might make use of, viz. (*a*) if there were beats, due to the two instruments not being exactly in tune, the observer might infer that two were sounding, and not one; (*b*) if the sound-waves from one instrument reached the observer's right ear a little earlier (or later) than they reached his left, whereas those from the other instrument had different time relationships, he might infer that there were two sources of sound, from the observation that the two sources did not occupy the same position relative to his own plane of symmetry; and (*c*) if the sounds from the two instruments did not begin and end together the observer might get information from this also. All these possible methods of observation are compatible with the resonance theory, and therefore it is quite unnecessary to assume that the ear must be able to perform an analysis which is not in accordance with Fourier's theorem. It seems to me, therefore, that Dr. Perrett's objection must fail on all the above grounds.

May I take this opportunity of describing a fresh piece of evidence in favour of the resonance theory? Helmholtz showed, from physical considerations, that the coefficient of "sharpness of tuning" should be inversely proportional to the "persistence" coefficient in the case of resonators responding to tones of different pitch. This relationship does not postulate any special form of resonator, but appears to be a general rule equally as applicable to an electrical oscillating circuit as to a stretched string. If, then, it could be shown that the ear obeys this rule, it would be presumably very strong evidence indeed for the existence of resonators in the cochlea. The following table, calculated from observations by Mayer (published in *Amer. Journ. Sci.*, January, 1894), shows that the necessary evidence exists:—

A Mean tone in vibs. per sec.	B Per cent. difference of tone required to stop disonance (tuning factor)	C No. of vibrations performed during a subliminal silent interval (persistence factor)	B×C Tuning factor multiplied by persistence factor.
128	12·70	1·78	22·6
256	10·00	2·06	20·6
320	9·45	2·19	20·8
384	9·07	2·18	19·8
512	8·45	2·37	20·0
640	8·15	2·54	20·7
760	7·82	2·68	21·0
1024	7·22	3·01	21·7

Since multiplying tuning factor by persistence factor gives values nearly constant for different resonators (the average error is less than 3 per cent.), as shown in the last column in the above table, the tuning coefficient must be very nearly inversely proportional to the persistence coefficient. That is, the ear behaves quantitatively as it ought to do if it contained resonators.

I find a correction is necessary in my letter to NATURE of January 5. "Tide production" on line 20 should read "tide prediction." H. HARTRIDGE.

King's College, Cambridge.

A Curious Physiological Phenomenon.

IN Prof. Graham Brown's comments in NATURE of December 22 last on the letter with the above title, he points out that "the peculiarity of the present movement is that it is in the same direction as the original one." In this it resembles the sensory phenomena of positive optical after-images. Now these are periodically repeated after fairly strong stimulation, and it seemed worth while to look for such repetition in the present case. This is easily found, merely by increasing the time during which the hand is pressed against the wall up to about a minute until the whole arm feels tired. The rise and fall described occurs as usual; after a brief pause the arm again rises somewhat less vigorously, and a third much weaker rise may follow. This succession of movements does not always occur. In fact, in my own case even the first rise occasionally fails for no apparent reason.

I have found these repeated movements in the cases of colleagues who were not informed in any way what to expect. I am not familiar with the physiological theory of fatigue, but to a physicist these alternations of rest and activity inevitably suggest the accumulation and discharge of potential energy. I do not know if physiologists can find place for a (? cerebral) mechanism by which a thwarted stimulus can store up "strain" energy of appropriate kind, which after a brief interval is discharged by fulfilling its particular motor or sensory function. Further accumulation and discharge might follow, something after the fashion of the successive residual charges and discharges of a Leyden jar.

If this be so, positive visual after-images may have a similar origin. As is well known, the intensity of sensations only increases by equal increments when the exciting stimuli increase by equal ratios; thus strong stimuli fail, so to speak, to produce their full effect; there is inhibition and perhaps a storing of "strain" energy. Afterwards liberated, may this give rise in the sensory case to after-images, or with motor mechanisms to these involuntary muscular movements?

It may be added that the phenomenon can be produced in the leg by standing on one foot and pressing the outer side of the other against a wall, then allowing the leg to fall to the vertical with the foot still clear of the ground; after a short pause the leg rises laterally again. Or if the lower leg is drawn back so that its calf (or Achilles tendon) presses upwards and backwards against the edge of a heavy chair, and is then allowed to fall, the knee involuntarily flexes again after a very brief interval. In this case there is (with me, at any rate) a strong tendency for the pressure against the chair to cause acute cramp in the biceps muscle of the thigh.

J. H. SHAXBY.

Viriamu Jones Physical Laboratory,
University College, Cardiff, December 30.

Structures and Habits Associated with Courtship.

MR. JULIAN HUXLEY's letter in NATURE of December 29 last upon the habits of courtship brings to notice some of the recently ascertained facts. From these he concludes that the conspicuous colours, patterns, and forms made use of in these displays and ceremonies resemble copulatory organs in being subservient to efficiency in securing union of the gametes, and that, therefore, the problem of their evolutionary origin is much simplified and similar to adaptive characters in general.

However, the argument that because they are thus used they are therefore adaptations for the purpose of producing sexual excitement is not justified. It may well be that each animal for display makes use of a bright coloration or conspicuous structure of which the evolutionary origin is governed by some other factor. The dog uses its hind limb to scratch its back, but who would say that back-scratching controls its evolutionary origin?

The fact that polygamy is especially associated with brilliant males, whilst in polyandry females are usually the more highly coloured sex, clearly shows that some other factor governs the evolutionary origin of these secondary sexual differences.

A few other antagonistic facts may be mentioned. In birds it is the rule for the sexes to be similar when they both take part in the rearing of the young, as in the partridge; whereas when the male takes no part, as in ducks, secondary sexual differences are common.

In relatively unpalatable animals the sexes are usually similar, whereas it is in palatable animals that the greatest secondary sexual differences are to be found. Butterflies and birds especially exhibit this distribution.

In predatory animals it is the rule for the sexes to be alike. Instances of differences in coloration between young and adults exactly similar to the secondary sexual differences are widely distributed in birds. Further special difficulties arise in the case of insects, in view of their low visual acuity and poor colour perception which probably precludes the female from ever seeing the colour and pattern of the male. Further, the study of their courtship shows that scent and motion (which tends to conceal colour and pattern) are the means chiefly used to promote sexual excitement.

It is generally agreed that destructive criticism should be accompanied by some alternative explanation, but columns for correspondence do not permit of lengthy expositions. I would, however, offer the explanation that the distribution of secondary sexual colorations is related to the vision of preyer and preyed-upon and the necessity especially to protect the female even at the expense of the male. This thesis is fully expanded in J. C. Mottram's "Controlled Natural Selection" (Longmans, Green and Co., 1914).

J. C. MOTTRAM.

Radium Institute, Riding House Street,
London, W.

Spontaneous Ignition of Peaty Soils.

I OBSERVE in NATURE of August 25 last (p. 811), which has just reached me, a letter by Mr. E. A. Martin entitled "The Generation of Heath Fires," in which the spontaneous ignition of peaty soils brought about by exposure to the direct rays of the sun is mentioned.

It may be of interest to remark that in this part of the world such examples of ignition of peaty soils are quite common when the soils, in addition to being exposed to the heat of the sun, are brought into a condition of extreme drought.

In certain parts of Cachar and Sylhet, where the conformation of the land is that of a series of rounded hillocks with intervening depressions, the depressions are filled with peaty deposits, often of considerable depth, known locally as "bheels." These bheels have been formed in the usual manner by the continued growth of vegetation in a place where water accumulates, and in the ordinary course of events are always waterlogged.

Many of the bheels have been brought into cultivation and planted with tea, and one of the greatest problems in connection with the cultivation of these areas has been the removal of the enormous amount of water which accumulates in such places during the rainy season, for, in addition to the fact that more than 100 in. of rain may fall on the area in the course of five months, much of the drainage-water from the surrounding hillocks finds its way into the bheels. To this end it has been a common practice to dig an exceedingly wide and deep drain along the lowest part of the bheel, which is generally near the centre, and to drain into this from the edges. In this way the excess water is got rid of in the rainy season, but there has been an attendant disadvantage, in that the bheels are often dried out completely during the dry season. This occurs to such an extent that the crop-yielding period is often unduly shortened, and in many places it is a common practice to block up the mouths of the drains at the end of the rains to prevent excessive drying-out and prolong the period of yield.

Further, during the dry period the bushes are pruned and the land hoed clean, and the area thus loses its protective covering of foliage and weeds.

In such circumstances, in which the dried-out area is fully exposed to the sun's rays, spontaneous combustion in the soil is of common occurrence, and the soil becomes uncomfortably hot to walk on even in heavy boots.

Many acres of tea have been killed out in this way, but no ignition of the bushes occurs above ground, and it is questionable if jungle fires ever originate in this way, for it is only in the exceptional circumstances outlined above that the phenomenon has been found to occur.

E. A. ANDREWS.

Indian Tea Association, Tocklai Experimental Station, Cinnamara, Assam, December 14.

Microscope Illumination and Fatigue.

MR. BARNARD's letter in NATURE of December 29 last, p. 566, is unusually dogmatic as a contribution to a scientific discussion. As the title of this correspondence indicates, the original letter was written, not so much to direct attention to a particular method as to a general principle, with the intention of increasing the comfort of workers who have to work long hours at the microscope. It appears that Mr. Barnard has arrived at the same principle independently, but in a case of this nature there is no excuse for withholding from publication a matter which affects the well-being of a large number of workers.

Mr. Barnard condemns the method employed, but perhaps without having given the system described an unprejudiced trial. The ultimate test of any method lies in actual practice. Before publication the resistance-controlled illumination was tested out completely within the limits stated, imposed by the use of light-filters and the nature of the work of this laboratory. Since Mr. Barnard brought up the question of the shift of the dominant radiation—which was irrelevant at the time—further tests have been made with the unscreened light (which is never used for critical work here), and it was found that there was no perceptible loss of resolution or colour differentiation with the lowering of the current. The shift of the dominant is thus not a cause for alarm. A further test showed that to produce equivalent results with neutral filters some eight or ten screens would have to be made, and even then the optimum for every small variation of staining or thickness of section could not be obtained. Such an outfit, with the large amount of experiment and adjustment necessary to get the screens even approximately right, would be quite out of reach of most workers, and could not be conveniently standardised. Further troubles enter with small alterations in the light source due to age and variation of voltage, the general illumination of the laboratory, and, not least, the personal equation.

H. J. DENHAM.

Shirley Institute, Didsbury, January 4.

Tin Plague and Arctic Relics.

REFERRING to the letter on tin plague in NATURE of December 15 last, it may be of interest to record that in the Museum of Fisheries and Shipping at Hull, among a number of Arctic and Antarctic relics, we have two tins, each about 6 in. in diameter, provided with a thin iron handle on the top soldered on to assist in carrying. These tins, according to the "Guide to the Museum of the Hull Literary and Philosophical Society," published in 1860, and confirmed by that society's minutes, were picked up, among other relics and stores left by Capt. Parry, on Fury Beach in 1825. They were found by Capt. (afterwards Sir John) Ross in 1831, who brought them away with him. Capt. Ross was picked up at sea in a boat by Capt. Humphreys, of the *Isabella*, a whaler of Hull, in 1833, and these relics, among others, were in the boat with him. They were brought to Hull and given to the Literary and Philosophical Society. Eventually this society's collection was handed to the Hull Corporation.

About ten years ago I was curious to know the contents of these two tins, and had them opened; one was found to be full of corned beef in excellent colour and condition, and the other contained pea-soup. Both seemed to be quite fresh, and my attendant sampled them and stated that they were quite good and sweet. He still lives. The soup and the meat are now exhibited in glass jars, and are still in good condition.

My object in mentioning these facts is to show that after being left in the Arctic between 1825–31, and then taken charge of for another two years by Capt. Ross, which means that they were more or less subject to Arctic conditions for eight years, and then having been in Hull for eighty years, the metal does not seem to have deteriorated in any way and it had had no effect upon the contents. Possibly this may be due to the fact that the tins were painted with a thick coat of yellow and green paint respectively, which may have prevented any "plague." If this is the cause, the circumstances may be of value on future expeditions of this character.

The Museum, Hull. T. SHEPPARD.

Inheritance of a Cheek-Mole.

PERHAPS the following case of the inheritance of a mole on the cheek for three generations may be interesting. Records do not go back any further, but, as the representative of the present generation is nineteen, it may be possible to see whether it is continued. The grandfather had a peculiar mole right in the middle of his left cheek. Of his children, two daughters both showed it in almost the same position. The sons did not, but one daughter of one son now has it. There are two boys and two girls in family, but it has appeared only on one girl.

G. W. HARRIS.

The Royal Automobile Club, London, S.W.1, December 25.

War Against Insects.[1]

By DR. L. O. HOWARD.

COUNT KORZYBSKI, in his recent remarkable book, "The Manhood of Humanity," gives a new definition of man, departing from the purely biological concept, on one hand, and from the mythological-biological-philosophical idea on the other, and concludes that humanity is set apart from other things that exist on this globe by its *time-binding* faculty, power, or capacity. This is another way of saying that man preserves the history of the race and should be able to profit by a knowledge of the past in order to improve the future. It is, indeed, this *time-binding* capacity which is the principal asset of humanity, and this alone would make the human species the dominant type of the vertebrate series. But, biologically speaking, there is another class of animals which, without developing the *time-binding* faculty, has carried the evolution of instinct to an extreme, and has in its turn come to be the dominant type of another great series, the Articulates, or the Arthropods. As Bouvier puts it,

> Man occupies the highest point in the vertebrate scale, for he breaks the chain of instincts and assures the complete expansion of his intelligence. The insects hold the same dominating position in the Articulates where they are the crowning point of instinctive life.

