THURSDAY, OCTOBER 23, 1913.

LORD RAYLEIGH'S SCIENTIFIC PAPERS.

Scientific Papers. By John William Strutt, Baron Rayleigh, O.M., F.R.S. Vol. v., 1902–1910. Pp. xiii+624. (Cambridge University Press, 1912.) Price 15*s.* net.

THE fifth volume of Lord Rayleigh's papers contains his researches from 1902 to 1910; it is a volume of nearly eighty papers on subjects of a very varied nature—no slight record for a man during the seventieth decade of his life.

The four earlier volumes of the work have already been noticed in NATURE, and there is little more to be said with regard to the volume now under review.

The thanks of all interested in the advance of physical science are due in the first place to the author for thus reissuing in collected form his work during his own lifetime, and in the second to the Cambridge University Press for publishing it in the present admirable form. The issue of the collected works of great mathematicians—Adams, Cayley, Maxwell, Stokes, Rayleigh, Tait, and Kelvin—which the Press has undertaken in recent years has been of the utmost value to students throughout the world; and of this series no volumes have been more eagerly looked for or met with a more welcome reception than those of Lord Rayleigh. The pages under review afford ample evidence of the author's special powers, clearness of vision, whether in regard to the mathematical theory of his subject or to the essential details of an experimental inquiry; a firm grasp of mathematics as an instrument to solve the problem he is attacking; readiness to use simple methods of experiment where these suffice; the power to see when it is necessary to call in the highest skill of the instrument-maker or the minute care of the observer—these are manifest throughout.

It must suffice for the present to refer to one or two of the papers which appear of most interest to the present writer; the volume must find a place on the shelves of every physical library, and be continually referred to by students and workers.

One of the earliest papers reprinted from the Phil. Trans. for 1902 deals with the isothermal relation between the pressure and volume of a gas at pressures of from 75 to 150 mm. of mercury. The conclusion reached is that to one part in 5000 at least air, hydrogen, oxygen, and argon obey Boyle's law at the pressures concerned and at ordinary temperatures (10°–15°). For nitrous oxide the deviations are somewhat greater. The work was extended to higher pressures up to one atmosphere in a further paper (Phil. Trans., 1905).

In two interesting papers the question whether the earth's motion affects the rotatory polarisation or produces double refraction of light are both answered in the negative. Other papers, again, bear evidence as to Lord Rayleigh's activity as a member of the Explosives Committee, or as adviser to the Trinity House, while a large part of the volume deals with various problems of small vibrations either optical, acoustical, or electrical, *e.g.* on the bending of waves round a spherical obstacle; on the dynamical theory of gratings; on the application of Poisson's formula to discontinuous disturbances, together with a series of acoustical notes.

Reference should also be made to a series of papers dealing with the measurement of the wave-length of light, commencing with one in the *Philosophical Magazine* for 1906, on some measurements of wave-lengths with a modified apparatus, followed by another on further measurements of wave-lengths, *Phil. Mag.*, xv., 1908. Both these papers are admirable examples of Lord Rayleigh's method of dealing with experimental difficulties of a high order without any undue elaboration of apparatus, and of his success in securing results. The method employed was a modification of that of Fabry and Perot, and the observations recorded in the first paper verified to one part in a million the values found for the wave-lengths, in terms of that of the red cadmium line, of the more important lines of cadmium, mercury, zinc, and soda, by Michelson and Fabry and Perot.

In conclusion reference should be made to papers on skin friction on even surfaces, a note to a paper by Prof Zahm, *Phil. Mag.*, 1904, and on the application of the principle of dynamical similarity, Reports of the Advisory Committee for Aëronautics, 1909–10 and 1910–11.

These deal with the conditions to be observed when calculating the resistance on bodies moving through the air from experiments on models. On the assumption that the resistance depends on the velocity and viscosity of the air and on the size of the surface, and is approximately proportional to the square of the velocity, it is shown that the resistance R is given by the equation—

$$R = \rho V^2 f(\nu/Vl),$$

where ρ, V, and ν are the density, velocity, and viscosity of the fluid, and l a linear quantity defining the size of the body, f being an unknown function. It follows from this that if the resistances are to be treated as proportional to the squares of the velocities for the actual

body and the model, the comparisons must be made at velocities for which Vl is constant—*i.e.* at velocities inversely proportional to the size of the body and model respectively.

Enough has probably been written to direct attention to the wide range and absorbing interest of the subjects discussed in this volume.

CONCERNING BIRDS.

(1) XI. *Jahresbericht* (1911) *der Vogelwarte Rossitten der Deutschen Ornithologischen Gesellschaft.* Teil II. By Prof. J. Thienemann. Pp. 1–75.

(2) *The Food of some British Wild Birds: a Study in Economic Ornithology.* By W. E. Collinge. Pp. vi + 109. (London: Dulau and Co., Ltd., 1913.) Price 4*s.* net.

(3) *The Bodley Head Natural History.* By E. D. Cuming. With Illustrations by J. A. Shepherd. Vol. i., British Birds. Passeres. Pp. 120. (London: John Lane, 1913.) Price 2*s.* net.

(1) IN the second part of the eleventh annual report of the "Vogelwarte," or bird-watching station, at Rossitten in East Prussia, Dr. Thienemann sets forth the 1911 results of the migration inquiry. The method pursued is marking the birds with numbered and addressed rings, and it continues to yield very interesting results. We notice that more than one black-headed gull born near Rossitten has been recovered in England, and a starling marked in the nest in Livonia on June 10, 1911, was shot on December 26, 1911, near Buckfast Abbey, South Devon. Other black-headed gulls from Rossitten were reported from Hungary, Croatia, Switzerland, and Piedmont; and one marked at Munich was found again at Tunis. Best of all is the case of a Rossitten gull marked in the nest July 18, 1911, and shot in November in Barbadoes. We may recall the fact that a British marked gull has been reported from the Azores.

Some new records of German storks from Africa bring the total of such cases up to twenty-four. They include recoveries from the Mbomu-Ubangi basin (North Congo), German East Africa, and the Victoria East district of Cape Province (the southernmost locality, 32° 46′ S.). Interest also attaches to storks recovered in Europe, for while most of those from Germany (east and west), Denmark, and Holland have been found to migrate south-eastwards towards Asia Minor on their way to Egypt and further south, we have a second case of a West German stork migrating towards Spain.

It is difficult to pick and choose among the interesting records, such as three hooded crows recovered after intervals of more than six years; a lesser black-backed gull marked at Rossitten in autumn and reported from Servia after three weeks; a young woodcock marked near St. Petersburg, July 3, 1911, recovered in dept. Gers, S.W. France, December 12, 1911; a wood pigeon marked in the nest near Dresden and obtained five months later in dept. Lot-et-Garonne, S.W. France; a rough-legged buzzard marked in the nest in northern Swedish-Lapland in July, and shot near Vienna four and a-half months later; an eagle (*A. pomarina*) marked in the nest in Russian Kurland in July, and recovered two months afterwards in Southern Bulgaria. A discussion of certain rather puzzling movements of the red-legged falcon concludes this interesting paper. Dr. Thienemann is to be heartily congratulated on the success which has attended the inquiry which he so energetically pursues.

(2) Mr. Collinge has done a very useful piece of work in presenting in compact form the results of his *post-mortem* examination of 3048 adult birds and 312 nestlings, and in giving along with this an up-to-date summary of what is known in regard to the food of the commonest British birds. We do not speak without feeling when we say that it is no light task to examine the food-canals of 3000 birds, and to make sure, or as sure as one can, of the significance of their imperfectly preserved contents. Mr. Collinge has done his work carefully, and the results are proportionately valuable—helping us, none too soon, to get away from the practical mistakes engendered by prejudice and hearsay evidence. Mr. Collinge has also been careful in his presentation of the work done by other observers.

Attention may be directed to the interesting (but all too short) chapters on the food of nestlings, on the *rôle* of birds in destroying or distributing the seeds of weeds, and on the relation of birds to forestry. Of the twenty-nine species of birds which have been especially studied by the author, only five are regarded as distinctively injurious, viz., the house-sparrow, bullfinch, sparrow-hawk, wood pigeon, and stockdove; six are regarded as altogether too plentiful, and consequently injurious, viz., missel thrush, blackbird, greenfinch, chaffinch, starling, and rook; the blackcap is injurious, but not plentiful; the jay is held to be neutral; and the remaining sixteen are beneficial, most of them meriting protection, especially the owls, the wren, and the plover. It must be borne in mind, however, that these are average verdicts, and Mr. Collinge would doubtless agree that they require modification for different parts of the country. The book does not deal at all with fish-eating birds, in regard to some of which there is a warm difference of opinion—to be settled by gathering more facts

—between the champions of birds on one hand and angling associations on the other. We hope this book will pass through many editions, and gain in strength as it grows—incorporating new data and extending its scope.

(3) Of making books—big and little—about birds there is no end, and the more the merrier as long as each newcomer is accurate and sincere, with something fresh to reveal. There is no doubt of a welcome for the "Bodley Head" bird-book, for Mr. Shepherd's drawings are charming characterisations, quite unusually successful in revealing the ways and habits of the birds. There is a good deal of psychology in them. The text is pleasantly and clearly written, without waste of words, and with insight into what is most distinctive. We would suggest that the inclusion of rarities, such as the rose-coloured pastor, is uncalled for in a book of this kind.

NEW AMERICAN BOOKS ON AGRICULTURE.

(1) *Cooperation in Agriculture.* By G. H. Powell. Pp. xv+327+xvi plates. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1913.) Price 6*s.* 6*d.* net.

(2) *The Farmer of To-morrow.* By F. I. Anderson. Pp. viii+308. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1913.) Price 6*s.* 6*d.* net.

(3) *Animal Husbandry for Schools.* By Prof. M. W. Harper. Pp. xxii+409. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1913.) Price 6*s.* net.

(4) *Elementary Tropical Agriculture.* By W. H. Johnson. Pp. xi+150. (London: Crosby Lockwood and Son, 1913.) Price 3*s.* 6*d.* net.

(1) THE first book on the list contains a very interesting account of the cooperative movement in America, especially as applied to agriculture. The subject is a very difficult one, and the author shows in his opening pages that he is fully aware of the intricacies and pitfalls in which it abounds. In the first instance a cooperative movement is not necessarily organised for the sake of profit; it may also be—and is, indeed, primarily—run for the benefit of its members in other directions. Secondly, as the author brings out very vividly, the average farmer is not a specialist. He produces a variety of general crops, each of which has to be handled and marketed through different agencies. Moreover, the supplies he uses are secured from different sources. He is thus in an entirely different position from the specialist farmer, who devotes his main attention to some one crop, such as apples, potatoes, &c., and therefore has much in common with others who are in the same line of business. These men can easily combine; they have to face the same problems of production, transport, distribution, and sale. Everywhere it is found that cooperation is easier for them than for the ordinary farmer.

The author therefore considers it a fundamental principle that a successful industrial organisation among farmers must be founded on a special industry, such as cotton, tobacco, milk, &c. Further, that the unit must lie in a restricted area. It also seems necessary for success that the organisation must be born in times of adversity; if it springs up in times of prosperity it has less chance of surviving the competition of existing agencies. Having laid down these fundamental principles, the author proceeds to show what has been done in the various States to apply them to the case of the ordinary farmer producing various crops.

(2) In this book Mr. Anderson gives a vivid account of the problem of soil fertility as it is understood by the Bureau of Soils at Washington. It is written in the direct popular style that is being cultivated with marked success by some of the present American authors, and it gives a very lively picture of the work done by the Bureau and its bearing on present-day agricultural problems in America. The author does not attempt any discussion of the hypotheses, and his statement of the position of the other side is somewhat inaccurate; in a popular book, however, it is something if the other side is recognised at all, even though it is only set up to be knocked over.

Besides all this there is a very spirited account of the position of American agriculture to-day, the movement back to the land, the introduction of business methods, the rise in capital value of the land, and the question of soil treatment. All these matters are dealt with in a light and easy fashion which cannot fail to hold the reader's interest.

(3) The third book on the list is one of the Rural Text-book Series, and is designed for schools and for short-course students at the colleges. It is thoroughly worthy of its companions in the series. The descriptions of the animals are good, and the illustrations are both adequate and to the point. The general reader will be struck by the large part British live stock play in the animal husbandry of the United States. After an enumeration of the different breeds, the author passes on to the methods of judging. The animal's mouth affords useful guidance here, and some good illustrations are given showing the appearance of the teeth at different ages. Next follows a detailed description of the score card, an American invention of great value that has now found its way into English colleges.

The selection of animals to be fattened is no longer a haphazard matter. Farmers and graziers have learnt by experience that animals which fatten well possess certain points in common. Thus a good beef steer for fattening has a head with definite characteristics, which are thus set out by the author:—

"It should be broad and short, the face and cheeks should be full and deep with a broad, strong lower jaw. The nostrils should be large. The eyes should be large, prominent, and mild, indicating a quiet temperament. The forehead should be somewhat prominent, and covered with a mass of wavy hair. The ear should be of medium size, and covered inside and out with fine silky hair, and should be neatly attached to the head."

The other parts of the body have to be observed in similar detail. It would be interesting to inquire how far these "points" possess any real significance, and how far they are purely fanciful. Although the author does not help us in this matter, he has done good service by placing on record the points recognised in American practice.

(4) Mr. Johnson has gathered together in this little book—the only British book on the list—the main principles involved in tropical agriculture, with a view to the introduction of the subject into schools. He is convinced that West African youths must be encouraged to adopt agriculture as a profession if the immense potential agricultural wealth of the country is to be extensively developed; he considers that the unhealthiness of the climate must militate against the direct exploitation of the industry by Europeans. This being so, it is obviously necessary that the principles of agriculture should be introduced into West African schools, and the book is intended for this purpose. It begins with a chapter on soil, then with six chapters on the plant, dealing respectively with the seed, the root, the stem, leaves, the flower, and the fruit. Next follows an account of the food of plants, in which the author reverts once more to the soil. Two chapters on diseases and insect pests come next, and finally there is a section dealing with the school garden. The book is well got up, and is clearly written; it should serve very well the purpose for which it is intended.

THE POPULARISATION OF SCIENCE.

Harmsworth Popular Science. Edited by Arthur Mee. In 43 parts. (London: The Amalgamated Press, Ltd.)

THE days when Science was an intellectual preserve for the few are long since past, and popularisation has become an art—increasingly an art. For if we compare a work like that before us with the "Useful Information for the People," or the "Science for All," or the "Popular Educator" of half a century ago, we cannot but admit that popularisation has made strides. The scope is more ambitious, bigger and deeper subjects are tackled; the mode of presentation is more interesting, which implies greater psychological skill; the style tends to be clearer, more vivid, less wordy; the illustrations are often extraordinarily educative; and the whole thing is more vertebrated. Sometimes it is the evolution-idea that gives unity to the treatment; sometimes it is an enthusiastic conviction that Science is for Man—to aid him to enter into his kingdom; more rarely the unifying aim is to work out a course of intellectual gymnastics—"a brain-stretching discipline."

Those who have listened to fine examples of popular lectures, such as some of the Evening Discourses at the British Association or at the Royal Institution, or who have read Huxley's or Tyndall's, must admit that sound popularisation is possible. If the lecturer has a deep first-hand knowledge of what he is talking about, if he has lucidity, vividness, the teacher's instinct, and a few more gifts and graces, what may he not achieve—as we have seen and heard—in the way of making even a difficult subject luminous to an average intelligence, and that without any lowering of the scientific standard? And if sound popularisation is possible, it is also for many reasons desirable. Knowledge is power: *savoir pour prévoir, et prévoir pour pourvoir*; its increase is an increase not of sorrow to well-constituted minds, but of interest and zest, alleviating what Shakespeare calls "life-harming heaviness"; and thirdly, no one can doubt that one of the most pressing social needs of the age is the better education of the wage-earners, and, of course, of the leisured class as well. Therefore we heartily welcome the extraordinary work before us, because it is sound popularisation, and sometimes reaches a very high level of success.

The book runs to more than 5000 pages, and it has twelve main themes. It tells of other worlds in space, of the making of the earth, of early forms of life, of the pedigree of plants, of the evolution of animals, of the ascent of man, of the laws of health, of the mastery of natural forces, of the rise of industry, of the development of commerce, of the history of society, and of the possible improvement of the race. It is, of course, sketchy, selective, and sometimes a little sensational, but it keeps to the facts, it is written with great skill, and it seems to us a big educational success. There is vitality and earnestness throughout, and the illustrations are exceptionally vivid and arresting. The numerous portraits of

scientific workers give a personal touch to the text. We have tried it on a boy of ten and a somewhat *blasé* reader of fifty, and both give the same verdict—that it is extraordinarily interesting. We should like to have seen the authors' names, and we should like to cut the parts and bring, let us say, all the Hygiene together; but these are minor matters. We wish this popularisation all success, because it is sound; and what are the factors in this soundness?

It appears to us that the chief desiderata in an educational enterprise of this sort are the following:—Getting contributors with the gifts and graces already alluded to, plus the crowning humility of taking pains and obeying the editor (to whom our compliments); the good sense not to pretend that everything is easy, since nothing thorough is; the critical faculty of discerning what can be presented accurately, and at the same time intelligibly, for while most true ideas are clear there is a clarity that only dazzles the man in the street; and, last, the restraint which forbids "giving to the ignorant, as a gospel, in the name of Science, the rough guesses of yesterday that to-morrow should forget." We do not mean to suggest that this huge work has all these virtues in perfection, but it has striven after them, and therefore we wish it well.

OUR BOOKSHELF.

Arabische Gnomonik. No. 1. By Dr. Carl Schoy. Pp. 40+2 plates. Aus dem Archiv der Deutschen Seewarte.) (Hamburg, 1913.)

THIS mathematical account of Moslem dialling, by a writer already known for his studies of Arabic astronomy, forms one of the publications of the Deutsche Seewarte.

The author first touches on the bibliography. There is food for thought in the fact that but two references are given to English writers. The Arabic sun-dial differs from that of the Greeks in having a single point, at the apex of a spike, for index, in place of the gnomon. The horizontal dial is first treated, and rules are given for laying off "temporary hour-lines." These hours, duodecimal subdivisions of the daylight interval, vary in length; nevertheless, their inconvenience did not prevent their universal adoption until the time of Abu'l Hassan, who introduced equal hours about 1200 A.D. They are specially dealt with in the third chapter. The analysis of the clepsydra in this chapter gives unequal hours, since it assumes—erroneously—a constant rate of discharge.

Next follow two chapters on the determination of the Kibla and the times of prayer—sunset, nightfall, dawn, noon, and afternoon (asr). The last, with its various definitions, is discussed in some detail. The closing chapters concern vertical, cylindrical, and conical dials.

Though leaning towards the academic in places (the author employs declinations of 36°, −69°, −45°, and 63° on p. 21), the work is of high interest and much utility to all who have to do with Moslem chronometry. A few typographical errors apart, it is well printed, but an index would have been a useful addition. J. I. C.

Cotton Spinning. By W. S. Taggart. Vol. I. Including all Processes up to the End of Carding. Pp. xxxvi+262. Fourth edition. Vol. II. Including the Processes up to the End of Fly-frames. Pp. xiv+245. Fifth edition. (London: Macmillan and Co., Ltd., 1913.) Price 4*s.* net each.

THESE books have been brought up to date, and much new matter and many illustrations have been added. In all essential respects they resemble the previous editions, which have gained a wide circulation among students and practical cotton-spinners.

Modern Problems in Psychiatry. By Prof. Ernesto Lugaro. Translated by Drs. D. Orr and R. G. Rows. With a Foreword by Sir T. S. Clouston. Pp. vii+305. Second edition. (Manchester University Press, 1913.) Price 7*s.* 6*d.* net.

THE first English edition of Prof. Lugaro's book was reviewed in the issue of NATURE for January 6, 1910 (vol. lxxxii., p. 273). The present issue differs in no important respect from the former; a large number of minor changes, including the correction of several errors, have been made.

LETTERS TO THE EDITOR.

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

The Spectra of Helium and Hydrogen.

RECENTLY Prof. Fowler (Month. Not. Roy. Astr. Soc., December, 1912) has observed a number of new lines by passing a condensed discharge through mixtures of hydrogen and helium. Some of these lines coincide closely with lines of the series observed by Pickering in the spectrum of the star ζ Puppis, and attributed to hydrogen in consequence of its simple numerical relation to the ordinary Balmer series. Other lines coincide closely with the series predicted by Rydberg and denoted as the principal series of the hydrogen spectrum. The rest of the new lines show a very simple relation to those of the latter series, but apparently have no place in Rydberg's theory.

From a theory of spectra (*Phil. Mag.*, July, 1913) based on Rutherford's theory of the structure of atoms and Planck's theory of black-radiation, I have been led to the assumption that the new lines observed by Fowler are not due to hydrogen, but that all the lines are due to helium and form a secondary helium spectrum exactly analogous to the ordinary hydrogen spectrum. This view is supported by recent experiments of Mr. Evans (NATURE, September 4, p. 5), who observed the line 4686 in a helium tube not showing the ordinary hydrogen lines. Prof. Fowler (NATURE, September 25, p. 95), on the other hand, brings for-

ward some objections against the assumption that the lines are due to helium. In his communication Fowler states that the two series of lines, denoted by him as the first and the second principal series of the hydrogen spectrum, in his opinion cannot be united within the limits of error of observation in a single series, such as my theory claims. However, I believe that it is possible on the theory to account for the lines in satisfactory agreement with the measurements.

The first and the second columns of the table below contain the wave-lengths given by Fowler for the new lines and the corresponding limits of error of observation. The lines are marked by P_1, P_2, and S. according as they belong to the first or the second principal series or the Sharp series respectively. The figures in the third column are the products of the wave-lengths and the quantity $\frac{1}{n_1^2}-\frac{1}{n_2^2}$, where n_1 and n_2 are given in the bracket.

	$\lambda \cdot 10^8$		Limit of error		$\lambda\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)\cdot 10^{10}$	
P_1	4685·98	...	0·01	...	22779·1	(3 : 4)
P_2	3203·30	...	0·05	...	22779·0	(3 : 5)
P_1	2733·34	...	0·05	...	22777·8	(3 : 6)
P_2	2511·31	...	0·05	...	22778·3	(3 : 7)
P_1	2385·47	...	0·05	...	22777·9	(3 : 8)
P_2	2306·20	...	0·10	...	22777·3	(3 : 9)
P_1	2252·88	...	0·10	...	22779·1	(3 : 10)
S	5410·5	...	1·0	...	22774	(4 : 7)
S	4541·3	...	0·25	...	22777	(4 : 9)
S	4200·3	...	0·5	...	22781	(4 : 11)

The figures in the third column are very nearly equal, and apparently there is no indication of a systematic difference in the figures corresponding to the lines denoted by P_1 and P_2.

