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Imperial Aspects of Comparative Medicine.

THE Advisory Committee on Research into Diseases in Animals was appointed in November 1920 by the Development Commission "to report on the facilities now available for the scientific study of the diseases of animals, to indicate what extension of those facilities is desirable in the immediate future in order to advance the study of disease whether in animals or man, and to advise as to the steps which should be taken to secure the aid of competent scientific workers in investigating diseases in animals." The Committee comprised Sir David Prain (Chairman), Prof. O. C. Bradley, Captain W. E. Elliot, M.P., Sir Walter Fletcher, Sir William Leishman, Sir John M'Fadyean, Prof. C. J. Martin, and Mr. F. B. Smith, C.M.G. The report which has now been issued (H.M.S.O., 1*s.* 6*d.* net) affirms that the problem of disease and of health, whether in man, animal or plant, is in reality one, and that the acquisition of the greater part of our knowledge of human and of veterinary medicine, both curative and preventive, has resulted from the use of identical scientific methods. Moreover, the vast overseas trade of the United Kingdom in live-stock gives it a vested interest in the wealth annually at hazard from preventible causes throughout the Empire.

With this broad interpretation of its terms of reference, the Committee has had to deal with essentially the same problem as that of the Colonial Office "Committee on Research in the Colonies," to the report of which reference was made in the issue of NATURE for March 23, p. 365.

Whereas the Committee of the Colonial Office looked to the Universities as training grounds for future investigators, that of the Development Commission has concentrated attention on the Veterinary Institutions and Laboratories. It found that in the United Kingdom the only independent institution devoted to the investigation of animal diseases to which the name "Research Institute" could be applied was at the Royal Veterinary College, London. The aggregate State subsidy received by the five Veterinary Colleges during the year 1920–21 for research purposes totalled only 3696*l.* This condition of affairs renders impossible the proper payment of workers or the maintenance of laboratories or of field inquiries, and is stigmatised by the Committee as a national disgrace. In its survey of the facilities available overseas the Committee was embarrassed by the limited information at its command, but after excepting the Veterinary Laboratory at Onderspepoort on account of its valuable work for the Union of South Africa, the Committee adopts the dictum of the editor of the Tropical Veterinary

Bulletin that the state of research into animal diseases in the tropics is at present lamentable.

Affirming that the facilities available in the British Empire in men, laboratory accommodation and equipment, are totally inadequate for the interests at stake, the Committee recommends the gradual creation of a cadre of research workers under an advisory organisation of scientific experts. On both scientific and political grounds it is desirable that no demarcation should be drawn between research work in the United Kingdom and that in other parts of the Empire.

The Committee is of opinion also that, should financial conditions become less stringent, assistance from State funds would be justified towards the creation of one strong Institute to serve the needs of the United Kingdom and possibly of the Empire. In such an institute, research would be made into the comparative aspects of disease as a whole, and workers in different branches of the subject—veterinary, medical, botanical—would be brought into association.

It is unfortunate that the Committee terminated its labours before the announcement of the gift to the Government by the Rockefeller Foundation of two million dollars for the creation of an Institute of Imperial Hygiene in London. It is understood that the Government has already accepted the responsibility of providing staff and maintenance of the Institute when established. Moreover, the "Shakespeare Memorial" site adjoining the area recently acquired for the University of London has been purchased.

This new development must enhance profoundly the position of London as the post-graduate centre of the Empire. It is understood that the Ministry of Health favours the integration of certain activities of various bodies like the London School of Tropical Medicine with those of the proposed Institute. In view of the enormous advantages which would ensue to the whole science of medicine from the intimate association of research workers in human and animal disease, it is to be hoped that serious efforts will be made to meet the legitimate aspirations of the veterinary profession for better facilities for research and post-graduate study in connection with the new Institute.

The General Theory of Relativity.

Space—Time—Matter. By Hermann Weyl. Translated from the German by Henry L. Brose. Pp. xi + 330. (London: Methuen and Co., Ltd., 1922.) 18*s.* net.

PROF. WEYL'S work is the standard treatise on the general theory of relativity. It is the most systematic and penetrating book on the subject; it is also by far the most difficult. The reader must not expect a helping hand over difficulties which are merely analytical; only the barest indication of intermediate steps is given in passing from one formula to another. The book is not suitable for a first introduction to the mathematical theory; but those who have already acquired some familiarity with the methods and manipulations required will find here a deeper insight and a more general view of the logical coherence of the theory than is possible in more elementary text-books. We think too that Weyl, more than other continental writers, approaches the outlook natural to an English student. The subtle distinctions between the Cambridge and the continental schools survive the revolution which has overtaken scientific thought. Even with Einstein we feel a need to anglicise his mode of thought, and this is still more necessary with some other German writers. But Weyl strikes just the right note for us; and though he is often too far ahead for us to follow, we pay him the (perhaps doubtful) compliment of claiming him as one of our own school of thought.

In some branches of applied mathematics the analytical methods have obviously no connection with the physical processes. The lunar theory is a notable instance; we cannot conceive that the processes by which the moon finds out where it ought to be are in any way analogous to those by which the computer solves the same problem. It is part of the charm of Einstein's theory that the mathematical methods correspond step by step with physical processes, so that not merely the result but also the form of the analysis is significant. The deeper our comprehension of the mathematical tool (the tensor calculus) the deeper will be our insight into the structure of the world. There are perhaps some who cherish the hope that ultimately simpler mathematical methods of treating these problems will be devised; but even if this hope were fulfilled the simplification would cost us dearly. If to our minds it seems simpler to solve the problems of Nature for her by methods other than those which she herself follows, that only accentuates our unfittedness to comprehend her processes. In Weyl's treatment the physical significance of each analytical operation is most strongly emphasised.

A distinctive feature of Weyl's work is his use of the conception of tensor-density in addition to tensor. These differ by a factor $\sqrt{g}$. In any region of the world, we can always choose a system of co-ordinates such that $\sqrt{g}=1$ everywhere; from the analytical point of view the factor is a useless complication which can be omitted without loss of generality, so that tensors and tensor-densities become equivalent. But this computational simplification plays havoc with the physical significance of the formulæ. Intensity-measures and quantity-measures become hopelessly confused. Weyl seems to have been the first to insist on keeping these distinct. He brings a meaning into formulæ which had previously appeared to be artificial combinations. The student who has with difficulty acquired some skill in operating with tensors has to learn in addition how to manipulate tensor-densities; but the results repay the extra labour.

Einstein has amalgamated for us geometry and mechanics. He has shown that if we have given an exact specification of the geometry of a region of space and time, that specification will also determine all the mechanical properties existing in the region—gravitational field, inertia, momentum, and stress. Einstein accepted for this purpose the geometry of Riemann. In 1918 Weyl showed that Riemannian geometry contains a limitation which makes it appear inappropriate to the description of a physical continuum from which all action at a distance is excluded. He generalised the geometry and so gave to the state of the world additional degrees of freedom. Actually four additional quantities had to be fixed in this more general specification of geometry; and he identified these with the four electromagnetic potentials. In this way the whole electrodynamic scheme is associated with the mechanical scheme, both being amalgamated with the geometry of the world. There is, however, an element of speculation in Weyl's unification which does not appear in Einstein's; the mechanical and geometrical properties of the gravitational field are aspects of the same phenomena; the electrical and geometrical properties of the electromagnetic field are not shown to be the same phenomena though they are supposed to originate in the same source.

Nearly half of Weyl's book is devoted to the development on a logical basis of a system of geometry. In this part we have to be content with laying a foundation, with scarcely a hint of the well-known phenomena of relativity which will follow. Knowing Weyl's great reputation as a pure mathematician, we felt some apprehension lest he should approach the study of space as though it were a matter of pure geometry. The fear was groundless. He recognises fully that he is dealing with a physical subject; and in his geometry space is recognised at the outset as a *form of phenomena* (p. 11), not a mere continuum of n dimensions. Among the most novel investigations is a justification of the Pythagorean metric (the quadratic formula for the interval) by an argument involving the theory of groups. The reasoning is difficult to follow.

As the changes made in successive German editions bear witness, Prof. Weyl is still developing his ideas. We think that near the end of the present edition he has reached conclusions which were not in his mind at the beginning. Four pages from the end, after some illuminating remarks on the two modes of transferring a quantity from place to place by "persistence" and by "adjustment" respectively, he decides that actual transference by clocks and measuring-rods corresponds to *adjustment*. Whilst this conclusion seems to be undoubtedly correct, the reader has scarcely been prepared for it, and indeed the existence of anything with respect to which adjustment can be made has only been demonstrated a few pages earlier. But the beginning of the book needs reconsidering in the light of this conclusion. How are we to reconcile the two following statements?

(1) The same object, remaining what it is, could equally well have been in some other place. The correspondence between the portions of space occupied in the two positions is called congruent transference (p. 11).

(2) A measuring-rod even in a statical field does not in general undergo a congruent transference (p. 308).

These are not the exact words, but I think that they convey the sense intended. It would seem to follow that a measuring-rod at another place and time is not precisely the thing it was. But it must be remembered that the statement (1) was enunciated as an axiom, which we were expected to accept as a matter of common experience; it is no place for metaphysical subtleties, which indeed Prof. Weyl is not likely to indulge in. There is, I believe, a direct contradiction between the initial premises (1) and the final conclusion (2) which can only be removed by revising our ideas as to the status of Weyl's ultra-Riemannian geometry. In spite of its specialised character the geometry of Riemann is the geometry of space and time ("the form of phenomena"), as Einstein assumed. Weyl's generalisation does not refer to actual space and time; but it gives us the needful mode of treatment in graphical guise of those fundamental relations which underlie the world of space and time and things.

Not until the last third of the book do we enter on the general theory of relativity. Then in a hundred pages we hasten through all the main results, including the re-formulation of mechanics to which Weyl has so largely contributed. De Sitter's and Einstein's rival views of a curved world are compared, and we gather that the author is not so hostile as most continental writers to the former. In either case, by noticing that $G^2\sqrt{g}$ (not $G\sqrt{g}$) is the fundamental scalar-density of zero dimensions, he is able to show that the cosmical curvature-term appears naturally and inevitably. Much of the more advanced theory depends on the Hamiltonian method of stationary variation of a volume-invariant. This is applied in two forms—

(1) Variations arising from changes of the reference-

frame vanish on account of the invariance. Equations so derived are mathematical identities which cannot be controverted.

(2) The vanishing of the variation for *all* small changes of the parameters is a possible form for a law of nature. Equations so derived rest on a particular hypothesis which challenges criticism.

We wish that the author had kept the results of these two applications distinct. We believe that most of the ascertained laws of physics are derivable by the first application, and the second is responsible for some additional results which cannot be tested and do not appear to us particularly probable.

The translator of such a book as this has our sincere sympathy. He has done a useful work which yet falls far short of complete success. There are many passages in the original which we have turned to again and again, and only very slowly grasped their meaning; others still defeat us. It was not to be expected that the translator would penetrate the thought behind them, and he has evidently given up the attempt to make his rendering convey any possible sense. We would not recommend any one to make a profound study of this work without having the German original at hand to consult when a difficulty is encountered. There are other mistakes harder to excuse. Weyl's treatment of space turns on the two conceptions of affine and metrical geometry, and it is impossible to proceed without mastering these. But the exposition of affine geometry on p. 18 refers continually to postulates I and II, and the reader will search in vain for any postulates so indicated. In the German edition a misprint of 1 for I is comparatively harmless; but in the English edition the further substitution of 2 for II extinguishes the reader's last hope of discovering what the argument refers to. On pp. 141-2, two axioms are printed as though they were headlines of the paragraphs following. Absurd mistranslations such as "mass of the earth" for "mass of the world" on p. 296 will probably not do much harm, though they shake our confidence. All the same, there is much good work in the translation, and those who are struggling to master Weyl's indispensable treatise will welcome the partial aid which it affords. A. S. E.

New Methods of Arctic Exploration.

The Friendly Arctic: The Story of Five Years in Polar Regions. By Vilhjahmar Stefansson. Pp. xxxi + 784 + plates. (London: Macmillan and Co., Ltd., 1921.) 30*s*. net.

NO such original and assertive explorer of the Arctic regions as Mr. Stefansson has appeared since Dr. Nansen startled the admirals by dispensing with a line of retreat. Mr. Stefansson's views are however, far more upsetting than those of Dr. Nansen, for he denies practically every theory and many reputed facts regarding the North Polar area, and contemns almost all the long-established methods of Arctic travel.

We cannot go on to Mr. Stefansson's vindication of his own powers as a pioneer without first deprecating his contemptuous tone with regard to arm-chair geographers and their views. Those harmless drudges do their best to follow the published narratives of explorers and to reconcile the contradictions between successive travellers' reports. If they say in their compilations that the Arctic Sea in its farther recesses is devoid of life it is because explorers have told them so, and if they dwell upon the hardships and dangers of Arctic explorations it is because earlier and less expert explorers did suffer and perish in the attempt to do, amid difficulty and pain, what proves easy and pleasant to Mr. Stefansson. We gladly acknowledge that Mr. Stefansson treats Peary as a great and successful explorer, and does full justice to McClintock's marvellous sledge journeys on the Franklin search; but he would have thought so much more of them if they had seen how easy it was to "live off the country"!

In pp. 30-32 much is made of the assumed ignorance on the part of Sir John Murray that sea-ice after long exposure on the surface of a floe can yield drinkable water. It seems to us that Sir John Murray probably controverted Mr. Stefansson's statement on this point not from ignorance but merely in order to test his character, for it was a common thing with Murray to see if a young man who knew something could be shaken in his confidence as to his own knowledge by the weight of an older man's authority. If Mr. Stefansson had wavered, as we are very sure he did not, Sir John Murray would have thought the less of him. As a matter of fact, we know that Murray was greatly impressed by the young Canadian's knowledge and fitness. With this book before them we are sure that the works of oceanographers and arm-chair geographers will henceforth be purged of some errors and fortified by many new facts; but the whole load of learning left by the old heroes of the North will not, on that account, be thrown into the sea like Stefansson's despised canned goods.

In 1913 the Canadian Government took over and financed an Arctic expedition which Mr. Stefansson had been organising in co-operation with the National Geographic Society of Washington and the American Museum of Natural History. These institutions withdrew their claims and so Stefansson's third Arctic expedition was purely Canadian. A great programme was prepared for work in two divisions, a northern in a strong whaler, the *Karluk*, under Mr. Stefansson himself with a large staff and complete oceanographical equipment; and a southern for work on the coast of the continent under Dr. Anderson, who was second in command, and provided with a smaller vessel. The southern party proceeded on the whole according to plan; but the *Karluk* forced her way into the ice north of Alaska on August 13, 1913, and remained fast, drifting westward. On September 20, when the ship was ten miles off the land Stefansson thought it right to go ashore for a few weeks' caribou hunting; but the ship had disappeared when he was ready to return, and after quite old-fashioned difficulties and hardships, including the crushing and sinking of the ship, most of the men succeeded in reaching Wrangel Island off the coast of Siberia and were ultimately saved. Mr. James Murray, the biologist, and Dr. Mackay, both of whom had been with Sir Ernest Shackleton in the Antarctic, were amongst those who perished on the ice.

Ignorant of the fate of the *Karluk*, and deprived by her loss of all the carefully prepared equipment and trained assistants, Stefansson had to decide whether he should accept failure or put to a test his long-cherished idea of living on the resources of what he had come to look on as a friendly Arctic. He chose the latter alternative, found two old friends amongst the Arctic traders, named Storkerson and Andreasen, who were willing to take risks, got together some sledges and dogs, a few instruments, and a large quantity of ammunition, and on March 22, 1914, started on a great journey over the sea-ice from Marten Point in 70° N. No one on shore expected to see him again. A support party was sent back on April 5, when fifty miles from shore, and the three men with six dogs and provisions for thirty days marched northward over the floes along the meridian of 140° W. By May 5, they had reached 74° N. in 135° W., and seals and bears kept them in food and fuel in an eastward march until they landed on Banks Land on June 25, after travelling a thousand miles, never having been hungry, cold, or tired, and the dogs in better condition than at the start.

The summer was spent hunting and exploring in the unknown interior of Banks Land; the ship appointed to bring supplies arrived, and the winter over Stefansson started again north-westward over the sea-ice, reaching almost 77° N. in 130° W. early in May 1915. From this point he travelled due east to Prince Patrick Land, skirted its north-west coast, and to the north-east of it discovered a new land (Borden Island) in 78° N. 115° W., and the summer being then so far advanced as to make travel over the sea-ice very difficult he hurried back almost 600 miles by the west coast of Melville Island to his old base in Banks Land. Thence opportunity was taken of a chance trader, whose ship Stefansson purchased as a matter of course, to pay a brief visit to the comparative civilisation of Herschel Island, but on returning to Banks Land the party made an interesting journey eastward to visit the Copper Eskimos of Victoria Island. After wintering in Banks Land, Stefansson in the spring of 1916 made a journey across Melville Island to Borden Island, thence north-eastward to 80° N., where another new land, Meighen Island, was discovered in 100° W., and on his way back he found a third new land, Longheed Island, in 77° N. 105° W. The winter quarters for 1916–17 were in Liddon Gulf, Melville Island, classic ground of the Franklin search.

Early in 1917 Mr. Stefansson was again on his way north, this time along the eastern coast of Borden Island and onwards over the sea-ice almost to 81° N. in 110° W. Here his two companions, who were new hands on this occasion, broke down from scurvy, due to their surreptitious diet of tinned foods during the previous winter, and the most promising of all these wonderful journeys had to be cut short. The return journey reads like a sheer romance, and Stefansson well says that if Stevenson had only known of facts like these he would never have had to invent the plot of "Treasure Island." The accumulating interest of chapters 59 to 63 is tremendous, and will prove to most European readers a revelation of what is possible in Arctic America. On September 13 Stefansson landed from his stranded steamer at a little harbour in Alaska, and here his luck deserted him, for after planning another trip into the Beaufort Sea he was attacked successively by typhoid fever, pneumonia, and pleurisy, and 1918 was well advanced before he could leave the hospital in Fort Yukon that nothing but his indomitable spirit enabled him to reach. His old friend Storkerson undertook an eight months' journey over the Beaufort Sea north to 74°, then drifting on a floe to follow the currents, and he returned safely, showing that he also could live on the natural bounty of the friendly Arctic.

We have given a condensed narrative, for the book is confused by digressions which obscure the sequence of events. The digressions, however, are full of interest, telling much of the habits of caribou, musk-oxen, seals, polar bears, and Arctic foxes, and more of Mr. Stefansson's own special subject—the habits and beliefs of the Eskimo, and the prejudices as to diet of all sorts of men and dogs.

The scientific results are being worked out at Ottawa, and we can refer here only to the unique value of the soundings taken by Stefansson and Storkerson in the Beaufort Sea. These determine the position of the Continental Shelf on several lines at right angles to the coast of America and to the western islands of the Arctic archipelago. They also point to great possibilities in the way of more detailed oceanographical work by sledge journeys in the future.

HUGH ROBERT MILL.

An Epic of Science.

The Torch-bearers. By Alfred Noyes. Pp. lx+281. (Edinburgh and London: W. Blackwood and Sons.) 7*s*. 6*d*. net.

EPIC is perhaps too large a word to apply to this beautiful book, though Mr. Noyes himself suggests it in his preface. There is, as he says, "an epic unity—a unity of purpose and endeavour"—in the story of scientific discovery, and "the great moments of science have an intense human interest and belong essentially to the creative imagination of poetry." The world of science and of poetry, therefore, both owe Mr. Noyes a great debt of gratitude for his attempt—the first of the kind—to bring them together; and, apart altogether from the high scope which he announces, every reader who submits himself fairly to the influence of his verse will be carried away by the charm of the language, the human, sometimes humorous, touches of character, and the triumphs, mixed with pathos, of the story.

We are told in the preface that this volume is the first of a trilogy, though the subjects of the two which are to follow are not revealed. This one deals with the pioneers of astronomy, and the other two might well be given, one to the discoverers of physics and chemistry, ending in the marvels of the electrons, and the other to the story of evolution, linking the record of geology with the gradual establishment of the continuity of organic structure. These we shall await with intense interest, and with full confidence that Mr. Noyes will do justice to the broad outlines of the theme and its human bearings, without too much concern as to the absolute accuracy of his account in details. Of course there are mistakes here and there; Kepler's laws are not quite accurately given. But what a *tour de force* to present them at all, approximately and attractively, in poetic form! Of course, too, there are plenty of prose-like lines, about which some of the critics in the press have made merry. But at the most they are a very small proportion of the whole, far smaller than in any of the long narrative poems of Wordsworth.

Speaking of Wordsworth, it is a little strange that Mr. Noyes does not invoke his great authority in favour of his enterprise in this trilogy. He invokes Matthew Arnold, who prophesied forty years ago that poetry would carry on the purer fire of human thought and express in new terms the eternal ideas of faith and hope which must be the constant stay of the human race. But Wordsworth, in the Preface to the second edition of the "Lyrical Ballads," came nearer still to Mr. Noyes's idea. He showed how the Poet, being in that respect the Man, *par excellence*, looked always "before and after" and held our human ideals together. He carried everywhere relationship and love, and wove into the fabric of his vision all that mankind has ever done or known or dreamt. Thus the material of science is just as fit an object of the poet's art as any upon which it is more usually employed. "If the time should ever come when what is now called science, thus familiarised to men, shall be ready to put on, as it were, a form of flesh and blood, the Poet will lend his divine spirit to aid the transfiguration, and will welcome the Being thus produced as a dear and genuine inmate of the household of man."

More than a hundred years have passed since Wordsworth made that prophecy. The volume of the poetry written, either in this country or abroad, with that inspiration is but slight. Tennyson gave us some thoughts suggested by the doctrine of evolution, Matthew Arnold some others. On the whole, Sully Prudhomme has come nearest to Wordsworth's ideal of the poet inspired by science, but it takes with him the guise of a stern, sad doctrine of resignation and fortitude under inexorable laws. It remained for Mr. Noyes to strike a new note, of triumph in the growth of the human spirit, of patient search for truth, of romantic beauty in the linking up of relationships between the heavenly bodies, which have inspired the worship and wonder of man since he first looked upwards.

The figures Mr. Noyes has chosen for the protagonists of his drama have all some points of personal interest, as well as permanent importance in the building up of science. These personal aspects he rightly stresses. Copernicus is described upon his death-bed, waiting for the issue of his long-delayed work. Kepler is the fantastic poet, visited by Sir Henry Wotton, who quotes verse for verse. The trial of Galileo—dramatically the most effective thing in the poem—is given in the form of letters from his daughter Celeste and from others, friends and foes, somewhat in the manner of Browning.

It is tempting to quote some of the most telling lines in the poem; one reviewer, at any rate, has read some of them several times already. Two extracts only shall be given, not by any means as among the most beautiful, but as conveying the dominating spirit of the whole. The Prologue raises the question, is there

. . . not one to touch
With beauty this long battle for the light ?
The blind, blood-battered kings
Move with an epic music to their thrones,
Have you no song, then, of that nobler war ?
. . . for, in these wars,
Whoever wins a battle, wins for all.