Unlike the Echinoderms and the Molluscs, which have retained their hard coverings or shells, and have therefore progressed more slowly—for, as Bergson says, "The animal which is shut up in a citadel or a coat of mail is condemned to an existence of half sleep"—Vertebrates, culminating in man, have acquired the bodily structure which, guided in man by the equally acquired intelligence, has enabled him to accomplish the marvels which we see in our daily existence. Moreover, the Articulates have in the course of the ages been modified and perfected in their structure and in their biology until their many appendages have become perfect tools adapted in the most complete way to the needs of the species, until their power of existing and of multiplying enormously under the most extraordinary variety of conditions, of subsisting successfully upon an extraordinary variety of food, has become so perfected and their instincts have become so developed that the culminating type, the insects, has become the most powerful rival of the culminating vertebrate type, man.

Now this is not recognised to the full by people in general—it is not realised by the biologists themselves. We appreciate the fact that agriculture suffers enormously, since insects need our farm products and compel us to share with them. We are just beginning to appreciate that directly and indirectly insects cause a tremendous loss of human life through the diseases that they carry. But apart from these two generalisations we do not realise that insects are working against us in a host of ways, sometimes obviously, more often in unseen ways, and that an enormous fight is on our hands.

It is difficult to understand the long-time comparative indifference of the human species to the insect danger, but even during the active lifetime of the speaker there has come a change. Good men, men of sound laboratory training, have found themselves able in increasing numbers, through college and Government support, to devote themselves to the study of insect life with the main end in view of controlling those forms inimical to humanity, and to-day the man in the street realises neither the number of trained men and institutions engaged in this work nor the breadth and importance of their results, not only in the practical affairs of life, but also in the broad field of biological research. The Governments of the different countries are supporting this work in a manner that would have been considered incredible even five and twenty years ago, and this is especially true of the United States and Canada, and scarcely less so of France, Italy, Japan, South Africa, and, at least until four years ago, Russia.

It may be worth while here, however, to point out that certain European countries are combining their studies of agricultural entomology and crop diseases under the term phytopathological studies, or an Epiphyte Service (*Service des Epiphyties*), as in France, and this is undesirable, since it obscures to a certain extent the great issue of insect warfare and divides the great field of economic entomology in a most unfortunate way. Let us hope that the movement will not grow. Let the entomologists co-operate with the pathologists, both plant and animal, wherever there is something to be gained by such co-operation, but let us keep the respective fields entirely clear.

The war against insects has, in fact, become a world-wide movement which is rapidly making an impression in many ways. Take the United States, for example, where investigations in this field are, for the time being, receiving generous Government support. Every State has its corps of expert workers and investigators. The Federal Government employs a force of four hundred trained men and equips and supports more than eighty field laboratories scattered over the whole country at especially advantageous centres for especial investigations. Also there are teachers in the colleges and universities, especially the colleges of agriculture, who are training workers in insect biology and morphology and in applied entomology both agricultural and medical.

[1] Abridged from the presidential address to the American Association for the Advancement of Science delivered on December 27, 1921, at Toronto.

All this means that we are beginning to realise that insects are our most important rivals in Nature, and that we are beginning to develop our defence.

While it is true that we are *beginning* this development, it is equally true that we are only at the start. Looking at it in a broad way, we must go deeply into insect physiology and minute anatomy; we must study and secure a most perfect knowledge of all of the infinite varieties of individual development from the germ cell to the adult form; we must study all of the aspects of insect behaviour and their responses to all sorts of stimuli—their tropisms of all kinds; we must study the tremendous complex of natural control, involving as it does a consideration of meteorology, climatology, botany, plant physiology, and all the operations of animal and vegetable parasitism as they affect the Insecta. We must go down to great big fundamentals.

All this will involve the labours of an army of patient investigators and will occupy very many years—possibly all time to come. But the problem in many of its manifestations is a pressing and immediate one. That is why we are using a chemical means of warfare, by spraying our crops with chemical compounds and fumigating our citrus orchards and mills and warehouses with other chemical compounds, and are developing mechanical means both for utilising these chemical means and for independent action. There is much room for investigation here. We have only a few simple and effective insecticides. Among the inorganic compounds we have the arsenates, the lime and sulphur sprays, and recently the fluorides have been coming in. Of the organic substances we use such plant material as the poisons of hellebore and larkspur, pyrethrum and nicotine; and the cyanides and the petroleum emulsions are also very extensively used. No really synthetic organic substances have come into use. Here is a great field for future work. Some of the after happenings of the war have been the use of the army flame-throwers against the swarms of locusts in the South of France, the experimental use against insects of certain of the war gases, and the use of the aeroplane in reconnaissance in the course of the pink bollworm work along the Rio Grande, in the location of beetle-damaged timber in the forests of the North-west, and even in the insecticidal dusting of dense tree growth in Ohio. The chemists and the entomologists, working co-operatively, have many valuable discoveries yet to make, and they will surely come.

All this sort of work goes for immediate relief. Our studies of natural control follow next. It is fortunately true that there are thousands upon thousands of species of insects which live at the expense of those that are inimical to man and destroy them in vast numbers; in fact, as a distinguished physicist, in discussing this topic with me, recently said: "If they would quit fighting among themselves they would overwhelm the whole vertebrate series." This is, in fact, one of the most important elements in natural control, and is being studied in its many phases by a small but earnest group of workers.

So far, while we have done some striking things in our efforts at biological control, by importing from one country into another the natural enemies of an injurious species which had itself been accidentally introduced, and while we have in some cases secured relief by variations in farm practice or in farm management based upon an intimate knowledge of the biology of certain crop pests, we are only touching the border of the possibilities of natural control. For an understanding of these possibilities we must await the prosecution of long studies.

Let us summarise. Few people realise the critical situation which exists at the present time. Men and nations have always struggled among themselves. War has seemed to be a necessity growing out of the ambition of the human race. It is too much, perhaps, to hope that the lesson which the world learned in the years 1914 to 1918 will be strong enough to prevent the recurrence of international war; but, at all events, there is a war, not among human beings, but between all humanity and certain forces that are arrayed against it. Man is the dominant type on this terrestrial body; he has overcome most opposing animate forces; he has subdued or turned to his own use nearly all kinds of living creatures. There still remain, however, the bacteria and protozoa that carry disease and the enormous forces of injurious insects which attack him from every point and constitute to-day his greatest rivals in the control of Nature. They threaten his life daily; they shorten his food supplies, both in his crops while they are growing, and in such supplies after they are harvested and stored, in his meat animals, in his comfort, in his clothing, in his habitations, and in countless other ways. In many ways they are better fitted for existence on this earth than he is. They constitute a much older geological type, and it is a type which had persisted for countless years before he made his appearance, and this persistence has been due to characteristics which he does not possess and cannot acquire—rapidity of multiplication, power of concealment, a defensive armour, and many other factors. With all this in view it will be necessary for the human species to bring the great group of insects under control, and to do this will demand the services of skilled biologists—thousands of them. We have ignored the insect group to a certain extent on account of the small size of its members, but their small size is one of the great elements of danger —is one of the great factors of their success in existence and multiplication.

Let all the departments of biology in our universities and colleges consider this plain statement of the situation, and let them begin a concerted movement to train the men who are needed in this defensive and offensive campaign.

What the Public Wants.

A Study of the American Museum of Natural History.

THE American Museum of Natural History probably stands at the head of those museums which set out to interest and attract the general public. In so doing it obeys the clauses of its Acts of Incorporation, but it obeys also the more imperative law of its continued life: to live, a museum, like everything else, must progress; to progress, it needs sustenance. The American Museum, being neither a Government museum, nor a State museum, nor a municipal museum, has to rely upon private endowment and subscriptions. The annual appropriation of the city is confined to the maintenance of the building, and is inadequate even for that purpose. To instal its exhibits, to send out its expeditions, to pay its staff, and to prosecute those scientific researches for which it is celebrated, the museum must arouse private individuals to that degree of enthusiasm at which they will part with their dollars. The mechanism is the enrolment of such individuals as members of various grades, and so successful is it that no less than 5556 members are now enrolled.

Of the numerous ways in which the museum appeals to this great public, and to the far greater public as yet only on the road to membership, we can mention here a bare selection. The most obvious, and the most characteristically a museum method, is the preparation of popular exhibits. The example set by our own Natural History Museum has here been left far behind. The present report furnishes two illustrations, which we are permitted to reproduce. Fig. 1 shows part of a group of the northern elephant seal, from a colony recently discovered on the island of Guadalupe. A small portion of the new Bryozoa group, which represents two square inches of sea-bottom magnified twenty-five diameters, is depicted on two-thirds that scale in Fig. 2. Groups of this latter kind, based on prolonged studies, and carried out with extreme technical skill, are among the most instructive, as well as the most fascinating, novelties. Then there are the larger series, such as the exhibit of the natural history of (modern civilised) man, projected by the Department of Public Health. We in England have done something in this direction, as witness the exhibits of food, of human parasites, and the biology of water-works at the Natural History Museum, but we have not formulated the conception of man in relation to his whole environment of to-day. Temporary exhibitions are useful as keeping a museum alive and attracting fresh sections of the public. Dr. Lucas, the director, does not favour the expenditure of curatorial energy on these, but when they are installed by outside bodies, as the wireless telephone display or the posters teaching kindness to animals, it is only space that he grudges. During 1920 all this activity in the exhibition galleries attracted 937,265 visits (exclusive of attendance on lectures), which compares favourably with the corresponding totals of 851,483 at the British Museum (Bloomsbury), and 527,701 at the British Museum (Natural History).

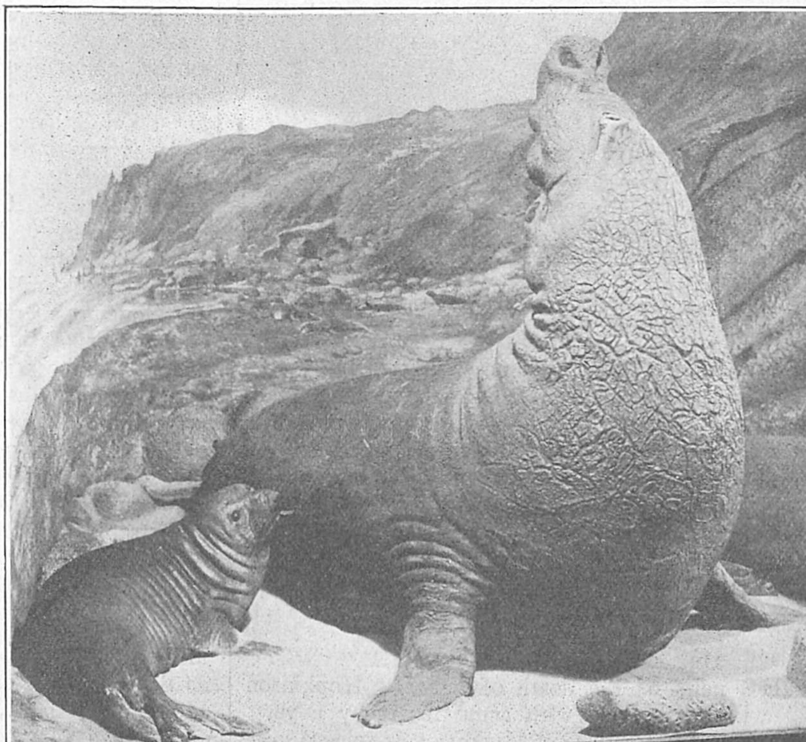

Fig. 1.—California sea-elephant group. By the courtesy of the American Museum of Natural History, New York.

This number, however, does not represent half the people reached by the popularising and educational work of the American Museum. Forty-eight societies have been welcome to hold meetings, exhibits, or lectures in the meeting-rooms of the museum during the year. Lectures have been given to school children and adults by a special department of public education co-operating with the City Board of Education. This increases the number of visits by 100,750. This department also carries its lectures to the schools themselves, lends lantern-slides by myriads, and circulates 887 special collections among schools and libraries. The number of pupils reached by this outside work cannot be less than a million.

To this direct appeal of the museum specimens the publications are supplementary. Confining our attention to those of educational character, we find, as elsewhere, guides, handbooks, and leaflets, for use primarily in the museum. But reaching far beyond its walls is the well-known Journal of the museum, now issued as a bi-monthly under the title *Natural History*. A copy of this is received by every member, and additional subscriptions amount to 1,570 dollars. The circulation may therefore be taken as well over 6000. Besides its own publications, the American Museum avails itself of the newspaper Press, and by the steady contribution of interesting paragraphs obtains valuable advertisement.

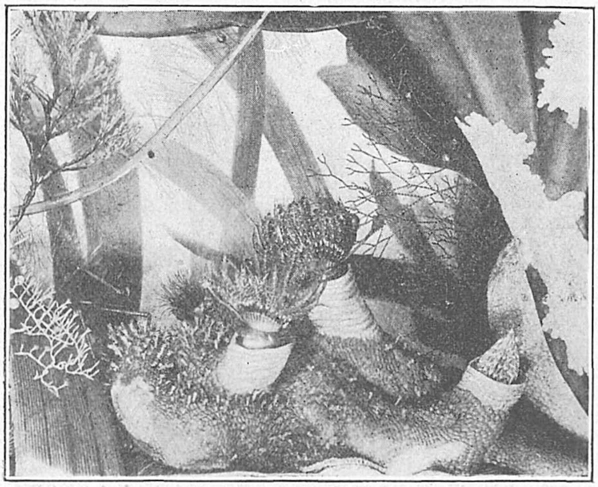

FIG. 2.—Bryozoa group: detail. By the courtesy of the American Museum of Natural History, New York.