The corresponding figures for the first lines in the ordinary spectrum of hydrogen (Ames, *Phil. Mag.*, xxx., p. 48, 1890) are :—

$\lambda \cdot 10^8$			$\lambda\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)\cdot 10^{10}$	
6563·04	...	...	91153·3	(2 : 3)
4861·49	...	...	91152·9	(2 : 4)
4340·66	...	...	91153·9	(2 : 5)
4101·85	...	...	91152·2	(2 : 6)
3970·25	...	...	91153·7	(2 : 7)

According to the theory in question we have

$$K=\lambda\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)=\frac{ch^3(M+m)}{2\pi^2E^2e^2Mm},$$

where c is the velocity of light, h Planck's constant, e and m the charge and mass of an electron, and E and M the charge and mass of the central positive nucleus in the atom. This formula is deduced exactly as that given in the *Phil. Mag.*, where, however, in order to obtain a first approximation the mass of the electron is neglected in comparison with that of the nucleus.

The above tables give for hydrogen and for helium respectively

$$K_H=91153.10^{-10}, \quad K_{He}=22779.10^{-10}.$$

The ratio between these values is :—

$$\frac{K_H}{K_{He}}=4{\cdot}0016.$$

From the theoretical formula we get for hydrogen, putting $E=e$ and $M=1835m$, and using recent determinations of h, e, and m :—

$$K=92.10^{-7}.$$

The agreement with the experimental value is within the uncertainty due to experimental errors in h, e, and m.

The theoretical value for the ratio between K for hydrogen and for helium can be deduced with great accuracy, as it is independent of the absolute values of h, e, and m. Putting $E_{He}=2E_H$ and $M_H=4M_H$, we get from the formula :

$$\frac{K_H}{K_{He}}=4{\cdot}00163$$

in exact agreement with the experimental value.

It may be remarked that according to the theory helium must be expected to emit a series of lines closely, but not exactly, coinciding with the lines of the ordinary hydrogen spectrum. These lines, hitherto not observed, correspond to $n_1=4$ and $n_2=6$, 8, 10 . . ., and have the wave-lengths 6560·3, 4859·5, 4338·9 . . . The lines are expected to appear together with the lines of the Sharp series observed by Fowler and to have intensities of the same order as the latter lines.

N. BOHR.

The University, Copenhagen, October 8.

I AM glad to have elicited this interesting communication from Dr. Bohr, and I readily admit that the more exact form of his equation given above is in close accordance with the observations of the lines in question. It will be seen that the equation now introduces a modified value for the Rydberg series "constant," 109675, in addition to its multiplication by 4 for the particular series under consideration. The constant 22779, which is deduced from the wave-lengths of the lines is the reciprocal of this modified number, and in the usual numerical form, for oscillation frequencies corrected to vacuum, the equation for the lines would be :—

$$n=(4\times 109{,}720)\left(\frac{1}{3^2}-\frac{1}{m^2}\right)$$

where m takes the values 4, 5, 6 . . . .

With this modification, the agreement with the observations is very close; in only two cases do the calculated values differ from those observed by amounts greater than the estimated limits of error, and I should not like to insist that such errors in the measurements are inadmissible. It may therefore be possible to unite the P_1 and P_2 series in a single equation, as Dr. Bohr's theory requires, but it should be noted that the combination demands the recognition of a type of series differing from those previously known. The result of this combination is to give what may be called a "half-step" series, such as would be obtained by combining ordinary first and second subordinate series, in the special case where the fractional parts of the terms $(m+\mu)$ in Rydberg's equations for the two series differed by exactly 0·5. Consideration of the relative intensities of the two sets of lines would in general prohibit this procedure, but this objection cannot be made in the case of the lines under discussion. It is possible that the magnesium spark lines, which I have recently described, form another series of the same kind, but I know of no others.

The corrected formula given by Dr. Bohr leads to the further important result that alternate members of the ζ Puppis series cannot be superposed on the Balmer hydrogen lines, as at first appeared, but should be slightly displaced with respect to them. Dr. Bohr, however, appears to have inadvertently interchanged the last two figures of the constant 22779 in working out the wave-lengths, and the lines should be expected, within very narrow limits, at 6560·37, 4859·53, 4338·86, 4100·22 . . . . This should provide a valuable test of the theory, as the lines near Hβ and Hγ, at least, should not be very difficult to detect, if present, in stars of the ζ Puppis

type. The tables published by Lockyer and Pickering give no indications of lines in the positions calculated, but further examination of the photographs is highly desirable.

It should be noted in conclusion that Dr. Bohr's theory has not yet been shown to be capable of explaining the ordinary series of helium lines.

A. FOWLER.

Imperial College, South Kensington, October 14.

Azolla in Norfolk.

A VERY interesting case of the rapid spread of an introduced species is afforded by *Azolla caroliniana*, a North American species. So far as the Norfolk Broads are concerned, this free-floating water-fern has hitherto been confined to a single ditch or "dyke" near Horning Ferry, on the river Bure. Here the plant flourished greatly, covering the entire surface, but owing to the isolation of the "dyke" was prevented from spreading. According to an inhabitant of the neighbouring village of Ranworth, the plant has been observed in this one spot for the past fifteen years. I have no evidence as to its original introduction. The disastrous floods of August, 1912, carried some of the plant into the Bure, and its increase during the past twelve months has been extraordinary. Distributed by the tide it is now abundant in several of the Broads, and is carried by the tide in large quantities along the Bure and its tributaries, the Thurne and the Ant. It has found the still waters of South Walsham and Ranworth Broads particularly suited to its needs. It is most partial to the reed swamps of *Typha angustifolia*, so characteristic of the borders of our fen-lakes, and with this protection it is seen in large crowded expanses. More and more of the marsh and fen "dykes" are being invaded. It seems probable that the spread of the species to the other rivers of the Norfolk system, the Yare and the Waveney, will be prevented by the brackish nature of the water below Acle Bridge. I understand that a hard winter would probably kill the plant off, but its abundant sporocarps would carry it over to the succeeding spring.

Undoubtedly ecologists will soon find it necessary to include *Azolla caroliniana* in the local open reed-swamp association as a subdominant. It is a highly ornamental plant, being pale green in spring, and exhibiting a hundred shades of brown and red in autumn.

It would be interesting to know the result of competition between Azolla and members of the Lemnaceæ, and I am at present carrying out experiments to test this point. W. E. PALMER.

Great Yarmouth.

The Theory of Radiation.

I OWE Prof. Nicholson an apology. His work is, of course, earlier than Dr. Bohr's, and is actually cited by the latter. The wording of my letter (NATURE, October 9) implies the reverse.

S. B. MCLAREN.

University College, Reading, October 18.

RESEARCH IN AERODYNAMICS.

THE fourth volume of researches from the Institut Aerodynamique de Koutchino covers the period 1910–1912, and deals mainly with determinations of the air-resistance of various bodies and with comparisons between the results obtained at Koutchino with those of observers elsewhere. A change in the standard temperature corresponding to the published results has been made since the publication of the three earlier volumes, the later determinations being referred to 15° C. instead of 0° C. to bring the results to a form more easily comparable with those of other experimental establishments.

An examination into the velocity standard of the institution has been carried out, the ultimate standard being the movement of the end of a whirling arm 16 ft. in radius. Three independent methods of estimating and correcting for the motion of the air in the room were used prior to the calibration of various anemometers on the whirling arm. The anemometers were divided into two groups, the first containing "vane instruments" and the second "pressure tubes."

It was found, when the anemometers were transferred to the wind-channel of the laboratory, that the vane type of anemometer gave somewhat lower results than the pressure tubes, and it was concluded that the latter were more trustworthy, since the centrifugal effect of whirling on the vane instruments might easily account for the differences found.

Using the new calibration of the air-channel resulting from these experiments, a series of determinations of the resistance of square plates normal to the air-current was made. The plates were 12·5, 25, and 50 millimetres side, and the values of the absolute coefficient of resistance are given as 0·58, 0·57, and 0·57 respectively. This is somewhat higher than the value hitherto accepted for plates of this size, and is more nearly equal to that previously given for plates of from 300 to 500 millimetres.

The same plates were also tested at inclinations to the air-current, the curves obtained for the normal force showing the well-known maximum at an inclination of about 35°.

Amongst the theoretical investigations is one entitled, "Méthode des variables de dimension zéro et son application en Aerodynamique." Reference is made to papers by Lord Rayleigh and others, but, curiously enough, there does not seem to be any indication throughout the paper that the author considers the method to have any further importance than that of convenience. Approached from another point of view, the method of no-dimensional variables arises directly from the principles of dynamical similarity, and is only one of the many uses of the laws governing similar motions. The importance of the physical meaning behind the mathematics appears to have been overlooked.

In the articles in this volume which deal with comparisons with other observatories it is concluded that the type of channel having enclosing walls is preferable to that of Eiffel, and that the channel used at Göttingen is more steady than that at Koutchino.

An attempt was made to repeat an experiment by Rateau on a discontinuity in the centre of pressure variations of an inclined plate. Between inclinations of 25° and 50° Rateau found a sudden change, whilst at Koutchino a continuous and well-

defined curve was obtained over the same range, the curve linking up the ranges 0 to 25° and 50° to 90°. It is definitely stated that, although difficult to measure, the position of the centre of pressure for any inclination was always unique.

THREE BOOKS OF TRAVEL.[1]

(1) THE type of travel-narrative to which Sir Edward Thorpe's volume belongs is one of the commonest among books, but his manner of treating his subject is by no means common. The book bears upon it the stamp of a labour of love; to any reader who is attached to France, attracted by river navigation, or even generally interested in the picturesque in scenery or architecture, it will make exquisitely pleasant reading; the personal element in the narrative, which introduces the companions who made the voyage, is never (as it often is in such books) given an exaggerated prominence, and withal there appears here and there indications of the scientific authority of the writer which suffice to give the book a further peculiar value. The journey with which the book deals was made in a steam yacht across the Channel, up the Seine to Paris, and back. It was made, it would appear, leisurely, and gave ample opportunity for the travellers to become well acquainted with the many beautiful places on the river, and for one of them, Miss Olive Branson, to prepare the admirable series of sketches with which the book is mainly illustrated, though some of the pictures are drawn from another source, and there is also a series of large-scale maps (1 : 125,000) of the rivers; these last will be found of real service to those who follow Sir Edward Thorpe on this fine river, as will the directions he gives in regard to its navigation and the official arrangements connected therewith.

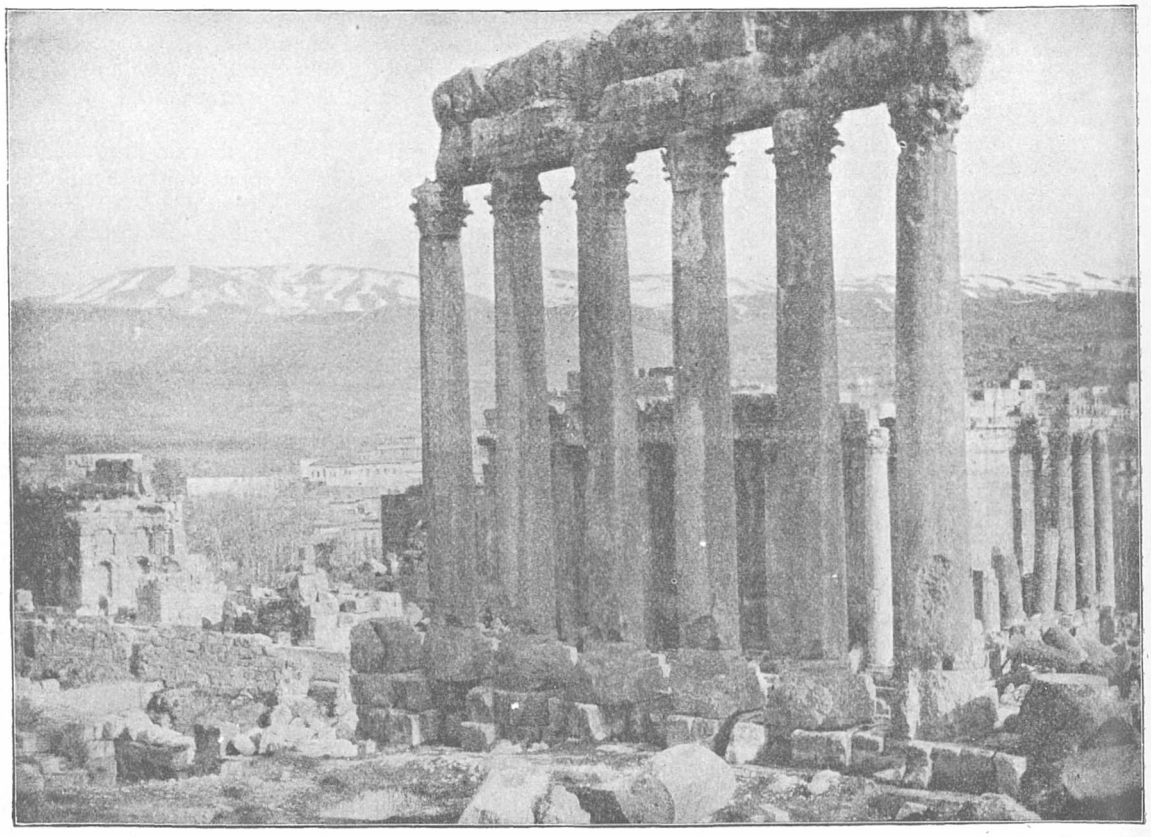


FIG. 1.—Ba'albek, temple of Jupiter and Anti-Libanus. From "The Fringe of the East."

(2) Mr. Lukach, in the sub-title of his book, describes his journey as lying "through past and present provinces of Turkey." He has visited Mount Athos and other Levantine monasteries, and the islands of Rhodes and Cyprus, to each of which he devotes chapters. With the Holy Land, and especially Jerusalem, he deals at greater length, and his travels, which are dealt with in this volume, extended along the Syrian coast, inland along the north-and-south line from Jerusalem and the Dead Sea through Damascus, Hama and Aleppo, and as far as the Euphrates at Tell Ahmar, a village-name famous in association with Hittite and Assyrian remains. Much of the book consists merely of the

[1] (1) "The Seine from Havre to Paris." By Sir Edward Thorpe. Pp. xxi+493. (London: Macmillan and Co., Ltd., 1913.) Price 12s. 6d. net.
(2) "The Fringe of the East. A Journey through Past and Present Provinces of Turkey." By H. C. Lukach. Pp. xiii+273+plates. (London: Macmillan and Co., Ltd., 1913.) Price 12s. net.
(3) "A Naturalist in Cannibal Land." By A. S. Meek. Pp. xviii+238+plates. (London: T. Fisher Unwin, n.d.) Price 10s. 6d. net.

narrative of travel, but this is very well told, and many experiences which are likely to be of value to other wanderers in the somewhat intricate paths of the Nearer East are given prominence. Mr. Lukach has already written on Cyprus, and perhaps his chapter on that island in the present volume may be indicated as of special value, including as it does a brief historical review, but throughout the book, a medley as it must necessarily be, there is found a laudable tendency to avoid assuming for the reader a foreknowledge of the complex lines of Levantine history. For example, the note and "genealogical" table of the Eastern Churches on pp. 113, 114, will be welcome to those who have striven to comprehend the religious divisions of Eastern Christendom. The book is illustrated with many good photographs, mostly the author's own, and there is a small route-map.

(3) Mr. A. S. Meek has made extensive zoological collections for the Tring Museum, and in the present volume he narrates his adventures while doing so, and also, at the outset, gives some account of his preparation for a collector's career. We follow him, in his narrative, to New Guinea and to various island-groups in the region of that great island—the Trobriands, the Louisiades, the Solomons, &c. In New Guinea itself he has travelled widely, and not in British territory only; his two last chapters deal with expeditions into the heart of the Dutch area. Mr. Meek asserts that he can claim to be neither a man of science nor a descriptive writer; his colleagues at the museum, on the one hand, and his readers, on the other, may be willing to find undue modesty in the statement. Certainly he has provided the museum with much new material; an introduction to his book by the Hon. Walter Rothschild makes that clear, while so far as the literary claims of the work are concerned, the book has had the benefit of editorship at the hands of Mr. Frank Fox, who is well qualified for the task by his authoritative knowledge of Australasia. Mr. Meek's text unquestionably increases in interest as it progresses, and in addition to his personal adventures (from which, quietly narrated as they are, his own spirit of intrepidity emerges clearly enough) and his successes as a collector, a tribute is certainly due to his ability in dealing with the natives, on whose friendly aid—of the winning of which there is but one method and that the right one—he has often needed, and been able, to rely.

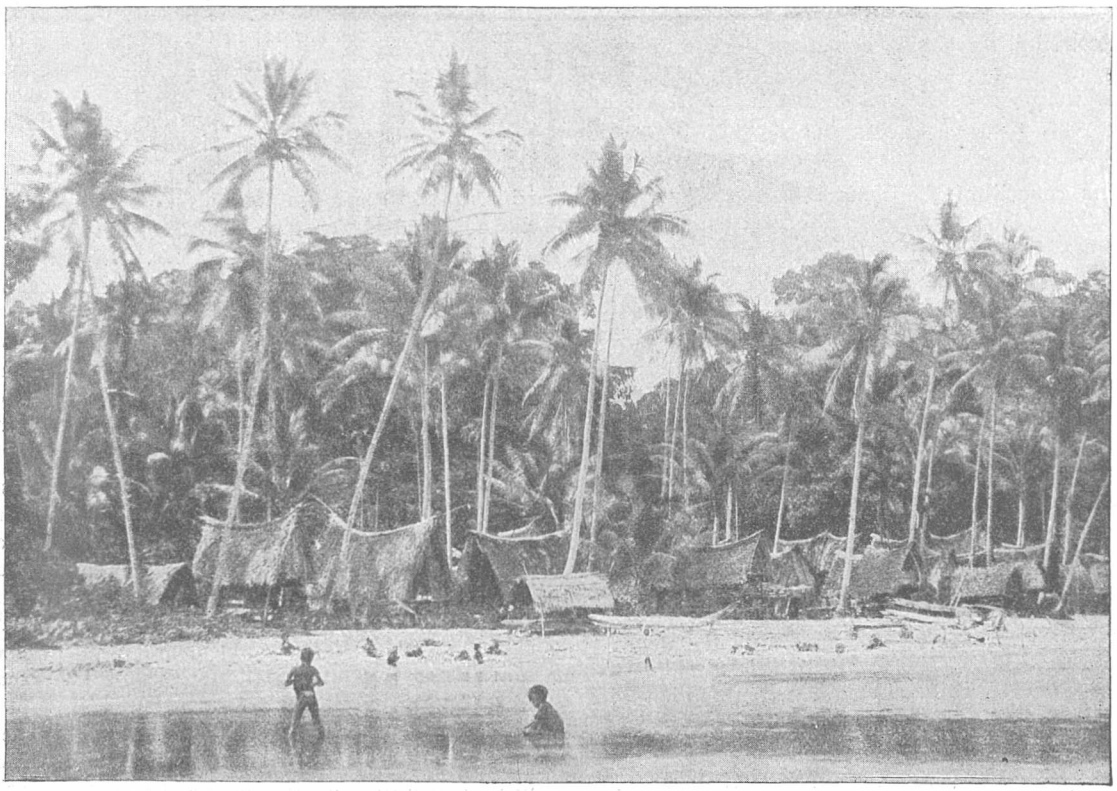


FIG. 2.—Scene, Trobriand Islands. From "A Naturalist in Cannibal Land."

NOTES.

THE council of the Royal Meteorological Society has awarded the Symons gold medal to Mr. W. H. Dines, F.R.S., in recognition of the valuable work which he has done in connection with meteorological science. The medal will be presented at the annual meeting of the society on January 21, 1914.

THE annual Huxley Memorial Lecture of the Royal Anthropological Institute will be de-

livered on Friday, November 14, by Prof. W. J. Sollas, F.R.S., who will take as his subject "Paviland Cave." Prof. A. Keith, F.R.S., president of the institute, will occupy the chair.

THE death is announced, at sixty-two years of age, of Mr. H. Herbert Smith, vice-president of the Surveyors' Institution, a member of the council of the Royal Agricultural Society, and Gilbey lecturer on the history and the economics of agriculture, Cambridge University, 1900–03.

THE Paris *Temps* has just instituted an inquiry in scientific, industrial and medical circles as to directions in which developments of research are most desired. The object is to suggest the most useful discoveries which it is possible to make in the present state of scientific knowledge, and to indicate those awaited eagerly by workers in such various branches of science as electricity, mechanics, chemistry, physics, bacteriology, astronomy, &c. The result of the inquiry will show the point of view from which, at the close of this year, men of science are looking toward the future.

THE council of the Yorkshire Naturalists' Union has elected Mr. T. Sheppard, of Hull, the president for next year. The Yorkshire Naturalists' Union is one of the most successful associations of its kind in Great Britain, and has published many important monographs on the flora and fauna of the county, and also issues *The Naturalist,* which is one of the oldest scientific monthly magazines in the country. The union has a membership of nearly four thousand, and about forty important natural history societies are affiliated with it.

THE Harveian oration was delivered before the president and fellows of the Royal College of Physicians, on October 18, by Dr. J. Mitchell Bruce, who took for his subject "The Origin and Nature of Fever." The president of the college, Sir Thomas Barlow, presented the Baly gold medal to Dr. J. S. Haldane, F.R.S. The award of this medal is made every alternate year, on the recommendation of the president and council, to the person who shall be deemed to have most distinguished himself in the science of physiology, especially during the two years immediately preceding the award.

THE report of the council of the Cardiff Naturalists' Society adopted at the recent annual meeting shows that the membership is now 505, of whom twenty are life members. We notice that the council in May, 1913, adopted a suggestion made by Principal Griffiths that steps should be taken towards securing an early visit to Cardiff of the British Association. At the subsequent meeting of the City Council the suggestion was approved. An invitation has been forwarded to the council of the British Association, but the earliest practicable date now vacant is 1919. The programme for the present session deals with a diversity of topics, among which various aspects of animal and plant life are prominent.

THE council of the Institution of Civil Engineers has made the following awards for papers published in the Proceedings without discussion during the session 1912–13:—A Telford gold medal to Mr. James Mackenzie (Johannesburg); Telford premiums to Messrs. H. Hawgood (Los Angeles), J. K. Robertson (Bombay), G. S. Perry (Sydney, N.S.W.), and Gervaise Purcell (Los Angeles); and the Crampton prize to Mr. William Mason (Liverpool). The council has made the following awards in respect of students' papers read before provincial associations of students during the past session:—The James Forrest medal and a Miller prize to Mr. P. M. Chadwick (Birmingham); and Miller prizes to Messrs. A. J. S. Pippard (Bristol), T. P. Geen (Bristol), C. E. Holloway (Bristol), J. W. Burns (Glasgow), and B. A. E. Heilig (Birmingham).