And then of Copernicus. The first effect of the new theory was to dwarf the importance of man, to make him "creep like ants upon our midget ball of dust, lost in immensity." But this is not the true or final issue :

This new night was needed, that the soul
Might conquer its own kingdom and arise
To its full stature.

F. S. MARVIN.

Biochemistry.[1]

Biochemistry : A Study of the Origin, Reactions, and Equilibria of Living Matter. By Prof. Benjamin Moore. Pp. vii+340. (London : Edward Arnold, 1921.) 21*s*. net.

As is pointed out in the preface, this book does not claim to be a general text-book of biochemistry. Hence, it is necessary, in the first place, to indicate the nature of its contents. The first two chapters are new ; they deal with "biotic energy" and with the relation of life to light. There is much of interest and of suggestive thought for workers in that field of vital phenomena discussed in these chapters. The author's views on "biotic energy" are well known. We may note that, while being an independent form of energy, this is supposed to be quantitatively convertible into the "inorganic" forms of energy and to obey the laws of energetics. This being so, it is difficult to see what is gained by the assumption, unless it implies the function of a directing agency or "entelechy." Perhaps the author has in his mind something of the kind, since he speaks of "biotic energy" as *controlling* the chemical reactions in the living cell. A mild criticism may be made in this connection of the somewhat hazy and unintelligible nature of occasional statements in the book. This is doubtless due to oversight ; but if one were able to attach a more definite meaning to certain expressions, it is likely that they might prove more useful than appears at first sight.

The following six chapters deal with photo-synthesis. They are practically reprints of the author's papers in the Proceedings of the Royal Society. While these experiments are of much interest, and will repay perusal, some doubt may be expressed as to the need for repetition of experimental detail, since the original papers are accessible elsewhere. With regard to the formaldehyde theory of carbon assimilation in plants, it may be remembered that Prof. Moore's experiments did much to give reasonable ground for holding this view, which has recently been made still more acceptable by the work of Baly, Heilbronn, and Barker. The assimilation of atmospheric nitrogen by the cell of the green plant under the influence of light, however, requires more convincing evidence than has been brought forward as yet.

The remaining chapters are reprinted and re-edited from "Recent Advances in Physiology" and "Further Advances in Physiology." The reader will be glad to have these articles again made available, but it is to be regretted that the opportunity was not taken to bring them more adequately up to date by correcting statements which no longer represent what is known on the subject. It may savour too much of "asking for more" if the opinion be expressed that readers would have been grateful for some account of the views of Langmuir on adsorption and catalysis, and of those of Bancroft on the latter. The application of the modern conception of "activity coefficients" to physiological phenomena is also a matter worthy of consideration.

Prof. Moore gives much destructive criticism of the assumption of a semi-permeable membrane on the surface of cells. It may be pointed out here that physiologists at the present day do not suppose such a membrane to be a permanent inert structure, but to be formed from the protoplasm in equilibrium with it and therefore liable to be affected by all kinds of functional change. Thus it becomes permeable in the state of activity of the cell, and most of Prof. Moore's arguments lose their weight.

There are certain interesting papers by the author which might well have been included in the present volume of reprints, such as those dealing with the osmotic pressure of colloids. This would have been a convenience to many workers.

When we find a section on the nervous mechanism of secretion amongst the questions dealt with in the book, we are naturally led to ask, what does the author understand by "biochemistry"? His biochemistry appears to be identical with what is properly called "physiology." The latter, however, as taught in the medical schools, is apt to be more or less limited to human or applied physiology, so that it was natural to institute a body of doctrine which should include the chemical phenomena of the lower animals and plants. But a complete physiological science includes these. Indeed, it is impossible to consider apart from one another the chemical and physical aspects of vital

[1] This review was written before the lamented death of Prof. Moore, the author of the work to which it refers.

phenomena. However convenient for practical purposes a separate department of biochemistry may be, it would be a matter for regret if this part of physiology became dissociated from the remainder. Indeed, it may safely be said that no physiological laboratory can carry on effectively any part of its work without the provision of a chemical department. Hence, biochemistry, as well as biophysics, must be included. What is needed seems to be the establishment of more chairs in what might properly be called "general" physiology, as distinct from "special" or human physiology. Since the term "general physiology" is sometimes misunderstood, and limited to the lower animals, perhaps the title of "biodynamics," suggested by the writer in another place, might be more appropriate. This name distinguishes the science of function from that of structure. Although, of course, one cannot exist apart from the other, such a separation is more scientific than that of the chemical from the physical departments of physiology, for the methods of both the fundamental sciences are needed for the proper investigation of vital problems.

At the same time, there may be said to be a more purely chemical branch of biochemistry, that devoted to the study of the properties of various compounds prepared from or by the living organism. This is really a special part of organic chemistry, and is obviously more related to the science of structure than to that of function, although it may conveniently be studied in connection with physiology. There is, however, an unfortunate tendency to call a man a "biochemist" who may be devoid of any acquaintance with vital phenomena. Another tendency, also apt to lead to confusion, is that of including pathological chemistry under biochemistry. This should surely be the chemical side of pathology, dealing with disease as physiology deals with normal processes. These remarks are not in any way intended to undervalue the pursuit of biochemistry, but as an attempt to make its position clear. Prof. Moore's book takes into consideration more than the chemistry of vital processes, so that the title is not altogether an appropriate one.

W. M. B.

Morphological Aberration.

The Echinoderms as aberrant Arthropods. By Austin H. Clark. Smithsonian Miscellaneous Collections, vol. 72, No. 11. Pp. 20. (Washington, July 20, 1921.)

FOR some years past Mr. Austin Hobart Clark has been flirting with the idea that the Echinoderms were derived from the Arthropods, but we all pretended not to notice. Now that he has come into the open with a paper published by no less a body than the Smithsonian Institution, and that he has sent us a copy for review, we are obliged to reprobate such goings-on.

What Mr. Clark suggests is not merely such connection of the Echinoderma with the Arthropoda as others find with the Protochordata; he is "convinced that they are undoubtedly closely allied to the crustaceans, and especially to the barnacles." No one can have failed to remark some resemblances between crinoids and cirripedes, due to a somewhat similar mode of life: normally both are attached—whether by a stem or immediately sessile; the body is encased in plates, and from it project jointed and often branched appendages used for collecting food. It is not easy to gather precisely how much importance Mr. Clark attaches to these and other adaptive resemblances: we may give him credit for the statement that "there can be no question of any direct homology between" them, and confine him to the suggestion "that it is not impossible to regard them as parallel manifestations of the same ancestral appendicular plan." The trouble is that he will keep dragging in, not merely the highly specialised sub-class Cirripedia, but the most modified forms of that sub-class, thus:—"A combination of the asymmetry of the Verrucidæ [a geologically late family of cirripedes] (inherent also in very many other crustaceans, and especially noticeable in the Paguridæ and Bopyridæ [hermit-crabs and parasitic isopods]) carried to its logical conclusion in the complete atrophy of one side, with the modifications of the body seen in Sphærothylacus or Sarcotaces [problematic parasites] in a less extreme form, the roots of the Rhizocephala [parasitic cirripedes], and a skeleton formed after the manner of the plates in the shell of the Operculata [sessile barnacles of late origin], furnishes all the elements needed for recombination to form the crinoid." It is fairer to Mr. Clark to ignore these and similar comparisons of incomparables, and to consider only the fundamental parts of his argument.

The "outstanding features" of the echinoderms are, says Mr. Clark, "the presence of a vascular, a respiratory, and a superficial skeletal system, the last composed of articulated (calcareous) elements, the absence of gill clefts, and the sharp division of the body externally into (five radial) segments. In these features they agree only with the arthropods." Probably he means: "In the combination of these features." But, take the characters singly, and what is the resemblance? The so-called vascular system of echinoderms is most feebly developed and possesses no heart or other means of causing its contents to circulate. The arthropods have a heart (except in some modified groups), a pericardium, and a large system of hæmocœlic spaces; the crustacea have definite arterial vessels. The arthropods, again, breathe by gills borne on the limbs or by tracheæ. But what Mr. Clark means by the respiratory system of the echinoderms is not clear: they aërate their body fluids in so many ways; such structures as papulæ, when developed, are not much like anything in arthropods. As for the crystalline skeleton of the echinoderms, deposited in the spaces of an interpenetrating mesoderm and resorbed as need arises, it can only be contrasted with the chitinous cuticle of the arthropods, hardened by the deposition of amorphous lime salts, and incapable of modification except through moulting. Lastly, how can the radial segmentation of echinoderms be homologised with the metameric segmentation of the arthropods? Mr. Clark does not tell us. He does, however, accept the general view that "the echinoderms are derived from bilaterally symmetrical ancestors," and he does later on quote Patten's hypothesis that the original metameres of the ancestor were suppressed on one side, and the remainder of the body bent round into a ring, so that the half metameres with their segmental organs became arranged in radiating lines—a hypothesis which places a very strained interpretation on the facts of embryology, and seems inconsistent with Mr. Clark's own views as to the relations of larva and adult.

No one would wish to assert that a study of the development and mode of life of the cirripedes can have no bearing on the origin of the echinoderms. There is much that is suggestive in the comparisons drawn by Patten and by Clark. But if those writers mean to conclude that the echinoderms were derived from the cirripedes by way of the crinoids, then assuredly they have been misled by adaptive resemblances. If they mean only that these resemblances imply a likeness of ancestral material no less than a likeness of external conditions, then we must ask them to indicate the connection between the ancestor of the Crustacea (nauplius-, Apus-, or trilobite-like, as they choose) and the bilaterally symmetrical ancestor (Dipleurula or what not) of the Echinoderma. It is quite possible that there was a primitive group of cœlomate animals from which the early echinoderms and the chætopod ancestors of the arthropods both arose; but to imagine that the arthropod type, once evolved on the "appendicular plan," as Mr. Clark calls it, retraced its steps towards anything that could have become an echinoderm, is contrary to all ascertained principles of evolution; and the alternative dream, that an arthropod, once recognisable as such, could progressively change into an echinoderm, is a baseless and unsubstantiated vision.

Mr. Clark will not, it is to be hoped, think we dismiss him in summary fashion. Many will say we ought to have done so. But there is a reason for treating the matter seriously. Any one has a perfect right to discuss the origin of the echinoderms and to maintain what views he pleases. Mr. Clark, as a distinguished authority on one class of echinoderms, certainly may claim a hearing. But whoever discusses morphological problems should have regard to the recognised principles and methods of morphology. He should have a sufficiently wide knowledge of comparative anatomy to be able to estimate the relative values of the facts that he adduces. There is at the present time a real danger that this discipline may be forgotten in the rush after alluring discovery in genetics, biochemistry, and other novel branches of biology. Among many examples of loose thinking in morphology, this of Mr. Clark occupies a bad eminence, exaggerated by the place of its publication and by the high merit of its author in his own field. F. A. BATHER.

Physics for Students.

(1) *An Outline of Physics.* By L. Southerns. Pp. xv + 202. (London: Methuen and Co., Ltd., 1920.) 6*s.* 6*d.*

(2) *General Physics and its Application to Industry and Everyday Life.* By Prof. E. S. Ferry. Pp. xvi + 732. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1921.) 24*s.* net.

(3) *Laboratory Projects in Physics: A Manual of Practical Experiments for Beginners.* By F. F. Good. Pp. xiii + 267. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1920.) 9*s.* net.

(4) *An Introduction to Physics for Technical Students.* By P. J. Haler and A. H. Stuart. Pp. 240. (London: Library Press, Ltd., 1921.) 4*s.* 6*d.* net.

(5) *Experimental Science.* 1, *Physics.* By S. E. Brown. Section 5, *Light.* Pp. vii + 273-424. (Cambridge: At the University Press, 1920.) 6*s.* net.

(6) *Elements of Natural Science.* By W. Bernard Smith. Part 1. Pp. viii + 207. (London: Edward Arnold, 1921.) 5*s.* net.

(1) MR. SOUTHERNS has faced the difficulty, which many university lecturers have experienced, of providing a course in physics for college students in their first year. Not only are there great differences in the preliminary knowledge with which the students are equipped, but also different groups—say, engineers and medicals—look at the subject from very different angles. The first year should be a year

of inspiration. Broad outlines should first be presented in an elementary but scientific manner. Part 1 of this book, which is intended to be used in conjunction with a theoretical text-book, aims at giving such a general sketch in which new knowledge is incorporated as an essential part of the course. Part 2 comprises a course of laboratory work suitable for general purposes. In an interesting preface Mr. Southerns has some suggestive observations as to the methods of dividing students into classes, with the view of allowing the better students to undertake more advanced work. Such subdivision is advocated in connexion with both tutorial and practical work. The book has been well thought out, and may be recommended to teachers who have similar problems to solve.

(2) In this new volume Prof. Ferry, who is known as the author of a useful handbook of practical physics, has placed teachers of physics under fresh obligation by providing a text-book for college students "in which especial emphasis is laid on the diverse relations of physics to Nature, agriculture, engineering, and the home. Much of the motivation and illustrative material has not appeared heretofore in any text-book." Even if we do not fully grasp what is implied by the term "motivation," we may admit the general accuracy of this claim. A lecturer on physics in search of novel or up-to-date illustrations should certainly consult this volume. By studying the series of kinetoscope photographs of a freely falling cat and the accompanying letterpress he will learn why the cat alights on its feet. "The recent war has produced many highly important and interesting devices, some of which are here presented to students for the first time." We find, for example, descriptions of acoustic goniometers, based on binaural hearing, for locating invisible submarines and aeroplanes, and of the "radio-compass," by means of which the position of a vessel at sea may be found by wireless signals.

The amount of information that has been packed into these 700 pages is remarkable. But it must not be supposed that this is merely a popular or descriptive book; it is a scientific treatise, and every page bears evidence of the fact that it is the work of one who has considered with care the theory of each subject and the best method of presenting it to the student. A few points of interest may be mentioned. For the familiar "latent heat of fusion" the term "heat equivalent of fusion" is suggested. The paragraph dealing with the black-body temperature scale seems to us to make a simple matter complicated by its treatment of "the black-body temperature of a non-black body." There seems no good reason for speaking or thinking of this as the temperature of the non-black body itself; it is simply the temperature of a black body which emits radiation at the same rate. Electric resistance is discussed before electromotive force or Ohm's law, being measured by the amount of heat developed in a conductor by the passage of unit current for unit time.

There are interesting chapters on the electron hypothesis (including a description of the three-electrode vacuum tube) and on electromagnetic waves. The section on light is excellent; the cardinal points and the aberrations of lenses and lens systems are well treated, as also are various optical instruments. Physical optics claims attention in three interesting chapters. The statement on p. 626 that it is impossible to have a blue sea when the sky is overcast has been contradicted recently by Prof. Raman (NATURE, vol. 108, p. 367). The volume contains numerous solved problems in the text, and nearly 700 unsolved problems with answers in an appendix; the illustrations deserve a special word of commendation.

(3) Space is lacking for a full account of the high ideals which have inspired the author of this manual. Suffice it to say that the physics course in a modern (American) high school "should proceed toward an organisation of practical situations, activities, and phenomena, the value of which will be recognised and approved by teachers, students, parents, administrators of education, and others who are responsible for the work which boys and girls do in the high school"! Hence these ninety-five "projects" include the construction of "a model of a kitchen hot-water heater" (*sic*); studies of methods of heating or lighting a room; experiments on electroplating, saucepan conduction, and wireless; studies of the camera, the kerosene stove, the phonograph, and the sewing machine; and lastly a section headed "automobile work" dealing with carburettors, ignition systems, and the engine of a Ford car. Here is a course "organised according to the recognised function of education in a democratic society"! We cannot help feeling a certain amount of envy of the boys and girls in the modern high school.

(4) Messrs. Haler and Stuart have produced an introduction to physics based on experiments which can be carried out with simple apparatus. The scheme is intended to cover a two-years course for technical or trade schools, when two or three hours a week are devoted to the subject. Questions and numerical exercises are plentiful. It is scarcely logical to say that the absolute zero of temperature would be reached at -273° C. when the only scale of temperature that has been described is that of the mercury thermometer.

(5) Mr. S. E. Brown has prepared a useful course on light to occupy two terms for pupils about fourteen years of age. There are plenty of experiments and illustrations, and the Barr and Stroud range-finder is

shown as a frontispiece. Teachers will welcome the large collection of examples and revision questions.

(6) Part 1 of the "Elements of Natural Science" includes mechanics, chemistry, heat, properties of matter, light, and sound. With part 2 the course is intended to cover the "general science" syllabuses of School Certificate and Army Entrance Examinations. The treatment of the subject-matter, together with the experiments in illustration, should prove successful in exciting and maintaining the interest of the student.

H. S. A.

Parasitism and Symbiosis.

Le Parasitisme et la Symbiose. Par Prof. M. Caullery. (*Encyclopédie Scientifique : Bibliothèque de Biologie Générale.*) Pp. xiii + 400 + xii. (Paris : Gaston Doin, 1922.) 14 francs net.

FEW zoologists are so well qualified as Prof. Caullery, who is editing the series of works on general biology to which the volume under notice belongs, to survey the range of parasitism and symbiosis. He is the pupil and successor at the Sorbonne of Alfred Giard, and like him is distinguished by a remarkable versatility, having brilliantly investigated the life histories of parasites belonging to many phyla. In his laboratory, too, there was largely carried out the work of Guyenot on aseptic life, which is fundamental for future attempts to solve the problems of symbiosis.

There are good modern treatises on medical parasitology, but these naturally concern themselves with a much narrower field than that required by the student of general biology for whom this book is designed. Throughout, it is characterised by an admirable lucidity, and the vast amount of information it contains does not interfere with the well-balanced arrangement. Recent research which has a general bearing on parasitism is presented with great care, and the bibliography is complete and invaluable.

Commensalism, parasitism, and symbiosis are dealt with successively as related phenomena. The series of more or less modified parasites which exist in many animal groups offer perhaps the most striking illustrations which can be given of the reality of evolution. Prof. Caullery has treated the groups he knows best in detail from this standpoint. The adaptation of the parasitic isopods (especially Entoniscidæ) to their diverse hosts, the evolution of the Rhizocephala in the cirripedes, and the clear series of parasites in the gasteropods are given the attention they deserve. There might also have been included with advantage an account of the passage in the nematodes from forms with a perfect alimentary canal through the intermediate group of the Mermithidae to those complete parasites which absorb food only through the skin.

Passing over the very useful chapters on the various types of parasitic life-history, the migrations of "heteroxenous" forms, and the adaptations for reproduction in parasites, there follows an interesting discussion of specificity of parasites, especially in connection with human interference with the distribution of insects and the parasites they convey. We miss a reference to the very rigid specificity which is stated to exist in the Mallophaga, occurring on birds. Here the association of host and parasite apparently took place at an early stage in the evolution of both groups, and the well-marked systematic relationships of the different Mallophaga actually throw light on those of the bird genera on which they are found.

In the chapters on symbiosis reviews are given of the large number of cases recently described where unicellular symbiotes are found in different invertebrate groups, and then of the extraordinary extension of research on these lines by Pierantoni and Portier. The claim of the latter that every living cell contains symbiotic organisms was seriously considered and rejected by a committee of French biologists, but interest in research on symbiosis is still intense in France.

F. A. POTTS.

Our Bookshelf.

Anleitung zur mineralogischen Bodenanalyse. Von Dr. Franz Steinriede. Zweite umgearbeitete und erweiterte Auflage. Pp. viii + 240. (Leipzig : W. Engelmann, 1921.) 60 marks.

THE original appearance of this book in 1889 marked the first serious attempt to apply petrological methods to the study of the minerals of the soil. During the thirty-two years that have since elapsed, petrological methods have undergone considerable development, while, on the other hand, our knowledge of the soil has similarly been enormously extended. The development of these two subjects, however, has proceeded mainly on quite separate lines, particularly in this country, where soil investigators have studied chiefly the chemical and biological aspects of soil fertility. That our present methods of examination of soil frequently fail us in accounting for observed differences in fertility is an indication of the need for new methods of attack, among which mineralogical analysis is undoubtedly of importance.

The appearance of the new edition of a book by a pioneer in the subject is thus welcome, especially as no similar book exists in this country. The author gives a succinct but adequate account of all the important aspects of the subject, including elutriation and flotation methods of separation, optical and other physical as well as chemical methods of examination. The data for the application of these methods are collected in a series of useful tables, together with a detailed classified description of all minerals likely to be met with in soils. Finally, there is a systematic scheme for the detection and identification of the commoner of such minerals, and a bibliography of 136 references. This book and its subject merit the attention of all soil investigators. H. J. P.

Webbia: Raccoltà di scritti botanici. Edita da Prof. U. Martelli. Vol. Quinto, Parte 1a. Pp. 355+xiii plates+maps. (Firenze: Mariano Ricci, 1921.)

THE portrait of Odoardo Beccari which serves as frontispiece to the most recent instalment of "Webbia" reminds men of science that the death of that eminent traveller and botanist at the age of 77, on October 20, 1920, meant the loss of the chief authority on the natural history of Palms. Much of this part (pp. 5-198) is devoted to two important articles left complete when Beccari died. A "Review of the Old World *Corypheæ*" is an epitome of the monograph prepared by Beccari for the Annals of the Royal Botanic Garden, Calcutta, in continuation of those on "Asiatic Palms" published in 1908 and 1911. An account of "The Palms of New Caledonia" is of exceptional interest because the palms of this group of islands, though few in number, are all endemic species.

In "La Culla del Cocco" (pp. 201-294) Prof. E. Chiovenda reviews the evidence available as to the home of the coco-nut. Historical and ethnological considerations may be adduced in favour of either the Asiatic origin accepted by P. Miller (1752), R. Brown (1818), and A. R. Wallace (1853), or the American origin suggested by von Martius (1840), considered at first by A. de Candolle (1855) to be probable, and regarded by B. Seemann (1873) as assured. The taxonomic judgment of von Martius turned the scale in favour of America until Beccari (1877) showed that this judgment was contrary to morphological facts. These facts, indeed, contraindicate an American origin so that Beccari suggested instead a Polynesian one, while A. de Candolle (1883), writing now "with more information and greater experience," favoured a Malayan rather than an American origin. The renewed advocacy of an American origin by Dr. O. T. Cook (1900 and 1910) left Beccari (1916) indisposed to modify his earlier view. Careful consideration of all the evidence leads Chiovenda to agree with A. de Candolle's later belief.

"Webbia" since its inception has contained many important results of Beccari's botanical studies, and the editor, Prof. U. Martelli, fittingly concludes this part with a sympathetic "Memoir" (pp. 295-343) of that eminent man of science, to which is appended an invaluable bibliography (pp. 344-353) of Beccari's contributions to botanical literature.

The Journal of the Institute of Metals. No. 2, 1921. Vol. xxvi. Edited by G. Shaw Scott. Pp. x+760+pl. xxxiv. (London: Institute of Metals, 1921.) 31*s.* 6*d.* net.