We have by no means finished with the ways in which the American Museum increases its membership and otherwise raises its funds. There is, for example, the luxuriously furnished members' room "near the elevator" (Natural History Museum, please note!), and there is the exchange of membership privileges with other museums. But enough has been said to show that all the energy is spent on lines that are productive, and that fact explains how it can be done. In the larger cities of our own country circumstances are not the same. There are limited appropriations for definite purposes, and the governing body, whether municipal or bureaucratic, is not going to take risks with the taxpayers' money. Possibly some of our museum officials rejoice that they do not have to spend their time beating the big drum, and prefer to devote most of their energy and the services of their museums to the advancement of learning rather than to its vulgarisation. Research, they say quite rightly, must come first. None the less, there are features in the educational work of the American Museum which could and should be imitated by more of our Government museums. With them, as with the private corporation of the American Museum, the question reduces itself to one of business. Additional officers must be appointed in charge of these activities, and these officers must be paid. But the public is ready to pay for what it wants, and the case of the guide-lecturers has shown that the Government will respond to intelligently directed and strongly enforced public opinion

Obituary.

DR. EDWARD HOPKINSON, M.P.

THE news of the death of Edward Hopkinson will be received with acute regret by a very wide circle of friends in all branches of science and engineering. Since the General Election of 1918, when Dr. Hopkinson became Member for the Clayton division of Manchester as a Unionist, he was the victim of repeated attacks of influenza, for want of a better name, and was little seen in London; gradually failing, he died on Sunday, January 15, at the age of sixty-two years.

Dr. Hopkinson was the fourth among five sons in a Manchester family, peculiarly united and brilliant, belonging to an aristocracy of industry. His father, John Hopkinson, sometime Mayor of Manchester, was of the firm of Wren and Hopkinson, mechanical engineers, who constructed the machinery for grinding the glass for Chance's lighthouses, a successful demonstration of science and higher industry. His mother, always the true focus of the family, was a Dewhurst of Skipton. The Wills's of Bristol were relatives. The eldest brother, John, the great electrician, whose work was cut short by his untimely death in the Alps, is nobly commemorated in Cambridge; he started on his work as Senior Wrangler. The next brother, Sir Alfred Hopkinson, K.C., of Lincoln College, Oxford, formerly a Member of Parliament for a division of Manchester and for the Cricklade division of Wiltshire, who is still active, had a distinguished legal career, was principal of Owens College, and first vice-chancellor of the University of Manchester. The third son, Charles, a consulting engineer, who died recently, was the trusted counsellor of the whole family. Albert, the youngest brother, of Emmanuel College, Cambridge, became a successful medical practitioner in Manchester, and is now back again in Cambridge as a teacher of anatomy. Of the next generation, Bertram, the lamented head of the Engineering School at Cambridge, lost his life in a flying accident in 1918, and Austin, a successful manufacturer and M.P., is a very vigorous controversialist in social questions. These different distinctions merely represent prominences of characteristics which all shared.

Edward Hopkinson was born in Manchester, and, after completing the course at Owens College, joined Emmanuel College, Cambridge, as scholar, was ninth Wrangler in 1881, and D.Sc. of London in the same year. He became a fellow of Emmanuel in 1883. He began his fellowship by installing electric light in the hall and chapel for the tercentenary of the college in the following year, and thus anticipated by a few weeks the installation which Lord Kelvin introduced into Peterhouse. He was first with Siemens Brothers, and was resident electrician for the Portrush and Bushmills Railway and the Bessbrook and Newry Railway. He afterwards joined the firm of Mather and Platt when they began electrical work, and ultimately became vice-chairman of the company. He carried out the scheme for the City and South London Railway, and while engaged upon industrial work of that kind he joined his brother John in a paper on dynamo-electric machines in the Transactions of the Royal Society, a paper which speedily became classical. Thereafter he was engaged in electrical and engineering work which brought him into contact with all the active electrical and engineering experts of the country. During the war he was engaged in India on the Indian Industrial Commission. He was president of the Institution of Mechanical Engineers in 1919, but not well enough to deliver the presidential address which he wrote for that body.

Electricity and machinery were not Dr. Hopkinson's only interest; like other members of his family, he was deeply and sanely interested in social questions, and his latest writings are to be found in letters to the *Times* and *Morning Post* on financial matters. Like all the rest of his family, too, he was a keen Alpine climber and member of the Alpine Club, and, like so many climbers, was a remarkably genial host and an ever-welcome guest. He lived in an atmosphere of business, science, and common sense, to which access was easy on account of his family associations; but he contributed his own full share to its maintenance, and the loss of his knowledge and experience is a grave misfortune. He and his brother Charles married sisters, the daughters of John Campbell, of Whiteabbey, near Belfast. His wife survives him. They have one son, formerly an officer in the Army, who is now devoted to anthropology at Cambridge, and a daughter.

NAPIER SHAW.

SIR WILLIAM MATTHEWS, K.C.M.G.

THE civil engineering profession has lost an eminent personality by the decease of Sir William Matthews, who died on January 8 at the age of seventy-eight. From the obscurity of a little Cornish town he rose in the practice of his profession to become the trusted consultant of Government authorities on the most important harbour undertakings in the Empire. His name will long be associated with the annals of harbour construction, and substantial breakwaters in various parts of the world remain as a testimony to his engineering skill. The firm of Coode, Matthews, Fitzmaurice, and Wilson, of which he was until lately the senior surviving partner, have acted as technical advisers to the Admiralty, the Board of Trade, and the Crown agents to the Colonies. At home they were chief engineers for the National Harbour at Dover; abroad they have been consulting engineers for similar undertakings at Gibraltar, Malta, Cyprus, Colombo, Singapore, and Hong-Kong. They are also consultants to several Colonial Governments, the Mersey Conservancy, the Humber Conservancy, and the Tyne Commissioners.

Sir William Matthews was a native of Penzance, where he was born in March, 1844. He served part of his apprenticeship in an engineering works at Hayle, a few miles away. Afterwards he entered the office of his father, who practised as a civil engineer in Penzance. There in 1864 he came under the notice of the late Sir John Coode, who had been called in to advise the Corporation of Penzance. The young assistant was employed to make a survey of the harbour, and acquitted himself so creditably that Sir John took him into his office in London, and ultimately in 1892 into partnership.

The value of Sir William Matthews's services to the Government gained him the C.M.G. in 1901, and the K.C.M.G. in 1906. In 1907 he was elected president of the Institution of Civil Engineers. He became a member of the International Commission on the Suez Canal in 1908, and during the later portion of his career served on a number of committees of public and scientific utility.

COL. CHARLES EDWARD CASSAL, who died on December 22 last, in his sixty-fourth year, was public analyst for the Metropolitan Borough of Battersea, the Royal Borough of Kensington, the Parts of Holland and Kesteven (Lincs), and Chipping Wycombe (Bucks), and joint public analyst for the City of Westminster. He was educated at University College School, and received his professional training at University College, London, where he was demonstrator in the department of hygiene and public health from 1879 to 1888. He was a fluent and forcible speaker, and, having qualified, by examination, for the fellowship of the Institute of Chemistry, he took a prominent part in the discussions relating to the interests of his profession, particularly those of public analysts and official agricultural analysts. Col. Cassal served on the council for six periods of three years each, and as a censor for one year. He frequently accompanied deputations from the institute to Government departments. For fifteen years he was editor of the *British Food Journal*, to which, as well as to other journals, he contributed many articles on the chemistry of food and drugs, on water supplies, and on sewage treatment and disposal.

WE regret to have to record the death of MR. B. P. LASCELLES, who was a science master at Harrow from 1885 to 1901. His great success as a teacher rested on his unbounded interest in everything which appealed to him. It was not enough for him to know about dyes; he made them and coloured his own ties to his fancy! That was in the early days of the synthetic industry. Such interest is contagious, and so he firmly established the Harrow Scientific Society, as he had helped to found the Junior Scientific Society at Oxford. Though a chemist by training—he was a fellow of the Chemical Society—his activities were at least as wide as those of the British Association, of which he was a keen supporter. His knowledge of palæontology and of archæology was deep. Few indeed were the branches of learning along which he could not guide a young inquirer, so he fulfilled perfectly the offices of librarian and curator of the school museum. The municipal life of his adopted town and county owe much to Mr. Lascelles, whose many friends will ever remember his genial personality with gratitude.

PROF. W. FOORD-KELCEY, professor of mathematics at the Royal Military Academy, Woolwich, since 1903, died on January 3 at the age of sixty-seven. He was a scholar of Exeter College, Oxford, and obtained a First Class in the Final Mathematical School in 1877. He joined the Royal Military Academy as instructor in mathematics in 1878; later he was called to the Bar, and for a time combined legal work with teaching, but eventually gave up the former. Altogether, Prof. Foord-Kelcey was at the Academy for forty-three and a half years, and nearly all serving gunner and sapper officers knew him. He was a man of great ability with brain, hand, and eye, being a first-rate practical mechanic. He had a wide knowledge of mechanism, and retained his interest in the teaching of mechanics to the last. He was due to retire in the summer of this year, and in him the Royal Military Academy has lost a great personality.

FATHER GIUSEPPE LAIS, S.J., whose death in Rome was recently announced, was born in Rome in 1845. He was the author of a very long series of papers dealing with meteorology, both mediæval and modern, solar eclipses, comets and meteors, and astronomical photography. He published some little-known meteorological records of the sixteenth and seventeenth centuries. He took a deep interest in the astrographic chart, and published researches on the best methods of measuring and developing the plates. As vice-director of the Vatican Observatory since 1903 he has had a large share in taking the plates of the zone allotted to that observatory. He was also interested in the question of calendar reform, publishing papers on this subject in 1892 and 1901. Father Lais was for many years vice-secretary of the Accademia dei Nuovi Lincei, Rome.

WE regret to announce the death on January 15, in his ninetieth year, of SIR JOHN KIRK, G.C.M.G., K.C.B., F.R.S., chief officer and naturalist of Livingstone's expedition to the Zambezi in 1858–63, during which he made large collections and many observations of great scientific value. He was the author of numerous contributions to the botany, zoology, and geography of Eastern tropical Africa.

WE regret to see the announcement of the death on January 8, at eighty-six years of age, of PROF. J. H. COTTERILL, F.R.S., formerly professor of applied mechanics, Royal Naval College, Greenwich.

Notes.

THE gold medal of the Royal Astronomical Society has been awarded to Dr. J. H. Jeans for his contributions to theories of cosmogony.

M. RAYMOND POINCARÉ, who has succeeded M. Briand as Prime Minister of France, held that office in the years 1911–13, and was President of the French Republic in 1913–20. He is a brother of M. Lucien Poincaré, the distinguished official head of the University of Paris, who died nearly two years ago, and a cousin of the great mathematician and philosopher, Prof. Henri Poincaré, who died in 1912. In 1914 M. Poincaré was elected Lord Rector of the University of Glasgow, and in November, 1919, he delivered an inspiring address on Franco-Scottish unity to an assembly of four thousand students and other members and friends of the University.

THE Strangers' Hall, Norwich, an interesting old city merchant's house, with groined undercroft, fifteenth-century banqueting hall, and other panelled rooms of later date, has been offered by its owner, Mr. Leonard G. Bolingbroke, to the Corporation of Norwich for the purpose of an English Folk and Historical Museum, in conjunction with the Norwich Castle Museum. Mr. Bolingbroke has also offered his collection of old domestic appliances and other "bygones" illustrative of the various phases of a middle-class Englishman's home during the last four or five centuries, which will find a fitting environment in the various rooms of the house. While the aim of the museum will be historical rather than scientific, there will be found many exhibits of interest to students of the early history and development of such subjects as the production of light and fire, domestic cookery, and other kindred objects.

THE annual meeting of the Institute of Metals will be held in London on March 8–9, when ten important papers are to be presented for discussion. The annual May lecture will be delivered on May 3 by Sir Ernest Rutherford on "The Relation of the Elements." The autumn meeting will be held at Swansea on September 20–22. A large gathering is expected in this important metallurgical centre, and the Mayor and corporation have extended a very hearty invitation to members of the institute. Last year the membership of the institute increased from 1298 to 1410—a record year's growth. Such an increase, occuring during a year of great trade depression, indicates that makers and users of non-ferrous metals and alloys are on the alert to take advantage of the scientific information obtainable through association with the institute that exists to foster their interests. It is largely through the adoption of more scientific methods of manufacture that the British manufacturer will be able successfully to meet foreign competition, and it is just here that invaluable service is being rendered by our scientific institutions.

THE officers of the Ramsay Memorial Fund announce that the Dean and Chapter of Westminster have consented that a tablet containing a medallion portrait of Sir William Ramsay should be placed in Westminster Abbey in the place immediately below that occupied by the Hooker tablet. The tablet is being executed by Mr. Charles Hartwell, A.R.A. It is anticipated that the unveiling will take place in October next. An announcement will be made on the subject in due course. At the request of the Ramsay Memorial Committee a commemorative medal of the late Sir William Ramsay has been executed by the distinguished French sculptor, M. Louis Bottée. The medals will be struck shortly in London when it is known approximately how many will be required.

ON January 2 occurred the centenary of the birth of Rudolf Julius Emmanuel Clausius, the distinguished mathematical physicist and the predecessor of Hertz in the chair of natural philosophy at Bonn. The son of a pastor and schoolmaster, Clausius was born at Koslin, in Pomerania, and after attending the gymnasium at Stettin, spent four years at Berlin, where he studied under Dirichlet, Steiner, Dove, and Magnus. Before going to Bonn he held appointments at the Royal Artillery School, Berlin, Zürich Polytechnic, and Würzburg University. Recognised as one of the founders of the science of thermo-dynamics, it was in his memoir to the Berlin Academy of Sciences in 1850 that he re-stated Carnot's principle in its correct form. To him is also due the conception of entropy. His chief work, "Die Mechanische Wärmetheorie," appeared in 1867. The kinetic theory of gases and the theory of electrolysis also owed much to his labours. Among his honours was that of the receipt of the Copley medal, while the Institution of Civil Engineers made him an honorary member. He was called to Bonn in 1869, served as Rector of the University during 1884–85, and died there on August 24, 1888.