THE Faraday Society has arranged for a general discussion on the passivity of metals to be held on Wednesday, November 12, in the rooms of the Chemical Society, Burlington House. The president-elect, Sir Robert Hadfield, F.R.S., will preside, and the following provisional programme has been arranged: Dr. G. Senter will open the discussion with a general introduction to the subject, and there will be papers by Dr. G. Grube (Dresden) on some anodic and kathodic retardation phenomena and their bearing upon the theory of passivity; Dr. D. Reichinstein (Zürich) on interpretation of recent experiments bearing on the problem of the passivity of metals; Dr. H. S. Allen on photo-electric activity of active and passive irons. Communications will also be read from Profs. G. Schmidt (Münster), Max LeBlanc (Dresden), E. Shoch (Texas), and Günther Schulze (Reichsanstalt, Charlottenburg).

A PARIS telegram announces the death, in a state of destitution, of M. Charles Tellier, the inventor of the cold storage system, at eighty-six years of age. Appreciative accounts of M. Tellier's work appear in *The Times* of October 21, and are here summarised. Born at Amiens, he devoted himself to scientific research, and his experiments found a practical outcome in 1876, when the first experimental cargo of frozen meat left France for Buenos Aires in *Le Frigorifique,* which had been built under his direction with cold storage compartments. His invention met at first with little appreciation, but at the present day cold storage has not only changed completely the set of the world's food trade, but has deeply affected the economic development of many important nations. Although *Le Frigorifique* was M. Tellier's finest achievement, he did not cease from the early 'sixties on to his death to apply all his forces to the advancement of that scientific knowledge on which practical refrigeration depends. His two books, written in very early days, "Le Froid appliqué à la Bière," and "La Conservation de la Viande par le Froid," laid the foundation of our knowledge of cold storage, and they have been followed by numerous other publications and papers, setting forth, as he made them, the results of his researches.

IT is announced in the October number of *The Museums Journal* that the next meeting of the Museums Association will be held at Swansea, the

special object of meeting at that town being to offer advice with regard to the work of a newly established museum and art institute. In a later paragraph of the same issue reference is made to the question of the future of the museums established and furnished by the late Sir Jonathan Hutchinson at Haslemere, Selby, and Charles Street, London. Although the founder is believed to have spent something like 30,000*l.* on these institutions, no provision for their future maintainance is made in his will, the executors being empowered to dispose of them in such manner as they think best. At a meeting held at Haslemere last week it was announced that Mr. Jonathan Hutchinson, writing on behalf of the trustees of Sir Jonathan Hutchinson's estate, had stated that if it were found possible to raise the necessary endowment fund, the trustees were willing to hand over by deed the freehold site and the museum with all its contents to a suitable trust committee. It was also intimated that other members of the Hutchinson family were prepared to give substantial monetary help to any fund which it might be proposed to raise. The value of the site at Haslemere is estimated by the trustees at about 4000*l.*

THE inaugural lecture for the newly founded lectureship in palæobotany at University College, University of London, was delivered on Friday, October 17, by Dr. Marie Stopes. Dr. Teall, F.R.S., the director of the Geological Survey, was in the chair. In the course of her lecture Dr. Stopes communicated the view that palæobotany is an independent science, though its main results are of particular service to botany, geology, or in practical mining. The first part of the lecture was devoted to a historical account of the subject, and a number of quotations were made from old books not generally known to palæobotanists. Historically the science has passed through three phases: the first when fossil plants were looked on as wanton ornaments, even at a time when animal fossils were recognised as being of organic origin; the second when plant impressions were drawn accurately and described, but without true understanding; the third when a scientific study of plant fossils revealed their importance in the conceptions of evolution and morphology of living plants, their value as "thermometers of extinct continents," and their importance to the stratigraphical geologist and coal miner. Dr. Teall said that he had been recently much impressed by the results of fossil botany, and expressed a hope that more students would give it careful attention. Prof. F. W. Oliver, F.R.S., in thanking Dr. Teall and the lecturer, said that he realised that the botanical side of palæobotany was not its only one; he agreed with the lecturer that palæobotany was an independent science, and he hoped before long to see a department of palæontology in the University.

ON Wednesday, October 15, a conversazione was held at King's College, by the Royal Microscopical Society, when nearly five hundred fellows and their friends were received by the president, Prof. G. Sims Woodhead. The object was to bring together, so far as practicable, a series of exhibits which would demonstrate the many uses to which microscopes may be put at the present time, both in science and commerce, and to enable those interested or engaged in microscopic work to demonstrate the methods they employed and the results they had obtained. The centre tables in the Great Hall of the college were occupied by pond-life exhibits, and more than forty microscopes were arranged under the direction of D. J. Scourfield. These were the centre of interest to a large number of visitors throughout the evening, many of the living objects being beautifully shown. Among the exhibits which also engaged the attention of visitors, that by F. W. Watson Baker, a demonstration of the actual grinding of a lens for a microscope objective, holds a high place. The subjects of other interesting exhibits were:—A beautiful series of slides showing wild flowers under opaque illumination, Conrad Beck; preparation of rock sections, C. H. Caffyn; an experiment with the Abbe diffraction microscope to illustrate the effect of altering the phase of one of the spectra forming on image of a grating, J. E. Barnard; transparencies in colour, E. Cuzner and T. E. Freshwater; colour stereoscopic slides of water mites, H. Taverner; an eyepiece micrometer with diffraction grating—an ingenious method of avoiding the errors common to most micrometers, J. W. Gordon; foraminifera, E. Heron-Allen and A. Earland; apparatus for stereo-photomicrography and also for high-power binocular observation, J. W. Ogilvy; fluorescent objects illuminated by ultra-violet light, Max Poser; and exhibits to illustrate differential colour illumination, J. Rheinberg. Two lectures were delivered during the evening, one by Dr. E. J. Spitta on diatom structure and a demonstration of the microscopic structure of rocks, by C. H. Caffyn.

SOME "Notes on the Struggle for Existence in Tropical Africa" are contributed to the current number of *Bedrock* by Mr. G. D. H. Carpenter, who spent nearly three years on the equatorial islands of Lake Victoria in studying the tsetse-fly on behalf of the Royal Society's Sleeping Sickness Commission. He emphasises the importance of studying mimicry under natural conditions rather than in the cabinet, and advances it as a strong argument in favour of the truth of the mimetic theory that the resemblance of one insect to another is explicable in exactly the same way as the resemblance of an insect to a dead leaf. On the theory of natural selection through minute variations, mimetic resemblances are simply a special case of coloration analogous to other special cases.

THE October number of *The Fortnightly Review* contains an article by Henri Fabre, the veteran naturalist of Sérignan, on his relations with Charles Darwin. The article illustrates in an interesting way some of the leading characteristics of these two remarkable men—the combined fertility and caution in speculation shown by Darwin, with his determination to bring every hypothesis to the test of experiment; and the unrivalled powers of observation possessed by Fabre, his enthusiasm in the pursuit of his favourite study, and the charm of his literary style. Darwin, being interested in the homing instincts of

the mason-bees, suggested to Fabre the making of experiments to determine, if possible, whether this instinct was at all dependent on a perception by the insects of the direction in which they were first carried away from their nests. A whole series of trials was carried out by Fabre, the essential feature in which was the enclosure of marked bees in a dark box, the carrying of the box with its inmates in a direction opposite to that from which the release was to take place, and the repeated rotation of the box at different points of the route, in order to ensure that the captive bees should lose their bearings during the journey. The experiment was repeated, with variations, many times over, the almost uniform result being that from 30 to 40 per cent. of the liberated bees found their way home without difficulty. This was contrary to the expectation of both inquirers, and Darwin next proposed to try the effect of placing the insects within an induction coil, "a curious notion," as Fabre observes. The experiment was performed, with amusing results. But in the end the experimenter was fain to confess that the homing instinct of his bees remained a mystery.

The Gypsy Lore Journal (vol. vi., Part 4) is largely devoted to an account by Mr. E. O. Winstedt of "The Gypsy Coppersmiths' Invasion of 1911–13." Owing to the reticence displayed by these people, the origin of the party which visited England is uncertain. Some claimed to be Caucasians, others Russians, and many seem to have forgotten the place whence they started. Galicia seems to be the probable home of many of the immigrants. They appear to be genuine gypsies, their skin colour being practically identical with that of the Russian peasantry. In their metal work there are remarkable coincidences with Indian art products. This monograph contains a very complete account of their religious beliefs, organisation, dress, manners, and customs. The excellent work being carried out, with very limited resources, by the Gypsy Lore Society, which has its headquarters at 21A Alfred Street, Liverpool, should invite support from all who are interested in this remarkable race and from students of anthropology.

RECENTLY the Prehistoric Society of East Anglia formed a committee to investigate the "Red Crag shell portrait" at present in the possession of Dr. Marie C. Stopes. The report of the committee has now appeared in the excellent Proceedings of that society (Part 3, vol. i.). The shell represents a typical Red Crag species, and bears the crude carving of a human face. The committee reported that "the weight of evidence was in favour of the Pliocene age of the human work on the shell . . . it was impossible to speak with absolute certainty on the point." One has only to glance at the other articles included in this volume to see how much and varied is the prehistoric research which is being carried out at present in East Anglia. Dr. Allen Sturge has applied Drayson's theory to explain the occurrence of periods of glaciation; a description is given by Mr. J. Reid Moir of worked flints from the mid-glacial gravel and chalky boulder clay of Suffolk; an account is written by Col. Underwood of Pleistocene bones and flint implements from a gravel pit at Dovercourt, Essex. The description of a Palæolithic site on Wretham Heath, near Thetford, by Dr. J. E. Marr, of Cambridge, is particularly interesting. Mr. W. G. Clarke contributes a paper on Norfolk implements of Palæolithic "cave" type. The Proceedings of the East Anglia Prehistoric Society contain matter which archæologists and anthropologists cannot afford to overlook.

A PARAGRAPH in NATURE of October 9 (p. 175) upon a pamphlet recently issued by the National Equine Defence League, referred to a Bill to prohibit the docking of horses, printed at the end of the pamphlet, as having become law. The honorary secretary of the league writes to say that the Bill was abandoned last session in order to be amended, and will again be introduced next session. A clear statement to this effect might with advantage have been printed upon the same page of the pamphlet to prevent a mistaken conclusion such as was arrived at by our contributor. The honorary secretary will be pleased to forward any information upon the subject to anyone applying to him at Beaconsfield Road, New Southgate, London, N.

IN No. 2014 of the Proceedings of the U.S. National Museum (vol. xlvi., pp. 93–102) Mr. C. W. Gidley gives a preliminary account of mammalian remains from a Pleistocene cave-deposit near Cumberland, Maryland. Lower jaws of a bear and a dog are described as new species—*Ursus vitabilis* and *Canis ambrusteri*. As the former differs from the American black bear (*U. americanus*) merely by the larger lower canines, it might well have been regarded as a race of that species. The latter is of the size of a wolf, but has the lower carnassial tooth approximating to that of a coyote or a jackal. In the legend to the figures on p. 100 and the first paragraph on the opposite page, no fewer than eight misprints are noticeable, one of which, namely *Hyscins*, for *Lyciscus*, is distinctly puzzling.

THE size of litters and the number of nipples in swine forms the subject of an interesting paper by Messrs. G. H. Parker and C. Bullard in the Proceedings of the American Academy of Arts and Sciences, vol. xlix., No. 7. The authors have prepared a record of 1000 litters of unborn pigs of various breeds, and by means of tables arranged in order of the number of pigs in the litter are shown the relative position of the pig in the uterus, its sex, and the number and arrangement of its nipples. Of the total number of pigs examined 3024 were males and 2946 females, and in the whole population it was found that the nipples ranged from 8–18, with a mean of 12·2 and a mode of 12. In the majority (3559) the arrangement of the nipples was regular in character. No obvious relation would appear to exist between the size of the litter and the number of nipples in the females; though there may be as few nipples as eight and as large litters as fifteen, disadvantageous combinations of large litters borne by females with few nipples cannot be of frequent occurrence. Commonly there are about twice as many nipples, twelve, as young, six.

IN the course of an article, "The Transmutation of the Elements," in the October number of *Bedrock*, Dr. Norman Campbell deals with the apparent synthesis of neon out of helium and oxygen by Messrs. Collie and Patterson, which was described last February, as well as with Sir J. J. Thomson's observation that helium, hydrogen, and neon can be obtained from many solids by kathode-ray bombardment. Dr. Campbell takes the view that to apply the word "transmutation" to these processes is rather an unfortunate step, although it might be described as mere quibbling to say that the kathode rays do not produce transmutation when the results of transmutation can only be made evident by means of kathode rays. If gold could be "liberated" from lead by such bombardment, the amount so liberated would only be the amount accumulated by long ages of spontaneous disintegration, and would utterly fail to materialise the traditional idea of "transmutation."

VOLS. ix. and x. of the Collected Researches of the National Physical Laboratory maintain the high standard of excellence we have come to look on as natural in the work which issues from that institution. The present volumes cover the twenty-three papers published in the scientific or technical Press or in the proceedings of learned societies during the year 1912. One of the most important of the papers dealing with engineering problems is that on the properties of welded joints in iron and steel. It is found that acetylene welded joints are not so good as hand or electrical welded, and that while hand welded are somewhat better than electrical for alternations of stress, they are not so uniform in the results they give. Another important contribution to engineering knowledge is made in the report on the properties of alloys of aluminium and zinc. An extended series of tests leads to the general conclusion that the alloy containing 20 per cent. of zinc is the most promising. In electrical engineering the valuable papers on the properties of insulating materials and the circumstances which affect them supply much trustworthy information in a field in which uncertainty has reigned for too long a period. Other important facts are brought out in papers on the visibility of faint lights like those of vessels at sea, on photographic lenses and shutters, on the electricity emitted by carbon at high temperatures, and, lastly, that on a determination of the ohm by alternating-current methods, which has led to a result slightly less than the value at present accepted.

MESSRS. C. A. PARSONS AND CO., LTD., have despatched from their Heaton Works at Newcastle-on-Tyne the largest turbo-generator yet completed. An illustrated account of this machine appears in *Engineering* for October 17. The machine has been built to the order of the Commonwealth Edison Company of Chicago, a Corporation owning probably the greatest collective power-station in the world, and has been designed for a continuous load, at 750 revolutions per minute, of 25,000 kw., at a power factor of 0·95, the periodicity being 25 complete cycles per second. The steam consumption guaranteed is notable, and marks an epoch in steam plant. With steam at 200 lb. per sq. in., superheated to an extent of 200° F., and an absolute pressure in the condenser equivalent to 1 in., the guaranteed steam consumption at 20,000 kw. is 11·25 lb. per kw. output from the alternator; at 25 per cent. over or under the normal load, 11·65 lb. per kw. output; and at half-load, 12·5 lb. per kw. output. The steam consumption guaranteed for this turbine set—the largest ever fitted to a single shaft—is equal to 8·1 lb. per shaft-horse-power per hour, a result not hitherto attained in marine practice. Were oil fuel used in the boiler furnaces of a marine plant having this steam consumption, the fuel used would amount to 0·6 lb. per shaft-horse-power per hour, a result nearly comparable, from the point of view of radius of action in warships, with that attained by internal-combustion engines.

THE ninth half-yearly volume of the Journal of the Institute of Metals contains the presidential address of Prof. Huntington and some half-dozen papers of considerable scientific and technical interest, read at the spring meeting of the institute. These include a paper by Mr. Alexander Siemens on metal filament lamps, papers on corrosion by Mr. Arnold Philip and by Dr. G. H. Bailey, a paper on the microstructure of German silver, by Mr. O. F. Hudson, and papers on the heat treatment of alloys by Mr. G. H. Gulliver and by Messrs. H. S. and J. S. G. Primrose. The excellent photomicrographs which illustrate the presidential address and three of the papers are a noteworthy feature of the present volume.

MESSRS. NEWTON AND CO., 72 Wigmore Street, London, W., have issued new catalogues giving full particulars of the optical lanterns, kinematographs, and projection apparatus which they able to supply. The sectional catalogues now published separately by this firm will prove a great convenience, as it will be possible easily to keep each up to date. Among these catalogues those describing the new science lanterns and the arc lamps deserve special mention. These instruments are the result of many experiments, and deserve the careful attention of lecturers and science teachers.

THE October issue of Mr. C. Baker's list of second-hand scientific instruments contains particulars of more than two thousand pieces of scientific apparatus. Each instrument is guaranteed to be in working order, and the majority are in new condition. Especial attention may be directed to section 1 of the catalogue devoted to microscopes and accessories, of which a fine collection is available for selection.

AT the head of the review of "The British Parasitic Copepoda" in NATURE of October 16 (p. 193) the price of the work was erroneously given as 15*s*. The secretary of the Ray Society writes to point out that this is the price of vol. i. only; and that the price of vol. ii. is 25*s*. The price of the complete work is, therefore, 40*s*. net.

OUR ASTRONOMICAL COLUMN.

COMET NEWS.—*Astronomische Nachrichten* (No. 4686) gives improved elements for comet 1913*b* (Metcalf), and also an ephemeris, including the current week, from which the following positions are taken :—

12*h*. *M.T. Berlin.*

	R.A. (true) h. m. s.	Dec. (true) ° ′	Mag.
Oct. 23 ...	20 51 54 ...	+15 7·8	
24 ...	50 52 ...	13 18·9	
25 ...	49 57 ...	11 36·2 ...	9·1
26 ...	49 9 ...	9 59·7	
27 ...	48 26 ...	8 28·6	
28 ...	47 50 ...	7 2·9	
29 ...	47 19 ...	5 42·0 ...	9·4
30 ...	20 46 53 ...	+4 25·8	

The comet is rapidly reducing its northern declination, and as its magnitude is also decreasing it will become an object only for larger apertures.

Westphal's comet is becoming an interesting object, and will for some time be in a good observing position. It is moving into the constellation of Vulpecula, and during the first week of November will pass into Cygnus and become involved in the Milky Way. A photograph taken on September 28 showed a broad tail 3·5° long, a round nucleus of 20 min. in diameter, and a distinct nucleus. It has been glimpsed with the naked eye, and is an easy object for binoculars. The following is an approximate ephemeris :—

	R.A. h. m.	Dec. ° ′
Oct. 24 ...	20 48 ...	+19 46
28 ...	43 ...	22 23
Nov. 1 ...	39 ...	24 50
5 ...	20 36 ...	+27 16

It is worthy of note to mention that both Westphal's and Metcalf's comets are in about the same region of the sky, being less than two degrees apart on October 22.

The following are three positions for comet 1913*c* (Neujmin), now a faint object, published in *Astronomische Nachrichten* (No. 4685) :—

	R.A. (true) h. m. s.	Dec. (true) ° ′
Oct. 22 ...	23 34 0 ...	+13 55·7
26 ...	35 29 ...	14 33·3
30 ...	37 29 ...	15 7·4

The same journal (No. 4686) publishes the information received by Banachiewicz to the effect that the brightness of Neujmin's comet appears to be fluctuating. Its magnitude is fainter than 11.

ORBITS OF EIGHTY-SEVEN ECLIPSING BINARIES.—Dr. Harlow Shapley contributes to *The Astrophysical Journal* for September (vol. xxxviii., No. 2) a summary of an important though laborious piece of work on the orbits of eighty-seven eclipsing binaries. In the present publication he restricts himself to a few of the general results, leaving the complete statistical discussion for a future Princetown University Observatory publication. Some of the conclusions here briefly summarised show that the better the observations of an eclipsing binary are, the more satisfactory is the theoretical representation of the light variations. Further irregularities in the shape of the light-curves disappear with increased photometric accuracy. The existence of darkening towards the limb of the stellar disc is clearly indicated, and actually demonstrated in a few cases. There is a positive indication that the fainter star is self-luminous, and no case arises where it is necessary to assume one component completely dark. In discussing the distribution of densities relative to spectra the first-type stars (spectra B and A) show a marked preference for an intermediate density. The second-type stars fall into two groups, one preceding and the other following in order of density the first-type stars. Dr. Shapley points out that these two groups are obviously identical with the two classes of second-type stars of very greatly different luminosity discussed by Hertzsprung and Russell, and the facts collected afford direct support of Russell's theory that the differences in brightness of the two groups are to be ascribed in the main to great differences in the mean density.

VARIATIONS IN THE EARTH'S MAGNETIC FIELD.—In a short article in *Science* (August 29, 1913) Prof. Francis E. Nipher states that a series of open-air observations has fully verified the conclusions he has published regarding local magnetic storms. It appears that clouds prevent the solar ionisation of the air in their shadows, just as does the earth. When the molecules of air are ionised they become little magnets, and arranging themselves along the lines of force add their effect to that of the earth's magnetic field. In the absence of the solar radiation, wind or falling rain destroys this arrangement. It is hence suggested that local, daily, and annual variations are due to local variation in the weather. In a previous article in *Science* (May 30) Prof. Nipher describes a model with which a somewhat similar magnetic storm can be produced experimentally. In the model iron filings take the place of the ionised molecules of air.

THE LIGHT CURVE OF *o* CETI.—In the *Memorie della Società degli Spettroscopisti Italiani*, September, 1913, Sig. G. B. Lacchini publishes the results of his observations of this variable made during the period July 12, 1912–March 11, 1913. He used a telescope of 6 cm. aperture, 80 cm. focal length, with powers of 20 and 40, the comparison stars employed being those of the variable star section of the B.A.A. The epoch of minimum found was December 10, 1912, a result differing by only one day from that found by Dr. E. Guerrieri (December 9, 1912). The star lost one magnitude per twenty-seven days, and gained one magnitude per eleven days, according to Sig. Lacchini, which figures compare with 29·6 days and nine days respectively as determined by Dr. Guerrieri. The actual faintest magnitude recorded was 9·09 on December 3, 1912.

THE FRAUENFELD MEETING OF THE SWISS SOCIETY FOR THE ADVANCEMENT OF SCIENCE.

THE ninety-sixth annual meeting of the Société Helvétique des Sciences Naturelles was held, as already announced, at Frauenfeld in September. The set discourses were largely attended, and were listened to with considerable interest. Prof. Grubemann, in his lecture on the most recent methods employed in petrography, referred especially to the evolution of rocks, and the bearing of metallography and the chemistry of colloids on his subject. Prof. Maillefer gave an account of his researches on the geotropism of plants, partly from an experimental and partly from a mathematical point of view. He claimed to have proved that gravity has an effect on the curvature of a plant which requires time to take effect, and may be expressed by saying that the curvature possesses a velocity proportional to the sine of the angle made by the plant with the vertical and an acceleration proportional to the time of exposure. The effect is, he said, felt by the plant from the outset, though the time measurements seem to depend on the instruments used in the observations. His results were in a subsequent communication partly

corroborated by Dr. Tröndle, who, however, does not admit the presence of an acceleration.