THE growth in size of the half-yearly volumes of the Journal of the Institute of Metals is a striking indication of the increasing attention that is given in this country to the study of the non-ferrous metals. The lecture on the casting of metals by Prof. Turner, which occupies the first place in the present volume, directs attention to the comparative neglect of this important subject of casting by scientific workers, in spite of the high degree of practical skill that has been acquired by foundrymen, proceeding by a method of trial and error. The remaining papers deal with varied questions. A note on the characteristic defect which appears in some bars of extruded brass led to an interesting discussion at the meeting of the Institute, in the course of which laboratory experiments with wax models were cited in illustration of the mode of flow during extrusion. A second note on the casting of brass ingots shows the desirability of an exchange of information between ferrous and non-ferrous metallurgists, the device proposed having been long adopted in steel works. Other subjects treated are gun-metal, cold-working, scleroscope hardness, nickel-aluminium-copper alloys, etching methods, and the properties of rolled zinc. An important research by Dr. Hanson and Miss Gayler definitely connects the ageing of duralumin and similar alloys with the varying solubility of magnesium silicide in aluminium. The number of abstracts shows an increase on previous years. C. H. D.

(1) *A Short Course in Commercial Arithmetic and Accounts.* By A. Risdon Palmer. (Mathematical Series for Schools and Colleges.) Pp. x+171+xv. (London: G. Bell and Sons, Ltd.) 2*s.* 6*d.*

(2) *The Use of Graphs in Commerce and Industry.* By A. Risdon Palmer. (Handbooks of Commerce and Finance.) Pp. ix+47. (London: G. Bell and Sons, Ltd.) 2*s.* net.

(1) MR. PALMER'S books on the application of elementary mathematics to commerce and industry are a welcome addition to the literature on the subject. His "Short Course" is a brief account of the most important arithmetical methods and processes required in commerce. Those who know Palmer and Stevenson's "Commercial Arithmetic and Accounts" will expect to find the new volume useful and interesting, and they will not be disappointed. There is a touch of real life about most of the chapters, especially that on "The Home Trade": one only misses the Public Receiver and the creditors' meeting. But are contracted methods really used in commercial life?

(2) Graphical representation is a useful and important process in industrial and commercial life; its vogue is increasing, and we have already had the case of a Cabinet Minister using a graph in the House of Commons to illustrate the activity of his department. While the methods are not exactly the same as those used in mathematics as such, the ideas are of course similar. One often wonders whether and how the ordinary newspaper reader understands the diagrams used in connection with price fluctuations or statistical reports. Mr. Palmer's little book will certainly be useful to all who have to deal with such pictorial information: it is indispensable to the business man and economist.

The book is the third of a series of handbooks of commerce and finance. Co-ordinates are explained and applied to the broken straight-line diagrams used by commercial and other journals, and the rectangle method and the sector method of representation used in books on geography, economics, and commerce are then discussed. There are a number of useful exercises. S. BRODETSKY.

Ministry of Munitions and Department of Scientific and Industrial Research. Technical Records of Explosives Supply, 1915–1918. No. 8: *Solvent Recovery.* Pp. iv+22. (London: H.M. Stationery Office, 1921.) 3s. net.

IN the manufacture of cordite, which is the propellant used in practically all arms in warfare, a mixture of nitrocellulose and nitroglycerin is incorporated with a "solvent," consisting of ether and alcohol, and the doughy mass is extruded through dies to form the cordite strands. These are dried on trays in closed recovery stoves, where the solvent is evaporated in a current of warm air until only a small amount of volatile matter remains, which is finally expelled in drying stoves. The solvent-laden air may be treated in absorbers for the recovery of the solvents. The present report deals with the use of sulphuric acid, water, and cresol as absorbents, the last being found most satisfactory. The air and absorbent were brought together in a Whessoe scrubber, such as is used in gas works, and the solvent then expelled by distillation. Calculations dealing with the operation of the plant are given.

A Manual of Selected Biochemical Methods as Applied to Urine, Blood, and Gastric Analysis. By Prof. F. P. Underhill. Pp. xiv+232. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1921.) 17s. 6d. net.

A COLLECTED account of the various ingenious methods devised by American workers in the field of urine, blood, and gastric analysis will be found in this useful laboratory manual. Although doubtless the methods are adequate for the purposes described, it is somewhat surprising to find no reference to the Barcroft apparatus for determining oxygen capacity, nor to the almost indispensable comparator of Cole or Walpole for use with indicators in coloured solutions. Mett's tubes require more cautious criticism in quantitative work than is suggested by the author. These are perhaps minor blemishes, and, apart from them, the book can be highly recommended. It is to be feared, however, that the price will militate somewhat against a large sale in this country.

The Commercial Apple Industry of North America. By J. C. Folger and S. M. Thomson. (The Rural Science Series.) Pp. xxii+466+xxiv Plates. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1921.) 18s. net.

A FULL account of the growing of apples on a commercial scale in North America is given in this work, and much information that could be obtained only with difficulty elsewhere is embodied in the text. It would prove useful to any English grower or student of horticulture who wished to obtain information as to the way in which this important industry is carried on. The authors state in their introduction that they have visited practically every important apple-growing county in the United States, first in connection with an investigation into the cost of production, and later in connection with attempts to organise a system for estimating the apple crop of the United States.

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.*]

On Immediate Solutions of Some Dynamical Problems.

As a branch of science advances and its principles become more familiar to the mind of the investigator many things which before appeared involved and mysterious become simple and clear, and it is possible to find proofs of theorems so obvious and brief as to merit the name *intuitive* in a very real sense, though not that in which the term is frequently applied. For to say that a theorem or principle is intuitively perceived is often tantamount to saying that it is not perceived at all. By an intuitive proof of a proposition I mean a proof which is natural and direct, and it may be almost instantaneous in that the restatement of some element of the proof transforms the whole so that the proposition is at once recognised to be true. But the proof must be complete and rigid to be valid, and completeness and rigidity are qualities which have come to be almost denied by calling a proof "intuitive."

I have amused myself from time to time with endeavouring to devise what I venture to think are properly called *immediate* proofs of dynamical propositions, and some of these, with historical notes here and there, may be of interest to readers of NATURE. Many of the ideas of attractions have become so familiar, not to students generally by any means, but to those who have pondered over the connection between the theory of gravitational attraction and the mathematical theory of electrostatics for example, that the subject has acquired a very special interest and fascination to the minds of such workers. Accordingly I give here some propositions in attractions.

It is undoubtedly the case that Newton delayed the publication of the discovery of universal gravitation until he had discovered a proof which satisfied him that a uniform spherical shell attracts an external particle, as it would if the whole mass of the shell were comprised in a particle situated at the centre. For if this proposition were established, the earth, which there was reason to believe was a nearly spherical body with a distribution of density approximately symmetrical about the centre, would attract external matter as if its whole mass were collected at the centre, and this therefore was the point from which distances were to be measured in the numerical comparison of gravitational forces; for example, the comparison of the two unital attractions of the earth, that on a particle at the surface and that on the moon.

The proposition given by Gauss that the surface integral of normal force taken over a closed surface drawn in the field is equal to $4\pi k$ times the whole quantity of the attracting matter which is contained within the closed surface, is capable of many applications. This proposition may be more precisely stated as follows: Let dS be an element of area of the surface and N be the component of the field intensity at right angles to the surface (taken positive when acting outwards). Then the integral

$$\int \mathrm{N}d\mathrm{S},$$

taken over the closed surface, is called the surface integral of normal force, more properly normal field intensity, and we have the equation

$$\int N dS = k 4\pi M,$$

where M is the whole quantity of matter inclosed by the surface, and k is the so-called gravitation constant, the force between two unit masses at unit distance. Take an example: Let the field be produced by a uniform spherical shell of radius a, and describe a sphere of radius R concentric with it. Consider a point P on this sphere; the field due to the shell must by symmetry have the same intensity at every such point as P, and the resultant intensity at P, which we call F, must be at right angles to the surface; thus we have for the surface integral of normal force $4\pi R^2 F$; the whole quantity of matter within the surface if ρ be the density of the shell, and da the shell's thickness, is $4\pi\rho a^2 da$; thus by the theorem we have

$$4\pi R^2 F = 4\pi k (4\pi\rho a^2 da),$$

that is,

$$F = k\frac{4\pi\rho a^2 da}{R^2},$$

that is, the field intensity is the same as if the whole mass of the shell were collected at the centre.

The only parts of this proof which are not altogether satisfying are those which depend on considerations of symmetry; but it will be tolerably clear that any distribution of matter must attract a distant particle after the manner stated, and no valid exception to them can be taken.

I shall return to this theorem of Gauss for a proof of another proposition. No doubt it can be applied, though Gauss its discoverer does not seem to have done so, to establish other propositions in attraction. We may prove the proposition with which we have just been dealing by the following discussion, which shows that the *potential* of a spherical shell at an external point is the same as if the whole mass were collected at the centre of the shell. The idea of potential was given in the treatment of attractive forces set forth in the "Mécanique Céleste" by Laplace: the name *potential* was given by Green, who made considerable use of Laplace's idea. It is remarked somewhere, though I cannot remember by whom, that it is perhaps easier to show that the attractive *force* of a spherical shell on an external particle is the same as if the whole mass were collected at the centre than to prove the same proposition for the potential. The proposition for the attraction is proved in Thomson and Tait's "Natural Philosophy" (a classic which, like the other great treatises, nobody now has time to read) by a reference to the point which is the inverse,[1] with respect to the sphere, of the external point. The proposition is proved also by direct integration in the "Natural Philosophy." In a paper on the historically famous problem of the attraction of an ellipsoid I have shown how the reference to the inverse point, in the case of the sphere, may be dispensed with, and the proposition as to the force established by what is practically an instantaneous proof. I shall here modify the method to give a proof of the theorem of the potential. Use of the inverse point for the potential was first made by my friend Mr. C. E. Wolff, and I have here adopted his idea of dealing with the attractions of two elements at once, the two intercepted by a small cone with its vertex at the point which I call the point corresponding to the external point P. This is the point A in the diagram (Fig. 1) in which the line CP intersects the shell so that A and P correspond to one another, as do two corresponding points on confocal ellipsoids. Of course the concentric spherical surfaces on which P and A lie are a particular case of confocal ellipsoids.

Let the circle EAE_1 (centre C) be a section of the shell by the paper, and P be the external point. Through P describe a sphere, radius f, concentric with the shell. Consider an element of area dS of the shell at E. If k be the gravitation constant, and σ the surface density of the shell, the potential at P due to the element is $k\sigma dS/r$. Produce all the radii to the boundary of dS to meet the concentric spherical surface, and give a new element of area dS' $(=dS \cdot f^2/a^2)$ on the concentric surface at E'. From the points of the periphery of dS' draw lines all passing through A. These lines will include a cone of small solid angle ω with vertex at A, meeting the outer surface in the two elements dS' and dS_1' at E' and E_1' respectively. The element dS_1 at E_1

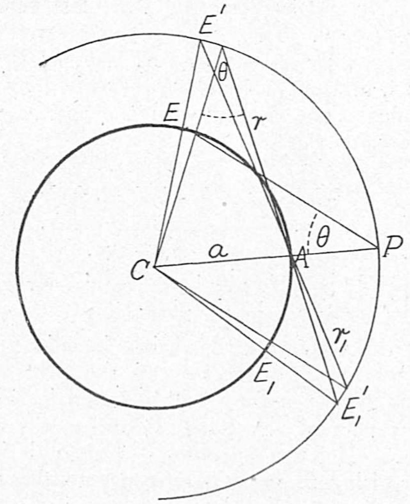

FIG. 1.

corresponds to an element dS_1' of the shell at E_1' at distance r_1 from A.

We have $dS' = \omega r^2/\cos\theta$, $dS_1' = \omega r_1^2/\cos\theta$.

The potential at P due to the two elements at E and E_1 is equal to the potential at A (the intersection of CP with the shell) due to the elements dS', dS_1' at E', E_1', multiplied by the ratio a^2/f^2.

Thus if dV be the potential at P due to the pair of elements at E', E_1' we have

$$dV = k\sigma\frac{a^2}{f^2}\omega\left(\frac{r^2}{r}+\frac{r'^2}{r'}\right)\frac{1}{\cos\theta} = k\sigma\frac{a^2}{f^2}2\omega f,$$

since $(r+r')/\cos\theta = 2f$. The potential at P produced by the whole shell is thus given by

$$V = k\sigma\frac{4\pi a^2}{f},$$

since the whole solid angle subtended at A by the external concentric sphere is 4π.

The proof of the theorem for the force is curiously different from that for the potential. Consider only a single element E in the diagram, and draw radii through all the points of the periphery of the element to meet the concentric surface through P; an element of this latter surface will be intercepted at E'. Let dS be the area of the element at E, and dS' that of the element at E', and f the radius of the concentric sphere through P, and a as before the radius of the shell. We have then

$$dS = \frac{a^2}{f^2}dS'.$$

[1] The idea of using the inverse point in attractions of spheres seems to be due to Newton. See the "Principia," Book i., Proposition lxxxii., in which the attraction at an internal point of a spherical shell is deduced from that at an external point when the law of attraction is any function of the distance. In the text the law of the inverse square is alone considered.

Now from the diagram it will be seen that $\angle$CE′A $=\angle$CPE$=\theta$, say, and EP$=$E′A$=r$. The attraction due to E at P is equal to $k\sigma d$S $\cos\theta$, but this is clearly, if $r=$EP,

$$k\sigma\frac{a^2}{f^2}\frac{dS'\cos\theta}{r^2}.$$

Now the factor $dS'\cos\theta/r^2$ is clearly the solid angle subtended at A by the element dS'. The whole force exerted at P by the shell is thus, to a constant factor, equal to the solid angle subtended at A by the whole concentric surface of radius f, which is 4π. The attraction of the shell on a unit particle at P is thus $k4\pi\sigma a^2/f^2$, that is, it is the same as it would be if the whole mass were collected at the centre.

If the point P be internal to the shell the concentric surface with A falls within, and the total solid angle subtended by the shell at A is zero so that the attraction is zero.

This process extended to an ellipsoid and the confocal ellipsoid through an external point is made to give the force due to the shell at the point. The integration is made immediate by the use of a theorem of solid geometry which holds, as I pointed out, for confocal conicoids. The theorem may be stated here. Let A and P, E and E′ be pairs of corresponding points; then the distances AE′ and PE are equal, also if p and p' be the lengths of the perpendiculars from the centre on P and E′, θ the angle which PE makes with the perpendicular p, θ' the angle which E′A makes with the perpendicular p', then the theorem holds—

$$\frac{p}{\cos\theta}=\frac{p'}{\cos\theta'}.$$

This theorem shows the result of the integration over the ellipsoid to be, to a constant, equal to the solid angle subtended at an internal point by a closed surface in the manner just illustrated by the spherical shell. It is curious that this geometrical theorem which enables this result to be obtained is, as I have found, generally unknown to writers on geometry, and is not contained in any of the treatises which I have examined.

The next problem is one of which, I believe, the only simple solution given before 1900, was due to the late Prof. Tait, of Edinburgh. The problem was the determination of the pull between the two halves of a homogeneous sphere due to gravitational attraction. Prof. Tait's solution was a quasi-hydrostatic one, and I believe that he held the opinion that the only choice was between this and straightforward sextuple integration. There are, however, at least three other methods of attacking the problem, and one of these which occurred to me a long time ago I will indicate here. This has only been published so far as I know in a collection of exercises lithographed nearly twenty years ago by the late Dr. Walter Stewart, who was then my assistant, for the use of students in Glasgow. It makes use of the theorem of Gauss referred to above.

Consider the homogeneous sphere of radius a and let a closed surface be described consisting of a plane part dividing the sphere into two segments, and a spherical part fitting close to the smaller segment of the sphere. The surface integral of normal force over this surface will consist of two parts, I, the integral over the plane, and Σ the integral over the spherical portion. The mass M of the enclosed segment can easily be calculated and $4\pi k$M is equal to I$+\Sigma$; of course Σ is also easily calculated, and thus I is obtained. If r be the radius of the plane section, z the distance of that section from the centre, ρ the density of the sphere, the mass of unit area of a disc of radius r and thickness dz is ρdz. Multiplying this by I, we see that the product Iρdz is the force due to the whole sphere on the disc of radius r and thickness dz, and if this be integrated from $z=a$ to $z=0$ we obtain the attraction of the whole sphere on the hemisphere throughout which the integration has been carried; this attraction of the whole sphere on the hemisphere includes the attraction of this hemisphere on itself, which, of course, is zero. Thus the integration gives the attraction of one hemisphere by the other.

The mass M of the segment within the closed surface is easily seen to be

$$\frac{1}{3}\pi\rho(2a^3-3a^2z+z^3);$$

the integral of normal force over the curved part of this segment is

$$\Sigma=2\pi ka^2\left(1-\frac{z}{a}\right)\frac{4}{3}\pi a\rho;$$

thus

$$I+\frac{8}{3}k\rho\pi^2a^3\left(1-\frac{z}{a}\right)=\frac{4}{3}k\rho\pi^2(2a^3-3a^2z+z^3),$$

that is

$$I=\frac{4}{3}k\rho\pi^2z(z^2-a^2).$$

We have therefore for the product of I by the mass per unit area of the disc coinciding with the plane surface of the segment

$$I\rho dz=\frac{4}{3}k\rho^2\pi^2z(z^2-a^2)dz.$$

Integrating from $z=a$ to $z=0$ we get for the pull P on one hemisphere exerted by the other,

$$P=\frac{1}{3}k\pi^2\rho^2a^4,$$

or $3k\text{M}^2/16a^2$, where M is the mass of the sphere supposed of uniform density ρ.

A numerical estimate of P for the earth must be very rough, for the earth is not of uniform density, and there are other causes of inexactitude. But by the formula an estimate can be made in any units that may be preferred. In c.g.s. units k is $6{\cdot}7\times10^{-8}$. The force between the two hemispheres of a body of such great dimensions as the earth must be almost entirely due to gravitational attraction (for cohesion must be negligible in comparison), and this figure may be taken as giving an idea of its amount.

ANDREW GRAY.

The University, Glasgow.

The Conquest of Malaria.

THE obituary notice of Sir Patrick Manson, in NATURE of May 6, concludes with the hope that his memory may ever be kept alive as the Father of Tropical Medicine. As to this it is not difficult to forecast that the medical profession will fully concur. To the enthusiasm and inspiring teaching of Manson is due the existence of tropical medicine as a speciality, and the ever extending benefit tropical races receive at the hands of men trained on the lines indicated by him.

In the present day, the views of the medical profession are apt to change rapidly in accord with accumulated investigations and experiences of world-wide origin; opinions rigidly adhered to for fifty years may be rendered taboo by a single telegram received from some expert at a remote corner of the earth. If the new view stands the test of criticism the practical results are grasped; but few care to memorise how the change was effected. If this be so with the profession specially concerned with disease prevention, it is not surprising to find that certain lay journals, in their biographical notes of Sir Patrick Manson, have given erroneous views of his connection with malaria prevention. Although, obviously, the well-informed writer of the obituary notice in your columns has no such intention, it seems to me that his quotation from NATURE (Vol. 61, 1900, p. 523) of matter by Sir Ronald Ross, unless considered side by side with other historical facts, is liable to accentuate the popular assumption that Ross, having been instructed by Manson as to what he would find in the mosquito, forthwith[1] performed the necessary hara-kiri—and the key to the etiology of malaria was found; and, therefore, to Manson and not to Ross is due the credit of the epoch-making discovery of malaria transmission. Yet Manson, with no less courtesy and frankness than displayed by Ross in elevating (in the matter quoted by your writer) what Manson himself termed a hypothesis to the rank of an induction, expressly disavowed any such claim.

In thus acting, Manson was fully aware of the great value to the British Empire and the world generally of the solution of the malaria problem which had been secured by Ross. In his paper read before the Royal Institute of Public Health Congress at Aberdeen, in 1900, he said: "I feel safe in asserting that malaria is far and away the most important of the many problems of tropical empire—that empire on which so much of our present and of our prospective national prosperity depends. The politician and the soldier may not think so. They are wrong. Such people habitually magnify their offices. . . . Our little wars and rebellions in their effects and importance are insignificant in comparison to the great natural phenomena, disease—to malaria for example." "My purpose . . . is to state . . . the . . . leading facts of the new knowledge which dawned only some twenty years ago with the discovery by Laveran of the cause and nature of malaria, and which culminated only two years ago when our countryman Ross showed how the infection is acquired, and in doing so clearly indicated in what way it is to be prevented."

To understand Manson's position it is necessary to indicate what was the actual "induction" he placed at the disposal of Ross. The following is found at pp. 16 and 17 of the first edition of "Tropical Diseases," by Manson: "I consider that the flagella—which as already stated are to be regarded as flagellated spores (*sic*)—are endowed . . . with locomotive powers, in order that they may be able to pass from the blood in the mosquito's stomach to the tissues of the insect. . . . The plasmodium, I hold, is an intracellular parasite both outside as well as inside the human body, and that when outside the human body it is parasitic in the mosquito. . . . The mosquito generally dies in the water beside the eggs she has deposited. When the eggs are hatched the young larvæ commonly devour the body of the parent and consequently her parasites. On the infected larvæ becoming mature insects the plasmodia they have swallowed continue, I conjecture, to develop. These insects, in their turn, infect their larvæ and so on. . . . *Man, I conjecture, may become infected by drinking water contaminated by the mosquito; or, and much more frequently, by inhaling the dust of the mud of dried-up mosquito pools; or in some similar way.*" (Italics not in original.)

Whilst, then, it is true Manson's induction of 1894 strengthened the hypotheses of Dr. A. F. A. King and Laveran as to mosquito agency, and this resulted in an inquiry by Ross as to possible extra-corporeal existence of the plasmodium, it is equally true that the work of Ross proved Manson's theories in essential details incorrect and misleading.

[1] Unaided by public funds, Ross devoted years of laborious experiments to the solution of the problem.

Holding in mind the Manson hypothesis, as stated by himself, if the quotation used by your writer be placed side by side with Manson's disavowal, it is not apparent there was any intention of Ross to say more than that the Manson hypothesis proved an incentive to action, and that in its absence it is probable research on the subject would have lapsed:

ROSS.	MANSON.
(Vol. 61, 1900, p. 523.)	("Tropical Diseases," ed. 1900, p. 21.)
"I have no hesitation in saying it was Manson's theory, and no other, which actually solved the problem; and, to be frank, I am equally certain that but for Manson's theory the problem would have remained unsolved at the present day."	"Thus by direct observation and analogy Ross distinctly, and first, proved that the extra-corporeal phase of the malaria parasite is passed in particular species of mosquitoes, and, by analogy, that the parasite *is transferred from man to man by the mosquito.*" (Italics not in the original.)

It need not be said that sanitary efforts based upon the mosquito contamination water theory of Manson could have secured no conquest of malaria.

W. G. KING.

Transcription of Russian Names.