IN his presidential address to the American Association for the Advancement of Science, delivered in December last at Toronto, Dr. L. O. Howard made some interesting remarks on the ages of presidents of the British and American Associations. The average age of the presidents of the British Association during the period 1895–1920 was sixty-one years and eleven months, and of those of the American Association sixty-one years and five months. The youngest president of the British Association during that period was fifty-three years of age, and Sir A. W. Rucker (1901), Sir J. J. Thomson (1909), and Prof. W. Bateson (1914) were each fifty-three years of age when serving as president. The oldest was Prof. T. G. Bonney (1910), whose address was delivered at the age of seventy-seven. The youngest of the American presidents were Minot and Richards, whose addresses were delivered at the age of fifty; and the oldest was Eliot, whose Philadelphia address was delivered when he was seventy-nine years of age. "We may safely assume," remarks Dr. Howard, "that the usefulness of the man past middle age is granted, and that, while he may not have the illuminative bursts of inventive or speculative genius which come to the younger man, he is better able to make the broad generalisations based upon accumulated experience—in other words, to prepare an appropriate presidential address as president of the British or the American Association for the Advancement of Science."

AT the Institution of Electrical Engineers on January 12 there was an interesting exhibition of instructive American cinematograph films. The first film, which was exhibited by Dr. Garrard, showed tests of high-tension switchgear. The experiments with switches were made with currents of the order of 100,000 amperes, the object being to find out how the apparatus withstood the enormous mechanical stresses set up by these very large currents. The films were first shown at the ordinary speed; they were then shown at a reduced speed, so that the various effects produced could be followed. The tests made on current and potential transformers showed clearly the types which withstood the stresses best. In some cases switching on the power produced effects similar to those produced by a high-explosive bomb. A noteworthy educational film called "The Audion" was also exhibited. It explained very clearly the operations which are believed to take place between the transmitter and the receiver in radio-telegraphy. The electrons are shown in active motion round the filament of a thermionic tube, and the artist shows by means of them the valve action of the tube. Similarly, the amplifying action of the grid is explained by the motions of the electrons. The currents in the antenna and the waves leaving it were also shown in motion, the whole producing a very lively representation of what takes place. The films were made by the Western Electric Co. of America for the instruction of their employees. Another film showed the building up of a telephone, all the various parts of it slowly and deliberately getting into their proper places apparently by their own agency.

THE annual meeting of the Mathematical Association was held on January 2–3, and Sir T. L. Heath was elected president as successor to the Rev. Canon J. M. Wilson. Papers were read by Sir George Greenhill on "Mathematics and Artillery: Before and After the War: A Review of the Outlook: Then and Now," and on "The Structure of the Atom" by Dr. J. W. Nicholson. Prof. C. Godfrey delivered an address on the importance of the introduction of vectors in the work of the secondary school—a subject on which several writers in the *Mathematical Gazette* have written strongly of late. Miss F. A. Yeldham's paper on "The Dalton Plan and the Teaching of Mathematics" aroused considerable interest; an animated discussion followed, with many inquiries as to the details of her experiences of the plan as at work in the Streatham schools. Prof. G. H. Hardy gave a most interesting address on the life and work of that Indian genius, the late Srinivasa Ramanujan, which was full of personal recollections. He set forth with consummate skill the nature of Ramanujan's researches, his successes, and his failures. He also made an eloquent appeal for a wide extension of education in India, assuring his audience that with such opportunities for the great peninsula as we enjoy here in the West there would soon be an Indian school of mathematics at least equal to anything that can be shown in Europe or America. Incidentally he condemned the folly of those who have decried the Germans as lacking in originality. The next paper was by Mr. A. Dakin, who pleaded with much effect that pure and applied mathematics should be taught and developed *pari passu* in boys' secondary schools. The meeting was brought to a close with a discussion opened by the Rev. E. M. Radford on the best ways of keeping teachers of mathematics in touch with modern developments and methods—a most important problem, and one for which a solution must be found in the near future.

In an interesting paper contributed to the Journal of the Royal Anthropological Institute (vol. 51, part 1) Prof. F. G. Parsons arrives at conclusions, which may be quoted in his own words, in connection with the Long Barrow race, and its relationship to the modern inhabitants of London. He believes that "the shape of the skull is the result of vital or physiological forces, some of which we grasp feebly, and others which we do not understand at all as yet, acting on it for a very long time; but that shape, once established, is very permanent, and most of its characteristics remain for thousands of years after the race bearing them has changed its habitat. Even when the race has been practically bred out by competing races, better adapted to the changed conditions, all the old characters reappear from time to time, sometimes singly, but occasionally all together." For example, the skull of Jonathan Wild reproduces all the characters of the Long Barrow race. "Finally, I must admit that the skull of the modern twentieth-century Londoner has changed from that of the eighteenth, but it is in the direction of increased breadth and shortness, and the change is due, I believe, to admixture with the Central European or Alpine race, which in the last two centuries has been pouring into this country in ever-increasing quantities."

As stated in NATURE of December 30, 1920 (vol. 106, p. 583), the first Pan-Pacific Scientific Conference resolved that fuller knowledge of the history and culture of the Polynesian race was essential to the solution of the ethnographic problems of the Pacific. The Report of the Director of the Bishop Museum, Honolulu, for 1920, just received, informs us that Mr. Bayard Dominick, of New York, is financing an expedition for the study of Polynesian origin and migration. This is organised by the Bishop Museum in conjunction with authorities from countries bordering on the Pacific. During 1920–21 parties have been stationed on the Marquesas, Austral, Tongan, and Hawaian Islands to establish standards of physical form, material culture, traditions, and language of the Polynesians. During 1921–22 a boat with a scientific staff is making observations in selected localities along the route Honolulu, Wake, Marshall, Eastern Carolines, Gilbert, Ellice, Samoa, Tonga, Friendly, Cook, and Society Islands, returning to Honolulu *via* Tongareva, Malden, Christmas, and Fanning Islands. The Bishop Museum acts as permanent representative of the first conference. Its director, Prof. H. E. Gregory, is chairman of a committee to arrange for future conferences, and associated with him are E. C. Andrews (Australia), C. M. Fraser (Canada), F. Omori (Japan), Charles Chilton (New Zealand), and T. Wayland Vaughan (United States).

The latest issue of the *Archiv für Kriminologie* (Bd. 72, Heft 3–4) contains an important article by Prof. W. Ostwald, of Leipzig, entitled "Das System der Kriminologie," in which he attempts a classification of the subject-matter of criminology. He starts from a classification of science as a whole under three main headings: (1) Mathetics, subdivided into logic, mathematics, geometry, and kinematics; (2) energetics, subdivided into mechanics, physics, and chemistry; and (3) biotics, subdivided into physiology, psychology, and sociology. Applying this classification to criminological studies, he arrives at a schedule in which criminology in the more restricted sense falls under sociology, while the contributions of sciences auxiliary to criminology proper, such as criminal anthropology and criminal psychology, fall under the earlier and more general headings. Prof. Ostwald gives an example of the working of his scheme as applied to a large number of titles taken from criminological literature. As an attempt to introduce some sort of order on a logical basis in a subject with a wide scope and a vast literature, this classification will be welcome to students. Its terminology, however, if only for the sake of clearness, needs revision and amplification. As it stands at present the titles of the divisions of the schedule are not sufficiently indicative of their content to be of much practical utility as guides. In addition to Prof. Ostwald's paper, this issue of the *Archiv* contains a number of interesting contributions by prominent criminologists, among the more noteworthy being a long account by J. P. L. Hulst, of Leyden, of a number of cases of necrophilia, an examination by Prof. Allfeld and Prof. von Beling of a proposal put forward by Dr. R. Hindl for the treatment of habitual criminals, and a valuable note by Mr. Arthur Macdonald, of Washington, on the possibility of using police records, particularly records for identification purposes, for the anthropological study of the population.

WE have received the Report of the Bacteriological Section, State Board of Agriculture, U.S.A., for 1920. Much work has been done on the keeping qualities of butters, the decomposition of peat, silage production, bovine infectious abortion, various fermentations, soil and food. For the isolation of the *Bacillus abortus*, the causative organism of infectious abortion, a liver agar medium is recommended with an addition of 1 in 10,000 gentian violet. The medium should have a hydrogen-ion concentration of between 6·6 and 6·4, and the cultivation should be conducted in a closed chamber, in which 10 per cent. of the air is replaced by carbon dioxide.

An account of the brachyuran crabs collected by the American Museum Congo Expedition has been published recently by Miss Mary J. Rathbun (Bull. Amer. Mus. Nat. Hist., vol. 43, pp. 379–474, 30 plates). The collection contains about 3000 specimens belonging to forty-three species, and the large series has enabled the author to define many of the previously known species with greater accuracy. Three of the four species of Callinectes known to occur on the West African coast are well represented in the collection, and details of their systematic characters are given. The author states that the collection of land crabs (Cardisoma), about 120 specimens, serves to demonstrate that certain differences between the African species, *Cardisoma armatum*, and the American species, *Cardisoma guanhumi*, are constant. The river crabs (Potamonidæ) form the most important part of the collection, and are represented by nine species, four of which are new. Notes on the bionomics of these crabs are added by Mr. H. Lang, leader of the expedition.

THE rodents of North America, prairie dogs, ground squirrels, pocket gophers, jack-rabbits, field mice and rats, are responsible for depredations amounting to 100,000,000*l*. a year to field crops, pasturage, and stored products. Mr. W. B. Bell, in the Year-Book of the United States Department of Agriculture for 1920, gives an account of the damage which they do, and of the measures taken to control or eradicate them. The matter was first taken up by the Biological Survey, which devised means both of prevention and cure. By their field operations and by demonstration plots they were able to convince the farmer and stockman of the efficacy of their measures, and in this way they won their co-operation, as well as financial support from the individual States of North America. The work now comprises thoroughly organised aggressive campaigns in sixteen of the Western States. The two chief methods of control are poisoning by strychnine and organised drives, and the methods of prevention include the erection of rodent-proof fencing and the introduction of rat-proof devices into buildings used for storage purposes. Mr. Bell's account gives a vivid idea of the menace which these rodents are to the food supplies of North America, and the valuable results obtained by organised effort on a comprehensive scale for their control and eradication. The menace is equally serious in this country, and the measures adopted in America deserve the serious consideration of the Government and local authorities here.

WE have received an interesting letter from Mr. J. Anderson, of Sewerby, near Bridlington, stating that one of a fine group of the Chilean tree, *Araucaria imbricata*, at Sewerby House had produced a large number of seeds from which healthy young plants have been raised; he asks if this is an unusual occurrence. Mr. W. J. Bean, Royal Botanic Gardens, Kew, informs us that this is not a rare occurrence, and for many years past trees in various parts of the country have borne fertile seeds. He remembers so long ago as 1906 seeing self-sown young plants at Castle Kennedy, in Wigtownshire, growing beneath the trees from which the seeds had fallen. Similar self-sown seedlings may be seen at Strathfieldsaye, the seat of the Duke of Wellington; and other places where fertile seeds have been developed are Beauport, Tortworth, Castlehill, in North Devon, and Bicton, in South Devon. Mr. Anderson also states that some twenty-five or thirty years ago one of the trees "bled to death" from a scar caused by the breaking away of a branch. This also has been known to happen before. A case is known where a tree died from a running wound made at its base by the scythe of a workman mowing the grass. Mr. Anderson, however, records an interesting fact that we do not remember to have seen noted before: when the roots of the dead tree were being removed the workmen dug up large quantities of resin which had set into hard, amber-like masses. The seeds are eaten by the Araucanos and other Indian tribes in Chile. Mr. H. J. Elwes, who visited the native forests of this tree in 1901–2, states that he has eaten them both roasted and boiled and found them very palatable, with a nutty flavour somewhat like that of almonds.

DEVELOPMENT of the petroleum resources in Alaska has been, as we might have expected from the nature of the country, an extremely slow and somewhat costly matter; the comparative inaccessibility of the oil-bearing territory and the rigorous climatic conditions have combined to retard progress to the point of questioning the justification of a continuance of operations. The first well was brought in at Katalla in 1901, and was followed by a short-lived oil boom, afterwards depressed by the wonderful results of Californian development; since that year forty wells have been drilled in Alaska, thirty-one in the Katalla field and the remainder in other prospects, including the Iniskin Bay and Cold Bay districts; Yakataga, on the Pacific seaboard, and Smith Bay, on the Arctic coast, are mentioned as further areas where indications are good. The total production to date amounts to some 56,000 barrels of crude oil which has been refined and used locally; the oil is of paraffin base, of specific gravity varying from 41° to 45° (Baumé), high in petrol, and with no sulphur content; it is obtained from Tertiary beds the structure of which is at present doubtful. Geological exploration is a matter of great difficulty, and the results set forth in the preliminary report on the country (U.S. Geol.

Surv., Bull. 719) can only be regarded as tentative. It is doubtful whether Alaska will ever take rank as an important producing country, but oil will probably be obtained in sufficient quantity to meet local requirements.