We pass over the remaining lectures, interesting as they were, remarking only on those of Profs. Keller and Dutoit. Prof. Keller dwelt on the points of resemblance between life in the Caucasus and that of the lake-dwellers in Switzerland in prehistoric times. Prof. Dutoit gave a brilliant exposition of the assimilation which is going on of the methods of analytical chemistry to those of physical chemistry and biology. The new processes employed—which are, in point of fact, due in great measure to Prof. Dutoit himself, and have already rendered considerable services both to manufactures and science—are indirect, and have the advantage of great precision and extreme rapidity.

Turning to the separate sections, we commence with botany. Prof. Chodat, whose unique collection of cultures of algæ now numbers more than half a hundred, spoke of the bearing of his experiments on the systematic classification of these plants. Dr. Baumann, who has been studying the vegetation of the Lake of Constance, described how the small shells of gasteropods in these regions become coated with tufa, deposited by the algæ. In this interesting way immense sandbanks of coarse sand, called after the little snails whose débris form it, "Schneckerlisand," are deposited in the lake. Prof. Ernst discussed parthenogenesis and apogamy among the Angiospermæ, and showed that, contrary to Treub and Lotsy, the embryo of the Balanophoraceæ is formed normally. The asexual reproduction of garlic from the point of view of heredity and natural selection was treated by Dr. Vogler. Prof. Edouard Fischer, who has been engaged in experiments on corn-rust, showed the connection between the appearance of this plague and the position of the leaf attacked with respect to the horizontal. Mr. Jaccard discussed the influence of a mechanical force on the production and constitution of wood and woody plants.

The section of geology occupied itself with the fossils, the stratification, and the relief of Switzerland. Prof. Albrecht Heine communicated his latest observations of glacial deposits as corroborating his somewhat controverted explanation of the formation of alpine lakes by a subsidence of the earth's crust in these regions during the diluvial epoch. Dr. F. Mühlberg showed by an interesting collection of lantern-slides the fallacious nature of the interpretation of the formation of part of the Jura given by the Bonn school. Prof. H. Schardt spoke on a subject which belongs properly to the borderland of geology, the typical phenomena of injection. He pointed out how, during the gradual cooling of a mass of magma, sudden pressures of a tectonic nature must sometimes occur, squeezing the molten material into the interstices of the neighbouring rocks and causing the phenomena in question.

In the chemical section the school of Geneva was strongly represented. Dr. Reverdin's determination of the constitution of certain anisidines, in particular of the two still doubtful trinitro-*p*-anisidines, is of a more advancedly technical character than Prof. A. Pictet's interesting discovery by the process of distillation *in vacuo* of a new kind of tar smelling of petroleum, and Messrs. Briner and Kühne's reinvestigation of the still obscure mechanism of the chamber process for the production of sulphuric acid. The opinion arrived at by these latter investigators is that SO_4H_2 is obtained by direct oxydisation of SO_2 into SO_3, the nitrous anhydride serving only as a catalytic. Of quite a different nature were Dr. Piccard of Munich's account of his experiments on certain dyes, and Dr. W. Baragiola's report on the physical, chemical, and physico-chemical experiments which have been made on wine and grape-juice.

In the physical section there were several communications deserving of mention; we content ourselves with signalising that of Prof. Perrier and H. Kamerlingh Onnes on the magnetisation of mixtures of liquid oxygen and nitrogen. These mixtures are found simpler to deal with than pure oxygen, the specific magnetisation coefficient of which had been already shown to differ materially from what would be expected by the law of Curie-Langevin. Experiments made at a temperature between $-195°$ and $-210°$ show that the deviation from the law in question depends on the mutual approach of the molecules caused by the fall of temperature.

In the mathematical section Prof. Fueter gave some instructive examples of algebraic equations possessing a prescribed group; Prof. Crelier read a paper, conceived in the order of ideas of Sturm, on correspondences in synthetic geometry, with special reference to the curve of the third order and third class; while Dr. Speiser and Prof. Bieberbach dealt with factorisation of algebraic forms and conformal representation respectively. Dr. Mirimanoff communicated a new and elegant proof of the theorem of Cantor-Bendixon, which, as he pointed out, falls into the same category as the first proof of that theorem without Cantor's transfinite numbers, that given by W. H. Young in "Sets of Intervals on the Straight Line" (Proc. L.M.S., 1, xxxv., pp. 245–268). Prof. W. H. Young gave a paper on "The Integral of Stieltjes and its Generalisation," showing how the theory of the integration of any function with respect to a function of bounded variation could be built up by the method of monotone sequences alone, and giving examples of new theorems, into the enunciation of which the new concept does not enter, and which he had obtained by means of its use.

Communications were also made to the sections for zoology, and for geophysics, cosmical physics, and meteorology, among them one by Dr. P. Mercanton, who added some details to Dr. de Quervain's account of the Swiss expedition across Greenland last year and the meteorology of that country. The rate of motion of the Greenland glaciers, which are mostly riddled with crevasses, was found, he said, to vary from one to two metres a day. At the base the grains of dust were not very large, the mean size not exceeding that of those in the alpine glaciers. Observations on some of the ancient glacial terraces showed that part of the dust was of cosmic origin.

PLANKTON DISTRIBUTION.[1]

IN the University of California Publications in Zoology (vol. ix., No. 6), Mr. C. O. Esterly discusses the vertical distribution of certain Copepoda as shown by a large number of hauls made in the region of San Diego, between the years 1905 and 1911. Dividing the twenty-four hours into a "day" period from 6 a.m. to 6 p.m., and a "night" period of the remainder, the author finds in the results obtained a distinct night migration towards the surface, with a corresponding downward movement during the day. For nine out of ten species specially considered the time of this maximum occurrence at the surface is found to vary between 6–8 p.m. and 10–12 p.m., *Calanus finmarchicus* attaining its maximum in the latter period. The depth shown for the day plurimum is more obscure, ranging between 50 and 200 fathoms.

[1] "The Occurrence and Vertical Distribution of the Copepoda of the San Diego Region, with particular Reference to Nineteen Species." By Calvin O. Esterly. (Berkeley: University of California Press.)

The paper contains a large collection of data especially important as all relating to the same area and extending over a long period, but a marked want of care is shown both in the handling of the records and in the conclusions drawn from them. Numerous errors left uncorrected in the tables are very confusing though not, it would seem, seriously affecting the main results. Greater importance attaches to conclusions formed often quite out of proportion to the evidence available. As regards the question of nocturnal migration to the surface, while the records show the strongest evidence of a surface maximum during the night hours, they are far too incomplete to be relied on as indicating any definite period of optimum conditions. The maximum obtained for *Calanus finmarchicus*, for example, between 10 and 12 p.m., rests on the slender evidence of a single haul of 2·8 hours in duration, in which between three and four thousand specimens occurred. If this were indeed an optimum period, a higher average than fifty-eight specimens per hour might be expected between midnight and 2 a.m. The occurrence of a species in exceptionally large numbers suggests the presence of exceptional conditions, it may be, a combination of several factors at the time, to account for it. In estimating averages such a haul may, if unsupported by other evidence, give results that are quite misleading, and where it is used, as in the present case, for time-frequency alone, it is unsafe to place narrow limits to the period in which it happens to fall. In the two-hour period preceding this, viz. 8–10 p.m., an average of 973 specimens per hour is obtained from eight hauls made during that time. Had no other data been available than the four hauls covering this period in Table 2, the average given would be no more than nineteen specimens per hour in place of the 973. The example serves to emphasise the need of repeated observations before any safe estimate of such averages can be formed, or any deductions made from the latter.

The same remarks are applicable to the averages for Eucalanus and Metridia especially. For the former three maxima are shown, for the afternoon, evening, and morning severally, and the suggestion is even put forward that these are probably of normal occurrence, and should be considered so. The maximum for Metridia, placed at 10–12 p.m., rests, like that of Calanus, on the unsafe basis of a single haul of 31,900 specimens, the same haul as that from which the maximum for Calanus was obtained. The second highest aggregate for this species, namely 3401 specimens, was obtained from three hauls made between midnight and 2 a.m., and is apparently likewise dependant almost entirely on one haul of 3200 specimens, leaving an average of 100 specimens for the other two. In the case of *Labidocera trispinosa* the disproportion is greater still. Here the maximum, falling between 6 and 8 p.m., shows an aggregate of 2630 specimens obtained during this period in five successful hauls out of thirty, one haul containing 2425. The second highest aggregate, falling between 4 and 6 a.m., with a total of 527 specimens obtained in seven hauls, includes one haul with 500 specimens.

It cannot be lost sight of that all of these higher figures occur between the late evening and early morning hours, and, as a matter of general observation, the night preponderance of Copepod plankton near the surface will not perhaps be questioned by many. But data such as these are manifestly too incomplete alone to bear any interpretation more restricted than this, and though regarded by the author as implying different optimum periods characterising the different species, seem rather to express collectively particular instances of more or less abundant occurrence, in which any one or other of the species considered might equally well have been encountered on another occasion. It is indeed difficult to understand how, reasoning on such frail evidence, the discussion is carried even to the point of recognising in these different maxima obtained hidden characters distinguishing the species which are supplementary to those of structural features, such as to indicate, it may be, with more extended knowledge the apparent rather than real nature of the latter.

In estimating the hourly averages for the surface hauls the time occupied is made to include, rightly it would seem, that of hauls from which a species was absent. Thus is obtained the average number of animals occurring per hour of hauling. In calculating the depths for the day plurima, as shown by the self-closing nets, the averages based on the number of animals per fathom passed through are not treated in the same manner, but merely express the depth of the layer of water as a fixed quantity regardless of the number of hauls made through it. Thus, for *C. finmarchicus*, the region of the day maximum shown between 50 and 77 fathoms is estimated by all the animals in all the hauls (seventeen) made through that section of water being treated as though occurring in one haul through 25 fathoms. The average found at this depth, namely, 15·7 per fathom, therefore denotes no more than the distribution over the layer concerned of an aggregate of animals captured between 50 and 75 fathoms, and cannot be considered as on the same plane with that found between 75 and 100 fathoms, where six hauls made through a similar depth of water show an average of 5·7 animals per fathom. If the repetition of hauls through a given column of water be not given a true value, the averages are incomparable with one another, and important evidence afforded will be lost in the results obtained.

Considerable distortion of the latter averages is liable to have arisen through no allowance having been made for differences in the size of the nets used, amounting to as much as one-half the mouth opening. The impression that such allowances are of no practical value, if intended to be understood literally, might have been removed had the author tested the different-sized nets against one another.

L. R. C.

THE BRITISH ASSOCIATION AT BIRMINGHAM.

SECTION K.

BOTANY.

OPENING ADDRESS BY MISS ETHEL SARGANT, PRESIDENT OF THE SECTION.

WE were welcomed to Birmingham last night, and now—made free of the city—we assemble this morning to justify our position as its guests. But before entering on the work of the section, your president is authorised, and even required by custom, to glance at the events of the past year in the botanical world.

My predecessor in this chair had a great loss to record in the death of Sir Joseph Hooker, the *doyen* of British botanists, and a familiar figure at so many meetings of this Association, where we were proud to feel that he belonged to our section. This year we have no peculiar grief, but we join with the whole Association in lamenting the death of Lord Avebury. We have some right to offer a special tribute to his memory, since several of his published works were on botanical subjects. His book on the "Fertilisation of Flowers" in the "Nature Series" opened a new world to many non-botanical readers, and there are

probably others here besides myself who have reason to be grateful to him for that charming introduction to field botany, and for the companion volume on "Flowers, Fruits, and Leaves." The great mass of first-hand information on the external characters of seedlings, contained in two massive volumes under the modest title of "A Contribution to our Knowledge of Seedlings," was collected under his direction and put together by himself. It is not only a book of reference to students of vegetable embryology, but no doubt played its part in reviving interest in that important subject. The work which he published was, however, the least part of Lord Avebury's contribution to natural history. He represented a small but most distinguished class of naturalists, amateurs in the best sense of the word, since they work for pure love of the subject. Whether they happen to be men of affairs in great positions, like Lord Avebury, or artisans devoting their Saturday afternoons to original research in natural history, they are the salt of the subject, preserving it from the worst effects of a purely professional and academic standard.

There is one more event of the past year to be mentioned before entering on the professional portion of this address. Section K has made a great innovation in choosing a woman for its president this year, and I will not refrain from thanking you in the name of my sex because I happen to be the woman chosen. And though I must and do feel very keenly the honour you have done me as a botanist in electing me to this position, yet that feeling is less prominent than gratitude for the generosity shown to all women in that choice. Speaking in their name, I may venture to say that the highest form of generosity is that which dares to do an act of justice in the face of custom and prejudice.

The main subject of my address this morning is the development of botanical embryology since 1870.

Botanists, as well as zoologists, have used the term embryology in two senses. Balfour's remarks apply to both sciences:—

"Strictly interpreted according to the meaning of the word, it ought to deal with the growth and structure of organisms during their development within the egg-membranes, before they are capable of leading an independent existence. Modern investigators have, however, shown that such a limitation of science would have a purely artificial character, and the term embryology is now employed to cover the anatomy and physiology of the organism during the whole period included between its first coming into being and its attainment of the adult state."

The older botanists used the term in the narrower sense. They included the study of the embryo-sac and the structures contained in it before the formation of the unfertilised egg-cell, as well as the fertilisation of the latter and its subsequent divisions. But they did not proceed beyond the resting-stage of the embryo within the ripe seed. Here, as in zoology, this division is arbitrary and inconvenient. Accordingly, in the following remarks on the embryology of Angiosperms, I include every stage in the development of the plant, from the first division of the fertilised egg-cell to maturity.

Systematists, from Cæsalpino onwards, have paid much attention to the structure of the seed, and their observations are the earliest we possess on botanical embryology. They were, indeed, forced to study the embryo because its characters are often of systematic importance. The number of cotyledons, for instance, is the most constant character which separates the two great classes of Angiosperms. Again, the endosperm is not part of the embryo, but its presence or absence in the ripe seed—so important systematically—determines the functions of the cotyledons after germination, and thus influences their structure profoundly. In this way botanists became familiar with the structure of the embryo in the ripe seed before they had traced its origin from the fertilised egg-cell or followed its development after germination.

The early history of the embryo was a sealed book to observers without the help of the compound microscope. Accordingly we find that work on the external morphology of seedlings preceded that on the formation of an embryo. For the description of seedlings we must go back to the middle of last century. The greatest name in this school is that of Thilo Irmisch (1815–79). His work, like that of earlier observers in the same field, was neglected by the succeeding generation owing to the rapid development of microscopic botany. For a time the study of anatomy eclipsed that of external morphology.

The earliest observers to study the embryo-sac of Angiosperms with the help of the compound microscope were naturally attracted by the history of the ovum and the process of fertilisation. Little progress was made in this direction, however, owing to the imperfect technique of the day. The divisions of the fertilised egg-cell are more easily followed, as Hanstein showed in 1870. His classical paper is the foundation of botanical embryology in the narrower sense—that is, of the study of the embryo from origin to germination.

This period in the plant's history would seem, indeed, very well defined. It begins with the first division of the fertilised egg-cell—undoubtedly a natural epoch, for a new generation dates from it. It ends with the formation of the ripe seed, which is a true physiological epoch, since it corresponds with a complete change in the conditions of life. We have seen also that the morphologists who have dealt with the immature plant have fallen naturally into two groups, one ending and the other beginning their work at this very point.

Experience, however, has shown here, as in zoology, that embryologists lose more than they gain by this division of their subject. It is, indeed, neither so simple nor so natural as it appears at first sight.

It is not simple because the embryo is not always completely dormant during the interval between the formation of the ripe seed and the first steps in germination. On the contrary, in a large proportion of Monocotyledons, and in a smaller but still considerable proportion of Dicotyledons, the embryo is an almost undifferentiated mass of meristem when the seed first ripens. It becomes differentiated internally and externally by degrees during the long interval before germination. This is sometimes called the maturation of the seed, and it is quite distinct from its ripening. Maturation is a process characteristic of the seeds of geophilous plants, which commonly lie in the ground for a year at least before germination.

In such cases the period of rest occurs immediately after the seed is ripe, and while the embryo is still undifferentiated. But the embryo is not comparable morphologically to that in the seed of an annual, for example, which may have ripened at the same time. The embryo of an annual has root, stem, and leaves, besides its cotyledons, and is ready to germinate immediately on the return of spring.

The morphologist, then, must continue the study of his geophilous embryo throughout the period of maturation if he is to compare it with that of the annual. Even then he will find it less advanced than the annual embryo, though both be examined as they break out of the seed. For the geophyte may perhaps

be four or five years before it flowers, while the annual has to complete its whole life-cycle in a single season.

Nor is the division of the subject into two parts, the first ending with the embryo in the ripe seed, a natural one, even if the time of maturation be included in that first period. The structure of the embryo cannot be completely grasped by reference to its past only. The observer must expect adaptive characters of three kinds: first, those imposed upon the embryo in the past by its development within the embryo-sac while it is still parasitic on the parent plant; secondly, certain adaptations to the process of germination itself; and, finally, characters which will be useful after germination. Before the utility of the characters included in this third class can be fully understood, the development of the seedling must be followed for some time. In short, the structure of the embryo is dependent on its future, as well as on its past; and a division of the subject which excludes that future is, as Balfour says, purely artificial. Thus the work done of late years on the anatomy of the seedling has not only completed Irmisch's work on its external morphology, but has also thrown light on the problems of early embryology attacked by Hanstein and his immediate followers.

These problems are of two kinds, relating to the internal anatomy or the external morphology of the embryo. Hanstein himself was chiefly interested in the former. It is curious to realise when reading his paper that up to the date of its publication botanists were prepared to find an apical cell in the embryo of Angiosperms. They acknowledged, indeed, that no such cell existed in the growing-points of the mature plant.[1] There each new portion of tissue was formed by the activity of a group of similar and equivalent cells. But it still seemed possible that the embryo might possess an apical cell in the earlier stages of its growth—a reminiscence of its Cryptogamic ancestors. Hanstein's work disposed once for all of this possibility. It was conclusive even against the great authority of Hofmeister, who had described an apical cell in the embryo of orchids.

One general result of the work on the embryo since Hanstein's time has been to discredit phylogenetic theories based on its early history. Indeed, it was scarcely to be expected that a small mass of meristem, developing within a confined space and feeding parasitically on the tissues of the mother-plant, should preserve ancestral features, and one is surprised to find a morphologist with the experience and the wide grasp of Hanstein attaching so much importance to the succession of divisions within such a body. The conscientious student finds it a laborious task to follow the work done in plant embryology during the period which succeeded the publication of Hanstein's great paper. No wonder that when the end is seen to discredit rather than crown much of that work, when he realises how little has been gained as a result of so much patient toil, he is apt to renounce the whole subject in disgust. Yet in science we dare not rule out the unexpected, perhaps even less in morphology than elsewhere. Hanstein and his successors did good service when they described the growth of the pro-embryo from the fertilised egg-cell, its division into suspensor and embryo, the general development of both, and the appearance of external and internal differentiation in the embryo before germination.

Some of Hanstein's general conclusions as to internal anatomy have become the common property of text-books; for instance, the early differentiation of dermatogen in the embryo, and its subsequent development into the epidermal system. He was less successful in demonstrating the initial independence of plerome and periblem and their relation to the vascular cylinder of the mature stem.

The early differentiation of plerome and periblem from the internal tissues of the embryonic axis, and their continued formation at the growing points of stem and root respectively, are processes which demand the most careful investigation, on account of their bearing on the stelar hypothesis.

Dr. Schoute's work on the exact relationship of plerome and periblem at the growing-point to the central cylinder and cortex as differentiated in the older regions of the same axes, whether stem or root, is very important. He accepts Prof. Van Tieghem's definition of the stele as the solid cylinder of root or stem enclosed within the endodermis. The endodermis itself, of course, is considered as belonging to the cortex, because in the root its cells are opposite the radial files of the inner cortex, and, indeed, form the inmost rank of those files This is assumed to indicate a common origin by repeated tangential division. The cells of the pericycle—the outermost layer of the stele—alternate with those of the endodermis. As a rule, there is no corresponding radial arrangement in the cortical tissue of the stem, but where such exists—as in the stem of Hippuris—the endodermis is again included in it and terminates it.

Using the microtome as an instrument of precision, Dr. Schoute in 1903 published the most careful observations on the growing-points of roots. His aim was to determine whether the limit between plerome and periblem (Hanstein) corresponded with that between stele and cortex (Van Tieghem). For this purpose Dr. Schoute was, of course, obliged to choose roots in which the plerome is clearly distinguished from the periblem at the growing-point. In the end he obtained precise results in three species: *Hyacinthus orientalis, Helianthus annuus,* and *Linum usitatissimum*. In each of these the periblem passed into the cortex, its inner layer becoming the endodermis, and the plerome gave rise to the stele only.

Owing to difficulties of observation, arising chiefly from the insertion of leaves close up to the growing-point and displacements in the original stem-structure consequent on this habit, Dr. Schoute was not equally successful in his work on stems. *Hippuris vulgaris* was the only species to give definite results. In this species he found that the plerome gave rise not only to the stele, but also to the endodermis, and to the two or three layers of cortex immediately beyond it. If these results are well founded the limit between plerome and periblem does not correspond with that between stele and cortex in the stem of Hippuris. Moreover, doubt is thrown on the assumption made by all previous observers that rows of cortical cells arranged in radial files must be of common origin.

Observations on a single species, however well attested, form a slender basis for conclusions regarding stems in general. Nor have Dr. Schoute's observations escaped criticism. Dr. Kniep has since examined the growing-point of Hippuris, and believes that he can identify plerome with central cylinder, and periblem with cortex, even in this test case. However this may be, no one denies the obscurity of stem anatomy in this respect compared to that of the root, nor the cause of that obscurity. The continuity of the stem stele is perpetually interrupted by the insertion of the leaf-traces, just as the symmetry of the stem growing-point is destroyed by the formation of leaf rudiments close up to its apex.