THE system for transcribing Russian names advocated by Dr. Bohuslav Brauner in the issue of NATURE for April 29, namely, by the adoption of a few letters from the Bohemian alphabet, is open to serious objection.

In the first place, Bohemian is not the only Slavonic "State-tongue of an independent State." If Russian is to be transcribed into Latin characters as used by Slavs, the obvious model is Serbo-Croatian, which employs both Cyrillic and Latin characters, with regular rules for transcription. The Bohemian and Croatian alphabets are by no means identical; for instance, *ch*, which has in Bohemian the same sound as in German and Gaelic, would convey to a Croat some such sound as *tskh*; and he would not recognise some of the Bohemian letters bearing diacritical marks.

But if we are trying to abolish the Germanised and Gallicised forms of Russian names, why substitute another foreign form? These Slavonic letters with the diacritical marks are as unfamiliar to the ordinary Briton as the Cyrillic letters themselves,—*vide* Dr. Brauner's examples; and from this follows a practical difficulty in adopting his system in this country, namely, that very few printing presses and certainly no linotype machines have the necessary type, and the cost of introducing it would be prohibitive. Thus Dr. Brauner's "advantage of a great economy in printing" is outweighed by the disadvantage of impracticability in printing.

There is no reason why Russian personal names should not fall into line with Russian place-names, many of both being identical. And for Russian place-names the Permanent Committee on Geographical Names for British Official Use has adopted the system that has been in use for many years at the War Office, and also, except in one or two particulars, at the Admiralty. This is a system of transcription without the use of diacritical marks, which are undesirable in maps; the vowels have Italian values (e.g. *e*, *i*, *u*), and the consonants English values (e.g. *ch*, *sh*, *y*), the only exception being *j* which has the French value and is preferable to the un-English *zh* for this sound. If it is desired to represent the Russian "soft sign," the apostrophe may be used. To take Dr. Brauner's examples, the Permanent Committee for Geographical Names would write Chicherin, Jemchujni, Mendeleev, Kon', Tatyana, Pushkin, Dyadya, Mechnikov.

Complete tables, not only of transcription from Russian but of the English values of other European and Near-Eastern alphabets, may be found in "Alphabets of Foreign Countries transcribed into English according to the R.G.S. II. System," recently published by and now obtainable at the Royal Geographical Society.

EDWARD GLEICHEN,
Chairman, Permanent Committee on Geographical Names.
Royal Geographical Society, Kensington Gore, London, S.W.7, May 7.

The Helmholtz Theory of Hearing.

DR. E. W. SCRIPTURE, in his letter on the above subject in NATURE of April 22, p. 518, has dealt with the case in which the note is continuously *changing*, and shows that when this is so every resonance organ of the ear must act at every instant for every vibration of the voice. Now suppose a pure fundamental note (*i.e.* one without harmonics) to be started and continued. At the start it would, on the principle of the apparatus designed by Dr. Hartridge, cause *all* the resonance organs of the ear to act, and we should hear a certain quantity of sound. Then gradually all, except one, of the resonance organs would cease to act, and we should hear only by means of the one which was synchronous with the pure note, and if this were so, presumably the quantity of sound would then appear to us much less than at the start. Has such an effect ever been recorded? If not, there would appear to be something wrong with the hypothesis.

A. S. E. ACKERMANN.
17 Victoria Street, Westminster, London, S.W.1, April 27.

PROF. SCRIPTURE has advanced in his letter in NATURE of April 22, p. 518, an argument which, if it were sound, would indeed necessitate the abandonment of the resonance theory. He must, therefore, excuse me if I point out what I consider to be the weak links in his chain of reasoning.

The first statement in his letter with which I find myself at variance is that according to the resonance theory only one resonator should respond to one tone. This is not only in disagreement with what Helmholtz wrote, but is also in disagreement with experiment. The resonance model referred to by Prof. Scripture, of which a photograph is reproduced in Fig. 1, showed that beside the intune resonator marked C being in vibration, there is also obvious movement in the one to the right-hand side as well. If there had been other pendulums of intermediate length mounted on either side of "C," there is no doubt that a number of these would also have been set into vibration, the actual number varying with the degree of damping applied to each. Helmholtz worked out the case of the ear resonators by means of calculations which appear to apply equally to all types of oscillating systems. He estimated that for tones about the middle of the musical scale, resonators having natural periods different from the incoming vibration by one semitone would be performing forced vibrations, the amplitudes of which would be approximately one-tenth that of the strictly intune resonator.

Now I have already stated (*Brit. Journ. Psych.*, April 1922, p. 370) the reasoning on which is based the estimate that some 600 resonators correspond to each octave in the musical scale. One semitone on either side of the intune resonator would, therefore, include about 100 resonators, and all these must be vibrating with one-tenth the amplitude (or more) of that of the intune one.

We see then how completely this estimate is at variance with Prof. Scripture's suggestion that according to the resonance theory only one resonator should be in vibration.

The second statement with which I cannot agree is that every vibration in a glide (since each vibration is different from the one which preceded) or every

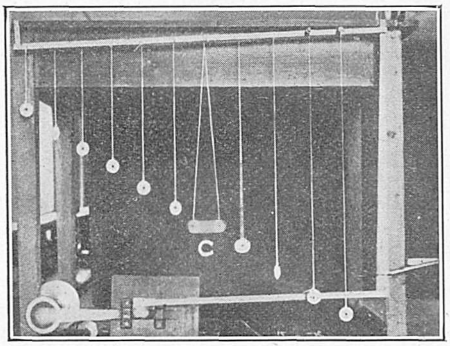

FIG. 1.

spoken word (since the voice tone is continually changing) must therefore set every resonator into motion from the highest to the lowest, and I have never observed any behaviour on the part of my resonance model which would give any basis for such a supposition. I have attempted to calculate what would happen to a series of resonators which are set into vibration, not by a fixed tone, but by a tone changing in pitch. I find that, as in the case of a fixed tone, a group of resonators is set swinging, but that this group is larger than that set swinging by a pure tone, and I infer that the centre of this group moves up the scale with the same rate per second as does the incoming sound, but with a small time lag. For example, if the pitch of the tone is changing by as much as one octave per second the group of resonators appears to be only two or three times as large as that set swinging by a pure tone. Presumably then the tone will be quite recognisable, although it will not have the purity that a fixed tone possesses. This latter effect may possibly be correlated with the unpleasant character of a rapidly changing tone, *e.g.* the commencement of a steam syren blast. Whereas there does not appear to be any evidence at present by which the above estimate can be checked, yet I think that it must be at variance with the facts to state, as Professor Scripture has done, that when the pitch of the incoming vibrations vary, all resonators irrespective of length must be set equally into vibration.

I regret that it was my model which raised these doubts in Prof. Scripture's mind concerning the resonance theory. I should have made it quite clear to him that there was roughly a semitone difference of pitch between each pendulum and its neighbour. The model was not designed to demonstrate the better-known phenomena of resonance, but to elucidate the effect of interrupting temporarily a musical tone; for this purpose a few rather widely spaced pendulums sufficed. If the number of pendulums in the model had approximated more closely to the number apparently to be found in the ear, then Prof. Scripture would, I feel sure, never have criticised the resonance theory as he has done.

H. HARTRIDGE.
King's College, Cambridge, April 26.

Directive Radio-telegraphy and Navigation.

IN foggy weather, sound-signalling stations have proved useful as an aid to navigation. The sounds heard, however, cannot be trusted to give accurate indications either of the distance or direction of the station. Their range also is very limited. It is not surprising, therefore, that many suggestions have been made for utilising the electric waves used in radio-telegraphy to enable a navigator to find his bearings. The propagation of electric waves is unaffected by fog and, unlike sound or light waves, can be transmitted to any distance. Moreover, the apparatus required for radio-signalling is very cheap, requires little skilled attention, and can easily be installed in lighthouses and lightships. Until two or three years ago the radiophares —or radio-beacons as they are called in America—were purely stations for giving ships their positions. In order to find its bearings a ship must send a message to two or more stations, and its direction is located by direction-finding coils. The stations then communicate with one another and so, by the help of triangulation, find the position of the ship, which is communicated to it by radio-telegraphy. In practice the whole operation takes about five minutes. The most extensive chain of direction-finding stations is that controlled by the United States Navy. There are at least thirty stations on the Atlantic seaboard and several on the Pacific coast. France has about ten radiophares and this country has six. A drawback to the method is that valuable time may be lost in getting into communication with the radiophares and in getting the information back to the ship.

A new and very promising method has been recently developed by the Bureau of Standards at Washington in co-operation with the Bureau of Lighthouses. In this method lighthouses and lightships the locations of which are accurately shown on sailing charts are equipped with radio fog-signalling apparatus. A direction-finder operated by the navigating officer is installed in the ship. It is then easy to find the directions of the various radiophares within his range and thus work out his position on the chart. The results obtained by this method have been very successful, and it seems to be much preferable to the ordinary method of using the direction-finder at the fixed stations. It seems probable that every important lighthouse in America will soon become a radio fog-signalling station. The Bureau of Standards suggests that radiophares should be divided into three classes. The first, or long-range class, has a radius of action of 300 miles. The second, or short-range class, can signal to 30 miles; and the third class comprises the lightship stations which can signal to 10 miles.

The method has been made possible by the perfecting of a new radio direction-finder. The principle on which it acts is that the signals received by a flat coil have their maximum intensity when the direction from which they come is in the plane of the coil. When certain precautions are also taken in arranging the apparatus, the signals are of practically zero intensity when the plane of the coil is perpendicular to the direction from which they come. As Fig. 1 shows, it is designed to be installed over the ship's binnacle carrying the magnetic compass. The radio-bearings are read directly on the magnetic compass card. An additional scale, marked with the corrections obtained when calibrating the instrument, is attached to the top of the binnacle so that the true reading can be obtained at once. When taking a bearing the only operation necessary is to rotate the direction-finding coil until the sound is a minimum. The ordinary type of direction-finder for use on shipboard consists of a coil of ten turns of insulated copper wire wound on a wooden frame four foot square, which is mounted so that it can be rotated about a vertical axis. Suitable receiving apparatus is used in connection with this coil, namely, a variable air condenser for tuning purposes, a six-tube amplifier having three stages of radio-frequency amplification, a detector, two stages of audio-frequency amplification, batteries, and suitable telephone receivers.

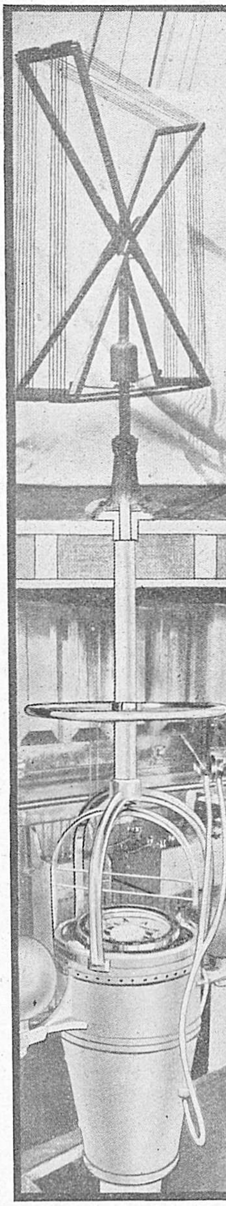

FIG. 1.—Magnetic compass with direction-finder attachment for reading the radio-bearing directly on the magnetic compass.

The Bureau of Standards have issued a pamphlet by F. A. Kolster and F. W. Dunmore giving a full description of the direction-finder, pointing out some of the difficulties that had to be overcome in developing it, and giving many experimental results.

The Cause and Character of Earthquakes.[1]

By R. D. OLDHAM, F.R.S.

THE study of earthquakes, using that word in the restricted, and original, sense of the disturbance of the ground which is sensible to human feelings, which causes alarm and destruction, and is properly that seism of the ancient Greeks, from which our modern term seismology is derived, has always been recognised as one of the departments of geology. This limitation is necessary, for, of late years, seismology has been extended to the study of a phenomenon of different character, the long-distance records of dis-

[1] Abridged from the presidential address delivered before the Geological Society of London on February 17.

turbances, only to be detected by very sensitive instruments of special construction; in some cases these are clearly connected with great earthquakes—as the word is here used—and by inference have been presumed to be so in all cases, even when there is no independent evidence of the earthquake proper. The records, regarded as records of the progressive enfeeblement of the larger disturbance of the true earthquake, would represent the cryptoseism, or unfelt earthquake, and be described correctly in the observatory records as earthquakes. That they are correctly so described is indisputable, if the word is taken in its literal interpretation as a quaking, however feeble, of the earth; but if the implication is added that they have the same origin as the greater disturbance, the correctness of the description becomes doubtful.

Some dozen years ago the results of a study of the records of the Californian earthquake of 1906 led me to point out that, while the immediate origin of the earthquake proper may be traced to occurrences which take place in the outermost parts of the earth's crust, these are but the secondary result of a deep-seated origin, or bathyseism, which gives rise, at the same time, to the disturbance which is recorded at long distances by suitable instruments. Later work and research has more and more confirmed both the correctness of this interpretation and the conclusion that the proximate cause, of great and destructive earthquakes, is distinct from that of the long-distance records, though the two origins are connected with each other as effect and cause.

In the present state of our ignorance of the nature of the bathyseism, it is difficult to give a clear and precise definition of the mode of connection between it and the earthquake proper; the subject is an interesting one, and a review of the evidence, together with the deductions which can be drawn from it, would fill the time available, but it is not my intention to do more than to attempt, by analogy, to illustrate and explain the nature of the connection of the bathyseism with its two independent results.

Not many years have passed since, in the south-eastern corner of England, we heard what were known as the guns of Flanders; and the description was correct. The sound—it was more a sensation than a sound—which was heard in Kent and Sussex was undoubtedly produced by the report of great guns, by the explosion, that is, of the charge in the gun itself; but had the explosion done no more than give rise to the sound waves which travelled far in every direction it would have little troubled the enemy. Simultaneously, however, with the production of the report, and by the same explosion, a projectile was sent flying through the air which exploded after a trajectory of some miles, causing the damage which was the purpose of its despatch. The effect of this second explosion was severe but local, and at a short distance away neither sound nor shock was sensible.

Here we have a very complete analogy; the explosion of the gun represents the bathyseism; the report and sound waves travelling afar, correspond to the disturbance which, propagated through the substance of the earth, gives rise to the long-distance records: the explosion of the shell to those dislocations in the outer crust which produce the destructive earthquake; and the trajectory to the connection, of which the character is as yet unknown, between the bathyseism and the surface shock.

If this interpretation be accepted, it becomes evident that the distant records represent something which is distinct from the earthquake, as originally understood, and that the study of records, with the deductions drawn from that study, have little or no bearing on the problems of geology, as we usually limit the scope of that science. It is otherwise with the earthquake proper; originating in, and affecting, the outermost crust of the earth, it has long, and rightly, been regarded as one of the departments of geology, both as regards cause and character, and it is with this aspect of the subject alone that I shall deal.

The character of earthquakes is known to an extent sufficient for my purpose; they are elastic waves, transmitted through the substance of the earth, not, as was once supposed, merely waves of elastic compression, but of most complicated character, and, in all but a small minority of cases, nothing but this vibratory movement, the orchesis, can be recognised. Occasionally, however, and only in the case of some earthquakes of destructive violence, there is also a bodily and permanent displacement of the solid ground, and this mass, or molar, movement has been distinguished as the mochleusis of the earthquake, as distinct from the elastic displacement, accompanied by return to the original position, which constitutes the orchesis. Now the elastic waves can only be initiated by some sudden impulse or disturbance, such as might be produced by the fracture of rock, and as, in those earthquakes where mochleusis can be recognised, there is usually evidence of sudden movement along some pre-existent fault-plane, or of rending and fissuring of the solid rock, faulting or fracturing has come to be regarded as the cause from which the vibratory disturbance, propagated through the unfractured rock, originates.

This conclusion is supported by the fact that the proximate origin of the shock can almost always be placed at a moderate depth from the surface. It is, unfortunately, impossible to give any precise figures, for none of the methods which have been suggested for determining the depth of the origin can be trusted, some because they depend on assumptions which the progress of knowledge has shown to be erroneous, others because they demand data which cannot be supplied with the requisite precision, if at all; but there is another way in which some idea of the depth of origin may be reached, based on the fact that there is usually a well-defined area of maximum intensity of shock, surrounded by regions of diminishing intensity, as the distance from the central area increases. Since the violence of the disturbance will decrease with the increase of distance from the origin, it follows that, the nearer the origin lies to the surface the more closely does the variation of surface distance from the epicentre approximate to the variation in actual distance from the origin; hence it is evident that the rate of variation of intensity of the disturbance will give some notion of the depth of the origin. In this way, quite apart from any numerical estimates which have been made, it becomes clear that, excluding a small minority of earthquakes which will be referred to later, the origin lies at a very moderate depth below the surface, probably seldom over ten miles, and usually less, that is to say, within the limits of the solid outer crust of the earth; and in this region it is difficult to conceive of any cause, sufficient to originate the elastic wave-motion of the earthquake, other than the sudden fracture of the solid rock, where strain has outgrown the power of resistance.

Apart from this general reasoning from observation, there are cases on record where considerable displacements of the ground have been measured by the comparison of careful and accurate surveys made before and after the earthquake. In three of these—the Cutch earthquake of 1819, the Sumatran of 1892, and the Californian of 1906—the largest movements took place close to the line of fracture, and in opposite directions on opposite sides of it, the displacements decreasing on either side till a region was reached in which no change, from the condition before the earthquake, could be recognised. As this is precisely what would take place if a solid body, capable of elastic deformation, was strained until fracture took place, the conclusion is justifiable that such was in fact the origin of the dislocation and displacements.

So far the conclusions, which may be drawn from observation, as they have been briefly outlined, belong rather to the domain of physics than of geology, but when we go on to consider the cause to which the strain is to be attributed, and more especially the rate of growth, we are brought into contact with problems and deductions which are intimately connected with geology proper, and to which I propose to confine attention in the remainder of this address. As regards cause: this is usually attributed to what are known as the tectonic processes, a term which may approximately be described as the processes by which the folding and faulting of rocks were produced, and, in accordance with this attribution, the class of earthquakes with which we are concerned is referred to as tectonic. The rate of growth of strain has almost invariably been accepted as very slow, yet when the subject is looked into, it will be found that there is really no evidence to support the acceptance; in part it must be attributed to the general belief that all geological action is necessarily slow, and in part to the conclusion that the Earth is a solid inert and highly heated body, cooling slowly by radiation, with the subsidiary deduction that all deformation of the outer crust must be referred to contraction, consequent on that slow cooling. The latter of these reasons is now abandoned by those who forced it on us, and the former, though true in general, must not be treated as an unchangeable law, for there are many cases where a process, slow on the average, and as a rule, is occasionally subject to temporary acceleration of rate. The evidence, too, which has been regarded as confirmatory of the slow growth of strain, is, in truth, more properly described as an interpretation of observed facts in accordance with an hypothesis.

In the report on the Californian earthquake of 1906, for instance, the displacements caused by that earthquake and an earlier one in 1868 are explained by a slow growth of strain, extending over a century or so, partly relieved by fracture in 1868, and again in 1906. The argument is conclusive in so far as it shows that the effects are consistent with the hypothesis, but it was not noticed that they would be equally consistent with a condition of quiescence throughout the whole period, with the exception of two short intervals immediately preceding the two shocks, respectively. The same may be said of all the supposed evidence in favour of a slow growth of strain; it is true that in those earthquakes which have been investigated in detail, and in which the observations allow of any definite conclusion, the indications point to the conclusion that the proximate cause is fracture resulting from excessive strain, but there is in no case any evidence of the rate at which that strain accumulated; nor is it possible that any such evidence could be found. The after-effects may satisfactorily establish the conclusion as to the cause, but they can give no indication of the time occupied in preparation; the earthquake comes and passes, it leaves certain records behind it, but these records would be the same whether the preparatory growth of strain was secular or instantaneous in duration.

Yet the problem is not insoluble, for there is another line of attack, which has only become practicable within the last few years. If we regard the growth of strain as continuous, there will be a certain increment which will lead to fracture, earthquake, and partial relief; then with a further increment the process will be repeated, and so we reach the concept of a mean-strain interval for each shock, which may be regarded as constant, on the average, for any given region, provided that the average is taken over a sufficiently long period. Any variation in the rate of growth of strain must be accompanied by a corresponding variation in the frequency of earthquakes. We have, then, four quantities so related to each other that if three of them are known the fourth can be determined. Of these four, two, namely the mean frequency and the variation from that mean in any chosen period, can be obtained from observation, and if the variation from the mean rate of growth of strain is also known, for the selected portion of the whole period, that mean rate which is the object of search can be obtained by a simple rule of three sum. So that if there were any external cause which, acting periodically and alternately in increase and decrease of the rate of growth of strain, and if it were possible to disentangle the variations due to this from those due to other causes, we would have a means of framing a numerical estimate of the general rate of growth of strain.

One such cause of periodic variation is to be found in the tide-producing stresses set up by the sun and the moon. It is true that many attempts have been made at different times to detect some connection between the frequency of earthquakes and the position of the moon, and that no such connection has yet been established, but these attempts have all been based on very imperfect records. In time it may, perhaps, be possible to apply to an earthquake record the method of harmonic analysis, which has proved so fertile in the case of the ocean tides, but the day is long distant when a record of sufficient completeness will be available. Meanwhile there are some simpler relations, of which a discussion is feasible, and the most promising of these seems to depend on the fact that the downward pressure is greatest at the time when the attracting body is on the horizon, and least when it is on the meridian. If, then, we divide an earthquake record into two groups, one containing all shocks which occur within six hours before a meridian passage, and the other all that happened within six hours after, one of the two groups will cover a period during which the downward pressure is, on the average, increasing, while the other will cover the period during which it is decreasing. As the amount of the change so introduced is known, with sufficient accuracy for the present purpose, and as it should, on the hypothesis being used, influence the frequency of earthquakes, it follows that we have here a method, which should enable us to make an estimate of the rate of growth of the strain, to which fracture is due.

Although simple in principle, the method is difficult in application. To begin with, a record is required of sufficient extent and continuity to give a trustworthy average, not merely of the general frequency, but also of the frequency in each of the two sections into which it is divided, and this in practice means that the record must contain at least two thousand shocks and ought to contain double that number or more. Then it must be reasonably accurate as to times and complete as to occurrences, or at least must be fairly uniform in its incompleteness over the whole period investigated. There are not many records which fulfil these primary requirements, but there is another even more important. In all records there is a noticeable variation in frequency at different times of the day, moreover, the nature of this diurnal variation has been found to vary in different regions, but appears to be constant and characteristic, in each region, over the period of record. The cause of this periodicity may reasonably be attributed to some effect, meteorological or other, connected with the daily course of the sun, but its nature, no less than its variability, shows that it can only be attributed in part, if at all, to gravitational attraction. It is only, therefore, by a conversion of the record from solar to lunar times that the influences of these other effects can be eliminated, and the gravitational attraction of the moon be detected and estimated, and, for the satisfactory application of this method, it is necessary that the record should cover a complete lunar cycle, or a period of nineteen years. There are only two records extant and available which fulfil this requirement, and of these the Italian is not only the most complete and accurate, but is the only one to which the conversion into lunar times has been applied.