SOUTHPORT CORPORATION has issued its annual report of meteorological observations for the year 1920, the results and discussions being carried out by Mr. Joseph Baxendell, meteorologist to the corporation. The report is circulated by the Air Ministry through the Meteorological Office and by the Corporation of Southport, as was done with the results for the year 1919. For many years these reports have stood out as specimens to show what can be done by corporations in England when there is a desire to aid in the advance of meteorology. The observations for 1920 are admirably treated, but there is rather less discussion of the observations than in some recent years, possibly due to the real lack of sufficient scientific assistants; it is stated in the report that a research computer is greatly needed. Research is going on to establish the trustworthiness of a five-year periodicity for wind direction, temperature, and rain in north-west England, and observations are contributed to the Meteorological Office for the daily, weekly, and monthly weather reports. The mean temperature of the complete year was 49·2° F., or 1° above the forty-five years' average. The total duration of sunshine in 1920 was 1277 hours, or 279 hours less than a twenty years' local average, and the smallest annual value yet recorded at Southport. North-westerly winds were deficient throughout the year, the deficiency amounting to little less than double the largest previous annual deficiency from that direction. The dominant feature of the year was the exceptional prevalence of winds from the southern half of the compass. The total rainfall for the year was 34·08 in., which is 1·24 in. above the normal. Observations of diurnal variation of wind direction and velocity, air temperature, and sunshine are of especial interest, as are also the observations of atmospheric pollution.

WIND observations in various Finnish lightships taken between 1914 and 1920 (Ström- och Vind-observationer vid Fyrskeppen) have been published by Dr. G. Granqvist in *Havsforsknings Institutets*, Skrift No. 10, 1921. The observations are from fourteen lightships in the Gulfs of Bothnia and Finland and one in Lake Ladoga. Most of them ceased late in 1914 and throughout the years 1915 to 1918, but the series is fairly complete in 1919 and 1920. The data, which were taken three times daily, are given in detail.

SEVERAL useful pamphlets on map projections have been issued by the Department of Commerce of the United States Coast and Geodetic Survey. A study of map projection in general (Special Publication No. 60) treats in a few pages with numerous illustrations of the fundamental ideas underlying the subject. A larger work is "Elements of Map Projection," by C. H. Deetz and O. S. Adams (Special Publication No. 68), which deals both with the theoretical side of the subject and the practical details of the construction of some of the most important projections. It is copiously illustrated with maps and diagrams and supplied with tables for the construction of Mercator's projection. At the low price of 50 cents it should find ready acceptance in this country. The third pamphlet (No. 67) deals with latitude developments connected with geodesy and cartography, and includes tables for the Lambert equal-area meridional projection.

THE paper read by Sir Vincent Raven before the North-East Coast Institution of Engineers and Shipbuilders on December 16 last is noteworthy, as it makes out a strong case in favour of electric traction on railways. The author is the chief mechanical engineer to the North-Eastern Railway Co., which is about to electrify 250 miles of its main-line system. It is well known that the steam locomotive engine has only half the economy of the steam stationary engine of the same size owing to the great difference in the economy of the boilers in the two cases. The question to be considered, therefore, is whether the great economy that could be effected by generating power on a large scale in a fixed station would be counterbalanced by the unavoidable losses in transmission and the interest on the capital cost of the transmission lines. The author quotes data which prove that electric traction is in nearly every case the more economical. As the North-Eastern Railway Co. intend to purchase their electricity from the supply companies operating in the district, a probable result will be the reduction in the price of electricity to ordinary consumers. This happened in 1904 when the Tyneside passenger lines were electrified.

IN a recent catalogue of the Snook apparatus by Messrs. Newton and Wright, Ltd., we find useful descriptions of two models of this well-known and trustworthy transformer; the Standard model is intended for radiographic work only, the Universal for all purposes, including deep therapy. This latter model is insulated with oil, and is also suitable for X-ray tests upon metals and for the many industrial purposes for which X-rays are being used. A brief description of a new time switch is given; this is based entirely on mechanical principles, and should form a useful addition to a radiographic outfit, for it has a working range of automatic action from 8 seconds to 1/30th of a second.

MESSRS. J. WOOLLEY, SONS AND CO., LTD., of 76 Deansgate, Manchester, have issued their annual pocket-book, "The Scientist's Reference Book and Diary for 1922," price 3*s*. 6*d*. In addition to the usual information given in diaries, there are brief particulars of the more important scientific societies and departments and numerous tables of physical and chemical constants which make the little volume extremely useful to teachers of science and other scientific workers.

DR. A. S. RUSSELL has written, for publication by Mr. John Murray, "The Chemistry of the Radio-elements." The work is intended to describe in a simple and concise form the main facts concerning the chemical properties of the radio-elements and the bearing of this knowledge upon inorganic chemistry and theories of the structure of the atom. Among the topics dealt with are the relation of the radio-elements to the periodic system of classification, the properties of isotopes, the separation and purification of individual elements, and the analytical chemistry of uranium, thorium, and radium.

THE spring announcements of the Cambridge University Press contain several items of scientific interest, among which is the first volume, bearing the sub-title Foundations, of a forthcoming book by Prof. H. F. Baker entitled "Principles of Geometry." We learn from the preface that the work seeks to introduce the reader to those parts of geometry which precede the theory of higher plane curves and of irrational surfaces. Vol. 1 is devoted to the indispensable logical preliminaries. It assumes only those relations of position for points, lines, and planes which, furnished with a pencil, a ruler, some rods, and some string, a student may learn by drawing diagrams and making models. It seeks to set these relations in an ordered framework of deduction, gradually rendered comprehensive and precise enough to include all the later theory; to this end it puts aside, at first, most of those intricate details which make up the burden of what is generally called elementary geometry. Later volumes will deal, on the basis of the results obtained in this volume, with conics (and circles), with quadric surfaces and cubic curves in space, and with cubic surfaces and certain quartic surfaces.

Our Astronomical Column.

THE ORIGIN OF BINARY STARS.—Dr. J. H. Jeans discusses this question in the January issue of *Scientia*. He notes that binaries are of such frequent occurrence (practically half the stars) that we cannot regard them as freaks or abnormalities, but must seek for some explanation of very wide applicability. He considers three possible origins: (1) through fission of a single mass; (2) formation of adjacent nuclei in the original nebula, sufficiently close to each other to be held together gravitationally; and (3) capture, arising from the appulse of two stars originally independent. The last could lead to capture only if a resisting medium were present; moreover, there would be far too few close appulses to explain any appreciable fraction of the existing binaries. Dr. Jeans estimates that in a universe of a thousand million stars there would be ten thousand captures in a thousand million years. The first suggestion is shown to be possible only when a certain density of the rotating star has been attained (probably about that of the stars of B type). It is shown that this explanation accords well with the observed phenomena in the case of spectroscopic binaries, notably the low eccentricity of their orbits. Russell and others, however, have shown that the latus rectum of the orbit cannot increase very greatly, save under the action of considerable external forces, which are certainly not present now, and could only have been present in the past if the interstellar distances were then much smaller.

A test of the fission theory is afforded by triple systems, which generally consist of a close pair with a distant companion. Prof. Russell showed that the density of the central star would be at least 380 times greater at the second fission than at the first, which leads to such an improbable figure as to throw very grave doubts on the fission theory in the case of the wide pairs. Hence the second suggestion is taken to be by far the most probable explanation of the latter pairs. It must, however, be considered to indicate the *how* rather than the *why*; for the question remains why there should be so marked a tendency for nebular condensations to occur in pairs.

Dr. Jeans notes that star groups with common motion, such as the Taurus and Ursa Major clusters, can be most readily explained as arising from adjacent condensations in a primitive nebula; in these cases, however, the mutual distances were so great that the stars were outside each other's field of gravitational control.

THE ORBIT OF CASTOR.—Dr. W. Doberck gives in the centenary number of *Astron. Nachr.* an explanation of Villarceau's method of computing double-star orbits, which is analogous to Laplace's method for planetary orbits. He illustrates it by revising the orbit of Castor from the following four positions: 1719·84, 357·0° (4·82″); 1832·0, 259·0°, 4·61″; 1880·0, 234·5°, 5·63″; 1920·0, 216·0°, 5·03″. The first distance was not observed, but calculated. The author utilises his earlier orbit to shorten the approximations, and obtains the following orbit: ☊ 222° 7′, λ 67° 19′, γ 116° 6′, e 0·2875, P 477·5 years, T 1960·51, a 6·573″.

Predicted places, 1930·0, 210·4°, 4·58″; 1940·0, 203·0°, 3·98″. Owing to the approach to periastron the motion is accelerating It should be possible to obtain the relative masses of the components before very long; this is desirable as a check on the result suggested by the spectroscopic observations, which give the faint star six times the mass of the bright one.

SPECTRUM OF α CYGNI.—This spectrum is interesting from its relationship to the spectra of novæ. Its classification is A 2 (peculiar), and Dr. W. H. Wright has made a special study of the ultra-violet region, which is described in Lick Obs. Bull. No. 332. A spectrograph with two quartz prisms was attached to the Crossley reflector, and three photographs taken on June 11, 1921, two of them being on films which were bent to correspond with the curvature of the field. The limiting wave-lengths are 3245 to 4102, and 184 lines are recorded in the table, most of them being identified with known metallic lines, but they are unusually sharp and narrow compared with other A spectra. The hydrogen Balmer series is complete from Hδ to Hω. Dr. Wright states that the resemblance to the spectra of novæ is still more striking in the ultra-violet than in the visual region. A curve is given of the spectral intensity on the photographs: it falls very steeply between 3750 and 3650, then slowly and uniformly to 3245. The paper also contains some measurements of the red end of the α Cygni spectrum taken on stained plates. It is incidentally proved that some lines announced in this region by Dr. Waterman from photographs with a grating spectrograph really belonged to the blue region of the overlapping third-order spectrum.

Congress of Philosophy in Paris.

THIS congress, which was held in Paris on December 27–31 last, was organised by the Société française de Philosophie. It was not international in the same sense as the series of conferences interrupted by the war, but consisted of a special session of the French society, in which British, American, Italian, and Belgian societies were invited to take part by sending delegates. The British delegates were members of the Aristotelian Society, and included Prof. Wildon Carr, Miss H. D. Oakeley and Dr. Dorothy Wrinch, of the University of London, Prof. J. A. Smith, Mr. W. D. Ross, and Dr. F. C. S. Schiller, of the University of Oxford, Prof. W. R. Sorley, of the University of Cambridge, and Prof. Hoernlé, of the University of Durham.

The session was admirably organised under four sections. The first, devoted to logic and methodology, was presided over by M. Paul Painlevé; the second, devoted to metaphysics and psychology, by M. Henri Bergson; the third, which dealt with the history of philosophy, was under the presidency of Prof. Levy Bruhl; and the fourth section, dealing with social and moral philosophy, was organised by Prof. Bouglé. The mornings were occupied with sectional meetings; in addition, each section arranged one general afternoon meeting. Receptions in honour of the delegates were given by the president of the Société française and by the Rector of the Sorbonne, and the Société française de Philosophie also entertained all the members of the congress to dinner at the Club de la Renaissance.

Recent Developments of Relativity Theory.

In Section I. two subjects of scientific interest were discussed, viz. the theory of relativity and the theory of probability. The discussion of relativity, under the chairmanship of the president of the Société française de Philosophie, was opened by Dr. Dorothy Wrinch, who gave an account of the developments of the theory of relativity due to Weyl and Eddington. She explained how the electromagnetic-force tensor has been identified with a quite specific function of definite significance, in virtue of the fact that the electromagnetic force satisfies the usual Maxwellian equations, by means of an extension of the geometrical system dealt with by Einstein. Dr. Wrinch pointed out that the method of achieving this result was logically similar to the method used by Einstein in his identification of the energy tensor, covering energy, momentum, and stress in a field, with a certain function in his generalised geometry, and, indeed, the function used by Eddington in his further generalisations (Proc. Roy. Soc., 1921). Dr. Wrinch then referred to the existence of the new tensor discovered by Eddington (*ibid.*), and also to the fact that, although it is a development of the ordinary $^*G_{\mu\nu}$ tensor (in the sense that the $^*G_{\mu\nu}$ tensor is an abbreviated summary of it), its physical significance is very uncertain at present. The important logical procedure adopted by Eddington in the introduction of the axiom of the comparability of proximate relations was then made clear.

Prof. Langevin, who followed, gave an account of the development of the theory of relativity from its origin in the experiment of Michelson and Morley to its ramifications at the present day. He laid particular stress on the parallelism which has occurred in the development of geometry and physics, and he contrasted at some length the very different characteristics of these two parts of the theory of relativity. Prof. Langevin then gave an account of the curious manner in which non-Euclidean geometry has been developed from the Euclidean geometry of the last century, and he described the successive generalisations due to Weyl and Eddington. In the course of his exposition of Eddington's results Prof. Langevin then pointed out the manner in which geometry seems now to have gone ahead of physics, in that the geometrical function referred to above has not as yet been identified with any physical idea.

M. Paul Painlevé, who was the next speaker, brought forward certain objections to the theory of relativity which he had already indicated in two communications to the Paris Academy of Sciences in October and November last. He discussed in particular the admissible forms of the interval length ds, and pointed out the fact that various generalised functions $f(r)$ might be substituted for r in the coefficients of the squared differentials in the usual formula for the square of this interval length. All these forms indifferently satisfy the conditions, giving (*e.g.*) the same resulting motion of the perihelion of Mercury, but differing, on the other hand, in regard to the effect of solar gravitation on light traversing the sun's field. M. Painlevé laid great stress on this multiplicity of possible forms, and criticised the theory of Einstein on the ground of the multiplicity of possible forms in this particular formula and in other formulæ introduced at later stages.

A further objection was brought against the theory on the ground that no dynamical system can be constructed unless a privileged set of axes exists. Prof. Langevin, afterwards dealing with this point and with some of the paradoxes arising from it, and also from certain other postulates, pointed out that all theories allow the existence of a privileged set of axes in the neighbourhood of each point, but that no one set is necessarily applicable to the whole universe. A spirited discussion between the above-mentioned speakers followed, which dealt chiefly with certain of the more striking paradoxes to which the theory appears inevitably to lead.

The Theory of Probability.