The stelar hypothesis is essentially an assertion of

[1] Korschelt in 1884 revived the hypothesis that the growing points of some Angiosperms at any rate increased by means of an apical cell. He worked chiefly on aquatic plants. His views have not been accepted.

the real homology between the vascular systems of stem and root throughout all vascular plants. This was pointed out to me more than twenty years ago by Dr. D. H. Scott, and it has been the sheet anchor to which I have since clung through much stress of morphological weather. No difficulty arises so long as we are dealing with roots only, or with the stems of those vascular Cryptogams in which the vascular system is a closed cylinder, without gaps at the insertion of the leaf-traces. In such stems the vascular cylinder is as well-defined as in all roots, and can be described in the same terms. But the case is quite different in the stems of Phanerogams, where to all appearance the primary vascular cylinder is a system built up of leaf-traces, embedded in a parenchymatous matrix. And the early anatomists were faced at once by this problem in its crudest form. Beginning with the anatomy of Phanerogams, they first became acquainted with the primary structure of the Dicotyledonous stem. That of the root was not clearly understood until many years later; perhaps because anatomists attempted to interpret it by reference to the skeleton of the stem, and in the same terms. But there is nothing in the vascular anatomy of the root to correspond with the leaf-trace, and the leaf-trace is the vascular unit of stem-structure in all Phanerogams. Here, as elsewhere, confusion of nomenclature went hand in hand with confusion of thought, and it is difficult to say which was cause and which effect.

Even when the facts of root-structure were accurately known, the conception of the leaf-trace bundle as the structural unit continued to be a stumbling-block. In 1877 De Bary published his monumental work on plant anatomy, and though it still keeps its place as the great book of reference on that subject, his descriptions of root anatomy appear to the modern botanist to be written in a dead language. When he calls the vascular axis of the root a "radial bundle" it is quite clear that he regards this as a purely formal term, not implying any true homology between the leaf-trace bundle of the stem and the axial core of the root. He does not, indeed, consider a bundle as a unit: he defines it as a compound structure "formed of tracheids and sieve-tubes definitely grouped."[2] But the word "bundle" was already impressed with another superscription. However defined originally, it had connoted the unit of stem-structure to a generation of botanists. With that connotation, De Bary's use of the term is in hopeless conflict. Moreover, the conception underlying that use was already out of date in 1877. Modern anatomy dates from 1871, when Prof. Van Tieghem published the first of his great series of memoirs on the subject. In these the axial core of the root was treated as equivalent to the whole system of leaf-trace bundles in the stem, though the word "stele" was not yet invented. This conception gained ground from the first; it was popularised by the happy choice of a name in 1886. From that date the stelar hypothesis has replaced all other schemes of vascular anatomy. The advance then made on all previous generalisations has been shown by the new impulse given to research, and the comparative simplicity introduced into text-book anatomy.

We cannot claim equal simplicity, I fear, for the technical language of research in this subject, and this alone should inspire caution, for obscurity of language rarely persists where there is no corresponding obscurity of thought.

No one now doubts that the central cylinder of the root in Phanerogams is far more closely comparable to the leaf-trace cylinder of the stem than to any one of the traces within it. Yet when the comparison becomes detailed, difficulties are constantly arising. Where, for example, there is a medulla in the root it certainly forms part of the stele, which is a solid cylinder sharply defined by the specialised endodermis surrounding it. But the leaf-traces in the young stem surround a massive cylinder of parenchyma, precisely resembling the parenchyma of the cortex, with which it is in apparent connection through the gaps between the leaf-traces. Even the secondary formations do not completely divide one system from the other. When a specialised endodermis is present it is not so clearly defined as in the root: in many cases it is not present—in other words, there is no cell-layer outside the leaf-trace cylinder which is differentiated in any way from the surrounding tissues. In a few instances—most baffling of all—an endodermis surrounds each leaf-trace.

The stele in the stem of Phanerogams is not of necessity a morphological fiction, because in many stems its precise limits cannot be determined. If, indeed, the word be used as a descriptive term, its value is seriously impaired by every instance in which it fails to describe stem-structure with precision. But morphology is not merely descriptive. If we suppose that the stem-stele in remote ancestors of the Phanerogams was as well defined as that of the root and clearly comparable to it, we may attach a real morphological meaning to the term when applied to modern Phanerogams, provided we can show cause to believe that what we call the stele in their stems represents the ancestral stele. Its tissues will then have a history distinct from those of the cortex, though not clearly separated from them. The burden of proof, however, certainly lies with those who assert that an apparently continuous and uniform tissue can be separated into two parts of distinct origin.

The evidence advanced is of two kinds—one founded on the comparative anatomy of stems, and the other on the history of the tissues in the individual plant. Dr. Schoute has argued the case with great skill from the first point of view in his "Stelärtheorie." Depending to a large extent on his own researches, he has collected a great body of evidence to show that in the stems of Angiosperms a specialised layer is commonly distinguished from adjacent tissues either by the peculiar thickening characteristic of the endodermis in the root, or by the presence of starch in its cells. He shows that such a sheath surrounds the vascular cylinder in a very large proportion of the Dicotyledons examined, and in a majority of the Monocotyledons. Among Gymnosperms it occurs but rarely. Observing that the Angiosperms in which this bundle-sheath is obscure or wanting are commonly closely related to species in which it is perfectly well defined, Dr. Schoute concludes that its absence in such cases must be attributed to reduction.

Allowing that such a layer is as general among Angiosperms as Dr. Schoute believes, grave doubts may still exist as to its homology with the endodermis of the root. The latter is defined not only by its thickened walls, but also by the position of its cells. They form the inmost rank of the series of radial files which distinguish the inner cortex, and the morphological endodermis—the phlæoterma, as Strasburger calls it—can usually be distinguished by this purely morphological character, even when its walls are unthickened. In the stem, however, the cells of the inner cortex are not radially arranged, except in rare cases, such as Hippuris. Thus there is no morphological criterion to distinguish the phlæoterma, or inmost cortical layer of the stem, from adjacent tissues. The bundle-sheaths distinguished by their

[2] "Comparative Anatomy of Phanerogams and Ferns." 1st Eng. ed., 1884, p. 400.

thickened walls or by the presence of starch in their cells are physiologically similar; they play a definite part in the economy of the stem, but the presence of either character must depend mainly on the demands of the conducting or assimilating system, and need not imply the morphological identity of such layers with each other, or with the layer performing a similar function in the root.

Turning now to the second class of evidence—that drawn from the history of the tissues in the individual plant—we have already seen that the differentiation of plerome from periblem is far less definite at the growing point of the stem than at the root. Doubts have even been thrown on the identity of plerome and periblem with stele and cortex respectively. But we have not yet followed the development of the tissues of the embryo into those of the seedling.

The normal seedling[3] of all Phanerogams consists at first of cotyledons, hypocotyl, and root, the plumular bud being still rudimentary. The primary root lies as a rule in a straight line with the primary stem, or hypocotyl. The hypocotyl is commonly the first part of the embryo to lengthen, and then its xylem is lignified a little earlier than that of the root or even that of the cotyledon. But when—as in many Monocotyledons—the base of the cotyledon lengthens first, lignification begins in that region and advances through the hypocotyl to the primary root.

The anatomy of the seedling at this epoch has lately been investigated by many independent observers. They constitute, indeed, the third school of embryology to which I have referred as completing the work of two earlier schools—namely, morphologists of the type of Irmisch, and students of early embryology like Hanstein and his school. But though the subject is limited to a short period in the history of the plant, and to one in which its vascular structure is comparatively simple, yet it has been attacked from different sides, and the attempt to give a concise account of the results attained is beset with difficulties. For the present, however, I propose to consider only their bearing on the stelar hypothesis.

Indeed, seedling anatomy becomes extremely important when the vascular system of the root is compared with that of the stem. For in the seedling we have a complete and simple vascular skeleton, which at one end belongs to the primary root of the plant, and at the other to its primary stem. There must be an intermediate region in which stem-structure passes into root-structure, and the method of transition should at least suggest, if it does not precisely determine, the relation in which they stand to each other. For this reason great value has been attached by anatomists to the transitional region of the main axis. It was not completely investigated, however, until the microtome was introduced into botanical practice, for the change of structure is often very abrupt, and cannot be studied in detail unless all possible sections are present in their proper order.

In this, as in other branches of modern anatomy, Prof. Van Tieghem was first in the field. In his memoir of 1872, "Sur les Canaux Secréteurs des Plantes," he described the course of the bundles of the hypocotyl of *Tagetes patula*, an example of the second type of transition given in his textbook (1886). The three types were, indeed, already identified in 1872, for the first and third are defined in a footnote appended to the description of Tagetes.

Tagetes patula was, of course, examined in 1872 with the aid of hand-sections only. Two traces enter the hypocotyl from either cotyledon, and form in the end a diarch root. The plane passing through its xylem poles is the median plane of the cotyledons. In the upper part of the hypocotyl this plane bisects the space which separates the two bundles entering each cotyledon. So far the description of Tagetes given in 1872 is identical with the generalised account of type 2 in the text-book (1886). But a detail of some importance is mentioned in the description of Tagetes which does not reappear in the definition of type 2. In each of the spaces just mentioned—called, for convenience, xylem spaces, because they lie above the xylem poles of the root—lies an isolated xylem element, the direct continuation of the most external element in one of the root poles, and this element comes to an abrupt end higher up.

Thus Prof. Van Tieghem has tacitly assumed that Tagetes is exceptional in this respect, and this view was also adopted by Prof. Gérard in his laborious and accurate paper of 1881. He describes the transitional phenomena of a number of Dicotyledons, among them *Tagetes erecta*. Not only is the transition in this species exactly the same as that in *T. patula*, but the author records a similar isolation of primitive xylem elements in *Raphanus niger*, *Ipomaea versicolor*, and *Datura Stramonium*, still treating the arrangement as exceptional.

These details are important, because if certain protoxylem elements belonging to the root are not continued upwards in regular succession into the cotyledonary or plumular bundles, but end abruptly in hypocotyl or base of cotyledon, there is not that complete correspondence between stem- and root-structure which is assumed in Van Tieghem's three types. In all of them the xylem and phloem bundles of the root are continued into the cotyledons or plumule. On their way through the hypocotyl they may divide or be displaced, and the xylem bundles "rotate"—that is, they turn on their own axes until the protoxylem is internal. But all the elements present in the root are continued upwards in regular succession, and are simply rearranged in the upper part of the seedling. This is one of the main arguments advanced by Prof. Van Tieghem to support his view that the steles of root and stem are identical.

According to most later observers, however, such temporary prolongation of the root-poles upwards as that described by Profs. Van Tieghem and Gérard in a few instances, and considered by them as exceptional, is really of general occurrence. The protoxylem elements, indeed, are not commonly isolated from the main xylem of the cotyledonary traces as in Tagetes, but are in more or less complete contact with them on either side. Such contact is approached in *Raphanus niger*, where it is very clearly suggested in Prof. Gérard's figures.

There is then a real difference of opinion on a question of fact between Prof. Van Tieghem and his school, on the one hand, and certain modern embryologists on the other. Three distinct views are now held as to the interpretation of the isolated xylem elements in the hypocotyl of Tagetes. I shall try to state them as fairly and concisely as possible.

Profs. Van Tieghem and Gérard treat Tagetes and the genera which resemble it as exceptional, because part of the external xylem of the root is continued upwards between the cotyledonary traces, and dies out in the base of the cotyledon. They consider that the remainder of the external xylem turns on itself and becomes internal in the usual way.

Prof. Gravis and his pupils think that a similar prolongation of the xylem poles of the root into the hypocotyl or cotyledon is the rule, and that they terminate there abruptly. But in most cases this vestigal root-xylem is not isolated; it is in contact on either side with the early xylem of the cotyledonary

[3] By this qualification I mean to exclude cases in which the young seedling is very greatly reduced.

traces, and is therefore apt to be confused with it. The characteristic shape of so many cotyledonary traces arises in this way. They are often called double bundles, but according to Prof. Gravis they are more than double, for each really consists of two traces in close contact with the last vestige of root-xylem. The latter always disappears higher up in the cotyledon, and the two traces may then unite into a midrib, with or without lateral branches. As a consequence of this view, Prof. Gravis considers that there is no morphological continuity in the hypocotyl between the vascular systems of root, stem, and leaf.[4] Their traces are merely in contact sufficiently intimate for physiological purposes. There can, therefore, be no true homology between the central cylinder of the stem and that of the root.

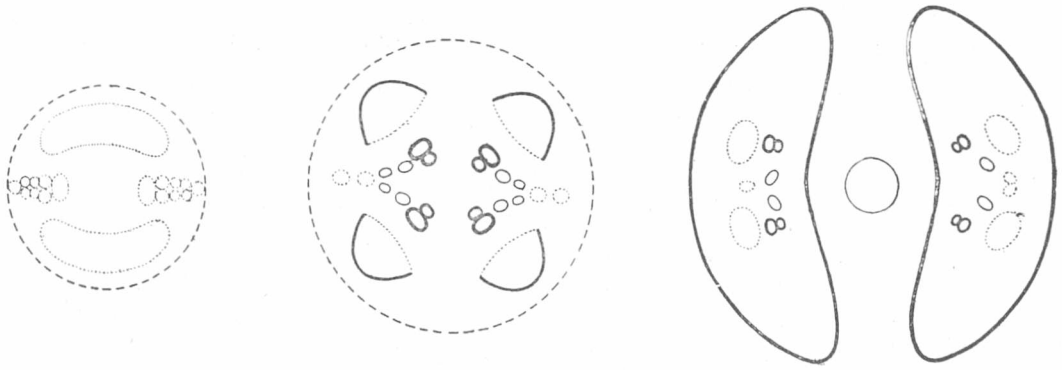
The third view is that of M. Chauveaud, who has been engaged for upwards of twenty years in following the development of the vascular elements in the hypocotylar region and its neighbourhood. He agrees with Prof. Gravis that the presence of external xylem is the rule in the hypocotyl and in the base of the cotyledon. But he considers that this external xylem belongs to the primitive structure of hypocotyl and cotyledon as well as to that of the root. We have already said that the vascular system of seedlings is first differentiated in the hypocotyl, base of cotyledon, and base of primary root. In all these regions M. Chauveaud thinks the primitive stele to be root-like—in his own phrase it belongs to the "disposition alterne." The xylem alternates with the phlöem, and its development is centripetal. This primitive formation, however, is permanent only in the root, and commonly in the lower part of the hypocotyl also. In the upper part of the hypocotyl and in the base of the cotyledons the first xylem elements are fugitive. They disappear so early that, as a rule, they are missed completely by the anatomist, who is apt to prefer well-differentiated tissues, and therefore to choose seedlings which are past their first youth.

In considering the theory of stelar evolution in which M. Chauveaud has correlated his own long series of observations with the results of other embryologists, I shall confine myself strictly to the question now under discussion—namely, the extent to which the stele of the young stem in Phanerogams can be considered to represent that of the root. Prof. Van Tieghem, as we have seen, considers them completely homologous, while Prof. Gravis denies that they are homologous at all.

M. Chauveaud occupies a middle position. If I understand his views rightly, he considers that there is an early phase in the development of the seedling in which the stele of the hypocotyl—at that time the only representative of the stem—is developing on exactly the same lines as the stele of the primary root, and is, in fact, continuous with it. At that epoch each cotyledonary trace is also developing on the same plan. It belongs to the same phase of evolution, and in many species of Dicotyledons the insertion of the cotyledons is the simplest imaginable. The original stele of the hypocotyl divides below the cotyledonary node, and one-half goes to each cotyledon.[5]

In species where this formation is clearly developed there cannot be said to be any transition between stem- and root-structure. Stem-stele and root-stele are continuous: their steles are developing in the same way. Even the leaf-traces of the first two leaves are on similar lines, and their insertion, therefore, does not modify the structure of the stele.

How, then, does the structure we associate with the stem of Phanerogams appear. In the transitonal region of the hypocotyl the first xylem elements—perhaps only two or three at each pole—alternate with the phlöem groups. The elements next differentiated lie within them, for development is still centripetal, but in two diverging groups. The xylem-ray is then shaped like an inverted V. Each arm of the V approaches the adjacent phlöem group as it travels inwards, until the last-formed elements lie on the same radius as the centre of the phlöem group, but well within it. The next elements are differentiated on that radius, but are directed towards the phlöem: development has become centrifugal. These successive xylem formations are called by M. Chauveaud the *alternate*, the *intermediate*, and the *superposed*. They are distinguished in the diagram by dotted lines for the alternate elements, thin lines for the intermediate, and thick lines for the superposed.



The alternate elements are fugitive in this transitional region; they commonly disappear as the superposed elements become conspicuous. The intermediate xylem persists. But higher up in the hypocotyl the intermediate elements, too, disappear as the seedling grows older. They vanish in the traces of the cotyledons also, and in the cotyledons themselves. Thus in seedlings of a certain age we have endarch bundles at the top of the hypocotyl, forming a stele of the stem type, and an exarch stele lower down, which passes unchanged into the root. The connection between the two is maintained by the intermediate xylem of the transitional region.

Although M. Chauveaud has been publishing his researches since 1891, yet he has only lately (1911) put his results into a connected form, and they are therefore less familiar than might otherwise be expected to anatomists who are not also embryologists. They clearly have a direct bearing on the theory of

[4] A. Gravis, "Recherches . . . sur le 'Tradescantia virginica,'" *Mém. de l'Acad. royal* . . . Tome lvii., Bruxelles, 1898. See account of hypocotyl(pp. 28–32), including insertion of cotyledon (pp. 31–32). Also memoir by same author on *Urtica dioica* (1885), footnote on p. 117. *Cf.* also Mr. R. H. Compton's paper in *New Phylologist*, xii., p. 13, 1912.

[5] Chauveaud, "L'Appareil Conducteur des Plantes vasculaires," 1911. See description of *Mercurialis annua* on pp. 216, 217, and figs. 62, 63.

the stele. Before, however, entering on this subject, I ought to say something on the question of fact. In my opinion M. Chauveaud's figures and descriptions represent the vascular development in the hypocotyl and cotyledons of Angiosperms more accurately than any others with which I am acquainted. He has dealt more fully with Dicotyledons than Monocotyledons, but I have been able to verify his account of the latter to some extent by reference to my own preparations, which include a number of species closely allied to those which he has cut. Among Dicotyledons I have had the great advantage of consulting the preparations of Miss Thomas and of Mr. R. H. Compton. Neither of these botanists made their preparations to illustrate M. Chauveaud's theory; indeed, they attacked the subject, as I did, with aims distinct from his. There has therefore, been nothing like complete verification in any single species, but so remarkable a correspondence with his figures in similar stages of the material, that I am satisfied of M. Chauveaud's fidelity.

Assuming, then, that his account of the vascular development in a young seedling is substantially correct, what are we to conclude as to the homology of the central cylinder of the stem with that of the root?

M. Chauveaud himself believes the stem cylinder in the upper hypocotyl of a fairly old seedling to be a true stele, but one belonging to a later phase of evolution than that of the root, and not, therefore, strictly homologous with it in the sense in which the earliest vascular formations in cotyledon and hypocotyl respectively were homologous with each other. He considers the successive vascular formations which we have just followed in these regions—formations marked by the appearance of alternate, intermediate, and superposed xylem in turn—to represent three successive phases of stelar development. The root-stele corresponds to the first of these phases only.

But questions of phylogeny are strictly historical, and the only precise meaning that can be attached to the expression "successive phases of stelar development" in the seedling of an Angiosperm is that at some past period a group of plants in the direct line of descent of Angiosperms possessed a stele resembling that which is now a mere stage in the life of the individual. Thus the alternate formation found throughout the very young seedling implies an ancestral group with an exarch stele in stem as well as root, and a leaf-trace of corresponding structure.

There is nothing at all improbable in this hypothesis, since groups with exarch steles in stem as well as root are found among living and extinct plants. But if adopted several important consequences would follow. The seedling while it consists of cotyledons, hypocotyl, and primary root only—the plumule present as a mere bud—must represent a past period in race-history when its ancestors possessed an exarch stele in stem and root alike; when the stem-stele belonged to the stem only, and the insertion of leaf-traces hardly modified its structure; when it entered the root without change, and therefore no transitional region occupied and puzzled the anatomist of the period.

This early stage in the development of the seedling is succeeded by that in which the epicotyl begins to grow, and as a rule the epicotyl is quite undoubtedly modern.[6] Its vascular skeleton is built up of leaf-traces, which are endarch from the first. At the cotyledonary node they are inserted on the vascular cylinder of the hypocotyl, which has become endarch at the top. This transition has been effected lower down in the hypocotyl, as described already, by the formation first of intermediate, and then of superposed xylem, together with the gradual disappearance of the original alternate xylem.

Thus the cotyledonary node may be considered to mark the interval between two acts in the drama of evolution—an interval the length of which cannot yet be estimated, but is clearly to be reckoned in geological epochs.

The race-history of the Phanerogamic stem-cylinder is at present unknown. How did the ancestral stele lose its exarch character, and what intermediate stages led up to its present construction from endarch leaf-traces? Possibly the development of the hypocotyl may give a clue as suggested by M. Chauveaud, and the change have been effected by the development of intermediate xylem. Or Prof. Jeffrey may be right in deriving the leaf-traces from a siphonostele which has been gradually more and more broken up by the appearance of foliar gaps. This process is said to be exhibited in the young epicotyl.[7] Until this point is cleared up the exact relationship of the vascular cylinder of the stem to that of the root will remain obscure. As a matter of convenience the stem-cylinder will, no doubt, be called a stele, even though anatomists should acknowledge that it cannot be considered as strictly homologous with the stele of the root. Much confusion of thought would, however, be avoided if the two structures were not treated as strictly comparable.

There can be very little doubt that the insertion of leaves has brought about the change, and I might suggest here that the insertion of leaves on an exarch stem-stele would be an interesting subject for research. The literature of the subject is scattered, and its treatment seems to me very incomplete. An exarch axis bearing leaves is, of course, exceptional, but more common among extinct plants than among recent species. So far as my very cursory examination of the literature has gone, it seems a general rule that the leaf-traces are inserted on the xylem poles of the stele.[8]

Hitherto I have considered modern embryology in relation to a single problem of internal anatomy—namely, the comparison of the vascular system of the stem to that of the root. But the evidence of embryology is also of great weight in questions of internal morphology and phylogeny.

Several questions of this kind are discussed by Hanstein, from whose classical paper I continue to date. For example, his account of the embryo of Monocotyledons suggests two distinct problems. One belongs to formal morphology—namely, the question whether a terminal member can be considered as a leaf. The other is a question of phylogeny: whether Dicotyledons are derived from a monocotylous ancestor or Monocotyledons from a dicotylus form. Both these questions I have discussed elsewhere,[9] and only refer to them now as examples of the way in which seedling anatomy has proved complementary to that of the older embryologists.

The most obvious interpretation of Hanstein's observations is that the single cotyledon of Monocotyledons is equivalent to the pair found in Dicotyledons. This would imply that Dicotyledons were

[6] The epicotyl in the *Vicieæ* has been described as containing centripetal xylem. The facts are given by Mlle. Goldschmid (1876), Prof. Gérard (1881), M. Chauveaud (1911), and Mr. Compton (1912). The theoretical interpretation is discussed by M. Chauveaud (*l.c.*, p. 348) and Mr. Compton (*l.c.*, pp. 93–95). There seems every reason to think, as Mr. Compton suggests, that the character is adaptive, depending on the twining habit. He points out that *Vicia Faba*, which does not twine, has a normal epicotyl.