From the summary of the figures obtained, published in our Quarterly Journal, it appears that in the six hours preceding and following a meridian passage the mean departure, from the general average for six lunar hours, is almost exactly 1 per cent. of the mean.

Passing over details of calculation, the average rate of growth of strain is found to be such that the breaking point would be reached in about two months from the start, with a wide variation on either side. Some other relations between the frequency of earthquakes and the diurnal variation of the tidal stresses might be, and have been, investigated; all give fairly confirmatory results, the longest period indicated as required for reaching the breaking strain being just about a year.

It must not be supposed that value can be attached to the precise figures. As is invariably the case, in all calculations regarding physics of the earth, many considerations are involved of a very uncertain nature, but the reasoning does show that the increase of strain must have taken place at such rate that the breaking point was reached in a period measurable at most by months, and shows that the period could not have been of such length as to be measurable by years or decades, for, had this been the case, the disparity dealt with would have been much greater than that actually found.

(*To be continued.*)

Obituary.

PROF. G. S. BOULGER.

BY the death of Prof. G. S. Boulger on May 4, botanical science has lost an accurate and advanced observer who did much to popularise the study of his favourite science, and left his impress on several generations of devoted students. He was an active botanist to the end. On April 26 he attended, as chairman, the meeting of the Botanical Section of the South-eastern Union of Scientific Societies, and he himself was struck by the difficulty in breathing which he experienced in mounting a number of stairs to the meeting-room. Almost his last words on his death-bed had reference to the preparation of the report to be presented to the Congress of the Union at Southampton in June. He died literally in harness.

Prof. Boulger was born in 1853, and was educated at Wellington and Epsom Colleges; at an early age he became Professor of Natural History at Cirencester College, holding the chair for thirty years. Among other appointments which he held were those of professor of geology and botany at the City of London College, and in recent years he was a guide at the Imperial Institute. But his students were a wider public than institutions afforded. He was in considerable request as a public lecturer, and frequently visited, as such, various local natural history societies. He was closely connected with the Selborne Society, of which he was a vice-president, and the magazine of which, *Nature Notes*, he edited for some years. In recent years he was much interested in what has come to be known as Regional Survey, and in this connection did good work for the Gilbert White Fellowship, an up-to-date survey of Selborne being now in progress.

As an author Prof. Boulger had an attractive style. For some time he edited the Proceedings of the Geologists' Association. His knowledge of geology enabled him to throw considerable light on the origin of the British flora. His "Biographical Index of British and Irish Botanists," with Mr. J. Britten, is a valuable book of reference. His "Familiar Trees," and "The Country Month by Month," with J. Owen (Mrs. Owen Visger), brought him into touch with a wide public, and his edition of Johns' "Flowers of the Field" has proved invaluable to thousands of amateur botanists. Other works of his were "The Uses of Plants," "Elementary Geology," and "Plant Geography." He was for a long time the Kew Gardens correspondent of the *Times*. He always faced troubles cheerfully, and, constantly active, it is to be feared that overwork may have had much to do with his regretted death. His loss will be greatly felt by workers in many fields.

BY the death of Dr. C. W. Waidner on March 10, the Bureau of Standards lost the third member of its original staff within the last year. Dr. Waidner was born in Baltimore in 1873, graduated at the Johns Hopkins University in 1896 and remained there, engaged first in research and afterwards in teaching, till he was appointed to the staff of the Bureau on its foundation in 1901. In a short time he became head of the Heat and Thermometry department, and organised the testing of thermometers of all kinds from clinical instruments to optical pyrometers. In conjunction with various members of his staff—most often with Dr. G. K. Burgess—he published a number of papers which did much to increase the precision with which temperatures could be determined. Of these papers it is only necessary to mention those on a comparator for thermometers, on radiation pyrometry, on the high temperature scale, on standards of light, on the platinum thermometer and the melting-point of platinum, and on the possibility of detecting the presence of icebergs by the temperature of the ocean, to show the nature and extent of his work. In recent years his interests have centred mainly in the applications of physics to problems of refrigeration and to the production of fire-resisting structures. In these fields his loss will be severely felt.

IN the *Chemiker Zeitung* of April 15 the death is announced, at the age of sixty years, of Dr. F. Voigtländer, emeritus professor of chemistry at the University of Hamburg.

THE U.S. Public Health Service has lost, by his death at the age of forty-eight, the skilled assistance of its assistant epidemiologist, Dr. David G. Willets. He had spent several years at Manila, at first in the biological laboratory of the Bureau of Science and afterward on the staff of the University of the Philippines. He had written many bulletins and monographs on pellagra, intestinal parasites, and other tropical problems.

Current Topics and Events.

THE one hundred and fiftieth anniversary of the foundation of the Royal Academy of Belgium will be celebrated in Brussels on May 23-24. More than ninety delegates, representing forty-five academies in eighteen different countries, in addition to foreign associates of the Belgian Academy, are expected to attend the function. France is sending a number of representatives; the Institute of France alone will have thirty-six delegates. We learn from the Secretary of the Academy that the learned societies of Great Britain will be represented as follows: Royal Society, Sir William Leishman and Prof. H. Lamb (also representing the Cambridge Philosophical Society); Royal Society of Edinburgh, Sir George Berry; Royal Academy, Sir George Frampton, Sir Reginald Blomfield, and Mr. H. Hughes-Stanton; Royal Institute of British Architects, Sir John Burnet, Mr. J. Simpson, and Mr. P. Waterhouse; Royal Geographical Society, Sir Frederick Sykes; Royal Historical Society, Mr. G. M. T. Omond; British Academy, Sir Frederic Kenyon and Mr. H. Stuart-Jones; Chemical Society, Sir William Pope; Zoological Society, Dr. G. A. Boulenger and Dr. P. Chalmers Mitchell; Asiatic Society of Bengal, Sir Thomas H. Holland and Dr. Pascoe. The following British Associates of the Belgian Academy will be present: Sir Frank Dyson, Sir T. Erskine Holland, Sir Frederick Pollock, Sir Thomas Jackson, Sir John Lavery, and Mr. J. Pennell. The learned societies of Australia and New Zealand and the Royal Irish Academy have sent congratulatory addresses.

THE *Times* of May 9 records the striking of petroleum (on the previous day) in a well put down at Darcy, near Dalkeith, on the property of Lord Lothian. The well was originally one of the two selected sites in Scotland in accordance with the Government's drilling programme of 1918, the other, at West Calder, having since been abandoned after being drilled to a depth of 3923 feet. The Darcy well is producing from a sandstone at a depth of 1810 feet, and the oil, though inferior both in quality and quantity to that obtained at Hardstoft, is of paraffin base, somewhat viscous, and carries much gas. Previous to the flow, 8-inch casing had been set in the hole and the oil accumulated afterwards for several hundred feet within it. The bringing in of this well is an event of scientific rather than economic importance, as the initial yield is, commercially speaking, insignificant, while the prospects of the area as a whole are geologically unfavourable to the development of a large oilfield. Hardstoft, the only other producing well in this country, makes an average of 20 barrels per week; the Darcy well is said to yield considerably less *pro rata*. The same number of the *Times* contains the report of a serious announcement concerning the world's oil supplies, made by Prof. Arrhenius, at the close of a course of lectures given at the Sorbonne. Prof. Arrhenius stated that at the present rate of consumption the existing oilfields in the world would, in his opinion, be exhausted within 15 years, an opinion shared by many experts both in this country and in America.

The natural corollary to such a prediction is the recognition of the need for conservation of the world's petroleum resources, especially those of the United States. The development of other sources of fuel, more particularly oil shale, and the ultimate harnessing of forms of energy such as Prof. Arrhenius suggested (plants, watercourses, winds, and the heat of the sun), are matters demanding the assiduous attention of scientific investigators.

The Governors of the Imperial College of Science and Technology have appointed Sir Thomas H. Holland to be Rector of the College in succession to Sir Alfred Keogh, who is retiring at the close of the Summer term. Sir Thomas Holland is best known by his work in India. Among the many important positions filled by him there were the directorship of the Geological Survey, the presidency of the Industrial Commission and of the Board of Munitions, and more recently membership of the Governor-General's Council. Apart from his important administrative experience his scientific interests centre round geology and oil. He has been a member of many commissions and committees concerned with oil, and for ten years was professor of geology and mineralogy at the University of Manchester. His appointment is also interesting in that he is an old student of the Royal College of Science, having been awarded his associateship in geology of that College, which is now an integral part of the Imperial College, in 1888; and also in that in 1910 he was president of the Old Students' Association of the College, and later a member of the governing body representing the Indian Empire.

The annual visitation of the Royal Observatory, Greenwich, will be held on Saturday, June 3.

Sir Richard Gregory has been elected president of the Decimal Association in succession to the late Lord Belhaven and Stenton.

At the meeting of the Royal Society on June 1, the Croonian lecture will be delivered by Prof. T. H. Morgan on "The Mechanism of Heredity."

The annual Conversazione of the Institution of Electrical Engineers will be held on Thursday, June 29, at 8.30 p.m. at the Natural History Museum, South Kensington, S.W.

The annual general meeting of the People's League of Health will be held at the Mansion House on Thursday, May 25, at 3.30 p.m. The Lord Mayor will preside, and among the speakers will be Sir Bruce Bruce-Porter, Dr. Farquhar Buzzard, Sir Gilbert Garnsey, Miss Olga Nethersole, and Dr. Saleeby.

The Linnean Society has recently elected the following as Foreign Members: Lucien Cuénot, professor of zootechnic, entomology, and parasitology in the University of Nancy; Gustave Gilson, director of the Royal Museum of Natural History, Brussels; Jakob Wilhelm Ebbe Gustaf Leche, professor of zoology in the High School, Stockholm; and Dr. Benjamin Lincoln Robinson, Asa Gray professor of systematic botany, and curator of the Gray Herbarium, Harvard University, Cambridge, Massachusetts.

Dr. W. Bateson, director of the John Innes Horticultural Institution, Merton, Surrey, has been elected a trustee of the British Museum, to fill the vacancy caused by the death of Lord Harcourt. Other Fellows of the Royal Society who are among the elected trustees of the Museum are Lord Rothschild, Sir Henry Howorth, Sir Archibald Geikie, and Sir J. J. Thomson.

The *Meteorological Magazine* for April has a note on wireless apparatus for Tristan da Cunha. The Rev. H. M. Rogers, who sailed from South Africa in March to take up the chaplaincy of Tristan da Cunha, has taken with him apparatus with a range of more than 1000 miles. The instruments were presented by the people of Cape Town, who have always shown a keen interest in the loneliness of the island. A meteorological equipment was also presented by the Government, so that Mr. Rogers may send reports of weather conditions in the islets by wireless telegraphy to South Africa and to passing ships; it is thought that the messages will greatly aid weather forecasting.

The sixtieth birthday of Prof. David Hilbert of Göttingen has been celebrated by the publication of a special number of *Die Naturwissenschaften* (January 27). Opening with a portrait of Prof. Hilbert, it contains an admirable account of his life work by Herr O. Blumenthal, of Aachen. There follow five more specialised appreciations, by different writers, of his work as an algebraist, a geometer, an analyst, a physicist, and a philosopher. Finally, appears a list of Prof. Hilbert's memoirs, eighty-three in all, accompanied in many cases by short abstracts of the results contained in them. Among the ranks of living mathematicians no name is more honoured than Prof. Hilbert's, and this tribute to his fame is well worthy of the occasion it celebrates.

In July this year, Mr. E. Grey, Field Superintendent of the Rothamsted Experimental Station, will complete fifty years of continuous work at Rothamsted. To mark the widespread appreciation of his valuable services during this long period, it has been decided to raise a fund for a testimonial which shall take the form most agreeable to Mr. Grey himself. There are probably many readers of Nature who may wish to associate themselves with this testimonial. The director and staff of the station therefore invite subscriptions, which should be sent as soon as possible to the Secretary, Rothamsted Experimental Station, Harpenden, Herts. Mr. Grey's book, entitled "Reminiscences, Tales, and Anecdotes of the Rothamsted Experimental Station Laboratories, Staff, and Fields, 1872–1922," is now in the press and copies can be obtained from the Secretary, Rothamsted Experimental Station, Harpenden, or from Mr. E. Grey, Laboratory Cottages, Harpenden. Price 5*s.* 9*d.* post free. All profits will go to Mr. Grey.

From the Report of the Board of the Institute of Physics for the year 1921 we learn that the Institute now has 400 members, 250 of whom are fellows. The income from subscriptions was a little over 500*l*. and the office salaries 500*l*. During the year the Board formulated a scheme for the publication of a *Journal of Scientific Instruments*, and the Institute has received a grant of 250*l*. from the Department of Scientific and Industrial Research to enable it to produce the first number. The Institute has provided 50*l*. for the expenses of distribution of the 10,000 copies which have been printed, and in a short time the number will be in the hands of those likely to be interested in such a Journal. The price will be 30*s*. per annum if sufficient support is provided by instrument makers, research associations, scientific societies, and the public to justify the regular issue of such a periodical.

THE Board of Education has issued a memorandum on the effect of the Summer Time Act on the health of school children. All Local Education Authorities in England and Wales were circularised in May 1921, and only 16 authorities, representing about 127,000 children, failed to reply. Of the 299 authorities from which replies were obtained, 183 authorities, representing 3,227,842 children, are definitely in favour of the Act; 89 authorities, representing 1,600,429 children, consider the Act detrimental, while 27 authorities, representing 232,402 children, have not formed a definite opinion. It should be added that nearly all authorities who hold that the Act is prejudicial to children, state that this is due, not to any defect inherent in the Act itself, but to the fact that parents do not use it rightly. If parental control were properly exercised nearly every authority in the country would approve the Act. The actual (though not the necessary) result of the Act appears to be that large numbers of children lose a valuable hour of sleep, because they go to bed at dusk as before, but have to get up an hour earlier, as the working part of the family rises by the clock. The Board is therefore issuing a circular to the parents of school children, pointing out how important adequate sleep is for the growing child, stating the amount of sleep necessary at the different ages, and supporting the arguments by some common-sense appeals to the parents.

IT is announced that the British Association for the Advancement of Science will publish, early next month, "The British Association: A Retrospect, 1831–1921," by the Secretary of the Association, Mr. O. J. R. Howarth, which will present a summary review of the activities of the association in every department of science since its foundation. The production of this volume has been rendered possible through the generosity of Sir Charles Parsons, ex-president, at whose suggestion it was undertaken.

Our Astronomical Column.

A NEW VARIABLE IN CYGNUS.—The star B.D. +34° 4217 (position for 1900: R.A. 20h. 54m. 12s. Decl. + 34° 47′·4) has been discovered by Mr. Stanley Williams to be a short-period variable (*Monthly Notices*, R.A.S., vol. 82, p. 300). He commenced visual observations on this star with a 6½-in. reflector in October last, and has deduced a light curve which at first appeared to be of an Algol type, but later was found closely to resemble that of β Lyrae. The period is about 15h. 9m. and the range of magnitude 10·42 to 9·93, the magnitude at secondary minimum being 10·15.

THE SPECTRUM OF THE CORONA IN 1918.—The expedition sent from the Lowell Observatory to observe the eclipse of June 8, 1918, was stationed near Syracuse, Kansas, and obtained some interesting results in spite of rather unfavourable weather. The equipment consisted of two single-prism and two three-prism spectrographs (one being a slitless instrument). The distribution of coronium was found to be very different from that of hydrogen and helium. The line at λ5303·0 showed that it extended to a distance of about one solar diameter above the sun's surface, and the condensations in the green coronium ring as shown by the objective-prism plates indicated a distribution which was not in any way related to individual prominences. There appeared to be a general correspondence in the distribution of coronium and the main features of the corona, since it was faint or absent in the regions occupied by the polar "streamers" and abundant beneath the main extensions of the corona. The arches over prominences were unusually well developed, but the presence or absence of coronium in them could not be verified. The principal results are described by Slipher in the *Astrophysical Journal*, 55, p. 73.

DETERMINATION OF LUMINOSITIES BY SPECTROPHOTOMETRY.—Two new methods for determining stellar absolute magnitudes are described by Lindblad in the *Astrophysical Journal*, 55, p. 85. The first of these is applicable to stars of higher spectral type than those for which Adams's spectroscopic method is available, and is based on the variations, with absolute magnitude, of the energy distribution of the spectrum between H_ϵ and H_ζ. The two regions $\lambda\lambda$3889-3907 and $\lambda\lambda$3907-3935 are compared, and faint stars found to show a considerable relative decrease in intensity of the former region when compared with bright stars. This is probably due to the widening of H_ζ and of some arc lines of iron and silicon. The actual measurements are made by taking a series of exposures of each star on the same plate with decreasing exposure-times. In the series of images thus obtained two are selected such that the intensity of $\lambda\lambda$3889-3907 in one is equal to that of $\lambda\lambda$3907-3935 in the other; and the ratio, E, of the two exposure-times is plotted against the absolute magnitude, M, of the star. Curves are given showing the relation between log E and M for different types, and it is claimed that for types B_8-A_3 absolute magnitudes may be found (with the dispersion used) with a probable error of only ±0·4 mag.

The second method is similar to the first, but is only applicable to stars (types G-M) in which there is appreciable cyanogen absorption. The relative density on either side of λ3889, and between the regions $\lambda\lambda$4144-4184 and $\lambda\lambda$4227-4272 are found and compared as above with the absolute magnitudes of the stars.

Research Items.

MENTAL TESTS AND MENTALITY.—At the present time when, owing to the exigencies of practical life, some method is needed whereby individuals can be selected rapidly and effectively for specific tasks, the question of mental tests is a serious problem. Selection by examination, by influence or personal opinion has been found to be inadequate, and so there is a tendency to expect too much from the alternative method known as mental tests. In *Psyche* (Vol. II. No. 4) Prof. Pear raises some very interesting problems connected with such tests. He insists that intelligence tests indicate only one kind of mental capacity; they are an attempt to provide a quantitative indication of some mental trait. In practical testing, however, the tester often ignores the characteristic apparatus possessed by the examinee; even though two people may be assigned like marks for a test, in actual life it may matter seriously whether the result was attained by the use of visual imagery, kinæsthetic imagery, verbal formulæ, or imageless thinking. Again, the attitude of mind of the examinee must be considered; a genius might display apparent lack of intelligence because he saw in the problem many more complications than the ordinary person, and the typical extrovert will react quite differently from the typical introvert. Lastly, the author discusses the problem of stupidity both intellectual and emotional, the latter type having been very much neglected. The paper is both critical and suggestive, and will be of interest to workers in this field whether from the educational or industrial aspect.

LIGHT REQUIREMENTS IN HOSPITALS.—At a joint meeting of the Illuminating Engineering Society and the Royal Society of Medicine on April 27 the lighting of hospitals was discussed. The subject presents many interesting problems, and has not yet received sufficient attention. Mr. J. Darch, who presented the introductory paper, showed a variety of illustrations of methods of lighting wards devised to avoid glare from lights shining in the eyes of patients—apparently a common fault in hospitals. He also discussed the lighting of operating tables where somewhat complex requirements exist, including a very high illumination, freedom from troublesome shadows cast by the person of the operator, and elimination of the possibility of dust falling from the fixture during an operation. A value of not less than 25 foot-candles on the operating table was suggested. Reference was also made to natural lighting, the somewhat revolutionary proposal being made that the operating theatre should be located at the top of the building so as to secure maximum daylight. A number of medical men and ophthalmic surgeons joined in the discussion. Mr. Conrad Beck contributed an analysis of the requirements to be met in microscope illumination. The suggestion was made that "artificial daylight" units would prove very serviceable in cases where correct appearance of colours forms an important feature in diagnosis. Mr. J. B. Reiner showed some compact forms of inspection lamps where the provision of a sufficiently bright and uniform illumination, without striations, presents difficulties. Prior to the discussion a series of queries relating to problems met with in hospital lighting had been drawn up and circulated, and Mr. Gaster suggested that these might form the subject of study by a small joint committee.

THE ORIGINS OF EXISTING CORALS.—Prof. P. C. Raymond ("The History of Corals and the 'limeless oceans,'" *Amer. Journ. Sci.*, vol. 202, p. 343, 1921) traces the hexacoralla back to Walcott's *Mackenzia costalis* from the Middle Cambrian of Burgess Pass, British Columbia, a limeless form first described as a holothurian, and referred to the actinians by H. L. Clark. Its modern representative is found in Edwardsia, an inhabitant of sandy shores. Prof. Raymond regards all the Palæozoic corals that adopted the habit of secreting—or, from the present point of view, excreting—calcium carbonate as tetracoralla. These were killed off in the cold waters of the Permian glacial epoch, leaving the Edwardsian line to pass on into a large number of hexacorallan types with calcareous skeletons, which first become prominent as reef-builders in Middle Triassic times. At this period, the warmer waters contained more salts, and the sedentary habits of the actinians decreased their power of elimination. These seem large conclusions to found upon the impress of a soft-bodied organism of Cambrian age; but palæontology at present glows warmly through the use of well-controlled scientific imagination.

GEOLOGY OF WESTERN SOUTHLAND, NEW ZEALAND.—The Geological Survey of New Zealand continues, in Bulletin 23, its admirable practice of combining geological description with illustrations of the scenery of the country. The fascinating South Island bids fair to be as well "visualised" by those who cannot travel as are the west central States of North America; and each new Bulletin issued by Mr. P. G. Morgan makes one wish that New Zealand could be floated nearer to its antipodal colleague on some favouring current of the "sima" (see Wegener's views, NATURE, vol. 109, p. 202). Prof. J. Park in No. 23 describes part of Western Southland, including Lake Te Anau, which simulates a fjord among the mountains. The deep dissection of the early Cretaceous peneplain that was worn across the folded masses of the New Zealand Alps has formed noble ravines like that of the Clinton River (Pl. III.), where intrusive diorites and granites, probably of Permian age, come to light. These valleys have been carved along Pliocene lines of fracture. Though Prof. Park gives a general summary of the geological history of New Zealand (pp. 25-28), he touches very briefly on the formation of the arc of which the axis of the islands forms a part. He significantly refers the folding and fracturing to compressive stresses set up by the sinking of the adjacent troughs; but he inclines to regard these troughs as very ancient and persistent features. One would like to know if the present islands, as a ridge between the great eastern and the shallower western deeps, owe their existence above sea-level to a Pliocene creep of the ocean-floor resisted by an unseen extension of the Australian block.