Another meeting of Section I. of the congress—on this occasion a purely sectional meeting—discussed the modern developments of the theory of probability. The chair was taken by M. Hadamard, in the regretted absence of M. Emil Borel on account of illness. In his paper on "Les Axiomes du Calcul des Probabilités," M. Paul Lévy made public some important results which he has recently obtained by the application of the analytical ideas used by Lebesgue in his work on the theory of functions to $F(x)$, the function representing the probability of an event x. The starting point of his theory is the fact that this function $F(x)$ is necessarily a monotonic increasing bounded function of x. M. Lévy introduces $\phi(z)$, a *fonction caractéristique* of the probability, by refining it in terms of a Stieltje's integral,

$$\phi(z) = \int_{-\infty}^{+\infty} e^{izx} dF(x).$$

This function he finds to be sufficient to determine $F(x)$, and to be of fundamental importance in the later development of the leading ideas in a strict mathematical form. The paper raised many new points of remarkable interest. For example, it pointed out the possibility of applying many of the most far-reaching results obtained by the modern school of analysts to this function $F(x)$ by means of a careful consideration of the assumptions which can plausibly be made concerning the characteristic properties of this function $F(x)$.

In the discussion which followed the reading of this paper, the "frequency" view of probability, according to which the probability of an event is a property definable in mathematical terms, was supported by M. Carvallo; but the contradictory view, which is, of course, the view of the majority of recent writers on the subject in England, was maintained in interesting speeches from M. Hadamard, Prof. Langevin, and others.

Geographical Outlooks.

THE Geographical Association held its annual meeting at Birkbeck College, London, on January 5 and 6. Lord Robert Cecil, as president, spoke on "Geography and Peace." If the Washington Conference was more efficient for peace than the League of Nations Council, this was partly because the latter had serious geographic constitutional defects, such as the absence of German, Russian, and United States representatives. Self-determination was easy to enunciate but most difficult to apply, because geographic conditions had resulted in extraordinary intermingling of peoples who, with inexplicable perversity, declined to live in watertight compartments. Racial and linguistic complexity is not, however, an impassable barrier to governmental unity, as Switzerland, with its three component peoples differing in history, language, and religion, indubitably proves. The Silesian decision was full of geographic interest. For purposes of tariffs, passports, and transportation the political boundary is ignored, and this may be a first experiment towards serious future modification of our State system.

Mrs. Ormsby (London School of Economics) from long-continued researches gave a demonstration lecture showing remarkable connections between original contours and drainage of London and Westminster and their present configuration. Her detailed contour maps are of great scientific interest, and should be published. Sir Halford Mackinder suggested that London originated as the port of St. Albans. Mr. R. L. Thompson (Rugby School), pleading for the better teaching of both history and geography, emphasised the need for superseding the narrowness of the personal and local points of view. We should envisage the weaving of the pattern of life linked through the ages by history and through space by geography. Sir Halford Mackinder spoke on problems of the Pacific. He asked for geographic imagination of the Pacific as a unity instead of the too prevalent view of it as a distant fringe of the European peoples. The Washington Conference had not laid down the limits of the Pacific, and this might be a serious omission, since such populous and prosperous islands as Java lie in the doubtful zone. The Pacific coastal fringes must become incalculably important because of their coal, mineral, and agricultural possibilities.

Dr. Fleure, hon. secretary of the association, lecturing to a joint meeting of historians and geographers, urged that subject-barriers in education should be diminished and that historians and geographers should co-operate to attain broader truth about human evolution. The long, bitter Russian winter so lowers human efficiency that continuously efficient popular criticism of government is impossible, and traditional routine is therefore important. In France the Roman South and the Paris basin differ historically in language, law, architecture, and economics. The boundary between them is a zone, not a line. Our political system needs re-adjustment by recognition of the zonal characters of frontiers. The maps of cities are full of clues for interpreting their life, and, when compared, illustrate remarkably the medieval spread of civic development from the Paris basin along the European plain. Mapping of prehistoric facts is another geographic study which will help to trace back the lineage of human institutions beyond the age of documents.

Miss L. Winchester (Liverpool University) discussed climatic variations in Palestine and factors of the serious summer drought which make storage for water from the winter rains an outstanding problem.

Dr. Hogarth lectured, with many original slides, on Hejaz as a central section of the age-long trade route between Syria and Yemen, with Mecca and Medina as stations on either side of an immense and high bluff of barren volcanic rock. The growth of Muhammadan life and pilgrimage on this basis was implicitly suggested, and its influence on the country was worked out to the practical conclusion that Hejaz could scarcely become a commanding political unit.

The outstanding features of the annual business meeting were the remarkable enthusiasm for geography shown by the fact that eleven hundred new members had joined the association during 1921, and the resolution sent to the Board of Education urging that, while fully recognising the enormous service which the system of advanced courses had rendered in raising the standard of secondary education, the Geographical Association felt that changed conditions emphasise the need for much greater freedom of teaching and grouping of subjects.

The Bow in Homeric Times.

THE Huxley memorial lecture of the Royal Anthropological Institute was delivered on November 29 by Mr. Henry Balfour, the title of the lecture being "The Archer's Bow in the Homeric Poems."

Mr. Balfour said that the principal passages in the Homeric texts relating to the archer's bow were: (1) the description of the bow of Pandarus (*Iliad*, IV.); (2) the account of the bow of Odysseus (*Odyssey*, XXI.). Both these bows were described merely as made of horn, but it was impossible to believe that *horn alone* was used in making so powerful a bow as that of Odysseus The bow of the Lycian Pandarus was made, according to the poet, from the horns of a single wild goat, but, on zoological grounds, this description could be shown to be inadequate, as such horns, if unaided, would not furnish material for making a practicable bow. It was suggested that either the horns of the Armenian wild sheep, or, more probably, those of the water-buffalo, were used for both the bows referred to, and that even these would have required to be reinforced with a powerful "backing" of sinews to render them strong and efficient. Zoological, archæological, and ethnological evidence was adduced to show that in all probability the Homeric bows were true composite bows, built up with staves of wood and horn, and "backed" with sinews, after the fashion prevailing among the more skilled Asiatic bow-makers of later times. A study of Asiatic and Turkish composite bows showed that in all cases the sinew "backing" was protected by a sheathing of thin bark or leather, which concealed this part of the structure; while in many instances the horn forming the "ventral" surface was left uncovered and exposed to view. This fact may account for horn alone being referred to by Homer, since only this element in the structure was visible.

The following facts supported the theory of composite, sinew-backed construction:—

(1) The bows referred to in Greek texts are very frequently described as *reflexed* (παλίντονα) in the *unstrung* state. This is a special feature of composite bows.

(2) The extreme curvature imposed upon the bow of Pandarus when fully drawn (κυκλοτερὲς τόξον ἔτεινεν).

(3) The use of bow-cases (γωρυτοί) to protect the bows when not in use.

(4) The shape of many ancient bows as rendered in paintings or sculptures.

(5) The manner in which bows the shape of which suggests a composite construction were strung, and the fact (*Odyssey*, XXI.) that considerable knack as well as strength was required for this operation.

(6) Many bows represented in ancient Greek art exhibit asymmetrical curves, corresponding with Strabo's description of Scythian bows.

It seemed probable that the ancient Greeks derived a knowledge of the Asiatic composite bows from the Scythians, either directly through Thrace, or indirectly through Persia and Asia Minor, and the statement made by Pliny, "Arcum et sagittam Scythen Jovis filium, alii sagittas Persen Persei filium invenisse dicunt," may, probably, be taken as reflecting the actual derivation of the Greek composite bow from the Scythians or the Persians.

At the conclusion of the lecture the Huxley memorial medal of the institute was presented to Mr. Balfour by the president, Dr. W. H. R. Rivers.

University and Educational Intelligence.

CAMBRIDGE.—Dr. Haddon, Christ's College, has been appointed acting curator of the Museum of Archæology and Ethnology.

H. F. Holden, St. John's College, has been re-elected to the Benn W. Levy studentship in biochemistry.

The Committee for Geodesy and Geodynamics has reported in favour of the erection and equipment of a two-roomed observation building near the Observatory as a first step towards the institution that the committee ultimately aims at to meet the requirements of international geodesy. Further, it is hoped to make provision for study and research in geodesy (including arc measurement, primary triangulation, precise levelling, and gravity determinations), geodynamics, and tidal phenomena. An appeal is to be made for assistance from private benefactions as soon as conditions are favourable.

The Alan Bodey prize of the annual value of 10*l*., for an essay in applied mathematics, has been founded at Gonville and Caius College.

THE LORD MAYOR OF LONDON tenders his thanks to all who responded to his recent appeal for English books for Latvia. The announcement of the shipment to Riga of several thousands of books (forming the first instalment of the New Year gift of 50,000 volumes which the Lord Mayor hopes, with the further help of the public, to get together) has been received with the liveliest satisfaction in the newly founded Baltic State which has decided to adopt English as its second language and is anxious to assimilate English ideals, particularly in education. Further contributions of English books are solicited. Parcels should be addressed (carriage paid if possible) to Sir Alfred T. Davies, c/o the Consul-General for Latvia, 329 High Holborn, London, W.C.1.

A PROGRAMME of University Extension Lectures for the coming term has been issued by the University of London. Courses of lectures will be delivered at some seventy local centres in different parts of London and its suburbs, and a wide range of subjects is being offered. A few of the courses are of interest to readers of NATURE. Dr. W. B. Brierley is giving a course of twelve weekly lectures on "Some Problems in Modern Biology," which commenced on January 9 at Gresham College, Basinghall Street, E.C., and six lectures on "Inter-racial Problems of Man" at the Central Library, Fulham, commencing on February 7; Mr. J. Lionel Tayler is delivering a course of thirteen lectures at the Morley College, Waterloo Road, S.E., on "Heredity: The Scientific Drama of Personal and Social History," which commenced on January 4; and Prof. F. E. Fritch a course of ten lectures on "Nature Study (Plant Life) in the London Area" at the Central Library, Walthamstow, starting on January 26. Further particulars about the dates and times of the courses available and the fees charged can be obtained from the Registrar of the University Extension Board, University of London, South Kensington, S.W.7.

THE results of an interesting inquiry undertaken by Dr. J. Brownlee, director of the statistical department of the Medical Research Council, are published in the *Times* of January 16. Dr. Brownlee has taken the figures of the census of the British Isles of 1911 and has estimated from them the number of persons of any given age less than twenty-five years at present living in the British Isles and the numbers which may be expected in coming years if the conditions of hygiene represented by the 1910–12 life-table prevail. Taking the age for compulsory education, 5–6 years, the estimated number of children of that age in 1921 is 682,000; in 1922 it is 645,000; in 1923, 568,000; in 1924, 573,000; in 1925, 642,000; and in 1926, 772,000. Put into words, the estimates mean that there will be a decrease in the numbers of children of this age until 1923 and afterwards a rapid increase. Taking the next group, children of 7–12 years of age, the numbers living in 1921 are estimated as 2 per cent. less than those living in 1911, while the estimated population for 1921 between the ages of 12 and 20 years is about 7 per cent. in excess of that of 1911. In no case has account been taken of the effects of the war, emigration, etc., on that part of the population falling within the above groups, but it is considered that no error greater than 1 per cent. is introduced on this account. It will be interesting when the details of the 1921 census of Great Britain are published to see to what extent they are in accord with Dr. Brownlee's figures.

Calendar of Industrial Pioneers.

January 19, 1891. Robert Forester Mushet died.—The son of the discoverer of the black-band ironstone, Mushet made experiments on spiegeleisen—iron and manganese—which proved of great value in the development of the Bessemer process of steel-making. He also investigated alloys of iron with titanium, tungsten, and chromium, and about 1870 introduced the first of the self-hardening steels.

January 20, 1901. Zenobe Théophile Gramme died.—A Belgian carpenter, Gramme went to Paris, where at one time he worked under Ruhmkorff. His fame as an electrician is due to his re-invention in 1870 of the ring-armature dynamo first devised by Pacinotti. A monument to him stands in the Conservatoire des Arts et Métiers in Paris.

January 21, 1901. Elisha Gray died.—A distinguished maker of electrical appliances, Gray took out upwards of sixty patents, and was connected with the Western Electrical Co. of Chicago. On February 14, 1876, he applied for a patent for a telephone only a few hours after Bell had deposited his specification.

January 22, 1831. John Blenkinsop died.—One of the pioneers of the locomotive, Blenkinsop was an agent to some collieries. He took out a patent in 1811, and in 1812 at Leeds constructed an engine with a pinion gearing into a fixed rack. One of his engines was seen by George Stephenson.

January 22, 1887. Sir Joseph Whitworth died.—Among the greatest mechanical engineers of the nineteenth century, Whitworth worked with Maudslay, Holtzapffel, and Clement, and in 1833 set up as a tool-maker at Manchester. He improved machine-tools, perfected measuring machines, introduced standard gauges, and in the 'fifties brought out his valuable system of screw-threads. He also made experiments in artillery and developed the process of compressing melted steel under hydraulic pressure. The Whitworth scholarships and exhibitions were founded by him in 1869.

January 22, 1918. Sir John Wolfe Wolfe-Barry died.—An acknowledged leader in the world of civil engineering, Wolfe-Barry was prominently associated with the transport problems of London. Among his notable works was the Tower Bridge, completed in 1894. He was president of the Institution of Civil Engineers in 1897, and he initiated the Engineering Standards Committees.

January 23, 1805. Claude Chappe died.—The inventor of the semaphore signalling apparatus, Chappe was born in 1763. The statue of him in the Boulevard Saint-Germain in Paris depicts him explaining his invention to the Legislative Assembly in 1792. One of the first messages by semaphore was sent from the roof of the Louvre.

January 23, 1896. Ferdinand Schichau died.—A native of Elbing, where he opened a small shop in 1837, Schichau built Germany's first steam dredger, engined some of the earliest German steam men-of-war, and became a famous constructor of locomotives and torpedo craft.