[7] Jeffrey, "The Morphology of the Central Cylinder in the Angiosperms." *Trans. Canadian Inst.*, vi., 1900.

[8] D. H. Scott, "Studies in Fossil Botany," 1908, p. 97 (*Sphenophyllum*); C. E. Bertrand, "Remarques sur le *Lepidodendron Harcourtii*," 1891, p. 109; M. Hovelacque, "Recherches sur le *Lepidodendron selaginoides*," 1892, p. 150; F. O. Bower, "Origin of a Land Flora," p. 334 (*Selaginella*), 1908; C. E. Jones, *Trans. Linn. Soc.*, ser. 2, vii., 1905, p. 19 (*Lycopodium*).

[9] E. Sargant, *Ann. of Bot.* xvii., p. 1, 1903, and *id* xxii., pp. 150–2, 1908.

derived from an ancestor with one cotyledon, apparently terminal, which gave rise to the existing pair by a process of fission. But other interpretations were always possible, and the terminal hypothesis received a shock when Count Sohms-Laubach discovered that in certain Monocotyledons the single cotyledon is lateral from the first.

The comparative antiquity of Monocotyledons and Dicotyledons has been one of the first questions raised by the study of seedling anatomy. It is remarkable that both the hypotheses founded on work of this kind assert the greater antiquity of the dicotylous form. But if the cotyledonary member of Monocotyledons is derived from one or both cotyledons of an ancestral pair, it cannot be considered as terminal. Thus the evidence of seedling anatomy bids fair to settle both these questions, as I think it will settle others of the same kind mentioned by Hanstein.

The descriptive work of Irmisch and the school he represents has been carried on of late years by an American naturalist, Mr. Theo. Holm, with all the technical advantages given by modern instruments of research. His papers are commonly written with systematic intention, but the external characters of the species he describes are correlated with their internal anatomy, and the structure of the adult form is traced from its origin in the seedling. His monograph on *Podophyllum peltatum* is an example of this method, and illustrates its advantages in a very striking way. But it is becoming much more usual to compare the seedling with the adult form, as may be seen in two monumental works now being published in parts: "Das Pflanzenreich," edited by Engler, and "Lebensgeschichte der Blütenpflanzen Mitteleuropas," edited by Kirchner, Loew, and Schröter.

In a very useful paper on modern developments of seedling anatomy Mr. Compton has pointed out that the subject has been attacked from several divergent points of view. I have already referred to the work of M. Chauveaud and Prof. Gravis, and have now come to that of a number of English botanists, whose aim—as Mr. Compton observes—is mainly phylogenetic. They are even more clearly distinguished by their methods, which are those of comparative anatomy. Instead of following the development of the seedling of a single species from germination to the age at which its cotyledons begin to decay, as M. Chauveaud has done in a number of carefully selected instances, they have compared the seedlings of different species and different genera at about the same age, generally choosing the epoch at which the tissues of cotyledon, hypocotyl, and primary root are most completely differentiated. There is nothing new in this treatment of the subject. It was employed in 1872 by Prof. Van Tieghem [10] in his paper on the anatomy of grass seedlings, in which he compares them with other Monocotyledons of the same age. Much greater precision is possible, however, now that the microtome has come into general use.

The literature of this subject has increased rapidly of late years. The list of references in the footnote [11] appended to this paragraph is, I fear, far from complete. But it is not part of my plan to review this work critically. The time is, perhaps, not ripe for such a review, and certainly the time at my disposal to-day is quite insufficient for it. Perhaps I may be allowed to offer some general remarks, first on the method itself, and then on the criticisms it has encountered.

To compare the structure of organisms with each other is, of course, the recognised method of comparative anatomy, of systematic botany, and, in fact, of all branches of morphology. The great difficulty in all such work is to distinguish between adaptive characters of comparatively recent origin and the characters inherited from remote ancestors. The history of systematic botany is very instructive in this respect. Systematists discovered by degrees, and by means of repeated failures, that characters could not be picked out as important for purposes of classification on *à priori* grounds. No character is of uniform importance throughout vascular plants, for example. On the contrary, it may be of great value in the classification of one group and worthless in another, though closely allied. Generations of botanists have laboured to build up the natural system in its present form, and it is constructed from the ruins of abandoned systems. We all agree now that the guiding principle in all morphology is that our classification should represent relationships founded on descent only. But the natural system was complete in its main features before that principle was understood. It represented the feeling for real affinity developed in botanists by the study of plant form, independently of any theory as to the cause of such affinity.

This, of course, is the commonplace of botanical history, but we do not always realise that all morphological work is done under similar conditions. The only valid appeal from criticism is to the future: a new method is approved by its results. Therefore, to embark on a new branch of morphology is a real adventure. The morphologist risks much time and much labour. He knows that the evidence which he proposes to gather painfully, to test critically, to present logically, may, after all, prove of little consequence, and he has to depend on his own instinct to lead him in the right course. In his degree he resembles Columbus, to whom a few sea-borne seeds and nuts meant a new continent.

[10] Prof. Van Tieghem, *Ann. Sec. Nat.*, ser. 5, xv., p. 236, 1872.

[11] The following references are arranged alphabetically:—

Arber, A., The *Cactaceæ* and the Study of Seedlings. *New Phyt.*, ix., p. 333, 1910.

Compton, R. H., An Investigation of the Seedling Structure in *Leguminosæ*. *Linn. Soc. Journ. Bot.*, xli., p. 1, 1912.

de Fraine, Ethel. The Seedling Structure of certain *Cactaceæ*. *Ann. Bot.*, xxiv., p. 125, 1910.

Hill, A. W., The Morphology and Seedling Structure of *Peperomia*. *Ann. Bot.*, xxi., p. 395, 1906.

Hill, T. G., On the Seedling Structure of certain *Piperales*. *Ann. Bot.* xx., p. 160, 1906.

Hill, T. G., and de Fraine, Ethel. On the Seedling Structure of certain *Centrospermæ*. *Ann. Bot.*, xxvi., p. 175, 1912.

Hill, T. G., and de Fraine Ethel. On the Influence of the Structure of the Adult Plant upon the Seedling. *New Phyt.*, xi., p. 319, 1912.

Hill, T. G., and de Fraine, Ethel. A Consideration of the Facts relating to the Structure Seedlings. *Ann. Bot.*, xxvii., p. 258 1913.

Lee, E. Observations on the Seedling Anatomy of certain *Sympetalæ*. *Ann. Bot.*, xxvi., p. 727, 1912.

Sargant, E. A New Type of Transition from Stem to Root in the Vascular System of Seedlings. *Ann. Bot.*, xiv., p. 633, 1900.

Sargant, E. The Origin of the Seed Leaf in Monocotyledons. *New Phyt.*, i., p. 107, 1902.

Sargant, E. A Theory of the Origin of Monocotyledons, founded on the Structure of their Seedlings. *Ann. Bot.*, xvii., p. 1, 1903.

Sargant, E. The Evolution of Monocotyledons. *Bot. Gaz.*, xxxvii., p. 325, 1904.

Smith, Winifred. The Anatomy of some Sapotaceous Seedlings. *Trans. Linn. Soc.*, series 2. Bot. vii., p. 189, 1909.

Tansley, A. G., and Thomas, E. N. Root Structure in the Central Cylinder of the Hypocotyl. *New Phyt.* iii., p. 104, 1904.

Tansley, A. G., and Thomas, E. N. The Phylogenetic Value of the Vascular Structure of Spermophytic Hypocotyls. *Brit. Assoc. Report*, 1906.

Thomas, E. N. A Theory of the Double Leaf Trace, founded on Seedling Structure. *New Phyt.*, vi., p. 77, 1907.

The references given above refer to Angiosperms only, but so much work of a similar nature has been done lately on Gymnospermous seedlings that I add a list of the principal papers:—

Dorety, Helen A. Vascular Anatomy of the Seedling of *Microcycas calocoma*. *Bot. Gaz.*, xlvii., p. 139, 1909.

Hill, T. G., and de Fraine, Ethel. The Seedling Structure of Gymnosperm. I., *Ann. Bot.*, xxii., p. 689. 1908. II., *id.* xxiii., p. 189, 1909. III., *id.* xxiii., p. 433, 1909. IV., *id.* xxiv., p. 319, 1910.

Matte, H. L'appareil libéroligneux des Cycadies Caen, 1904.

Shaw, F. J. F. The Seedling Structure of *Araucaria bidwillii*. *Ann. Bot.*, xxiii., p. 321, 1909.

Sykes, M. A. The Anatomy of *Welwitschia mirabilis*. . . . . *Trans. Linn. Soc.*, 2. Bot. vii., p. 327, 1910.

Thiessen, Reinhardt. The Vascular Anatomy of the Seedling of *Dioon edule*. *Bot. Gaz.*, xlvi., p. 357, 1908.

Hence the difficulty of criticising recent work. When once a conclusion of some importance has been formulated it may be tested by evidence drawn from other branches of research. Until that time criticism from outside is of little value. Those who are working at the subject must, of course, form their own opinion on its possibilities, for each has to decide for himself whether he shall continue on those lines.

The subject of seedling anatomy is no longer very new. It is too late now to debate on the *à priori* probability of ancestral characters surviving in the young seedling. No one doubts that a vascular stump sometimes persists after the organ it originally supplied has disappeared.[12] Therefore there is no glaring improbability in the suggestion that the vascular skeleton of the young seedling may afford a clue to the structure of a remote ancestor. But this is only saying in other words that botanists are justified in giving the subject a fair trial. That trial is now proceeding. Some general conclusions have been formulated already, but they have not yet stood the test of time. In all probability the final judgment on this subject will be given by a future generation of botanists on evidence not as yet before us. In the meantime we shall all form our own opinion as to the prospects of the method. Speaking for myself, I think that it has already thrown much light on embryological problems, and is likely to throw more.

At the end of this very short and imperfect sketch of the progress of botanical embryology in recent years, it is natural to look back and attempt to estimate the importance of the whole subject and its relation to other branches of botanical science. I have treated it from the morphological side only, but clearly every department of botany must deal with the immature plant as well as with the adult form. For example, the struggle for existence between two species in any particular locality must be profoundly affected by the characters of their seedlings. If one species should gain a decided advantage over the other early in life, the vanquished species may never live to form seed, and may thus disappear from that neighbourhood in the first generation. This is an extreme case to show the importance of considering seedling structure in problems of ecology and distribution.

The internal structure of seedlings is certainly a department of vegetable anatomy, just as their adaptation to the conditions of life is a department of vegetable physiology. That the connection between embryology and systematic botany must be equally close seems at first sight to be beyond dispute, but the exact nature of that connection is as yet undetermined. In systematic botany we have the net result of an enormous mass of experience. Generations of botanists have examined and described the external characters of plants; they have arranged and rearranged them in groups until at last the instinct for affinity has been satisfied. In this continual sifting of characters some have been separated out as generally of systematic importance—the floral characters, for examples, and those of the seed. Certain features of the embryo are included among those characters, as already mentioned, but, on the whole, systematists have dealt exclusively with the adult plant. The embryo itself has been treated rather as a portion of the seed than as an individual.

It would be rash to assume that seedling characters have been disregarded by systematists because they were too busy with the fully-developed plant to pay proper attention to the young forms. In all probability some of the earlier botanists examined the external characters of seedlings and rejected them when they proved of little systematic value. But embryology, like the other branches of botany, entered on a new phase when the compound microscope came into general use. It was commonly denied that the anatomical characters of mature plants had systematic value until the test case of fossil botany was decided in favour of anatomy. We need not be surprised that conclusions drawn from the new embryology—that is, the embryology which includes internal characters as well as external—sometimes appear to conflict with the results of systematic botany, and it does not necessarily follow that embryological evidence is of no systematic value. The fault may lie with the embryologists, who, being human, do occasionally misinterpret their facts, or possibly the natural system may need some modification in the light of new knowledge. When both explanations have failed to account for the discrepancy in a number of cases we may be forced to give up looking for phylogenetic results from embryology.

And so in the end the appeal is again to Time, who —as Milton says—devours

> "No more than what is false and vain,
> And merely mortal dross.
> So little is our loss,
> So little is thy gain."

[12] *Cf.* the discussion of the homology of the Orchis-flower in Ch. Darwin's "Fertilisation of Orchids," chap. xiii., p. 225 in second ed., 1888.

SECTION L.

EDUCATIONAL SCIENCE.

FROM THE OPENING ADDRESS BY PRINCIPAL E. H. GRIFFITHS, LL.D., F.R.S., PRESIDENT OF THE SECTION.

WE have now had forty years' experience of compulsory education, and more than ten years' experience of the working of the Education Act of 1902. We are spending at the present time out of the rates and taxes about thirty-four millions per annum upon education. It seems reasonable, as a nation of shopkeepers, that we should ask if we are getting value for our money, and the reply will, of course, depend on what we mean by value, for the man in the counting-house, the man in the street, and the man in the schoolroom all have different standards of valuation.

Some of us are old enough to contrast the position of to-day with that of forty years ago. Do we observe any definite advance in knowledge, intelligence, character, or manners, as compared with the pre-compulsory days? We must all be aware of the tendency to magnify the past at the expense of the present, but, after making due allowance for the fact that "the past seems best, things present ever worst," it appears difficult to find distinct evidence of improvement in any way commensurate with the sacrifices which have been made.

I have taken every opportunity of ascertaining the views of men of varied occupations and differing social positions upon this matter, and I confess that the impression received is one of universal discontent. The complaints are not only of want of knowledge, but also, which is far more serious, of want of intelligence. Consider a trivial example drawn from my own experience. I am a motorist in a small way. My ambition has been restricted in the matter of chauffeurs to lads fresh from our elementary schools, whom I have employed for what I may summarise as washing and greasing purposes. Some six or seven of such lads have passed through my hands during the past nine years, and all of them have been at a primary school for some seven or eight years. They came with good characters, and all had passed up to the fifth or sixth standard. None of them could spell correctly, keep simple accounts, or appear to derive any enjoyment from reading.

Nevertheless, two of them, at all events, gave evidence of a real liking for mechanics, and within a year or so could be trusted to take the engines to pieces, clean them, and replace them with but little supervision. It might be argued that although they had imperfectly acquired the rudiments of "the three R's," the aptitude of these lads was the result of their training. Of this, however, I could find no evidence. It is difficult to understand how these boys could have profited so little by their many years of school life. If such an example is in any way typical, it is time to consider what the country is obtaining in return for the thirty millions annually expended on elementary education alone.

It may be thought that I have been unfortunate in my experience. I do not, however, believe that my case *is* singular. In *The Contemporary Review* for July, 1909, Prof. Stanley Jevons contributed an article on "The Causes of Unemployment." He referred therein to the opportunities afforded him by University Settlement Boys' Clubs in London and Cardiff of forming a judgment concerning the products of our primary schools. He described the following experiment:—

"I arranged to test a few members of the Boys' Club. They were gathered in a room with pens and papers and were asked to write down the following short sentence, which was spoken to them distinctly twice, as an example of the kind of message which they might be expected to have to write occasionally for an employer: "I have not been able to find the book which you sent me to fetch." The test was one both of memory and spelling, and most of the boys failed in one or both respects."

Prof. Jevons gave facsimiles of the results, which I am unable to reproduce; but I can indicate the nature of the spelling. It will be noticed that there are no words of two syllables. The following is the best of the batch:—

Boy aged nearly sixteen: "I cannot (fetch) find the book which you sent me to fetch."

The following are from boys aged fourteen and fifteen respectively:—

"I have not been *abele* to find the *boock whi witch* I sent you (for) to *fitch*."

"I have Not *bend* able to find the book *With* I sent you to *fath*."

All these boys have been through one of our large primary schools.

Prof. Jevons added: "In contemplating the question of unemployment one is at once led to the conclusion to which so many other economic problems ultimately lead—that the only certain means of abating the evil is the improvement of the individual."

Passing from such limited experiences to the views of those who are brought into contact with the products in bulk, a sense of dissatisfaction and uneasiness is no less evident. Consider the following extracts from the presidential address of Mr. Walter Dixon, to the West of Scotland Iron and Steel Institute in October last:—

"I have, over a somewhat extended period and a wide area, made inquiries amongst those who have the control of about 200,000 men in our own allied industries, with the following results:

"It is the unanimous opinion that any book-learning outside the rudiments of 'the three R's' is considered a matter outside the requirements of the education of more than 90 per cent. of the usual manual workers. In other words, the work that these men are called upon to do, the labour which they have to perform in their daily avocation, would be as efficient, as successful, and as expeditiously performed if the men had no school education whatever outside 'the three R's.'"

If there is any truth in this severe indictment there is small cause for wonder if a general sense of uneasiness exists amongst those who consider that the future prosperity and safety of this country are dependent on the manner in which we train the rising generation.

In justice to Mr. Dixon I must give a further extract from his address:—

"During the recent meeting of the British Association in Dundee I spent some time amongst educational authorities, not only those belonging to our own country, but delegates from other nations, and I find that they themselves are beginning to see the futility of the present methods and to realise that they are ploughing the sands. Amongst other matters, it was of interest to note that they are at present promulgating a scheme for what they call vocational education. In other words, I gather that they are now attempting in a modified way to replace the old 'prentice system by teaching trades in their schools, so that children may enter the trades as skilled workers—a system which, to my mind, would render the present confusion more confounded. . . .We must recognise that the mechanical developments of the last half-century have done away in a large measure with the possibility of the interest which man could once take in his daily work, inasmuch that few men now make anything, but only a *small portion of something*. A statement was made at Dundee that 135 different persons were employed in the making of a boot. It is not to be expected that any of these 135 workers can get enthusiastic about their particular bit. We must recognise that as long as we live under the reign of industrial competition the hours of labour are likely to be hours of stress, and that when a man has finished his labour it is only right, it is only human, that he should have hours of reasonable recreation. It is with a view of making these hours of recreation worthy of the nation to which we belong that I feel that our educational methods might, and ultimately will, be altered and rendered valuable."

If I may venture to summarise Mr. Dixon's address as a whole, it appears to me that the argument is somewhat as follows: It is admitted that "the three R's" are necessary for all workers, of whatever grade, almost as necessary for the mental as are sight and hearing for the physical equipment. A large majority of manual labourers, however, are not rendered any more efficient in the discharge of their tasks by further instruction of an academic character, and therefore we should aim at providing them with some form of education which would so quicken their intelligence as to enable them to find an interest in matters external to their employment and thus lead them to utilise their hours of creation in a sane and healthy manner. It should be our object not so much to train all our soldiers as if they were to be generals, as to give them that education which would make them good soldiers, and to spare no expenditure of time or money in the further education and development of the small percentage who have shown those qualities which lead, under proper guidance, to high achievement.

The assumption that all children are fitted to profit by more than the rudiments of academic education is, I believe, responsible for many of our present difficulties. In physical matters we seem to be wiser. We take account of bodily disabilities; we do not train lame men for racing, or enter carthorses for the Derby; we do not accept the short-sighted or the colour-blind as sailors; but those who talk of com-

pulsory further education appear to think that all men are on an equality as regards mental equipment. Democracy in its control of education counts noses rather than brains, I observe, for example, that the education committees, on which I have, or have had, the honour of serving, are unwilling to continue those higher technical classes in science in which the numbers are necessarily small. A class of four in higher mathematics will probably be discontinued, whereas a class of one hundred in shorthand will be regarded as a highly successful achievement.

Such education committees, however, are only carrying out what is apparently the policy of those sitting in the seats of authority. A nation which expends but four millions for the encouragement of higher education and research and thirty millions on the rudiments cannot be said to lend that recognition, assistance, and encouragement to the best brains of the country which is the one form of educational outlay which is certain to bring, as Mr. Wells has truly indicated, not only the best return industrially, but also an immunity from invasion otherwise unobtainable.

It is possible that the views taken by Mr. Dixon and the employers and business men whose opinions I have attempted to gather are unduly pessimistic. I have, therefore, turned naturally to the teachers, with many of whom I am brought into contact.

I find, on the whole, much the same spirit of pessimism prevailing. I can only recollect one gentleman—a teacher of long experience and high standing—who takes a brighter view of the position. According to him, the children leave our schools better instructed, more intelligent, and better mannered than was the case some twenty years ago.

It is true that teachers as a body agree that there has been one real advance—viz., the abolition of the system of payment by results—but many of them admit that during the past ten years progress, if any, has been slight. They plead in extenuation that the large size of the classes is in itself a barrier to real efficiency, and that the teacher is so fettered by regulations, so bothered by the fads of individual inspectors, that we ought to be gratified, rather than disappointed, by the results achieved. It is a significant fact that the supply of teachers for our primary schools is diminishing, and that, as a necessary consequence, the proportion of fully trained and qualified teachers, although increasing, is unduly small. The attractions of the profession are undoubtedly insufficient. When we consider the meagre salaries, the slow, very slow, promotion, the few prizes and the slight social recognition, it is a surprising fact that so many able men and women are prepared to accept the lot of teachers in our primary schools.

The teaching profession, if profession it can rightly be termed, compares unfavourably with the so-called learned professions. It is noticeable that but few of our primary school teachers are prominent in civic affairs. Their representation on education committees, for example, is quite inadequate; during the discharge of their duties they are unable to mix with their fellow-citizens, and thus gain experience in the same manner as the clergyman, the doctor, or the solicitor. The regulations practically forbid participation in public life, and the teachers' activities are regarded as bounded by the walls of the schoolroom.

If the results of our educational system are disappointing, it is not for us to throw the blame on the teachers. Until we learn that satisfactory results can be obtained only when the life and emoluments of the schoolmaster are such as to offer avenues to distinction comparable with those of the learned professions, we cannot hope to attract into what should be, after all, the most important of all professions, the best brains and energies of the community.[1]

Undoubtedly, however, we *have* made advances within the last generation. Our outlook is different, but we are expecting higher achievement without affording that inducement which entitles us to demand it. Our industrial needs have impressed upon us the necessity of a wider view of the meaning of the word "education." We are slowly learning that we should aim at the awakening of the intelligence, rather than at the mere imparting of knowledge by what I might term force-pump methods. Forcible feeding is not proving a success either physically or mentally.

Some fifty years ago a leading name in the educational world was that of Todhunter—a name which I admit was regarded with terror rather than affection by many of us in our school days. As a correction to pessimism I venture to inflict upon you the following extract from Todhunter's "Conflict of Studies," published in 1873:—

"It may be said that the fact makes a stronger impression on the boy through the medium of his sight, that he believes it more confidently. I say that this ought not to be the case. If he does not believe the statement of his teacher—probably a clergyman of mature knowledge, recognised ability, and blameless character—his suspicion is irrational and manifests a want of the power of appreciating evidence, a want fatal to his success in that branch of science he is supposed to be cultivating."