CLOUD FORMS.—An article by Prof. W. J. Humphreys of the U.S. Weather Bureau on "International definitions and description of cloud forms, and supplementary remarks" is given in the March number of the Journal of the Franklin Institute. The article, which is continued from the February number, is based on a lecture on "Fogs and Clouds," given before the Section of Physics and Chemistry of the Franklin Institute on January 5 last. The different forms of cloud are well illustrated from photographs, many of which are new so far as cloud illustrations published on this side of the Atlantic are concerned. Cirrus clouds, from their light formation, are usually very difficult to represent in published form, but the illustrations given are good. Cirrus, which is the highest cloud, is said to occur at a height, approximately, of 5 miles in polar regions, 7 miles in middle latitudes, and 9 miles within the tropics. Many of the photographs were taken from Mount Wilson and other heights. A cumulus formed by convection over fire is exceedingly good, and several lenticular cloud specimens are of interest; types are given of the funnel cloud or tornado cloud. The height of clouds is discussed, and it is said that they are lower during winter than during summer, due to the difference in relative humidity. The extension of our knowledge of the upper air has added much to the better understanding of cloud development.

ELECTROLYTIC DISSOCIATION.—The Journal of the American Chemical Society for April contains an interesting paper by Prof. T. W. Richards and A. W. Rowe on the heats of neutralisation of alkalies with monobasic acids at various dilutions. As is well known, the approximate equality of the heats of neutralisation of strong acids by strong bases, indicating that the same reaction took place in all cases, namely, the union of hydrogen and hydroxide ions to form undissociated water, was one of the strong arguments for the theory of electrolytic dissociation put forward by Arrhenius. The careful measurements described in the paper show that the heats of neutralisation are slightly different, but since they all tend to the same limit with increasing dilution this is almost certainly the result of slight differences in the extent of ionisation of the different acids, bases, and salts. In solutions containing 100 grm. molecules of water to one of acid and base, the heats of neutralisation varied from 13·75 to 14·09 kilogrm.-calories. The heat of formation of water from its ions is found by slight extrapolation to be 13·62-13·69 kilogrm.-calories at 20°, in good agreement with the value 13·7 adopted by Arrhenius. These results would seem to rule out the assumption made by Ghosh and others that these electrolytes are all equally dissociated at the same dilution, and in a paper in the same journal by Prof. J. Kendall the theory of Ghosh is also adversely criticised from other points of view.

THE BRITISH BEET-SUGAR INDUSTRY.—In 1745 the Berlin chemist Margraaf discovered sugar in the beet, and in 1812 Napoleon laid down 75,000 acres for the cultivation of beet and established six centres of instruction. This was the result of the Continental blockade. Immediately before the outbreak of war in 1914, France and the United States each had half a million acres under sugar-beet, Germany had a million acres, and Austria, Belgium, Denmark, and Holland also made important contributions to the industry. Great Britain had only one factory, at Cantley in Norfolk, under Anglo-Dutch control. In the Journal of the Society of Chemical Industry for April 15 an account, with excellent illustrations, is given of the beet-sugar works at Kelham, Notts, owned by Home-Grown Sugar, Ltd. This works, which was designed by a French firm, and is almost entirely staffed by French workmen and managers, was the result of a grant of money from the Treasury. Up to date there has been a large deficit on the working of the factory, but as a result of the arrangement with the Government to remit the duty until the company is in a position to produce a total of 50,000 tons of sugar a year, it is hoped that progress will be made. The process is identical with that used in the North of France. Sugar-beet has been cultivated on 230 acres, and some 2300 acres have been grown locally by farmers, an average of 5·5 acres each. The sugar content of the roots has reached 15·92 per cent. The roots are washed, sliced mechanically, and treated with water in diffusion apparatus at about 70° C. The extract contains about 12·5 per cent of sugar, and the residue, after drying and mixing with molasses, is sold for stock feeding. The aqueous extract is treated with milk of lime and then with carbon dioxide to precipitate the lime. The clear liquor, after filtration, is treated with sulphur dioxide, evaporated *in vacuo*, cooled, and the crystals drained in centrifugal machines.

A NEW DESENSITISER.—We learn from the *British Journal of Photography* of May 5 that Dr. E. König, of the Hoechst firm of Meister, Lucius, and Brüning, who was associated with Dr. Lüppo-Cramer in his work on desensitisers of photographic emulsions, has continued the work on this subject. The practical result is that he has obtained a desensitiser fully equal in its effects to phenosafranine and without some of its disadvantages. The new desensitiser is called "Pinakryptol" and is a greenish-grey mixture of two desensitisers. One part is dissolved in 5000 parts of water for use, and its notable advantage is that it has no staining action on gelatine or celluloid or the fingers or nails of the user.

PETROLOGICAL MICROSCOPES.—We have received from Messrs. James Swift and Son, Limited, a catalogue of their petrological microscopes. The excellence of their work has earned them a well-deserved reputation which is still maintained. A number of types are described in the catalogue, some with a rotating stage and others with rotating nicols as originally designed for the firm by Mr. Dick. The former include the "Primex" for the use of elementary students, the "Advanced Student," the "Petros," and the "Survey." The "Petros" has a hinged analyser, which can be brought into position above the ocular. This has the advantage that a quartz-wedge can be introduced in the focus of the ocular. In the remainder the analyser is inserted in the lower end of the body tube, but a second analyser, which can be placed above the ocular, can be purchased as an accessory. In the "Advanced Student" the convergent system fits into a sleeve above the polariser, but the top lens can be removed if a less convergent system be desired. This arrangement can, however, be replaced by the convenient swing-out screw focussing adjustment which is fitted to the more expensive "Petros" model. The "Survey" is distinguished by its well-equipped substage. In all except the "Primex" there are two Bertrand lenses for the observation of interference figures, one at the upper end of the tube for measuring comparatively small crystals, and the other just above the objective, giving a much larger image. A more advantageous course is to employ, instead of a Bertrand lens, an auxiliary lens above the ocular. The light coming from a small crystal or part of a crystal, which it is desired specially to examine, can first be isolated by a perforated diaphragm in the focus of the ocular and the auxiliary lens then placed in position, when the interference figures can be observed unaffected by extraneous light. This procedure was recommended by a committee of the British Science Guild, and excellent auxiliary lenses of this description have been prepared by Messrs. Swift, which might have been expected to have had a place in this catalogue. Two types of microscope with rotating nicols are described, the well-known "Dick" microscope, and the "Grabham-Dick," distinguished by the triple nose-piece beneath the stage, which makes it possible to place three different types of condenser in position in turn. Full particulars are given, in the concluding pages of the catalogue, of different objectives, nose-pieces, centring objective changes, and other necessary or commonly employed accessories manufactured by the firm. It should have been stated in the case of quartz-wedges whether they are graduated to show the relative retardation at different points.

The Rat and its Repression.

By ALFRED E. MOORE, Hon. Director of the Incorporated Vermin Repression Society.

RATS have for more than three thousand years been regarded as noxious vermin by man. Boelter[1] reminds us that the Egyptian cat, *F. Caffra* (*Caligata* or *Maniculata*) was a domestic animal in Egypt twenty centuries B.C. and that it was held in the highest reverence as a natural protector of grain from rats and mice. Boelter relates how, when Ptolemy was doing all he could to conciliate the Roman power, a Roman accidentally killed a cat, and Diodorus Siculus, an eye-witness, tells how nothing, not even the terror of the Roman name, could save the unlucky Roman from punishment. To-day, when the rat army numbers almost countless legions, we find an apathy that is appalling, a stagnation of effort which is allowing the rat to encircle the earth, and like a creeping paralysis to leave death and destruction in its trail.

It is not so important to fix geographically or historically the origin of the rat, as it is to realise the fact that this rodent now inhabits practically every place where man has a dwelling, and that of all animals it is most fitted by nature to serve as a human scourge. Apart from the astonishing prolificacy of the rat, the animal is furnished by nature with first-class engineering and excavating tools in the shape of wonderful hand-like paws, a pair of incisor teeth of razor-like cutting power and hardness, a tail which serves a variety of uses, and a brain nimble, cunning, and educable. These advantages plus a courageous and adaptable disposition have served to make the rat ubiquitous.

It has been urged that all rats are cannibals and that the brown rat (*Rattus Norvegicus*) in England has driven out the black rat (*Rattus Rattus*), but too much reliance cannot be placed on these assumptions, for rats are cannibals only when driven by unsatisfied appetite, and it is doubtful if the number of black rats in any area in England is such as to diminish the food supply of the brown rat and force it to become an active cannibal, or, on the other hand, that the sexual appetite artificially stimulated under the Rodier system can diminish appreciably the number of rat hordes.

It is, of course, fairly easy to invite a charge of exaggeration when dealing with the rat, for the pest is without doubt a grave menace; it has been said by Dr. Khunart that the rat must be destroyed, or it will destroy man. Insistence on the serious character of the problem makes it extremely difficult, however, to wage an effective war on the animal; for it is easy to secure the label "crank" and to lead the man-in-the-street to remark that, if it be true that the rat is such a terrible fellow, "it's a wonder we are alive." Prominent leaders of thought in the veterinary world regard the rat as a disease carrier *par excellence*, and I am convinced that further research will establish the rightness of many suspicions, but for the moment let us consider the nature of proven charges. We know, for example, that rats transmit plague, trichinosis, malignant jaundice, parasitic mange, and rat-bite fever, and we know that these maladies are serious diseases. They are, of course, calculable in effect, but there are other human ills directly attributable to the presence of the rat, such as loss of sleep through nervousness, fright, etc., and these ills are burdensome in so far as that they contribute materially to the sum of factors in physiological fatigue and therefore occasion incalculable loss of human efficiency.

Economically, the rat is a charge upon the resources of the nation, which is only measurable in figures too great to be comprehended by the casual student. We know that rats commence to breed when three months old, that the female litters from 6 to 12 times a year, and that the litter consists of from 6 to 12 young; therefore, we have a population of about 1000 rats from one pair of rats in 15 months, and as a rat costs approximately 1½*d.* per day for food it will readily be seen that we are paying too dearly for this pest. How much we are paying will be more clearly realised when we remember that it is generally agreed that the number of rats equals the human population; in some cases the rat population is considerably greater, as at a sugar plantation in Porto Rico, where the population numbered less than five hundred people and a six months' rat drive accounted for 25,000 rodents killed. Bearing these numbers in mind, and taking the population of the British Isles as being about 47,000,000, we get a rat cost of as much as 75,000,000*l.* per annum after deducting ½*d.* per day per rat for garbage eating.

This is not, however, the total amount of taxation the rat imposes upon us, for it is my experience that the animal does an enormous amount of damage in pursuit of its food, and in poultry yards its depredations are very considerable. "Lantz (U.S.A.) quotes a Washington merchant to the effect that rats gnawed a hole in a tub containing 100 dozen eggs, and within a period of two weeks carried away 71 dozen without leaving either shell or stain." Cases are not rare where rats have disposed of half a lamb in a night, and it is an undoubted fact that if meat is condemned as tuberculous or unfit for food, rats seem to have an uncanny instinct for finding and consuming such portions of the carcases as are diseased.

It must not for one moment be imagined that fear of the rat is a fad, nor is it peculiar to the medical profession: medicine, hygiene, and commerce all have contributed men with international reputations—Crichton-Browne, Andrew Balfour, Arthur Shipley, Glen Liston, Mark Hovell, Akin, Pasteur, Creel, Emil Zuschlag, Hinton, Bruce Bruce-Porter, James Cantlie, Frederick Hobday, Banister Fletcher, Castellani, Nathan Raw, Sydney Hickson, Tanner Hewlett, and Lords Denbigh, Aberconway, Lambourne, Ernle, and others too numerous to mention have joined their voices to those of the informed public and members of Parliament in a call for rat repression, as a measure of public safety.

It is significant that the first determined effort to deal with the rat in England found definite shape in ordinances made in various parishes in 1740 and again in a Bill introduced into the House of Commons by Sir Chas. B. McLaren in March 1909, and reintroduced by him into the House of Lords, some ten years later, where he sat as Lord Aberconway. Although in common with America, Japan, Denmark, Sweden, Barbadoes, Antigua, and Hong Kong, we in England have now an anti-rat law, there is much amendment required to make it effective.

[1] "The Rat Problem," by Wm. Boelter. John Bale, Sons, and Danielsson, Ltd.

There are no financial provisions for the Rats Act's working to be found in the Act; it is punishable with a fine to harbour rats, yet reinfestation of a cleared habitation is not punishable, nor is trafficking in rats a crime. These weaknesses are being remedied in a Bill being drafted by the Incorporated Vermin Repression Society to amend the existing Act. The I.V.R.S. memorialised the League of Nations, and incidentally the memorial was signed by leaders of all shades of thought, with the view of securing an International Conference to deal with rats and shipping (the existing regulations being chaotic and tending to discriminate against this country) and to give a ruling on the vexed question of the employment of virus.

The virus question is one that should be settled without delay. Those—like the I.V.R.S.—who oppose its use, argue that it is unsound in principle to permit the unrestricted use of living virus, or germs, of mouse typhoid or any other disease which might possibly become communicable to man, and that, moreover, it is a waste of money and opportunity to create a race of rats immune to the effects of virus in the process of killing what is, after all, an infinitesimal proportion of the rat population. Attempts to get manufacturers interested in the production of virus to agree to a round table conference with unbiassed bacteriologists, pathologists, Government representatives and business men, have unfortunately, so far, been unsuccessful.

The question is often asked—"What is the best method of destroying rats?" There is only one answer—"There is no *best* method of destroying these pests." Rat destruction is a problem of urgency, and also one of extreme difficulty, and a moment's reflection shows that this difficulty cannot be dismissed with a shrug of the shoulders, because the rat is far too clever to be caught except in negligible numbers by any crude method. It is an omnivorous feeder, and since the rat's diet comprehends bacon, bananas, eggs, lamb, young chicks, offal, bread, sponge-cakes, young rabbits, young game, biscuits, human flesh, apples, sweetbreads, corn, bulbs, and other eatables too numerous to mention, it is hopeless to pin one's faith to poisoning, since all poisoning, that is to say, effective poisoning, is a matter of baits. Again, this method of destroying rats demands fool-proof preparations, which limits the field in this respect; obviously it is dangerous to place poisons such as arsenic, strychnine, antimony, phosphorus and the like in places accessible to children or domestic animals; therefore, for all practical general purposes we are limited to barium carbonate, squill, and sodium fluoride. Cats and dogs are very useful, but it is a mistake to assume, as does one port authority, that an excellent sufficiency of cats is a good insurance against rats; as a matter of experience it is nothing of the kind, for, like practically all domesticated animals, the cat is companionable, and unless it has a spare diet, and is deprived of the association of too many of its kind, it becomes a hunter after the fleshpots of Egypt rather than a menace to rats. Ferrets are useful only in the hands of practical rat-catchers; for in unskilled hands they get lost. Nevertheless, since they are useful in skilled hands, they may render excellent service to the community when they are associated with a game terrier in an anti-rat club, and such clubs should be a feature in every village and rural town. Gassing, too, has its advantages, sulphur dioxide being perhaps the safest to use, but as a lethal agent it is inferior to chlorpicrin gas. The U.S.A. Government report favourably on a gas called cyanogen-bromide. There is much to be said for the raising of the status of those who are engaged in the war against rats; for modern drainage systems, while aiming at efficient sanitation, undoubtedly provide excellent facilities for rat locomotion, and tend to defeat the object of rat-weeks by allowing the hard-pressed rats of one district to escape to another district where the rat-week is next week. The vast emporiums, too, provide problems in rat repression which no ordinary rat-catcher can grapple with effectively. To sum up, if rats are to be appreciably diminished in number it is imperative that—

(1) An International Commission be created to extract the best of all existing rat laws and codify them in such a manner as to ensure their being concurrently effective in all countries, and in all ships and vehicles of water transport.

(2) Our own rat laws be amended: (*a*) to make rat trafficking a crime; (*b*) to make rat reinfestation a crime; (*c*) to make financial provision for the carrying out effectively of the rat law; and (*d*) to make it an obligation upon the Ministry charged with the administration of the Act to enforce its being carried out by the authority concerned.

(3) All *bona fide* rat-catchers be registered and given instruction in elementary pathology, sanitary engineering and hygiene, and certificates be issued to competent and honest persons engaged in this business, withdrawable publicly in the Press in the event of petty larceny, offences against the Rats Act, or for other specified reasons.

(4) The question of the use of virus should be settled, and whatever conclusion is arrived at in this regard be given the widest publicity.

(5) Twice a year all British authorities be compelled to co-operate and synchronise their efforts in rat destruction, and during the period, public lectures on rat destruction, rat proofing, and the necessity for eliminating possible rat-breeding grounds, be organised by the authorities.

(6) The authorities responsible for the zoological laboratories of all universities, colleges, and institutes be invited to set apart a portion of their time for the teaching of economic biology in so far as it concerns the rat, the diseases it carries, its movements, the nature and extent of its depredations, its natural enemies, and the known poisons which are safe to use, this with the view of discovering improved methods of ensuring its destruction.

(7) In all elementary schools pupils be taught the life-history of the rat, regarding the rat as man's natural enemy, the toxicity of the various raticides in common use, the value of the barn owl (*Strix Flammea*), the ferret, the weasel, the common kestrel, and the pine marten, the use of baits, varnishes, traps, the progress made by gassing as a method of rat destruction in ships and in places where it is possible to confine the gas, and the best methods of destroying rats (by water-flooding) in their runs, an effective method of killing rats in the country.

(8) All local authorities should frame their bye-laws so as to encourage rat proofing, and all employers of labour should exhibit in canteens, etc., a card, 12 in. × 10 in., warning their employees against leaving about the debris of food, and a reminder: "NO SCRAPS, NO RATS."

It cannot be urged too strongly that of all remedial measures against the rat, the most important are rat proofing and the withholding of food and water, especially water, for rats can exist much longer without food than without water.

Science and Gas Warfare.[1]

I LOOK upon it as a great honour to have been invited to come here to-day, and I appreciate the compliment which has been paid me. It was my privilege to be associated with many of the leading British men of science during the war, and, if I may say so without presumption, I regarded them with the greatest admiration. I was intimately connected with certain phases of their work, and I was also brought into contact with the war work (carried out on the same lines) of most of our allies, as well as of our late enemies: and while implying nothing derogatory to the latter, I have no hesitation in declaring that in the matter of practical achievement British men of science were second to none.

The war was one in which science played a part which increased progressively in importance: and the Empire owes a debt, the extent of which perhaps it does not fully realise, to the able scientific workers who gave their services—often in an honorary capacity—in solving the various vital problems which were put before them—problems in preventive medicine, optics, sound-ranging, aeroplane design, chemical warfare, and so on: and to the scientific institutions all over the country which provided them with facilities for their researches.

It is not surprising to find that this College, with its Imperial associations and great record of public service, took a leading part in this work—the work of winning the war. A prominent feature in the Nominal Roll of the College is the variety of the service which was given by its past and present students. Their names appear in every department of army activity, but more especially in the various branches of my own Corps, the Royal Engineers. We have been called the scientific Corps; but while not pretending that this is an accurate description, we are, and always have been, at any rate the link between the army and the scientific world, and I think I can claim that we are very receptive of all scientific proposals and alive to their developments. Many of the students of this College served in that branch of the Corps with which I was most intimately concerned, and the names of some of them are engraved on this tablet.

Owing to the secrecy which it was necessary to maintain during the war, the general public has still, I believe, little idea of the prominent part which chemical warfare played on the field of battle on the Western Front. Between the Battle of Loos, in September 1915, and the armistice, the activity of the Special Brigade was almost incessant, and gas attacks were carried out on an average on two nights out of every three during the whole period. Some 800 separate attacks were made—against about 25 by the Germans against us—and nearly ten thousand tons of gas were liberated, quite apart from the work of the artillery: and many were the variations practised in the form of attack, as regards tactics, mechanical appliances, and meteorological conditions.

The enemy's casualties from these gas attacks probably numbered between 100,000 and 200,000, amongst whom the percentage of mortality was very high. These operations were carried out, for the most part, by young students fresh from civil life, who had had little preparation for the work and practically no military training whatever. In spite of the heavy artillery bombardments to which they were subjected—the retaliation for which each gas discharge was the signal—these young men combined with their technical skill a standard of personal courage worthy of veteran soldiers: and many distinctions were conferred on them, including the Victoria Cross. But it was not only in the front-line trenches that British men of science distinguished themselves in France. When the Germans launched their first gas attack against us in April 1915 our soldiers were unprepared and quite unprotected: and it must remain one of our proudest memories that they stood at their posts, and hundreds of them died there: it was due to the initiative and the energetic action taken by your Rector, Sir Alfred Keogh, then the head of the Medical Service at the War Office, and the steps devised by Prof. Haldane of Oxford, Prof. Baker and the late Prof. Watson of this College, and Prof. Jones of Manchester—then a private in the London Scottish—that the lives of thousands of British soldiers were saved in the course of the next few weeks. The protective appliance then extemporised was gradually developed in efficiency, chiefly by the late Lt.-Col. Harrison, until it became eventually a very perfect apparatus, millions of which were issued to the American and Italian armies as well as to our own.

This, however, was not the only scientific work undertaken for the protection of our troops. Knowing that we were only on the threshold of scientific discovery in its relation to gas warfare, we were always keenly sensitive to the appearance of any new chemical substance on the field of battle. In order to recognise it immediately it appeared, and to take the necessary steps to combat it, a very efficient chemical intelligence department was organised—quite separate from that which served the General Staff. A gas officer was appointed to each division in the field, one of whose duties it was to report all German gas attacks and bombardments—by telephone, and during its actual progress if it was an important one. If any novel symptoms of gas poisoning appeared anywhere on the front an able physiologist, who made a speciality of this work, went immediately to investigate them. If a new gas shell was suspected, samples of earth and water from the shell craters were collected for analysis, and an unexploded shell-case was located and dug up as soon as possible and sent in to a central laboratory for examination.

Opening these shells, the contents of which were often under pressure, was difficult and dangerous work: and I have little doubt that it was owing to his personal devotion to it, and the complete disregard of his own safety, that the late Prof. Watson, who was the Director of this laboratory, sacrificed his health, and eventually his life. I think it would interest you to hear that such was the efficiency of this chemical intelligence service that when the Germans first introduced mustard gas—then practically an unknown substance—warnings were telegraphed to all our armies, tabulating the injuries caused and the precautions which should be taken to avoid them, while an approximate analysis of the contents of one of the shells had also been made—all between 24 and 48 hours of its first use. When we came to summarise our knowledge of mustard gas at the end of the war, after a further 18 months' experience of it, it was found that there was little that could be added to the statement originally issued.

In conclusion, I ought not to omit reference to the devoted work done at home in connection with chemical warfare in the various research laboratories and munitions factories all over Great Britain. One of

[1] Address by Col. C. H. Foulkes when unveiling the War Memorial of the Royal College of Science on March 29.

our gas factories was closed on certain occasions for days at a time because most of the workers were put out of action, suffering from gas poisoning: there were other similar incidents, and in a number of cases men lost their lives; which shows that service at home was by no means without its risks. In fact, I might almost say that work in a poison gas factory entailed suffering from gas poisoning sooner or later.