January 25, 1917. George Andrew Hobson died.—As partner with the late Sir Douglas Fox, Hobson was responsible for many pioneering construction works in America and South Africa, his most remarkable work being the railway bridge over the Zambezi River at the Victoria Falls, the central span of which is 500 ft. long with a rise of 90 ft. He also worked out the plans for generating electricity at the Victoria Falls for the gold-mines of the Rand. E. C. S.

Societies and Academies.

LONDON.

Royal Society, December 8, 1921.—Sir C. S. Sherrington, president, in the chair.—Lord **Rayleigh**: A study of the glow of phosphorus: Periodic luminosity and action of inhibiting substances. The intermittent or periodic luminosity observed when the last traces of oxygen are being removed from air by means of phosphorus, or when air is allowed slowly to leak into an exhausted vessel containing phosphorus, requires the presence of water-vapour. Moderate drying (*e.g.* by sulphuric acid) makes the glow perfectly steady. Water-vapour has therefore the power of inhibiting the combination of phosphorus-vapour and oxygen within certain limits. When the composition of the mixture becomes favourable beyond those limits, a wave of combustion is propagated. Other substances are known to inhibit the glow of phosphorus, and exhibit the above phenomena in a more striking form than water. Camphor, ammonia, and pear-oil are among the most effective. The propagation of these waves of combustion cannot be attributed to the rise of temperature of one layer igniting the next layer, for the rise of temperature is too small. An alternative theory of the propagation is proposed, which assumes that it depends on the provision of nuclei, as in the propagation of crystallisation through a super-cooled liquid. On this basis a theory of the action of the inhibitors or "negative catalysts" is developed.—Lord **Rayleigh**: The aurora line in the spectrum of the night sky. The spectrum of the night sky at Terling (near London) has been photographed systematically. The aurora line at wave-length 5578 Å.U. is recorded on about two nights out of three. Its intensity on ordinary nights is not obviously related either to the amount of magnetic disturbance or to the transit of spots over the sun's central meridian. The intensity in the neighbourhood of Newcastle is notably less than near London, thus the effect appears to increase towards the south. It appears, therefore, to be due to some different cause from the Polar aurora. The aurora line does not coincide with krypton, and experiments to determine its origin gave negative results.—E. F. **Armstrong** and T. P. **Hilditch**: A study of catalytic actions at solid surfaces. VII.: The influence of pressure on the rate of hydrogenation of liquids in presence of nickel. The comparative rates of absorption of hydrogen at different pressures by a variety of unsaturated compounds in presence of nickel have been studied; the relation between the hydrogen pressure and the rate of hydrogenation is dependent on the type of organic compound examined. Simple ethylenic compounds are hydrogenated at rates almost proportional to the absolute pressure of the hydrogen. At very low concentrations of catalyst the increase in rate of hydrogenation becomes less than proportional to the increase in pressure. If the unsaturated compound contains another group which has affinity towards nickel, but is not open to hydrogenation, increase in hydrogen pressure causes an increase in the rate of hydrogen absorption. These results are in harmony with the authors' theory that catalytic hydrogenation is primarily conditioned by an association of the ethylenic linkage with the catalyst, the latter being also associated with hydrogen.—W. D. **Womersley**: The energy in air, steam, and carbon dioxide from 100° C. to 2000° C. Hydrogen and carbon monoxide mixed with either air or oxygen were exploded in a Hopkinson recording calorimeter for explosions. Curves showing the energy in the various gases and the mean volumetric heats from 100° C. to 2000° C. are given. The values are, where comparable, about $7\frac{1}{2}$ per cent. higher than those of Holborn and Henning. The difficulty in estimating the heat liberated in a closed-vessel explosion is due probably to a spontaneous time reaction between the combustible gas and oxygen when the two are mixed, in which about 10 per cent. of the gas is consumed. The combustion of carbon monoxide is considerably slower than that of hydrogen. This makes the estimation of the heat liberated in the carbon monoxide experiments very uncertain.—J. W. **Gifford**: Atmospheric pressure and refractive indices, with a corresponding table of indices of optical glass. The modulus of rigidity for glass precludes its being sensibly affected by pressure, and therefore any pressure effect must be due to air alone. Two measurements of refractive index of the same wave-length, at different temperatures, are made, and by means of a new formula the refraction temperature-coefficient at standard pressure for 1° C. is determined. Using this as a final correction, indices for other wave-lengths at standard pressure and observed temperature may be brought to standard pressure and temperature (15° C.).—H. P. **Waran**: A new form of interferometer. A thin layer of transparent liquid floating over mercury is employed as a parallel plate interferometer—a substitute for Lummer and Ghercke's glass plate. Viscous castor-oil was successfully used, but its poor transparency stood in the way of securing high resolving power. The disturbing influence of the tremors of the ground was overcome by mounting the trough on a float suspended from the ceiling in a tank of water carried on a massive brick pillar with deep-laid foundations.—H. **Harle**: The viscosities of the hydrogen halides. An experimental determination of the coefficients of viscosity of the gaseous hydrogen halides was undertaken with the view of affording a check upon the theoretical investigation by A. O. Rankine on the diameters of unsymmetrical molecules. The method of continuous transpiration through a capillary tube was employed, using the known data for air. The gases were liquefied, and, by controlling the evaporation, established their own steady pressure while transpiring through the tube. The volumes of gas passing in a given time were found by absorbing in water and titrating with standard alkali solutions. Values of η were obtained at two temperatures, round about 15° C. and 100° C., and from them Sutherland's constant of temperature variation is calculated for each of the gases.

PARIS.

Academy of Sciences, January 3.—M. E. Bertin in the chair.—J. **Effront**: The distinctive properties of amylases of different origins. Specimens of amylase of different origins can be distinguished by the ratio between their liquefying power and sugar formed, by the optimum temperature when acted upon by diastase, and by their resistance to temperatures of 70°, 95°, and 100° C.—P. **Montel**: Quasi-normal families.—M. **Auric**: The generalisation of continued fractions.—MM. **Gossot** and **Liouville**: The principles of interior ballistics.—G. **Sagnac**: Newtonian invariants of matter and of radiant energy and the mechanical ether of variable waves.—H. **Chaumat**: The ballistic galvanometer.—R. **Jouaust**: The reception of waves maintained by modulation. In wireless telegraphy the detectors utilised at the receiving end give a very low yield. In the modification suggested the intensity of the current circulating normally in the receiving apparatus is modulated periodically with a given frequency. A current audible in a telephone is thus obtained the amplitude of which is half that circulating in the receiving apparatus. The method has been applied practically in transmission between Lyons and Paris, and proved to give increased sensibility.—M. **Taffin**: The annealing of glass. The formula given by Kundt in 1881 has been recently shown by Adams and Williamson not to apply rigorously to glass. The author has extended the experiments of Adams and Williamson, and proposes two modifications of their formula. The experimental results are compared with the three formulæ.—R. **Fosse** and A. **Hieulle**: The synthesis of hydrocyanic acid by oxidation, in ammonio-silver solution, of alcohols, phenols, and amines. In presence of ammonia and silver nitrate, hydrocyanic acid is one of the products of oxidation of various alcohols, phenols, and amines by permanganate. Quantitative figures are given for forty compounds, methylamine giving the highest proportion.—L. **Gentil**: The age of the phosphates of Morocco. A study of the fossils in the phosphate deposits of Morocco leads to the conclusion that they are mainly Cretaceous.—P. **Viennot**: The abnormal contact of the north Pyrenean Flysch at the north of Saint-Jean-Pied-de-Port.—P. **Négris**: Atlantis and the quaternary regression. A summary of facts proving a lowering of the level of the Atlantic by the subsidence of the sea-floor, and a discussion of the bearing of these facts on the legends of the submerged continent Atlantis. The facts cited include the form of the submarine floor of the Hudson River, the markings on the Island of Siphnos (Greece) up to a level of 700 metres, and the levels of the wood *débris* deposited by the Gulf Stream on Iceland.—A. **Allemand-Martin**: The lignites of Cap-Bon (Tunis). These lignites are comprised between the levels containing *Turritella fimbriata, Cerithium lignitarum,* and that of *Ostrea crassissima*; they are nearer the Tortonian period than the Helvetian.—L. **Moret**: The presence of limestones containing Alveolina, probably of Auversian age, at the base of the Nummulitic of the Arâche plateau (Massif de Plati, Haute-Savoie).—J. **Savornin**: The watershed of the Oum er Rebia (Morocco) and the general hydrography of the Moroccan middle Atlas.—P. **Lesage**: Study of saline plants during the period in which anomalies are produced.—R. **Combes**: The detection of the pseudo-bases of anthocyanidines in plant tissues. The results obtained by Noack on the extraction of the pseudo-bases of anthocyanidines from plant tissues are shown to be untrustworthy; the colour reactions obtained were probably due to the presence of phlobatannins.—M. **Martin-Zédé**: The influence of orientation on the success of the transplantation of trees. In trees transplanted without reference to their original orientation the loss in the following winter was 50 per cent., but taking care that the sides of the trees facing north were transplanted with the same orientation the loss was reduced to about 7 per cent.—M. and Mme. A. **Chauchard**: The measurement of the excitability of a secretory nerve: tympanic chord and the sub-maxillary gland.—R. **Stumper**: The poison of ants, and in particular formic acid. A proof that no other volatile acid than formic acid is present in ant poison.—A. **Lécaillon**: The characters of a hybrid issuing from the union of *Cairina moschata* and *Chenalopes aegypticus*.—R. **Courrier**: The independence of the seminal gland and the secondary sexual characters in fishes. Experimental study.—R. **Hovasse**: The regulation of the number of chromosomes in the parthenogenetic embryos of the reddish-brown frog. Its mechanism.—L. **Léger** and E. **Hesse**: The coccidia of marsh birds. The genus Jarrina.—A. **Sartory** and L. **Moinson**: A case of bronchial moniliasis. The fungus *Monilia Pinoyi* was isolated from the sputum of a patient suspected of tuberculosis.—

MM. **Rousselot** and A. **Marie** : A peculiarity of audition as a sign of syphilis.—A. **Zimmern** and E. **Salles** : The spectrographic study of the colour change of barium platinocyanide in the Villard effect.

SYDNEY.

Linnean Society of New South Wales, November 30, 1921.—Mr. G. A. Waterhouse, president, in the chair.—R. **Veitch** and W. **Greenwood** : The food-plants or hosts of some Fijian insects. A guide to the economic entomology of the Fiji Islands. The nature of the attack, the economic status of the insect, and the name of its food-plant or host are indicated.—J. G. **Myers** : The Australian apple leafhopper (*Typhlocyba australis,* Frogg.). This species has been introduced into New Zealand, where it does considerable damage to the foliage of apple and hawthorn, signs of its attack being rusty spots and patches on both sides of young and old leaves.—Vera **Irwin-Smith** : Notes on nematodes of the genus Physaloptera, with special reference to those parasitic in reptiles. A list of the species parasitic in each group is followed by a review of those found in reptiles, with special reference to their distribution in Australia. All known reptilian hosts for the genus, with the species parasitic in each, are given.—A. R. **McCulloch** : Notes on, and descriptions of, Australian fishes (2). Most of the fishes discussed were hitherto imperfectly known.—M. B. **Welch** : The occurrence of oil ducts in certain Eucalypts and Angophoras. Ducts occur in the medulla of the stems and leaves of certain Eucalypts of the Corymbosæ class and of *Angophora lanceolata.* They contain oil similar to that in the leaf oil glands—though not directly connected therewith—and function as storage reservoirs. The ducts indicate a primitive character, and show a close phylogenetic affinity between the Eucalypts and Angophoras.

Official Publications Received.

The National Union of Scientific Workers. Annual Report for Year ending 30th September, 1921. Pp. 36. (London: 25 Victoria Street.)

Royal Botanic Gardens, Kew. Bulletin of Miscellaneous Information, No. 10, 1921. Pp. 353-416. 1*s*. 4*d*. net. Bulletin of Miscellaneous Information: Appendix I-1922. Pp. 28. 8*d*. net. (London: H.M. Stationery Office.)

Memoirs of the Geological Survey of India. Vol. 40, Part 3: Petroleum in the Punjab and North-West Frontier Province. By Dr. E. H. Pascoe. Pp. x+330-494+xxii+plates 70-88. (Calcutta: Geological Survey; London: Indian Trade Commissioner.) 5 rupees.

Department of Agriculture, Punjab. Veterinary Bulletin, No. 2 of 1920: The Treatment of Surra in Camels by Intravenous Injections of Tartar Emetic. By Capt. H. E. Cross. Pp. iv+58. (Lahore: Government Printing Office.) 3 annas.

Department of Commerce. Scientific Papers of the Bureau of Standards. No. 423: Operation of the Modulation Tube in Radio Telephone Sets. By E. S. Purington. Pp. ii+377-406. (Washington: Government Printing Office.) 10 cents.

University of Illinois Bulletin. Vol. 18, No. 36. Bulletin No. 125, Engineering Experiment Station: The Distribution of the Forms of Sulphur in the Coal Bed. By H. F. Mancey and T. Fraser. Pp. 94. (Urbana: Engineering Experiment Station; London: Chapman and Hall, Ltd.)

Bulletin of the National Research Council. Vol. 2, Part 7, No. 15: A List of Seismologic Stations of the World. Compiled by H. O. Wood. Pp. 397-538. (Washington: National Research Council.) 2 dollars.

New Zealand. Department of Mines: Geological Survey Branch. Bulletin No. 23 (new series): Geology and Mineral Resources of Western Southland. By J. Park. Pp. vi+88+8 plates+2 maps. (Wellington, N.Z.) 5*s*.

Diary of Societies.

THURSDAY, JANUARY 19.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—S. Gordon: Mountain Birds of Scotland.