I take a singular pleasure in this extract. In times of depression it serves as a tonic and drives one to the conclusion that, after all, our progress, however slow, is real, although I have an impression that the Todhunter school is not entirely extinct.

So far, the only result of my inquiries has been the discovery, if discovery it was, that dissatisfaction with our present system was the prevailing sentiment. I decided, therefore, to take the somewhat bold step of endeavouring to ascertain the attitude of those who have most to do with the administration thereof. I ventured to send to all the directors of education in England and Wales a series of questions, the answers to which I hoped might throw light on the matter. In order to elicit, if possible, free expression of opinion I stated that their replies would in general be used only for statistical purposes, and in no case would indication be given of the authority with which the writer was concerned.

I take this opportunity of most sincerely thanking the many directors who have been so good as to assist me in this inquiry. No fewer than 121 of these gentlemen have undertaken the task of returning replies, and when I reflect upon the extent to which their energies are employed in compiling returns for their various authorities and for the Board of Education, I realise my temerity in thus adding to their labours.

In analysing the replies it has been necessary to divide them into the following classes, viz.: (1) Counties, (2) county boroughs, and (3) boroughs and urban districts, as the conditions in these areas, under the Act of 1902, differ considerably.

We must remember that as the directors of education have to work the machinery, they are perhaps in a better position than any others to form a judgment as to excellences and defects. True, they look on the matter through official spectacles, which are always more or less tinted, and they may, like many owners of motor-cars, have a tendency to hide imperfections.

[1] It appears that our average expenditure per child per working week (including interest on buildings, &c.) is about 1*s.* 8*d.* Perhaps we are getting in return as much as we deserve at the price.

In Class 1 (counties) I received replies from thirty-six directors; in Class 2 (county boroughs) from forty; and in Class 3 (boroughs and urban districts) from forty-five.

The authorities concerned are fairly representative of all portions of England and Wales, and both of rural and urban districts. In order to render comparisons possible, I express the nature of the replies in percentages of the whole of the class. I believe, however, that the effect of reading out, in circumstances of this kind, a large number of tables containing numerical data would be to occupy a considerable portion of your time, and yet leave but little definite impression. I have, therefore, given these tables as an appendix to this address, and will now only trouble you with a reference to the results and some examples of the interesting remarks included in the replies.

My first question was:—

I. "Do you consider that the centralisation of authority in the hands of county councils has caused any decay of interest in education in your district?"

Reference to Table 1 will show that while in large areas the effect of the Act has been to stimulate interest in educational matters, in small boroughs and urban districts the reverse has been the case. It is difficult, however, to classify strictly many of the replies, as will be seen from the following examples.[2]

As a natural sequence to this interrogation I made the following inquiry, namely:—

II. "Would you prefer the educational authority to be one elected *ad hoc*, as in the days of the school boards, rather than the system as at present established?"

As might be expected, those directors who considered that the present system has caused a decay in local interest are, with some few exceptions, in favour of a return to an authority elected *ad hoc*. Replies in the affirmative form a large proportion of the whole, no less than 72 per cent. of the boroughs and urban districts being in favour of a return to the old system. In considering the answers to both these questions it should be remembered that previous to the Act of 1902 counties, as such, had no experience as regards primary education.

The Act of 1902 gave to the county councils, as regards the constitution of their education committees, considerable powers of cooption. I was anxious to find to what extent this power had been utilised, and, therefore, my third question was:—

III. "To what extent has cooption of members of the education committee been adopted in your area—*i.e.* what proportion do the coopted members bear to the whole committee, and what is the proportion of coopted women members?"

The average percentage of coopted members is curiously equal in all three classes—viz. thirty-one, thirty-three, thirty. The highest percentage is forty-eight, and the lowest three. It is noticeable that the percentage of coopted members is less in Wales than in England. A reference to the tables will show that a considerable number of directors are desirous that the principle of cooption should be extended.

My fourth question was:—

IV. "Have your local committees, or bodies of school managers, the right of appointing (*a*) head teachers, (*b*) assistant teachers?"

I find that, as regards head teachers, more than one-half of the counties, one-third of the boroughs, but only a small proportion of the county boroughs, have delegated all powers; the right of appointing assistant teachers being delegated to a slightly greater extent.[3]

The general result of the replies indicates that the power of appointment is unsatisfactorily exercised by local bodies of managers.

V. "Has the authority established a college for the training of elementary teachers, under its own management, or in conjunction with others?"

I find that as large a proportion as one-seventh of the authorities (counties and county boroughs) whose directors have returned replies have established training colleges. It does not appear, therefore, as if the present dearth of teachers was due to lack of training facilities.

I was anxious to ascertain if the effect of such local training colleges was to restrict the freedom of teachers, and the sixth question was as follows:—

VI. "Is the general effect of the present system to restrict the freedom of choice of teachers to those from your own locality?"

In about half the counties the answer is in the affirmative, and in the county boroughs about four-fifths.

It would appear that, on the whole, the opinion of directors is that the effect of the establishment of local training colleges has been to encourage the evil of what I may term "inbreeding."

VII. "Do you consider the curricula of (*a*) primary, (*b*) secondary, schools under your authority as overcrowded? If so, can you indicate the directions in which you consider there could be a reduction?"

Rather more than half of the authorities consulted considered that the curricula of the elementary schools are overcrowded, and rather more than a third are of the same opinion as regards the curricula of the secondary schools.

VIII. "Are you in favour of an increase in the number of vocational schools? Or do you consider that the effect of such increase would be detrimental to the standard of general education throughout the country?"

One-third of the county directors consulted, and almost half of those of the county boroughs and boroughs, answer in the affirmative, whereas rather more than one-fifth state their inability to arrive at a conclusion. A number of those who answer in the affirmative qualify their replies by stating: "For children over fourteen," or "General education must be first considered," "Provided general education is continued."

As a whole, the weight of opinion is strongly against any increase in vocational schools for children who have not completed their primary education.

IX. "What is the average size of the classes in your primary schools?"

I find that the average size of the classes in the counties is thirty-four, and in the boroughs forty-two, and they vary from over sixty-three down to ten. The smaller average in the counties is evidently due to the large proportion of rural schools.

My next question concerned the counties only. I was anxious to ascertain the effect of the clause of the Act which places on the locality the task of finding the greater portion of the money for additional buildings, viz.:—

X. "Do you consider Par. 18, 1 (*a*), (*c*), (*d*) of the 1902 Act to work harshly or to the disadvantage of educational progress?"

It appears that some 40 per cent. of the directors are of opinion that the effect of the clause is unsatisfactory. It must be remembered that it is not probable

[2] The examples referred to will be found in the address as printed in full and issued by the British Association.

[3] As regards non-provided schools, in all cases (by the Act) the power o appointing head teachers is in the hands of the managers.

that the officials of county councils would regard this matter from an impartial point of view, for, no doubt, the existing conditions lighten the burden of the county rates. It is somewhat surprising that in such circumstances the percentage of those answering in the affirmative is so large.

XI. "Has your council delegated to your education committee all the powers permitted by the Act? If not, are you in favour of such delegation?"

I find that while over 90 per cent. of the county authorities have delegated all powers, less than one-half of the county boroughs and three-fifths of the boroughs and urban districts have adopted the same course. An overwhelming majority (85 per cent.) of the directors of all classes are in favour of full delegation.

XII. "Please add any special criticisms of, or suggestions for, improvements in the Act."

It was very evident that most of my correspondents were anxious to avoid an expression of their views in this matter. The nature of many of the replies may be indicated by that of one of the directors—namely, "No, thank you." On the other hand, several have been so good as to write me short treatises on the subject, containing very valuable expressions of opinion. It is difficult, however, to quote from many of these without betraying the condition on which I invited confidence—namely, that I would give no indication as to the localities concerned. On one matter all who have expressed their opinions are in accord, viz.: "The greatest difficulty of the Act is the dual control for non-provided schools, more especially with regard to staffing."

It is stated that "the transfer and promotion of teachers is almost impossible under the present system." I feel, however, that the less I touch on this aspect of the matter the better for the peace of mind of this section. Again, all directors urge the necessity of relieving the increasing burden of the rates. One states that the proportion of Treasury grants has dropped from 66 per cent. in 1906 to 48 per cent. in the past year, while the local rate has been nearly trebled. Again: "Some means should be obtained to enable authorities with a large number of rural schools to provide adequate education without increasing the overwhelming burden now imposed upon them."

I may sum up as follows the impression left on my mind by the study of all the replies, of which I have given only a few examples.

1. The Act appears to give greater satisfaction in the counties than in the county boroughs and boroughs and urban districts, although even in the counties the position of the smaller rural schools is a cause of dissatisfaction.

2. That in the boroughs there is, on the whole, a preponderance of opinion in favour either of an authority elected *ad hoc*, or a more liberal exercise of the power of cooption.

3. That there is a preponderance of opinion that the appointments of school teachers should in all cases rest in the hands of the L.E.A.

4. That there is a tendency under the present system, except in centres of large population, to restrict the choice of teachers to those who have received their education locally, and that the effect of such restriction is detrimental.

5. That greater freedom in educational matters is advisable. The effect of the present system is to produce a dull uniformity, although it is doubtful whether the head teachers themselves or the Board of Education are most to blame.

6. That an increase in the number of vocational schools is not desirable, unless great care is taken that only those scholars are admitted who have received a sound general education.

7. That one of the greatest hindrances to progress is the large size of the classes.

8. That there should be a greater delegation of powers to the education committees, and that the L.E.A. should have complete control over all forms of education within its own area.

9. That a Redistribution Bill in the matter of areas is desirable, especially in the relation of urban areas to the rural districts connected with them.

10. That the dearth of fully qualified teachers cannot be remedied until the profession is made sufficiently attractive by increased emoluments and more rapid promotion. Mere increase in the number of training colleges is no remedy.

11. And, lastly, there is a consensus of opinion that a greater proportion of the cost of education should be borne by the Treasury, and that the danger to education arising from the rapid rate of increase in the education rate is a very real one. If education in this country is to be successful it must be made popular. This is impossible when every step in advance means an addition to the local burdens.

I am afraid that the tenor of this correspondence does little to modify the pessimistic views to which I have previously directed attention. Regarded in bulk it conveys the idea that the writers are endeavouring to make the best of a bad case. As shown by the last reply quoted (*supra*), the race of Mark Tapleys does not appear to be entirely extinct.

I wish it had been possible to obtain the confidential opinion of H.M.I.s, but I, at all events, am not one who would dare to question the gods, the distinguishing characteristic of those admirable officials being a cold infallibility which renders approach inadvisable. It must be remembered, however, that veiled hints of the need of drastic reforms have emanated from the highest quarters, and one of the most hopeful signs of the situation is that such information as has been vouchsafed to us appears to indicate that those who are moving in the matter actually acknowledge that there is an educational as well as a sectarian and a political aspect of the question. Nevertheless, so far as I am personally concerned I still find my chief consolation in the quotation from Todhunter which I have already inflicted upon you.

I am now going to take a bold step—namely, to express my own opinion on this matter of primary education. I consider that we are proceeding in the wrong order, in that we give greater prominence to the acquisition of knowledge than to the development of character.

There is truth in Emerson's dictum that "the best education is that which remains when everything learnt at school is forgotten." We appear to think that the learning of "the three R's" *is* education. We must remember that in imparting these we are only supplying the child with *means* of education, and that even when he has acquired them the mere addition of further knowledge is again not education. If we impart the *desire* for knowledge and train the necessary mental appetite, the knowledge which will come by the bucketful in after life will be absorbed and utilised.

It is, I know, easy to talk platitudes of this kind. We have, in justice to the teacher, to remember that character depends on home life, as well as on school life; but, nevertheless, if we could educate public opinion on this matter progress might be possible. We want to introduce the spirit of our much-abused public schools into all schools, namely, a sense of

responsibility—and, as a necessary sequence, a sense of discipline—a standard of truthfulness and consideration. In this connection I have been greatly impressed by a report issued by the Warwickshire County Council on the effect of the establishment of the prefect system in the elementary schools of that county, and I wish it was possible to place this report in the hands of every teacher in the country. It is stated in the introduction that "the fundamental idea of the prefect system is the formation and development of character and the utilising for this purpose of the efforts and activities of our pupils themselves."

The pamphlet contains a description of the system as established, and the different methods adopted in the schools of the county in carrying it into effect.

A summary of the head teachers' remarks, compiled by the Director of Education, is given as an appendix, and I cannot resist the temptation to quote largely from his report:—

"In the autumn of 1911 a conference of head teachers was held on prefect systems in elementary schools. It was then decided that all the head teachers present should try the system for a year, each one on his or her own lines, and then report as to its working.

"Nearly all have now made reports, one only having failed without good cause. Reports have come in from six large or middling boys' schools, three large girls' schools, two large mixed schools, mostly in villages, and one infants' school—twenty-three in all, embracing schools of practically every type.

"The record, with one exception, is a story of success, in most cases of extraordinary success, so much so as to put the possibility and value of the system beyond a doubt. Whether in developing the prefect's own character, or in creating a sense of school honour among the other children, or in smoothing the whole working of the school, the result is equally striking. And the more ambitious the scheme of a school, the more it approximates to the public school tradition, the bigger the faith in boy and girl nature, the greater has been the success. The few evidences of comparative disappointment come from schools where the system has been tried haltingly and with distrust. Where there has been courageous faith in the children they have risen to it to a degree that must surprise even those who were readiest to believe in school self-government. Nor is the success confined to large schools or boys' schools. Boys' and girls' and mixed schools, town schools and village schools, all have the same tale to tell. A supply teacher who has served in seven schools since the conference has found that 'from all classes of children, town and country, a ready response is made to an appeal for added responsibility and trust on their part.' . . .

"The prefect, being in authority himself, comes to see the necessity and value of discipline. He is as keen as is his head for the school's honour; he worries the unpunctual, he takes charge of the playground. He is proud at being asked and able to help in matters of school routine, most of all when the teacher is called out of the class-room and he is himself responsible for order. And woe then to the disorderly or slack! . . .

"In its way one of the most remarkable applications of the system is its appearance in a miniature form in an infants' school. Children of six and seven, happy in the possession of the monitor's bow of ribbon, take care of the younger children and remove dust which has escaped the caretaker's eye. . . .

"It is a moot point whether a written constitution helps or not. Some teachers deprecate rules, as limiting a prefect's sense of responsibility and his freedom to follow out his own ideas. That rules, however, meet some want seems to be proved by the fact that at a school where the head master had purposely made none the boys themselves drew up their code, and, the head master adds: 'I could not have got out any better rules.'"

The origin of the movement the results of which are thus described is due to the man whom I regard as the greatest educator of our time—namely, Sir Robert Baden-Powell. I believe that the Boy Scout movement is rendering greater service than our complicated State machinery in preparing those who are brought within its influence for the struggles of life. It is a matter for regret that so small a fraction of the children in our schools is able to share its benefits. I only wish it were possible for our political system to admit the appointment of Baden-Powell as Minister of Education, with plenary powers, for the next ten years!

He states that when visiting a great agricultural school in Australia he asked the principal to inform him briefly what was the general trend of his training. The reply was: "Character first; then Agriculture."

If this, suitably modified, could be adopted as the motto for all our schools, the present attitude of the man in the street towards education would soon undergo modification.

There is truth in Dr. Moxon's statement that "A man has to be better than his knowledge, or he cannot make use of it," and our efforts should be mainly directed to making the character and the intelligence of the child so much better than his knowledge that increase in knowledge will follow as a matter of course. Let us devise some kind of universal junior scout system which may so brighten the intelligence that the boy will *want to know*. Let him also discover that the paths to knowledge are reading, writing, and arithmetic; he will then gladly follow his guides and gather more by the way than when he is pushed along those paths in a perambulator.

So long as we attach greater importance to the results of examination than to the judgment of the teacher our system stands self-condemned, for it places knowledge above character.

It is natural that the discontented amongst us should try to cast the blame on those in authority, and I confess that at times I feel as if I could join the militant section and relieve my feelings by throwing stones through the windows of the Board of Education; but in recent years I have been privileged to pass to the other side of those windows, and I have, to some extent, been led to realise how able and how devoted are the men to whom the guidance of our educational system is entrusted. All who are brought in contact with them must acknowledge their earnestness and their zeal in the cause in which they are enlisted, and it is remarkable how, in the discussion of educational questions, they can, in moments of partial *abandon*, cease to be strictly official and become almost human. It is evident, however, that the aim of such men must ever be the smooth working of the machine as a whole. The comforting words "coordination," "uniformity," "efficiency," are ever in their minds. A system planned on one great design and perfected in all its details is the ideal for which they are bound, consciously or unconsciously, to strive. The pity of it is that the more successful their efforts, the worse it is for education in this country.

Evolutionary progress is only possible where variety exists, and variety is necessarily abhorrent to the official mind. Freedom for local authorities to adopt their own methods, to experiment—and often to fail—is the system, if system it can be called, by which

alone advance is possible. The curse of uniformity, perhaps the greatest curse of all, is a necessary consequence of over-centralised control.

I have trespassed so greatly upon your forbearance in discussing matters connected with primary education that I must give but brief expression to any views concerning the secondary and higher branches.

As I have previously indicated, State aid should be restricted to those who are able to profit thereby. The 25 per cent. free-place regulation has, it is generally admitted, brought into the secondary schools many really able students. On the other hand, there is no doubt that a certain proportion thereof would be more profitably employed in serving their apprenticeship in the business in which they are to earn their bread-and-butter. It is, of course, understood that those whose parents can afford to pay for the further education of their children and who are ready to do so are not here referred to, but, careful selection assured, generous assistance to those in need of help suggests itself as the best policy.

Another subject for consideration is the disproportion between the assistance given by the State to the training of primary and of secondary teachers. I understand that to the latter object, so far as England and Wales are concerned, the not impressive sum of 5000*l.* is delegated. After making due allowance for the difference in numbers under the respective headings, it is difficult to understand how it is necessary to expend a sum approaching 700,000*l.*[4] on the training of primary teachers, and only 1/140th of that amount on training those who are to guide our most able students in the pursuit of knowledge.

Had time permitted I should have liked to dwell on the evil effects of what I may term our conspiracy of silence regarding sexual instruction. If the proverbial visitor from Mars was engaged in a tour of inspection in our country, I think nothing would strike him as more extraordinary than that a subject which so closely concerns the progress of the race and the welfare of the individual should be entirely ignored in our system of education. By our action (or rather want of action) we tacitly admit that knowledge is harmful, and that we deliberately prefer such knowledge, which must necessarily be attained in one way or another, to arrive by subterranean channels and by agencies which will present facts of vital importance in their worst possible aspect.

We cannot be said to be really educating our children so long as we withhold from them all guidance in one of the most difficult problems which will be presented to them in later life, and when one reflects on the misery and wreckage consequent on our silence, it is difficult to speak with due moderation. I will therefore content myself with suggesting to those interested in this matter a study of the procedure adopted in the schools of Finland, in which systematic instruction is given by carefully selected teachers; it is stated with the happiest results.

I have referred, when speaking of primary education, to the curse of uniformity as one of the greatest evils of our educational system. So far, at all events, our provincial universities have escaped, although not entirely unscathed, from the cramping effects of departmental control. The situation, however, is not free from danger. It is necessary that these universities should be State-aided. It is also evident that, if we are to hold our own in competition with other nations, State assistance must be increased. There is danger, therefore, that the blight of uniformity and official control may descend upon them. The danger is not immediate, but it is nevertheless real. To some of us an ominous sign was the transference of the dispensation of the university grants from the Treasury to the Board of Education. It is true that we have evidence that no desire for undue control is manifest at the present time, and it is an encouraging sign that the Minister of Education, in a recent dispute connected with one of our youngest universities, intimated that he considered it beyond his province to interfere with its proceedings.

In this connection Mr. Austen Chamberlain has given me permission to read the following extract from a letter which I recently received from him:—

"I am in complete agreement with you as to the importance of preserving to the universities the greatest possible freedom and liberty. For this very reason I was at first strongly opposed to transferring the administration of the Treasury grants to the Board of Education; but I found that, for one reason and another, a considerable portion of their receipts were already received from the latter Board, and it was represented to me that this involved unnecessary complication and overlapping, and that the universities were likely to receive more generous consideration if the whole of the grants were placed in the hands of a single authority. At the same time I was assured that the Board of Education had no desire to claim a control different in character or extent from that which the Treasury had previously exercised. On receiving these assurances I withdrew my opposition to the transfer and sent word to the Chancellor of the Exchequer that I no longer held him bound by an undertaking which he had given me in the House of Commons that the transfer should not take place."

Another encouraging sign is the *personnel* of the Advisory Committee which the Board has established to guide it in matters connected with the University grants. We cannot, however, be certain that such wise views will always prevail, and I have already dwelt on the inevitable tendency of any department of State to influence and control the policy of all bodies receiving assistance from the Treasury.

The freedom of the universities is one of the highest educational assets of this country, and it is to the advantage of the community as a whole that each university should be left unfettered to develop its energies, promote research and advance learning in the manner best suited to its environment. It is conceivable that it might be better for our universities to struggle on in comparative poverty rather than yield to the temptation of affluence coupled with State control.

The State is at present devoting some 180,000*l.* to the support of university education in England and Wales. If, in addition, we include such institutions as the National Physical Laboratory and the grant of 4000*l.* to the Royal Society, we may say that this country is expending about 200,000*l.* per annum on the highest education and the promotion of research, a total but slightly exceeding that devoted to *one* of the universities of Germany. Comment appears needless.

When we reflect on the magnitude of the results

[4] Note I.—Grants for 1911–12:—

1. Grants from Board of Education:—		
(*a*) Maintenance grants to training colleges and hostels	£470,910	
(*b*) Building grants	93,406	
		£564,406
2. Grants from L.E.A.'s:—		
(*a*) To training colleges	21,682	
(*b*) To hostels	787	
(*c*) Scholarships (not possible to ascertain total)	?	
		22,469
Total		£586,875

Note II.—To the above must be added the grants in aid of bursars and pupil teachers, which amount to £101,802.

which would inevitably follow an adequate encouragement of research, the irony of the position becomes more evident. It was stated on authority that Pasteur during his lifetime saved for his country the whole cost of the Franco-Prussian War. It is computed that nearly one and three-quarter millions of our population are to-day dependent for their living upon industries connected with the mechanical generation of electricity—a population which may be said, without undue use of imagery, to be living on the brain of Faraday. We possess mathematicians who, granted encouragement, opportunity, and time, could establish laws of stability of aëroplanes. Suppose we spent some millions in discovering *the* man and enabling him to complete his task; the result might be an addition to our security greater than that of a fleet of super-Dreadnoughts. Unfortunately, there are no votes to be gained by the advocacy of opportunities for research!