In research work, Profs. Baker and Thorpe were very prominent throughout the whole period of the war. They, with other eminent men, gave themselves whole-heartedly to this work, to their own financial disadvantage, and without the prospects of reward which the successful soldier has in view. In science, at any rate, there was no profiteering. A lady of this College, Dr. Whiteley, introduced the use of "S.K." —symbolising South Kensington—a substance that was largely used against the Germans—as well as a new explosive.

In all the preliminary physiological tests, of course, animals were used; but volunteers were never wanting for the more important experiments in the lethal chamber: and at one time many of the experimental staff at Porton were in a constant state of ill-health owing to the trying nature of this work. One gallant action worthy of record was that of Mr. Barcroft of Cambridge, who, in order to confirm a theory which had an important bearing on our gas tactics, entered the lethal chamber together with a dog, both being entirely unprotected, and remained there while exposed to prussic acid gas until the dog died.

All honour, then, to the distinguished scientific workers of our nation in general, and of this College in particular, staff and students, who responded to the call of patriotism on the battlefield, in the committee-room, the research laboratory, and the munitions factory; but, above all, let us hold in grateful remembrance those whose names are inscribed on this tablet, who not only served their country to the best of their ability, but who gave their lives in doing so.

The Evolution of Plumage.[1]

THE paper by Prof. Ewart referred to below contains much good and new matter, but the good observations are not exactly recent discoveries, whilst the new conclusions and speculations are rather contestable, or at least startling.

The bulk of the paper is very technical, but some of the generalisations concerning the evolution of the coat or coats of feathers of birds never fail to interest a wider circle of readers. The first coat of the young chick is composed of structurally rather simple little feathers, the Neossoptiles or nestling feathers; the final or finished feathers were called Teleoptiles. The first set is structurally continuous with the next growing set or generation. Then it was found that in the majority of birds not one but two nestling coats were successively developed, both in structural continuity with each other (henceforth distinguished as Proto- and Mesoptiles; and the latter passing into the Teleoptiles).

These several sets or generations vary much in relative importance, time of their emergence or growth, size and temporary functions, in the different groups of birds. For example, whilst the first set forms the duckling's first and effective jacket, it is the second set which in the penguins makes a very woolly and warm coat which lasts the youngsters many months, until these fluffy down-like feathers are supplemented by typical adult feathers. Moreover, in the duckling this second set is in the interesting condition of reduction, being practically crowded out of existence between the first and the third set. It depends upon the group of birds whether and how and to what extent these Mesoptiles become vestigial.

Again, while in ducks and penguins—in fact, in the overwhelming majority of birds—the difference between their nestling coat and the final dress is enormous (let us remember the callow blind-born nestling of a thrush, with a few large wavy tufts, before the final feathers begin to sprout), in the cassowaries and emus the differences between the successive coats are reduced to a question of mere size. In short, the variations are almost endless and still promise many new discoveries, all the more interesting when correctly correlated with the bird's ecology. Indeed, here is a wide and fertile field for fascinating speculation. Let us see how Prof. Ewart has tackled the matter. The chapters dealing with a more general account of the evolution of the plumage are an instance of that kind of "Natur-Philosophie" which, entranced by the new Darwinism, did not allow itself to be hampered by facts nor to be checked by the perhaps equally sanguine speculations of others.

Although the earliest birds known are the two specimens of Archæopteryx from the upper Jurassic, our author states that at the beginning of the Jurassic age the coat of birds may have consisted only of Protoptiles; and the scene of the dawn of feathers of such low order is set in a land with desert climate, cold and dry, atmospheric conditions which would engender feathers. The dryness would cause the hypothetical feather "filaments" or cryptoptiles to split or fray into a kind of brush, and "whatever bird or beast became warm-blooded would appreciate an overcoat." Presumably the creature became heated by its attempts to flutter, and the increased temperature made it liable to catch cold and call for a feather coat. Thus a teleological unscientific notion is preferred to the suggestion that a gradually improving coat (and frayed brush-like scales would be less heat-conductive than ordinary reptilian scales) might induce first stable and then permanently increased blood-temperature. Surely the important feature would be the thermostatic result, resulting incidentally from the development of a better non-conducting coating.

In any case this first set of little Protoptiles formed at best a poor sort of flimsy overcoat. When, however, the climate changed from cold and dry to cold and damp, "during perhaps a cold phase of a glacial epoch," the coat was changed into the Mesoptile coat by the lengthening of the previously existing branches, or barbs, of the brush, and by the sprouting of new additional barbs. At any rate thus was evolved the thick, fluffy, warm coat of the young penguins, and it "is probably as useful now to the penguin chicks hatched within or near the Antarctic circle as it was when originally acquired during perhaps a cold stage of a glacial epoch."

Later, as the climate improved [interglacial] this fur-like second coat was in most other birds more or less suppressed [perhaps it proved too hot] and a third coat was constructed out of what gradually improved into feathers proper, which in turn were differentiated into downs and contour feathers, and some of these became, through use, etc., specialised into remiges and rectrices. At last there was a chance for a flying bird. Ostriches and similar birds perhaps never did

[1] "Nestling Feathers of the Mallard," by Prof. J. Cossar Ewart, Proceedings, Zoological Society of London, 1921, p. 609.

live in a cold damp climate, and consequently never went through the intermezzo of a "British warm."

But which glacial epoch wrought all these miracles? The author, surely, does not mean the Permian glaciation; and certainly geologists tell us there was none until towards the end of the Tertiary. Perhaps the penguins had a Jurassic glacial epoch in their Antarctic realm, while owls and petrels, which, by the way, have as thick and fluffy and long-lasting Mesoptile coats as any penguins, owe these coats to our Pleistocene bad times. We can scarcely date these birds back into early Jurassic times like the penguins, which until their first interglacial ease-off must have waddled about without feathers proper, all their lives long moulting from one thick Mesoptile coat into the next, generation after generation. This truly startling picture results from the confusing of generations of feathers, which are ontogenetic items, and stages in the evolution of the plumage, which are phylogenetic conceptions.

Archæopteryx likewise does not fit into this view, with its highly specialised remiges and rectrices, of late Jurassic date, and certainly long before penguins came into existence.

Apropos of the question of the origin of feathers from scales, we are told that the conversion of his Cryptoptiles (consisting apparently of hollow epidermal cones) into the Protoptiles took place "in some incomprehensible way," and that the Protoptiles "in some way soon acquired the chief characteristics of true feathers." Perhaps it was a case of miraculous mutation? But why incomprehensible, considering that there are at least two reasonable possible explanations, the only difficulty being which to choose. What is less comprehensible is that the author did not refer simply to that résumé (itself a large essay) by that experienced referee Prof. Keibel, in "Ergebnisse . . .," 1896, supplemented more recently by Schleidt (1913) and Steiner (1918), who adds a literature list well-nigh complete and appalling by its size.

H. F. G.

The Advance of Heliotherapy.

By DR. C. W. SALEEBY.

THE treatment of disease by sunlight is the newest of old things. It was systematically practised by Hippocrates, the Father of Medicine, and perhaps we need not trouble ourselves with questions of priority in our own times. At any rate, the first clinic for the heliotherapy of surgical tuberculosis was opened by Dr. A. Rollier at Leysin in 1903, and at last it would appear that his methods are to be followed throughout the world. Already in France and Italy the sun cure is practised, and I recorded lately in NATURE (March 2) the finding of many heliotherapeutic institutions on the Riviera, from Cannes to San Remo. The city of Lyons wisely sends its sick children to the Villa Santa Maria at Cannes, and the Italians have recently established the Istituto Elioterapico which I found outside San Remo a few weeks ago. In our own country we have Sir Henry Gauvain at the Treloar Hospital, Alton and Hayling Island, and Dr. Gordon Pugh, at Queen Mary's Hospital for Children at Carshalton. In the United States, Rollier is being followed at Perrysburg, near Buffalo.

Now there comes an admirable volume[1] which clearly presages the advance of heliotherapy into Spain. The number of the journal in question is devoted to a series of articles in Spanish by Dr. Rollier and his assistants at Leysin. First of these is a paper by Dr. Rosselet, a physicist, on the scientific bases of heliotherapy, and Dr. Amstad contributes a paper on the sun cure of non-tuberculous diseases. We shall do well not to associate the sun cure exclusively with tuberculosis nor solely with the proved antiseptic power of sunlight. The recent American work, both at Columbia University and Johns Hopkins Hospital, has shown that sunlight has potent influences upon nutrition and metabolism, and is capable, for instance, of preventing and curing rickets in a fashion hitherto unsuspected. Amstad refers to rickets, of course, but he is evidently not acquainted with this new American work.

The publication is completed with a series of well-produced plates which illustrate Rollier's methods and show, in several "before and after" photographs, the all but miraculous results which he habitually obtains.

Madrid, like Munich and Mexico City, is a city which teaches us that abundant tuberculosis may occur even at high altitudes. Even "Sunny Spain" needs the lessons of heliotherapy. At Mentone, a few weeks ago, myself in broad and ravishing sunlight, I saw a cobbler at work in a dark room, lit by a miserable oil-lamp, the rays of which ill served to illuminate his work. Answers of this order serve as reply to those who ask why, for instance, if the sun be such a preventive, there is any tuberculosis in India.

In his fine article in this present publication, Dr. Rollier insists, as ever, upon the superior value of the early morning sun. This point needs perpetually to be made. We tend to associate light and heat; so that, last year, the late Prof. Benjamin Moore actually asked, in the *Times*, whether "too much light and heat" may not be bad for us. The question is illegitimate. Light and heat must be distinguished. In Canada, according to my own observation there, it is the combination of light and cold that contributes to the superb Canadian physique and vitality. In Switzerland the same is true, and Leonard Hill has shown us the physiological basis of this valuable combination. But when thoughtless clinicians expose cases of pulmonary tuberculosis, for instance, to sunlight in warm weather, perhaps in the afternoon, perhaps even with exposure of the chest, and achieve only fever and hæmorrhage for their unfortunate patients, we are told that heliotherapy is useless in phthisis.

It is certainly high time that the fundamentals of the biology and physiology of light should be well and truly laid. Dr. Rosselet, in his interesting contribution, does not convince us that any one, as yet, really knows how sunlight achieves its results, but we shall expect to place heliotherapy upon broad and deep foundations when the committee lately appointed by the Medical Research Council gets to work. Meanwhile we must hope for English translations of "La Cure de Soleil" and the rest of Rollier's works, so that the present tragic farce of the treatment of tuberculosis in this country, with its desolating results, may yield to the intelligent use of sunlight.

[1] Archivos Españoles de Tisiologia, Num. 4. (Enero 1922, vol. 2. Barcelona, Calle de Aragon, núm. 282.)

The Universities and the Publication of the Results of Research in America.

ONE of the principal subjects dealt with by the Association of American Universities in their conference last November was the publication of the results of research. Scientific and learned periodicals are numerous in the United States, and there has until the present been but little co-ordination. "The American Chemical Society," says the editor of the *Yale Review*, "now has under its management three journals: a monthly devoted to the theoretical aspects of the subject, another monthly devoted to industrial chemistry, and *Chemical Abstracts*, which reviews twice a month all publications carrying new contributions to chemistry in its various phases. The question of a similar consolidation has reached at least the stage of discussion in several other National Societies in order, not only to avoid duplication, but also to reduce overhead costs, and to bring together where it may be readily examined material that now lies hidden in hundreds of places and so may be easily overlooked." He suggests that universities might support periodicals published by such national societies in preference to establishing their own separate periodicals, and in particular, that instead of requiring dissertations for the doctor's degree to be published *in extenso* they should cause them to be "cut down to the bone" and the skeletons thus obtained to be given to the national societies for publication in their journals. The societies on their part might, he suggests, have their printing done by the University Presses.

An interesting sketch was given by the Director of the Wistar Institute for the Advancement of Biological Science of the operation since 1908 of a "plan for assembling and publishing a number of national zoological journals under one central management." So successful has this proved that the combined annual sales of five journals has increased from 1410 to 5286 copies, while the income has been gradually overtaking the cost, notwithstanding a lavish distribution of free copies, notably 5000 dollars' worth to the principal libraries of Europe—a policy begun immediately after the armistice was signed and to be continued for five years.

The factors of success are thus summarised: a whole-hearted co-operation of the men of science interested, whether as author, editor, publisher, or reader, a centralised management looking ever to prompt publication and extensive distribution with efficiency and economy, concentration on a group of journals limited to one field of research, and guarantee both financial and scientific of an endowed institution devoted to the same field of science. A feature of the Institute's methods of publishing the results of research is the system of "Bibliographic Service Cards." These include the author's abstract as well as complete bibliographic references, and an announcement of the date when the complete article will appear. They are issued fortnightly to subscribers to all the Institute's journals, and extra copies are often distributed for advertising purposes.

University and Educational Intelligence.

Manchester.—The Council of the University has appointed Dr. Robert Robinson to the chair of organic chemistry which was vacant owing to the appointment of Prof. A. Lapworth to the chair of chemistry. Prof. Robinson graduated at Manchester University in 1905 with first-class honours in chemistry and was a graduate scholar and Le Blanc medallist. As research student, and later as a lecturer in organic chemistry in the University, a remarkable series of papers on natural plant products were produced in conjunction with Prof. W. H. Perkin and others. His synthetic work has also been singularly skilful. His work has been often concerned with the processes taking place in the living organism and has in many directions shown the way to development in biochemistry. In addition to his academic work, Prof. Robinson, as Director of Industrial Research to the British Dyestuffs Corporation, has gained experience of working conditions especially valuable to such an important centre of the dyestuff industry as Manchester. Prof. Robinson has previously held chairs of organic chemistry at Sydney and Liverpool, and the chair of chemistry at St. Andrews. He was elected a Fellow of the Royal Society in 1920.

The Delegacy of the City and Guilds (Engineering) College has appointed Prof. C. L. Fortescue, of the Royal Naval College, Greenwich, to succeed Prof. T. Mather, who is resigning the chair of electrical engineering in the College at the close of the present session.

The Dr. Edith Pechey Phipson post-graduate scholarship of the London (Royal Free Hospital) School of Medicine will be awarded in June. It is open to all medical women, preferably coming from India, or going to work in India, for assistance in post-graduate study. It is of the annual value of 100*l*., for a term not exceeding three years. Applications for the scholarship must reach the Warden and Secretary of the School, 8 Hunter Street, W.C.1 by May 31.

Recent appointments to the staff of the Technical College, Bradford, include Mr. R. E. Stradling, as head of the department of civil engineering in the college, and Mr. H. J. B. Chapple, as lecturer in electrical engineering.

Applications are invited for the Ray-Lankester Investigatorship at the Marine Biological Laboratory, Plymouth. The post is of the value of 100*l*. and is tenable for fifteen months, out of which the investigator will be required to devote five months at the laboratory to some subject of marine research. Applications should be addressed to the Director.

A conference of representatives of the Universities of Great Britain and Ireland was held on Saturday last, May 13, at University College, London, under the presidency of Sir Donald MacAlister, vice-chancellor and principal of the University of Glasgow. The discussion on advanced study and research was opened by Dr. J. C. Irvine, vice-chancellor and principal of the University of St. Andrews. Dr. Irvine expressed the opinion that research should be controlled in every university by a board or standing committee, with power to recommend changes in the teaching staffs of departments actively engaged in research, to allocate money voted for research purposes, and to consider such questions as travelling and publication grants.

Dr. L. R. Farnell, vice-chancellor of the University of Oxford, who opened the discussion on specialised study, stated that the idea of having one university for physical science and another for the humanities would be fatal to the cultivation of both branches of knowledge. On the other hand, it must be recognised that by reason of their surroundings, some universities were peculiarly fitted for certain studies. Mr. Fisher joined in this discussion, emphasising the growing need for co-operation between the universities, in respect of the distribution of studies according to the particular advantages of each. It was suggested that a committee of vice-chancellors should investigate claims for additional endowments by special departments and inquire whether the transference of trust funds to different subjects within the university was desirable or whether the migration of students requiring special subjects could be facilitated. Sir Henry Miers, vice-chancellor of Victoria University, Manchester, was emphatic on the point that higher education of the right type could be given only by universities or institutions of similar standing.

IF the number of suitable applicants is sufficient, the Board of Education will provide during the summer, courses of instruction of two weeks' duration for teachers of engineering science and electrical engineering in technical schools. The standard of the work will be that of the "National Certificates" in engineering of ordinary grade, but advanced treatment will be accorded to certain sections of the work. The courses will start on Saturday, July 22, and will end on Saturday, August 5. The courses will be held in Oxford, in the University Engineering Building, the University Electrical Laboratories, and in the new laboratories of the City of Oxford Technical School. The instruction in engineering science will be given by Prof. F. C. Lea, of Birmingham University, and that in electrical engineering by Prof. W. M. Thornton, of Armstrong College University of Durham, each of whom will have the assistance of a staff of tutors, lecturers and instructors. Teachers who wish to apply for permission to attend either course must fill up and return form 972 T/Engineering as soon as possible, so as to reach the Board's office not later than Monday, May 29.

MR. J. W. BISPHAM, of the London County Council service (Technology Section), has been appointed principal of the Borough Polytechnic Institute, to fill the vacancy caused by the retirement of Principal C. T. Millis. He will take up his duties in September.

IN Bulletin No. 6, 1921, of the United States Bureau of Education, published for the guidance of students in other countries contemplating advanced study or research in the U.S.A., particulars are given regarding the graduate schools of 28 universities, including, *inter alia*, admission requirements, periods of study for degrees, noteworthy facilities for particular lines of graduate study (equipment and research funds, library facilities, and facilities for publication of research results), expenses of tuition and board and lodging. The graduate school now usually co-ordinates into one administrative unit all the advanced teaching and all the facilities for original research provided by the university. To obtain a master's degree, one year (Yale and Johns Hopkins—two years) of post-graduate study devoted, as a rule, to not more than three subjects, including one "major," is usually required, while for a doctor's degree the minimum period is usually three years. Most universities require the dissertation for the doctorate to be published. The requirements for the Ph.D. degree parallel closely those proposed by the German universities, but attempts have recently been made to insist on a somewhat longer scholarly preparation and a more substantial thesis. Each university generally awards to graduate and professional students a number of fellowships and scholarships carrying stipends ranging from 100 to 600 dollars, the holders of which are sometimes required to do one to six hours' teaching weekly. Foreign students will usually find it necessary to spend at least a year in residence at an American university before qualifying for one of these grants. The enrolment in graduate courses in the United States increased from 4340 in 1893 to 16,470 in 1916.

Calendar of Industrial Pioneers.

May 18, 1747. Bernardo Zendrini died.—One of the most celebrated Italian hydraulic engineers of the eighteenth century, Zendrini was also a mathematician and was one of the first to apply the infinitesimal calculus to practical problems. As mathematician and engineer to Ferrara, Modena and Venice he carried out many works connected with the rivers and ports of north-east Italy.

May 19, 1907. Sir Benjamin Baker died.—Born in 1840, Baker was apprenticed at the Neath Abbey Iron Works in South Wales, and after gaining experience as a civil engineer became an assistant to Sir John Fowler, with whom he was afterwards in partnership. Among the great works he was associated with were the Forth Bridge, the Assouan Dam, the Central London Railway, and the Avonmouth Docks. As one of the leading engineers of his day he served on the Ordnance Committee, the Engineering Standards Committee, was elected a fellow of the Royal Society, and in 1895 served as president of the Institution of Civil Engineers. A memorial window to his memory has been placed in the north aisle of Westminster Abbey.

May 21, 1826. Georg von Reichenbach died.—A famous German mechanician and instrument maker, Reichenbach was born in 1772 at Durlach. In his youth he spent some time at Boulton and Watt's works at Birmingham, and after his return to Germany was employed with his father in the manufacture of munitions. In 1800 he invented a dividing machine; the transit circle was re-introduced by him, and he collaborated with Utzschneider, Fraunhofer, and Ertel.

May 22, 1900. William Lindley died.—Trained as a civil engineer under Francis Giles, Lindley worked under Brunel on the Thames Tunnel, and in 1838 became engineer of the Hamburg and Bergedorf railway. He was afterwards responsible for the sewage works, the water works, and many of the engineering schemes which turned Hamburg into one of the greatest modern seaports.

May 23, 1800. Henry Cort died.—The inventor of the important process of puddling and also of the grooved rolls for manufacturing wrought iron, Cort, between 1765 and 1775, made a fortune as a navy agent in Surrey Street, the Strand. Stimulated by the dearness of Russian iron, he then made experiments on iron-making and had works at Fareham and Gosport where, in 1783, he brought out his great inventions, but at the same time reduced himself to poverty. His inventions added enormously to the wealth of the country, and the puddling process supplied all the malleable iron for our engines, railways, and iron ships till the introduction of the Bessemer process of making mild steel.

May 23, 1915. Pierre Emile Martin died.—A native of Bourges, and born in 1824, Martin in the early 'sixties began experimenting on the manufacture of steel in a small Siemens regenerative furnace, and in July 1865 took out his patent for the process in which pig-iron, scrap steel, and iron oxide are melted together on an open hearth. Till the introduction of the basic-lined furnace of Thomas and Gilchrist, the Martin—or Siemens-Martin process, as it is known in England—made little headway against the Bessemer process. By 1913, however, of 74 million tons of steel produced only 30 millions were produced in Bessemer converters and the remainder by the Martin process. Martin reaped no pecuniary advantage from his work, but in 1910 a fund was raised for him, and a few weeks before his death he was awarded the Bessemer medal.

E. C. S.

Societies and Academies.

LONDON.