ROYAL SOCIETY, at 4.30.—Prof. L. Hill, H. M. Vernon, and D. H. Ash: The Kata-Thermometer as a Measure of Ventilation.—Lt.-Col. C. B. Heald and Maj. W. S. Tucker: Recoil Curves as Shown by the Hot-wire Microphone.—E. W. A. Walker: The Occurrence and Development of Dys-agglutinable, Eu-agglutinable, and Hyper-agglutinable Forms of Certain Bacteria.—Marjory Stephenson and Margaret Whetham: Studies in the Fat Metabolism of the Timothy Grass Bacillus.—J. A. Gardner and F. W. Fox: The Origin and Destiny of Cholesterol in the Animal Organism. Part 12: The Excretion of Sterols in Man.—Dr. S. J. Lewis: The Ultra-violet Absorption Spectra and the Optical Rotation of the Proteins of the Blood Sera.

LINNEAN SOCIETY OF LONDON, at 5.—Dr. E. Marion Delf: Studies in *Macrocystis pyrifera*, the Giant Alga of the Southern Temperate Zone.—J. L. C. Musters: The Flora of Jan Mayen Island.

ROYAL SOCIETY OF MEDICINE (Dermatology Section), at 5.

INSTITUTION OF MINING AND METALLURGY (at Geological Society), at 5.30.—J. F. Allan: A Typical Example of Magmatic Injection.—W. E. Whitehead: Steep Sights in Underground Surveys.

ROYAL AERONAUTICAL SOCIETY (at Royal Society of Arts), at 5.30.—Brig.-Gen. R. K. Bagnall-Wild: Aeroplane Installation.

INSTITUTION OF ELECTRICAL ENGINEERS (Joint Meeting with Institution of Heating and Ventilating Engineers), at 6.—Discussion: The Utilisation of Waste Heat from Electrical Generating Stations, with the following Introductory Papers: C. I. Haden: Utilisation of Exhaust Steam from Electric Generating Stations, and Coal Economy.—F. H. Whysall: The Utilisation of Waste Heat from Electrical Generating Stations.

CHEMICAL SOCIETY, at 8.—Prof. A. Smithells: Models of the Lewis-Langmuir Atom, with Explanations.

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at 11 Chandos Street, W.1), at 8.15.—Dr. E. J. Butler: Some Relations between Vegetable and Human Pathology.

FRIDAY, JANUARY 20.

INSTITUTE OF TRANSPORT (at Royal Society of Arts) (Graduates' and Students' Lecture), at 5.—G. T. Hedge: The Operation of an Important Railway Goods Terminal.

ROYAL ASTRONOMICAL SOCIETY, at 5.—Geophysical Discussion on Isostasy: Capt. Alessio, Col. Sir G. P. Lenox-Conyngham, Prof. Plumbach, and others. Col. H. G. Lyons in the chair.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Sir Arthur Keith: Hunterian Lecture: The Mongolian Face and its Modifications.

ROYAL SOCIETY OF MEDICINE (Otology Section), at 5.—A. Tweedie: Short Account of the Research Work being conducted in Utrecht on the Saccular, Utricular, and Allied Reflexes (continued).

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—H. S. Denny and N. V. S. Knibbs: Some Observations on a Producer-gas Power Plant.

INSTITUTION OF ELECTRICAL ENGINEERS (London Students' Section), at 7.—L. T. Hinton: Some Applications of the Thermionic Valve to Telephony.

GEOLOGISTS' ASSOCIATION (at University College), at 7.30.—S. Hassledine: Classifications of the Pleistocene Age.

JUNIOR INSTITUTION OF ENGINEERS, at 8.—Lecturette: Geology in its Relation to Engineering.

ROYAL SOCIETY OF MEDICINE (Electro-therapeutics Section), at 8.30.—Dr. Zimmern, Dr. Agnes Savill, Dr. Sloan-Chesser, Dr. C. A. Robinson, Dr. W. J. Turrell, and others: Discussion: Electro-therapy in Gynæcology.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Sir James Dewar: Soap Films and Molecular Forces.

SATURDAY, JANUARY 21.

BRITISH MYCOLOGICAL SOCIETY (in Botany Lecture Theatre, University College), at 11 a.m.—Dr. W. Brown: The Germination and Growth of Fungi at Various Temperatures and in Various Atmospheres.—Miss D. M. Cayley: Die Back of Stone Fruits due to Diaporthe Perniciosa and the Behaviour of Monospore Cultures in Artificial Media.—W. B. Crow: The Morphology and Affinities of Leuconostoc Mesenteroides.—Dr. H. Wormald: Notes on Crown-gall.—Dr. M. C. Rayner: Obligate Symbiosis in Calluna.—W. J. Dowson: Michaelmas Daisy Wilt.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Dr. C. Macpherson: The Evolution of Organ Music (1).

MONDAY, JANUARY 23.

PHYSIOLOGICAL SOCIETY (at King's College).—Annual General Meeting.

VICTORIA INSTITUTE (at Central Buildings, Westminster), at 4.30.—S. T. Klein: The Invisible is the Real, the Visible is only its Shadow.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Sir Arthur Keith: Hunterian Lecture: The European Face and its Chief Variations in Type.

INSTITUTION OF ELECTRICAL ENGINEERS (Informal Meeting), at 7.—R. J. Mitchell and others: Discussion: Electric Vehicles: Present and Future.

INSTITUTION OF MECHANICAL ENGINEERS (Graduates' Meeting), at 7.—F. A. Best: Airships.

ROYAL INSTITUTE OF BRITISH ARCHITECTS, at 8.—Prof. W. Rothenstein: Architectural Draughtsmanship.

ROYAL SOCIETY OF ARTS, at 8.—C. Ainsworth Mitchell: Inks (Cantor Lectures) (1).

MEDICAL SOCIETY OF LONDON, at 8.30.—Dr. F. J. Poynton and Dr. J. W. McNee: A Case resembling Leukœmia, but presenting unusual Clinical and Pathological Features.—T. H. Kellock: A Method of Treating Abscesses.—Dr. W. Broadbent: Observations on Heart Disease.

ROYAL GEOGRAPHICAL SOCIETY (at Æolian Hall), at 8.30.—C. J. Edmonds: Luristan.

TUESDAY, JANUARY 24.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Dr. F. H. A. Marshall: Physiology as Applied to Agriculture (2).
NEWCOMEN SOCIETY (at Caxton Hall), at 5.—Dr. T. E. Jones: Mechanics of Engineering from the Time of Aristotle to that of Archimedes.
ROYAL SOCIETY OF MEDICINE (Medicine Section), at 5.30.—Dr. C. Boulton, Sir Cuthbert Wallace, Dr. Ryffel, and Dr. A. E. Barclay: Discussion: The Diagnosis of Gastric Ulcer.
INSTITUTION OF CIVIL ENGINEERS, at 6.—A. W. Rendell: Control of Trains, in Relation to Increased Weight and Speed Combined with Reduced Headway.—Sir Henry Fowler and H. N. Gresley: Trials in Connection with the Application of the Vacuum-brake for Long Freight Trains.
WOMEN'S ENGINEERING SOCIETY (at 26 George Street, W.1), at 6.15.—Miss Gwynne Howell: Domestic Engineering.
ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—C. M. Thomas: The Plate and the Photographer.
INSTITUTE OF INDUSTRIAL ADMINISTRATION (at London School of Economics), at 8.—J. M. Fells: Industrial Economics in Relation to the Bearing on National Welfare of the Ascertainment of Cost, with discussion by Sir Lynden Macassey, Sir James Martin, and others.
ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.—Anniversary Meeting.

WEDNESDAY, JANUARY 25.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Sir Arthur Keith: Hunterian Lecture: The Study of Certain Aberrant Types: Bushmen, Eskimo, Lapp, and Ainu.
INSTITUTE OF CHEMISTRY (London and South-Eastern Counties Section) (at 30 Russell Square, W.C.1), at 6.—Exhibition of Apparatus other than Glassware.
INSTITUTION OF CIVIL ENGINEERS (Students' Meeting), at 6.—E. W. Monkhouse: The Economic Aspects of Various Methods of Power-transmission.
ROYAL SOCIETY OF ARTS, at 8.—H. M. Edmunds: Photo-sculpture.
ROYAL SOCIETY OF MEDICINE, at 9.—Prof. G. Elliot Smith: The Rhodesian Skull.

THURSDAY, JANUARY 26.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—S. Gordon: Sea Birds and Seals.
ROYAL SOCIETY, at 4.30.—*Probable Papers*.—W. B. Hardy and Ida Doubleday: Boundary Lubrication: The Paraffin Series.—Prof. W. A. Bone, A. R. Pearson, E. Sinkinson, and W. E. Stockings: Researches on the Chemistry of Coal. Part 2: The Resinic Constituents and Coking Propensities of Coals.—Dr. J. A. Crowther and B. J. Schonland: The Scattering of β-rays.—Ann C. Davies: The Minimum Electron Energies associated with the Excitation of the Spectra of Helium.—C. N. Hinshelwood, H. Hartley, and B. Topley: The Influence of Temperature on Two Alternative Modes of Decomposition of Formic Acid.—Prof. C. V. Raman: The Molecular Scattering of Light in Water and the Colour of the Sea.
CONCRETE INSTITUTE, at 7.30.—E. B. Moullin: Capillary Canals in Concrete, and the Percolation of Water through Them.
ROYAL MICROSCOPICAL SOCIETY (Metallurgical Section), at 7.30.—H. Wrighton: Demonstration of Polishing Metal Specimens.
ROYAL SOCIETY OF MEDICINE (Urology Section), at 8.30.

FRIDAY, JANUARY 27.

ASSOCIATION OF ECONOMIC BIOLOGISTS (in Botanical Lecture Theatre, Imperial College of Science and Technology), at 2.30.—Prof. E. P. Stebbing and others: Discussion: The Importance of Scientific Research in Forestry and its Position in the Empire.
ROYAL SOCIETY OF ARTS (Indian Section), at 4.30.—A. L. Howard: The Timbers of India and Burma.
PHYSICAL SOCIETY OF LONDON (at Imperial College of Science and Technology), at 5.
ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Sir Arthur Keith: Hunterian Lecture: The Facial Characteristics of the Races native to India.
JUNIOR INSTITUTION OF ENGINEERS, at 8.—L. M. Jockel: Fuels and the Boiler-house.
ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Viscount Burnham: Journalism.

SATURDAY, JANUARY 28.

ESSEX FIELD CLUB (in Physical Lecture Theatre, West Ham Municipal College), at 3.—C. Nicholson: The Rosy-Marbled Moth (*Erastria venustula*) in Britain (with special reference to Essex).—G. Morris: Some Neolithic Sites in the Valley of the Essex Cam.
ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Dr. C. Macpherson: The Evolution of Organ Music (2).

PUBLIC LECTURES.

(*A number in brackets indicates the number of a lecture in a series.*)

THURSDAY, JANUARY 19.

KING'S COLLEGE, at 5.30.—Dr. O. Faber: Reinforced Concrete (1).
ST. JOHN'S HOSPITAL FOR DISEASES OF THE SKIN, at 6.—Dr. W. Griffith: Diseases of the Skin Appendages (Chesterfield Lecture).

FRIDAY, JANUARY 20.

METEOROLOGICAL OFFICE, SOUTH KENSINGTON, at 3.—Sir Napier Shaw: The Structure of the Atmosphere and the Meteorology of the Globe (1).
MIDDLESEX HOSPITAL MEDICAL SCHOOL, at 3.—Sir James Kingston Fowler: Diagnosis (Emeritus Lecture).
KING'S COLLEGE, at 5.—Prof. R. Robinson: Orientation and Conjugation in Organic Chemistry from the Standpoint of the Theories of Partial Valency and of Latent Polarity of Atoms (1).
KING'S COLLEGE, at 5.30.—Rev. Dr. F. A. P. Aveling: Matter, Mind, and Man.

SATURDAY, JANUARY 21.

UNIVERSITY COLLEGE, at 10.30 a.m.—A. Chaston Chapman: Yeast: What it is, and what it does (Lecture for Teachers).
LONDON DAY TRAINING COLLEGE, at 11 a.m.—Prof. J. Adams: The School Class (1).

MONDAY, JANUARY 23.

KING'S COLLEGE, at 5.30.—Prof. C. L. Fortescue: Wireless Transmitting Valves (1).

TUESDAY, JANUARY 24.

KING'S COLLEGE, at 5.30.—F. H. Rolt: Accurate Measurements in Mechanical Engineering: The Use and Testing of Gauges (1).

WEDNESDAY, JANUARY 25.

HORNIMAN MUSEUM (Forest Hill), at 6.—W. W. Skeat: The Living Past in Britain (1).

THURSDAY, JANUARY 26.

UNIVERSITY COLLEGE, at 5.15.—B. S. Rowntree: Industrial Unrest.
KING'S COLLEGE, at 5.30.—Dr. O. Faber: Reinforced Concrete (2).
ST. JOHN'S HOSPITAL FOR DISEASES OF THE SKIN, at 6.—Dr. W. K. Sibley: Alopecia and its Treatment (Chesterfield Lecture).

FRIDAY, JANUARY 27.

METEOROLOGICAL OFFICE (South Kensington), at 3.—Sir Napier Shaw: The Structure of the Atmosphere and the Meteorology of the Globe (2).
TAVISTOCK CLINIC FOR FUNCTIONAL NERVE CASES (at the Mary Ward Settlement, Tavistock Place), at 5.30.—Dr. H. Crichton Miller: The New Psychology and its Bearing on Education (1).

SATURDAY, JANUARY 28.

LONDON DAY TRAINING COLLEGE, at 11 a.m.—Prof. J. Adams: The School Class (2).
HORNIMAN MUSEUM (Forest Hill), at 3.30.—F. Balfour-Browne: The Life and Habits of Mason Bees.

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