Associations such as ours should spare no effort to bring home to the minds of the people the truth of the statement that the prosperity of this kingdom is dependent on its industries, and that those industries are founded on applied science.

Some years ago the *Petit Journal* invited its readers to answer the question, "Who were the twenty greatest Frenchmen of the nineteenth century?" No fewer than fifteen million votes were recorded. The resulting list included the names of nine scientific men, and Pasteur led by 100,000 votes over Victor Hugo, who came second, Napoleon securing the fourth place. It is obvious that a poll of such magnitude must have been representative of all classes. I ask you to reflect on the probable result, *mutatis mutandis*, if such a poll was taken in this country. I am afraid we should find the names of football and cricket heroes included, but I doubt if the name of a single man of science would appear amongst the immortals.

It should be our mission to make evident to the working man his indebtedness to the pioneers of science. Demonstrate to him the close connection between the price of his meat and the use of refrigerating processes founded on the investigations of Joule and Thomson; between the purity of his beer and the labours of Pasteur. Show the collier that his safety is to no small extent due to Humphry Davy; the driver of the electric tramcar that his wages were coined by Faraday. Make the worker in steel realise his obligation to Bessemer and Nasmyth; the telegraphist his indebtedness to Volta and Wheatstone, and the man at the "wireless" station that his employment is due to Hertz. Tell the soldier that the successful extraction of the bullet he received during the South African war was accomplished by the aid of Röntgen. Convince the sailor that his good "landfall" was achieved by the help of mathematicians and astronomers; that Tyndall had much to do with the brilliancy of the lights which warn him of danger, and that to Kelvin he owes the perfection of his compass and sounding line. Impress upon all wage-earners the probability that had it not been for the researches of Lister they, or some member of their family, would not be living to enjoy the fruits of their labours. If we can but bring some 5 per cent. of our voters to believe that their security, their comfort, their health, are the fruits of scientific investigation, then—but not until then—shall we see the attitude of those in authority towards this great question of the encouragement of research change from indifference to enthusiasm and from opposition to support.

When we have educated the man in the street it is possible that we may succeed in the hardest task of all, that of educating our legislators.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

BIRMINGHAM.—A valuable addition to the equipment of the mining department of the University has been made in the form of an electrically-driven oil-boring derrick, which has been presented by the Oil-well Engineering Company, of Cheadle. The apparatus is capable of boring to a depth of 2000 ft., and by its means mining students will be able to acquire practical experience in the handling of oil-boring plant.

The following appointments have been made:—Mr. L. J. Wills, assistant lecturer in geology and geography; Mr. David Brunt, lecturer in mathematics (to succeed Mr. S. B. McLaren); Dr. C. L. Boulenger, reader in helminthology; Mr. H. G. Jackson, assistant lecturer in zoology.

By the will of the late Henry Follett Osler the University is to receive the sum of 10,000*l.*, with a prospective share in the residuary estate.

LEEDS.—The following appointments have been made to the staff of the University:—Mr. S. H. Stelfox, assistant lecturer and demonstrator in engineering; Mr. F. Powis, demonstrator in chemistry; Mr. E. Lee, assistant lecturer in agricultural botany; Mr. N. M. Comber, assistant lecturer in agricultural chemistry; Mr. D. B. Morgans, assistant lecturer and demonstrator in mining.

THE Concrete Institute has arranged a course of six educational lectures on reinforced concrete: its commercial development and practical application, to be given by Mr. H. Kempton Dyson, on Wednesdays in November and December, beginning on November 12. The lectures will be given in the Lecture Hall of the institute, Westminster. There is no fee for the course; admission will be by ticket, obtainable on application from the secretary, the Concrete Institute, Denison House, 296 Vauxhall Bridge Road, Westminster, S.W.

AN examination of the prospectus of the East Ham Technical College, which was opened in 1905, and on which some 33,000*l.* was spent, shows that the boroughs round London are fully alive to the importance of providing a practical training in technology and science for those engaged in the industrial pursuits of the locality. The work of the college is done in some eight departments, and important among these are those for men engaged in building trades, engineers, chemists, commercial men, and for women workers. The more elementary evening classes are held in three preparatory evening schools in different parts of the borough, but in the college itself a preparatory industrial course has been provided designed to enable students later to follow intelligently the lectures and laboratory work in the different departments of technology.

PRESIDING at a recent meeting of the Senate of Calcutta University, Sir Ashutosh Mookerjee made an interesting speech on some of the work of the University. According to a report of the speech given in *The Pioneer Mail*, the University has arranged for lectures for M.A. and M.Sc. students in eleven different branches of study, including pure mathematics and botany. The University has made itself directly responsible for the instruction of 1005 students in Calcutta in these subjects for the M.A. and M.Sc. examinations. Post-graduate teaching on this scale has never before been attempted in any Indian university, and that there is a genuine demand for higher instruction is established by the readiness with which students in large numbers have eagerly joined the classes in such subjects as pure mathe-

matics. The Government of India has made a liberal grant for the acquisition of a site, and plans have been nearly completed for further extension of the University buildings. When the new buildings are erected, there will be ample accommodation for the purposes of instruction, and, it will be possible to accommodate on the premises at least two hundred post-graduate students.

THE calendar for the session 1913–14 of the North of Scotland College of Agriculture has reached us. The classes of the college are held in the University of Aberdeen, except the class in agricultural engineering, which is held in Robert Gordon's Technical College, Aberdeen. The courses of instruction provided are arranged for the benefit of every section of the agricultural community. Persons who can attend the college only for four consecutive weeks in winter will find a short practical course extending over four weeks and including lectures on such subjects as feeding-stuffs, live-stock, diseases of animals, and so on. The full lectures on agriculture and agricultural chemistry extend over three years, but the complete course is modified in a variety of ways to meet particular needs and to enable students to secure the college diploma or the national diploma in agriculture. There is a special department of forestry, and for practical work, through the liberality of several landed proprietors, excellent facilities are afforded. The close proximity to Aberdeen of large wooded areas places it in an advantageous position for the teaching of forestry. Farmers residing within the college area are entitled to receive advice and assistance from members of the college staff free of charge. There is, also, a carefully arranged scheme of county extension work under the superintendence of a general county organiser.

THE calendar of the University of Sheffield for the session 1913–14, a copy of which has been received, provides striking evidence of the successful efforts which provincial universities are making to keep in close touch with the varied actvities of the districts they serve. Not only does the University of Sheffield train students who desire to follow the usual academic courses which culminate in degrees in arts, pure science, medicine, law, and so on, but it provides also graduated instruction in such applied sciences as engineering, metallurgy, and mining, and awards degrees in these branches of technology to students who at the end of the training comply with the reasonable regulations specified in the calendar. To meet the special needs of students whose circumstances make it impossible for them to devote the time necessary for complying with the conditions for degrees, associateship and diploma courses have been arranged. The mining department of the University carries out a system of extension lectures in technical science in the West Riding of Yorkshire; a works pupils' certificate course has been arranged by the University in consultation with the Sheffield Master Builders' Association to meet the requirements of students who are working with the object of becoming master builders; a diploma course in domestic science has been inaugurated; and in other ways the University is assisting the higher education of Sheffield workers.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 13.—M. F. Guyon in the chair.—Paul **Marchal**: The acclimatisation of *Novius cardinalis* in France. In 1912 *Icerya purchasi* was accidentally introduced into France, at Cap Ferrat, and caused great damage. This plant pest has been successfully fought in California and elsewhere by the introduction of its natural enemy, *Novius cardinalis*, and steps were taken to acclimatise this at Cap Ferrat. The results were completely successful, the Icerya being rapidly exterminated.—Charles **Depéret**: The fluvial and glacial history of the Rhône valley in the neighbourhood of Lyons. Evidence is given that there were three glacial invasions of this region and not two, as currently held, leading to the formation of three fluvio-glacial terraces.—Leopold **Fejér**: Trigonometric polynomials.—Michel **Fekete**: A property of the roots of the arithmetical means of a real integral series.—N. **Gunther**: The cononical form of algebraical equations.—M. **Tomassetti** and J. S. **Zarlatti**: The problem of two bodies of variable masses.—Thadée **Peczalski**: Relations between the coefficients of expansion and the thermodynamical coefficients.—France **Giraud**: Certain reactions depending on reply currents.—R. **Dongier** and C. E. **Brazier**: The sound effect produced at the contact of a metallic point and the surface of a crystal or a metal by the passage of an alternating current. A faint musical note was first noted in a galena detector at the Eiffel Tower. Means have been found to reinforce this note so that wireless signals can be heard at a distance of 22 metres from the apparatus.—Ch. **Gravier**: An automatic method of developing photographic plates.—B. A. **Dima**: The photo-electric effect of metallic compounds. The photo-electric effect of analogous compounds of the same metal depends on the valency of the metal in those compounds. The four oxides of manganese offer a clear example of this.—Yugi **Shibata** and G. **Urbain**: The spectrochemistry of the complex cobalt compounds. A study of the absorption bands in the visible and ultra-violet spectra of solutions of complex cobalt salts.—M. **Taffanel** and Le **Floch**: The combustion of gaseous mixtures. Mixtures of methane and air were heated to various temperatures between 535° C. and 640° C., and the rates of combustion measured. These results are extrapolated to evaluate the inflammation temperatures of these mixtures.—P. **Lemoult**: Leucobases and colouring matters of diphenylethylene. The first stage of oxidation of the *cyclo*hexylidenic leucobase,

$$E.H_{10}.=C.[EH_4N(CH_3)_2]_2.$$

Tetrahydro-malachite green.—C. **Gerber** and P. **Flourens**: The trypsin of *Calotropis procera* and the poison which accompanies it. The latex contains a proteolytic ferment very resistant to heat, and most active in alkaline or neutral media. It coagulates milk and digests casein and fibrin. Injected subcutaneously it is rapidly fatal to some animals (guinea-pig, pigeon), whilst in others it produces only local troubles (white rat, rabbit). Separation of the trypsin and the toxic substance has not been effected.—A. **Gouvel**: The genus Palinurus in Madagascar.—A. **Brachet**: The inhibiting action of the sperm of *Sabellaria alveolata* on the formation of the membrane of fertilisation of the egg of *Paracentrotus lividus*.—A. **Paillot**: Parasitic coccobacilli of insects.—Sabba **Stefanescu**: The structure of the crown of the elephant's molars.—Michel **Longchambon**: The breccia of the marmorean complex: conclusions which may be drawn concerning the age and the localisation of lherzolite.—François **Picavet**: The commemoration of Roger Bacon in 1914. It is proposed to publish a complete edition of Roger Bacon's works.

CAPE TOWN.

Royal Society of South Africa, September 17.—The president in the chair.—W. A. **Jolly**: The interpretation of the electrocardiogram. The interpretation of the electrocardiogram has remained doubtful, notwithstanding the large amount of work that has been

devoted to it in recent years, and very divergent views are entertained as to the significance of the various features of the curve without conclusive evidence having been adduced for them. The author gives an explanation arrived at from experiments on the isolated tortoise heart, and especially from cases of systolic alternation in auricles and ventricle.—Paul A. **Methuen** and John **Hewitt**: A contribution to our knowledge of the anatomy of the chameleon. After making a comparative examination of the lungs, sternum, and skull in various members of the family the authors conclude that the most generalised and probably most primitive forms are the genera Brookesia and Rhamphoteon (the latter not actually examined by the authors), whilst the viviparous small chameleons of the pumilus group, so characteristic of South Africa, are the most primitive in the genus Chameleons: for these latter species, pumilus and allies, the authors revive the old generic name Lophosaura of Gray. It appears probable that the family, as we know it to-day, has spread from a centre of origin situated in that portion of the Ethiopian region of which there now remains two separated components, Madagascar and the Cape province of Sclater. There is no evidence in favour of a northern origin for this family.—R. **Marloth**: Note on the Pollination of *Encephalartos altensteinii* (Kaffir bread tree). The insect on which the transport of the pollen from the male cone to the female cone of *Encephalartos altensteinii* and *E. villosus* depends is not a Phlœophagus, as stated in a paper recently published in the Transactions of the Royal Society, S.A., but *Antliarrhinus zamiae*, that means the same insect which lives in the seeds of these plants until the cones disintegrate and enable the mature insect to escape from them. The female insect pollinates the ovules while moving about between them for the purpose of depositing its eggs. Although according to Dr. Rattray's observations, some or most, or even sometimes all, the seeds of a cone are thus destroyed by the grubs of the insect, the visits of the insect are nevertheless essential to the plant, for without them no seeds would be formed at all. The case is quite parallel to that of the Yucca moth (Pronuba), which, while depositing its eggs into the pistil of the Yucca, pollinates the flower.

GÖTTINGEN.

Royal Society of Sciences.—The *Nachrichten* (physico-mathematical section), part 3 for 1913, contains the following memoirs communicated to the society:—

July 20, 1912.—A. **Ansel**: Seismic records at Göttingen during 1911 (with seven figures and a table, illustrating the graphical solution of spherical triangles).

March 8, 1913.—L. **Geiger**: Seismic records at Göttingen during 1909.

May 24.—G. **Pólya**: Approximation by means of polynomials, all the roots of which fall within an angular sector.—R. **Fueter**: A property of the *Klassenkörper* of complex multiplication.—G. **Tammann**: The melting point.—O. **Mügge**: Filiform crystals of green vitriol and silver.—L. **Godeaux**: Cyclic involutions of order $2a$ and genus 1 on a surface of genus 1.

July 5.—R. W. **Hoffmann**: The embryonic development of the Strepsiptera (preliminary communication, with figures).

July 19.—D. **Hilbert**: Remarks on the foundation of an elementary theory of radiation.—O. **Toeplitz**: A problem, connected with Dirichlet-series, in the theory of series of powers of an infinite number of variables.

The business communications (part 1 for 1913) include reports by H. **Wagner** on the Samoa Observatory for 1912–13, and by F. **Klein** on the progress of the publication of Gauss's works.

BOOKS RECEIVED.

Studies in Cancer and Allied Subjects. Vol. i., The Study of Experimental Cancer. A Review. By Dr. W. H. Woglom. Pp. xi+288+plates. Vol. iii., From the Department of Zoology, Surgery, Clinical Pathology, and Biological Chemistry. Pp. ix+308. (New York: Columbia University Press.) Each 5 dollars net.

A Geography of the British Empire. By W. L. Bunting and H. L. Collen. Pp. iv+159. (Cambridge University Press.) 3*s*. 6*d*.

Early Wars of Wessex. By A. F. Major. Edited by the late C. W. Whistler. Pp. xvi+238. (Cambridge University Press.) 10*s*. 6*d*. net.

Weeds: Simple Lessons for Children. By R. L. Praeger. Pp. x+108+iii plates. (Cambridge University Press.) 1*s*. 6*d*. net.

The Freezing-Point Lowering, Conductivity, and Viscosity of Solutions of certain Electrolytes in Water, Methyl Alcohol, Ethyl Alcohol, Acetone, and Glycerol, and in Mixtures of these Solvents with one another. By H. C. Jones and collaborators. Pp. vii+214. (Washington, D.C.: Carnegie Institution.) 2 dollars.

The Wonders of Wireless Telegraphy. By Prof. J. A. Fleming. Pp. xi+279. (London: S.P.C.K.) 3*s*. 6*d*. net.

A Text-book of General Embryology. By Prof. W. E. Kellicott. Pp. v+376. (New York: H. Holt and Co.) 2.50 dollars.

Industrial and Commercial Geography. By Prof. J. R. Smith. Pp. xi+914. (New York: H. Holt and Co.) 3.50 dollars.

Die Atomionen chemischer Elemente und ihre Kanalstrahlen-Spektra. By Dr. J. Stark. Pp. 43. (Berlin: J. Springer.) 1.60 marks.

Zur Krise der Lichtäther-Hypothese. By Prof. P. Ehrenfest. Pp. 23. (Berlin: J. Springer.) 60 pfennigs.

Die Europaeischen Schlangen. By Dr. F. Steinheil. Drittes Heft. Plates 11 to 15. (Jena: G. Fischer.) 3 marks.

Mendelism and the Problem of Mental Defect. I., A Criticism of Recent American Work. By Dr. D. Heron. Pp. 62. (London: Dulau and Co., Ltd.) 2*s*. net.

The Shetland Pony. By C. and A. Douglas. With an Appendix on the Making of the Shetland Pony, by Prof. J. Cossar Ewart. Pp. xi+176+plates. (Edinburgh and London: W. Blackwood and Sons.) 10*s*. 6*d*. net.

The Sugars and their Simple Derivatives. By Dr. J. E. Mackenzie. Pp. xvi+242. (London: Gurney and Jackson.) 7*s*. 6*d*. net.

The Absorption Spectra of Solutions as affected by Temperature and by Dilution. By H. C. Jones and J. S. Guy. Pp. vii+93+22 plates. (Washington: Carnegie Institution.) 2 dollars.

Reversion in Guinea Pigs and its Explanation. By W. E. Castle. Experimental Studies of the Inheritance of Color in Mice. By C. C. Little. Pp. 102+5 plates. (Washington: Carnegie Institution.)

A First Book of Nature Study. By E. Stenhouse. Pp. iv+148. (London: Macmillan and Co., Ltd.) 1*s*. 6*d*.

Die Grundlagen der Naturphilosophie. By Dr. H. Dingler. Pp. x+262. (Leipzig: Unesma G.m.b.H.) 6 marks.

Fortschritte der Naturwissenschaftlichen Forschung. Edited by Prof. E. Abderhalden. Neunter Band. Pp. 280. (Berlin and Vienna: Urban and Schwarzenberg.) 15 marks.

Objektive Psychologie oder Psychoreflexologie die Lehre von den Assoziationsreflexen. By Prof. W.

von Bechterew. Pp. viii+468. (Leipzig and Berlin: B. G. Teubner.) 16 marks.

Physikalisches über Raum und Zeit. By E. Cohn. Zweite Auflage. Pp. 24. (Leipzig and Berlin: B. G. Teubner.) 80 pfennigs.

Das Relativitätsprinzip. By H. A. Lorentz, A. Einstein, and H. Minkowski. Pp. 89. (Leipzig and Berlin: B. G. Teubner.) 3 marks.

The Silicates in Chemistry and Commerce. By Drs. W. and D. Asch. Translated, with Critical Notes and some Additions, by A. B. Searle. Pp. xx+456. (London: Constable and Co., Ltd.) 21*s*. net.

The Respective Standpoints of Psychology and Logic. By M. Castro. Pp. 77. (Chicago: University of Chicago Press; Cambridge University Press.) 2*s*. net.

Canada. Department of Mines. Mines Branch. Economic Minerals and Mining Industries of Canada. By the Staff of the Mines Branch. Pp. 77+xix plates. (Ottawa: Government Printing Bureau.)

Problems of Genetics. By W. Bateson. Pp. ix+258. (Oxford University Press.) 17*s*. net.

University College, Reading. Studies in History and Archæology: Black Glaze Pottery from Rhitsona in Boeotia. By Prof. P. N. Ure. Pp. 63+xix plates. (Oxford University Press.) 7*s*. 6*d*. net.

Insect Biographies with Pen and Camera. By J. J. Ward. Pp. xii+206+plates. (London: Jarrold and Sons.) 6*s*. net.

Die Elemente der siebenten Gruppe des periodischen Systems. Aus Abegg's Handbuch der anorganischen Chemie. Vierter Band. Zweite Abteilung. Edited by Dr. F. Auerbach. Pp. x+904. (Leipzig: S. Hirzel.) 26 marks.

Zellen- und Gewebelehre Morphologie und Entwicklungsgeschichte. I., Botanischer Teil. By E. Strasburger and W. Benecke. Pp. vi+338. II., Zoologischer Teil. By R. Hertwig, H. Poll, O. Hertwig, and others. Pp. vi+538. (Leipzig and Berlin: B. G. Teubner.) 10 marks and 16 marks respectively.

Biochemie der Pflanzen. By Dr. F. Czapek. Zweite Auflage. Erster Band. Pp. xix+828. Jena: G. Fischer.) 24 marks.

Flies in Relation to Disease. Non-Bloodsucking Flies. By Dr. G. S. Graham-Smith. Pp. xiv+292+xxiv plates. (Cambridge University Press.) 10*s*. 6*d*. net.

The English Year. By W. B. Thomas and A. K. Collet. Pp. viii+408+plates. (London and Edinburgh: T. C. and E. C. Jack.) 10*s*. 6*d*. net.

Industrial Organic Analysis. By P. S. Arup. Pp. xii+340. (London: J. and A. Churchill.) 7*s*. 6*d*. net.

Sleeping Sickness in the Island of Principe. By Surgeon-Captain B. F. Bruto da Costa. Translated by Lieut.-Col. J. A. Wyllie. Pp. viii+90. (London: Ballière, Tindall and Cox.) 2*s*. 6*d*. net.

Handworterbuch der Naturwissenschaften. Edited by E. Korschelt and others. Lief. 60 and 61. (Jena: G. Fischer.) Each 2.50 marks.

The Meaning of Evolution. By Prof. S. C. Schmucker. Pp. 298. (London: Macmillan and Co., Ltd.) 6*s*. 6*d*. net.

The Montessori Principles and Practice. By Prof. E. P. Culverwell. Pp. xvii+309. (London: G. Bell and Sons, Ltd.) 3*s*. 6*d*. net.

The London University Guide, 1914. Pp. xxii+227. (London: University Correspondence College.)

DIARY OF SOCIETIES.

THURSDAY, OCTOBER 23.

INSTITUTION OF CIVIL ENGINEERS, at 9.—Progress of Marine Construction: Alex. Gracie.

FRIDAY, OCTOBER 24.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—Modern Flour Milling Machinery: R. B. Creak.

PHYSICAL SOCIETY, at 5.—The Ice Calorimeter: E. Griffiths.—An Electrostatic Oscillograph: H. Ho and S. Kotô.

JUNIOR INSTITUTION OF ENGINEERS, at 8.—Mechanical Advertising and Similar Appliances: H. W. Sewell.

TUESDAY, OCTOBER 28.

ZOOLOGICAL SOCIETY, at 8.—Contributions to the Anatomy and Systematic Arrangement of the Cestoidea. XI. A New Genus of Tapeworms from Œdicnemus: F. E. Beddard.—The Fossil Crinoids referred to Hypocrinus, Beyrich: F. A. Bather.—*Batrachiderpeton lineatum*, Hancock and Atthey, a Coal Measure Stegocephalian: D. M. S. Watson.—The Brain and Brain-case of a Fossil Ungulate of the Genus Anoplotherium: R. W. Palmer.

WEDNESDAY, OCTOBER 29.

BRITISH ASTRONOMICAL ASSOCIATION, at 5.—Presidential Address.

FRIDAY, OCTOBER 31.

JUNIOR INSTITUTION OF ENGINEERS, at 8.—The Difference between a Drain and a Sewer: R. Kelsey Jones.

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