Royal Society, May 4.—Sir Charles Sherrington, president, in the chair.—C. **Shearer**: On the heat production and oxidation processes of the echinoderm egg during fertilisation and early development. The heat production during fertilisation and early development of the egg of *Echinus miliaris* has been measured by the differential micro-calorimeter, and the oxygen consumption and carbon dioxide output by the differential manometer. In one hour, 1 million unfertilised eggs (8 mgrm. egg N.) consumed 15·1 c.mm. of oxygen at standard barometric pressure and 14·5° C., and gave off 0·067 grm. cal. of heat. In a similar interval the same quantity of fertilised eggs consumed 86·4 c.mm. oxygen and liberated 0·397 grm. cal. of heat. The ratio of the heat production in one hour to the oxygen consumption gives a calorific quotient Q, which is 3·07 in the unfertilised and 3·22 in the fertilised developing egg-cell. Thus very little of the chemical energy liberated as the result of fertilisation is expended in bringing about the visible morphological structure of the developing ovum. The heat liberation, oxygen consumption, and carbon dioxide output of the ovum after fertilisation rise progressively during development, reaching the highest point when the free-swimming stage is reached.—Johan **Hjort**: Observations on the distribution of fat-soluble vitamins in marine animals and plants. The periodical changes in the size and quality of fish at different seasons of the year are associated with changes in the content of fat. In cod the changes in quality are demonstrated by inspection of the size of the liver, which is 50 per cent. "cod-liver oil." The liver of full-grown cod during the summer season, when the fish was feeding, weighed three times as much as in winter, during the spawning season. Seasonal variations in quality do not coincide with temperature variations, nor, in the case of the cod, with the availability of the animals which serve it as food. The distribution of fat-soluble vitamin in green algæ (Ulva), diatom-plankton, shrimps and prawns, and hard roes of herring and cod was studied. These substances had a marked effect in re-starting and maintaining the growth of rats, previously on a diet free from fat-soluble vitamin.—H. **Hartridge** and R. A. **Peters**: Interfacial tension and hydrogen ion concentration. The drop-weight method, which gives results similar to the capillary height and ripple methods, was employed for measuring the interfacial tensions. A decrease in interfacial tension between a fatty acid or glyceride and aqueous fluids occurs with increasing alkalinity of the aqueous fluid. It depends upon the concentration of the fatty substance in the oil phase, the presence of a certain concentration of alkali in the aqueous phase, and the hydrogen ion concentration at the interface. Only substances having a COOH group (free or combined, as tri-glyceride) gave these changes.—W. **Cramer**, A. H. **Drew**, and J. C. **Mottram**: Blood-platelets: their behaviour in "vitamin A" deficiency, and after "radiation," and their relation to bacterial infections. The absence of the fat-soluble vitamin from the diet leads, in the rat, in every case to a progressive diminution in the number of blood-platelets known as thrombopenia. Thrombopenia occurs before any obvious signs of ill-health appear. When profound thrombopenia has been established, addition of the missing vitamin A to the diet is usually followed by rapid increase in the number of platelets up to the normal. Exposure to radium produces lymphopenia, which is characteristic of vitamin B deficiency, and also, with large doses, thrombopenia. Animals generally recover rapidly if the application of radium is discontinued. If the number of platelets is reduced below a certain critical level—about 300,000 in the rat—the resistance of the animal to infection is greatly diminished and infective conditions develop spontaneously. Alterations in local or general resistance to the infection are associated with local or general changes in distribution of the platelets.

Royal Microscopical Society, April 19.—Prof. F. J. Cheshire, president, in the chair.—R. S. **Ludford**: Morphology and physiology of the nucleolus. Of the various functions which have been attributed to the nucleolus, recent work emphasises that it (1) represents secretory substances or enzymes elaborated by the chromosomes (chromatin) to bring about metabolic processes in the cytoplasm; (2) is the accumulation of waste products of nuclear activity which when extended into the cytoplasm are broken down with the liberation of energy, which is utilised for other purposes; (3) stands in some functional relationship to the morphological changes which take place in the chromosomes at different periods of cellular activity. There is considerable evidence in favour of each of these theories as to the function of the nucleolus.

Physical Society, April 28.—Dr. Alexander Russell, president, in the chair.—T. **Smith**: The position of best focus in the presence of spherical aberration. Focal variations of phase in the presence of spherical aberration are calculated directly from the axial intersection points of rays of known inclination. The new graphical method employed shows that the focus for which phase variations have a minimum value may be found and interpreted when the finiteness of the wave-length is disregarded.—F. **Twyman** and J. **Perry**: The determination of the absolute stress-variation of refractive index. The Hilger interferometer is employed in determining the stress-optical coefficients. Young's modulus of elasticity and Poisson's ratio are determinable simultaneously.—C. J. **Smith**: An experimental comparison of the viscous properties of (*a*) carbon dioxide and nitrous oxide, and (*b*) nitrogen and carbon monoxide. Direct comparisons have been made by observing the time required by a mercury pellet to force an equal volume of gas through a capillary tube at atmospheric and steam temperatures. The times of fall for each gas are equal at 15° C. and 100° C., and hence it is shown that the viscous properties are identical over this range. The absolute viscosity has been obtained by comparison with air, and the mean area of collision deduced by using Chapman's formula.—F. **Twyman**: An optical sonometer. The object of this instrument is to furnish graphs of the pressure variation in sound waves. The sound is directed by a trumpet upon a celluloid membrane a fraction of a wave-length of light in thickness, which is silvered at a point between its centre and periphery. Rays from a pointolite lamp are concentrated on the silvered surface, and are reflected thereby through an ordinary and a cylindrical lens on to a photographic strip carried by a spring-driven chronographic drum. The duration and incidence of the photographic exposure are controlled by adjustable devices revolving with the drum. The constants of the membrane can be determined by measuring its curvature with an interferometer when it is being stressed by gravity, pneumatic pressure or electrostatic attraction. Good sound records can be obtained so long as the pitch of the sounds investigated differs considerably from the resonance pitch of the membrane, which is of the order of 200 per second.

CAMBRIDGE.

Philosophical Society, May 1.—Prof. H. F. Baker in the chair.—H. **Lamb**: Waves of permanent type at the interface of two liquids.—A. E. **Western**: The number of primes of the form n^2+1.—S. **Chapman** and T. T. **Whitehead**: The influence of electrically conducting material within the earth on various phenomena of terrestrial magnetism.—Mr. **Ince**: The impossibility of the coexistence of two Mathieu functions.—V. **Trkal**: A general condition for the quantisation of the conditionally periodic motions with an application for the Bohr atom.—C. D. **Ellis**: Interpretation of the β-ray and γ-ray spectra. Taking a general view of a β-ray disintegration and of the radiations that accompany it, the β-ray line spectrum is entirely secondary in origin and due to the conversion of monochromatic γ-rays. The general β-ray spectrum and these γ-rays are the primary phenomena. This theory accounts for the thorium-*C* and radium-*D* spectra. Frl. Meitner's theory is unlikely to be correct; it offers no explanation of the general β-ray spectrum; it predicts that the total number of electrons emitted should be less than the number of atoms disintegrating; and, finally, certain lines in the radium-*B* spectrum should be primary and characteristic of the radium-*B* nucleus and therefore should not appear in the spectrum excited in lead by the γ-rays of radium-*B*. These lines, however, have been observed.

DUBLIN.

Royal Dublin Society, April 25.—Dr. G. H. Pethybridge in the chair.—W. E. **Adeney**, A. G. G. **Leonard**, and Miss A. M. **Richardson**: On the aeration of quiescent columns of distilled water and of solutions of sodium chloride. Columns of de-aerated distilled water and of sodium chloride solutions up to ten feet in length were exposed to a slow current of dry air for periods of 14-56 days. Samples were withdrawn from various depths and the nitrogen content determined. It is found that aeration is effected by the exposed layer mixing with the unexposed portions of the water to depths of at least 10 feet. This process is caused by the downward "streaming" by the constantly changing layer of water exposed to the air. It proceeds more rapidly, and more uniformly, to depths of at least 10 feet, in salt water than in fresh water. The rate at which "streaming" proceeds depends largely upon the rate at which the concentration and cooling of the surface layer is brought about by evaporation, and proceeds more rapidly at temperatures at and above 10° C. than below it. It is less rapid, and less uniform downwards to 10 feet deep, and probably to greater depths, at temperatures below 8° C., especially in fresh waters. The rate of mixing also depends upon the concentration of salt in solution. The optimum concentration appears to be about 1 per cent. sodium chloride.—T. A. **McLaughlin**: Cataphoresis of air bubbles in various liquids. Air bubbles show no cataphoresis in the following liquids: methyl, ethyl, and butyl alcohols, xylol, benzine, toluene, bromobenzine, benzyl alcohol, benzaldehyde, aniline, cinnamic aldehyde, ethyl malonate, lactic acid, oleic acid, ethyl acetate, and turpentine. It was not possible to trap an air bubble in acetone and volatile liquids such as carbon disulphide. In impure acetone foreign matter moved towards the positive pole. In distilled water, air bubbles moved towards the positive pole; in impure benzine, towards the negative pole; in "pure" nitrobenzine, to the negative pole. In impure nitrobenzine the motion may be to either pole.

PARIS.

Academy of Sciences, April 24.—M. Emile Bertin in the chair.—E. **Goursat**: The theory of integral invariants.—P. **Marchal**: The metamorphosis of the females and hypermetamorphosis of the males in the Coccidia of the Margarodes group. Both males and females pass through three forms—first a primary hexapod larva capable of migration; then a cystoidal larva adapted to life fixed to a plant; and, thirdly, a hexapod form, at which stage the development of the female is arrested. The male continues to develop through two or three other forms before reaching the winged stage.—L. **Lumière**: Capillary movement, diffusion, and displacement. A study of flow through filter paper and cotton strips used as siphons. The flow of liquid increases with the height of fall up to a certain distance and then remains constant. Some practical applications are given, including washing photographic negatives and precipitates with minimum quantities of water. A negative 9 cm. by 12 cm. can be washed completely in 15 minutes with less than 30 c.c. of water.—E. **Vessiot**: Surfaces generated by circles.—E. **Cartan**: The equations of structure of generalised space and the analytical expression of Einstein's tensor.—E. **Nörlund**: The interpolation formula of Newton.—B. **Gambier**: Point correspondence of two surfaces and a class of surfaces analogous with isothermal surfaces.—A. **Pictet** and J. H. **Ross**: The polymerisation of lævoglucosane. Lævoglucosane, heated to 140° C. in the presence of a trace of zinc chloride, polymerises in accordance with the equation $nC_6H_{10}O_5 = (C_6H_{10}O_5)_n$ in a few minutes. Different polymers are obtained by varying the pressure: at 15 mm. of mercury $n=2$ and the product is dilævoglucosane $(C_6H_{10}O_5)_2$, at atmospheric pressure $n=4$, under 4·6 atmospheres $n=6$, and at 13·3 atmospheres $n=8$.—P. **Gaubert**: The liquid crystals of calcium phosphate.—P. L. **Mercanton**: The magnetic state of arctic basalts. Since the Tertiary period the magnetic inclination of the earth in the northern regions would appear to have changed its sense: to complete the proof an examination of antarctic larvas is desirable.—S. **Stefanescu**: The phylogeny of *Elephas antiquus*.—A. **Carpentier**: The conifers and ferns of the Weald of Féron-Glageon.—J. **Maheu**: A retarded regeneration of moss. A detailed description of the growth of a specimen of *Barbula muralis*, after remaining 14 years in a state of absolute dryness.—G. **Nicolas**: Remarks on *Narcissus tazetta*.—G. **Malfitano** and M. **Catoire**: Amylocellulose considered as a compound of silicic acid and amylose. Experimental evidence that silica is an essential constituent of amylocellulose.—A. **Vila**: The influence of heat and of some solvents on the viscosity of horse serum. The coagulating effect of acetone, analogous with that of heating, can be reduced or even avoided altogether by taking certain precautions.—Y. **Manouélian**: Histo-microbiological researches on general paralysis. Existence of the treponeme in the cytoplasm of the nerve cells of the cerebral cortex.

Official Publications Received.

Annual Report of the Academy of Natural Sciences of Philadelphia for the Year ending November 30, 1920. Pp. 57+6 plates. (Philadelphia.)

Proceedings of the Academy of Natural Sciences of Philadelphia. Vol. 73, Part 2, 1921. Pp. 193-435+plates 9-47. (Philadelphia.)

State of Connecticut. Public Document No. 47. State Geological and Natural History Survey. Vol. 6, Bulletins 23-32, 1915-1920. (Hartford.)

Carnegie Institution of Washington. Annual Report of the Director of the Department of Terrestrial Magnetism. (Extracted from Year Book No. 20 for the Year 1921.) Pp. 307-357. (Washington.)

Jahrbücher der Zentralanstalt für Meteorologie und Geodynamik. Amtliche Veröffentlichung. Jahrgang 1917. Neue Folge, 54 Band. Pp. xxviii+A24+B38+C41+D22+E6+F18+G38. (Wien: Gerold und Komp.)

Leeds University. Seventeenth Report, 1920-21. Pp. 166. (Leeds.)

Royal Magnetical and Meteorological Observatory at Batavia. Observations made at Secondary Stations in Netherlands East-India. Vol. 8 (1918). Pp. ix+104. (Batavia.)

University College of North Wales. Calendar for Session 1921–22. Pp. 394. (Bangor.)

The Journal of the Royal Agricultural Society of England. Vol. 82. Pp. 8+298+cxxxii+x+28. (London: J. Murray.) 15*s*.

Review of Agricultural Operations in India, 1920–21. Pp. vi+120. (Calcutta: Government Printing Office.) 1.4 rupees.

Annual Report of the Director, Kodaikanal and Madras Observatories, for 1921. Pp. ii+25. (Madras: Government Press.) 6 annas.

Experimental and Research Station, Nursery and Market Garden Industries' Development Society, Limited, Turner's Hill, Cheshunt, Herts. Seventh Annual Report, 1921. Pp. 52. (Cheshunt: Cheshunt Press, Ltd.)

Department of Agriculture and Natural Resources: Weather Bureau. Annual Report of the Weather Bureau for the Year 1918. Part 4: Hourly Results of the Observations made at the Magnetic Observatory of Antipolo, near Manila, P.I., during the Calendar Year 1918. Pp 47. (Manila: Bureau of Printing.)

Diary of Societies.

FRIDAY, MAY 19.

INSTITUTE OF TRANSPORT (at Institution of Civil Engineers), at 10 A.M. —D. H. Davies: The Finance of the Modern Highway: A Problem and a Solution.—Prof. J. Carlier: Foreign Railway Practice.—Col. J. W. Pringle: Safety in Railway Operation.

ASSOCIATION OF ECONOMIC BIOLOGISTS (in Botanical Lecture Theatre, Imperial College of Science and Technology), at 2.30.—W. Rushton: Further Contributions to the Biology of Freshwater Fishes.—Prof. J. H. Priestley: Toxic Action of Illuminating Gas on Plants (with Demonstration).

ROYAL SOCIETY OF MEDICINE (Otology Section), at 5.—Annual General Meeting.

INSTITUTE OF TRANSPORT (at Royal Society of Arts), at 5.—F. V. Russell: The Operation of Heavy Suburban Passenger Services on a Steam Railway, with particular reference to Density of Service, Terminal and other Facilities.

INSTITUTION OF ELECTRICAL ENGINEERS (London Students' Section) (Annual General Meeting), at 7.—A. H. Reeves: The Elimination of Atmospherics in Radio-telegraphy.

ROYAL SOCIETY OF MEDICINE (Electro-therapeutics Section) (Annual General Meeting) (at Langham Hotel), at 7.15.

GEOLOGISTS' ASSOCIATION (at University College), at 7.30.—H. Dewey: The Sources and Transport of Non-local Rocks in the London Area.

JUNIOR INSTITUTION OF ENGINEERS, at 8.—F. W. G. Clark: Engineering Business in China.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Sir William Bragg: The Structure of Organic Crystals.

SATURDAY, MAY 20.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Prof. O. W. Richardson: The Disappearing Gap between the X-ray and Ultra-violet Spectra. II. Photo-electric Methods.

MONDAY, MAY 22.

ROYAL SOCIETY OF MEDICINE (Odontology Section) (Annual General Meeting), at 8.—E. Sprawson: The Significance of the Extra Cusp commonly found on the Antero-internal Aspect of the Maxillary First Permanent Molar in Man.—H. C. Malleson: Some Notes on Dental Histology.

ROYAL GEOGRAPHICAL SOCIETY (at Æolian Hall), at 8.30.—H. Lee Shuttleworth: The Border Countries of the Punjab Himalaya.

TUESDAY, MAY 23.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Prof. W. Bulloch: Tyndall's Biological Researches and the Foundations of Bacteriology (2). (Tyndall Lectures.)

INSTITUTE OF PHYSICS (Annual General Meeting) (at Royal Society), at 5.—Sir J. J. Thomson: Presidential Address.

ROYAL SOCIETY OF MEDICINE (Medicine Section) (Annual General Meeting), at 5.30.—M. P. L. Violle: A Practical and Accurate Method of Estimating Diuresis.—Dr. W. Hunter: The Nervous Disorders of Severe Anæmias in relation to their Infective Lesions and Blood Changes.

ZOOLOGICAL SOCIETY OF LONDON, at 5.30.—The Secretary: Report on the Additions to the Society's Menagerie during the month of April 1922.—Rev. H. N. Hutchinson and E. Godwin: Exhibition of a Plaster Cast of a Model Reconstruction of the Marine Reptile *Peloneustes philarchus*, a Pliosaur from the Oxford Clay.—Sir Sidney F. Harmer: Commerson's Dolphin and other Species of Cephalorhynchus.—C. F. Cooper: Miocene Proboscidia from Baluchistan.—R. I. Pocock: The External Characters of Scarturus and other Jerboas compared with those of Zapus and Pedetes.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—T. Thorne Baker and L. F. Davidson: Spectroscopic Measurements of the Hydrogen Ion Concentration Colour Changes in Recent Indicators.—K. C. D. Hickman: The Dyeing of Silver Iodide with Methylene Blue, including:—(*a*) A Method of measuring Small Quantities of Methylene Blue occluded by Silver Iodide Precipitate; (*b*) The Tanning of Gelatine by Development Action and its Influence on the Process of Dyeing.—E. L. Turner and C. D. Hallam: The Function of the Flash Exposure in Three-colour Work. (Experiments in half tone, 3rd series.)—A. C. Banfield: The Trist Three-colour Exposure Camera.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.—Dr. B. Malinowski: Theory and Practice of Witchcraft in Eastern New Guinea.

SOCIOLOGICAL SOCIETY (at 65 Belgrave Road, S.W.1), at 8.15.—E. Betham: The National Housing Policy: A Common Sense View.

WEDNESDAY, MAY 24.

LINNEAN SOCIETY OF LONDON, at 3.—Anniversary Meeting.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Very Rev. Dr. W. R. Inge: Theocracy (1). Theocracies in General.

GEOLOGICAL SOCIETY OF LONDON, at 5.30.

ROYAL SOCIETY OF ARTS, at 8.—G. Fletcher: The Natural Power Resources of Ireland.

FELLOWSHIP OF MEDICINE (at Royal Society of Medicine), at 5.—Sir St. Clair Thomson: The Surgical Anatomy of the Nose and Accessory Sinuses.

THURSDAY, MAY 25.

ROYAL SOCIETY, at 4.30.—*Probable Papers*.—Prof. C. H. Lees: The Thermal Stresses in Solid and in Hollow Circular Cylinders concentrically heated.—B. F. J. Schonland: The Scattering of β Particles.—N. K. Adam: The Properties and Molecular Structure of Thin Films. Part II. Condensed Films. Part III. Expanded Films.—E. Wilson: The Susceptibility of Feebly Magnetic Bodies as affected by Compression.—S. F. Grace: Free Motion of a Sphere in a Rotating Liquid parallel to the Axis of Rotation.

INSTITUTION OF MINING AND METALLURGY (Special General Meeting) (at Geological Society), at 5.30.—H. R. Sleeman: The Re-establishment of the Gold-basis of Currency.

INSTITUTION OF ELECTRICAL ENGINEERS, at 6.—Annual General Meeting.

ROYAL MICROSCOPICAL SOCIETY (Metallurgical Section), at 7.30.—L. S. Ward: Notes on Etching and Etching Re-agents.

ILLUMINATING ENGINEERING SOCIETY (Annual Meeting) (at Royal Society of Arts), at 8.—Report of Council;—at 8.30.—Sir John Herbert Parsons: Presidential Address.

ROYAL SOCIETY OF MEDICINE (Urology Section) (Annual General Meeting), at 8.30.—Prof. F. Hobday: Urinary Calculi in Animals.—K. Walker: The Genital System of the Rhinoceros.

FRIDAY, MAY 26.

ROYAL SOCIETY OF ARTS (Indian Section), at 4.30.—Sir Thomas W. Arnold: Indian Painting and Muhammadan Culture (Sir George Birdwood Memorial Lecture).

PHYSICAL SOCIETY OF LONDON (at Imperial College of Science and Technology), at 5.—Dr. F. W. Aston: Atomic Weights and Isotopes (Lecture).

ROYAL SOCIETY OF MEDICINE (Study of Disease in Children Section) (Annual General Meeting), at 5.

ROYAL SOCIETY OF MEDICINE (Epidemiology and State Medicine Section), at 8.—Dr. R. Dudfield: Reforms needed in the Notification of Tuberculosis.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Prof. W. E. Dalby: The Internal Combustion Engine: Its Influence and its Problems.

SATURDAY, MAY 27.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir Hugh Allen: Early Keyboard Music (1).

PUBLIC LECTURES.

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

FRIDAY, MAY 19.

LONDON SCHOOL OF ECONOMICS, at 5.—Dr. P. Giles: Modern Views of Indo-European Origins (2).

UNIVERSITY COLLEGE, at 5.15.—A. E. M. van der Meersch: Simplified Solutions for B.M. and S.F. Values for Rolling Loads (2);—at 5.30. —Prof. W. R. Shepherd: The Expansion of European Civilisation (3).

BIRKBECK COLLEGE, at 6.—Dr. E. J. Russell: Recent Work with regard to the Influence of Soil Conditions on Agriculture (2).

GRESHAM COLLEGE, at 6.—Sir Robert Armstrong-Jones: Physic (4) (Gresham Lectures).

MONDAY, MAY 22.

ROYAL SOCIETY OF MEDICINE, at 5.—Prof. F. Widal: Anti-anaphylaxie (in French).

KING'S COLLEGE, at 5.30.—Prof. F. H. Edgeworth: The Development of the Head Muscles of Vertebrates (1).

TUESDAY, MAY 23.

UNIVERSITY COLLEGE, at 5.—Sir Arthur Shipley: Insects and Disease (4).

KING'S COLLEGE, at 5.30.—Prof. H. Wildon Carr: The Principle and Method of Hegel (4). The Concrete Universal.—Prof. F. H. Edgeworth: The Development of the Head Muscles of Vertebrates (2).

WEDNESDAY, MAY 24.

KING'S COLLEGE, at 4.—Dr. A. Harker: Tertiary Igneous Action in Britain (2).—Prof. F. H. Edgeworth: The Development of the Head Muscles of Vertebrates (3).

SCHOOL OF ORIENTAL STUDIES, at 5.—Dr. R. A. Nicholson: The Idea of Personality in Sufism (2).

UNIVERSITY COLLEGE, at 5.15.—Dr. D. H. Scott: The Early History of the Land Flora (5).

THURSDAY, MAY 25.

CHELSEA PHYSIC GARDEN, at 5.—E. A. Bowles: Superstitions of Early Herbalists: particularly the Doctrine of Signatures, illustrated by Living Plants (Chadwick Lecture).

ST. MARY'S HOSPITAL (Institute of Pathology and Research), at 5.—Prof. E. H. Starling: Some New Experiments on the Kidney.

ROYAL SOCIETY OF MEDICINE, at 5.—Prof. H. Vaquez: De l'Érythrémie (Maladie de Vaquez-Osler) (in French).

KING'S COLLEGE, at 5.30.—Prof. F. H. Edgeworth: The Development of the Head Muscles of Vertebrates (4).

UNIVERSITY COLLEGE, at 5.30.—Prof. W. R. Shepherd: The Expansion of European Civilisation (4).

FRIDAY, MAY 26.

BIRKBECK COLLEGE, at 6.—Dr. E. J. Russell: Recent Work with regard to the Influence of Soil Conditions on Agriculture (3).