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African Natives and European Civilisation.

IN his presidential address to the British Association, H.R.H. the Prince of Wales spoke with singular felicity of the relations which do actually, and should, subsist between the State and scientific research. The discussion of a multiplicity of topics, which was released as it were from a floodgate immediately after the inaugural meeting, may have obscured the fact that the opportuneness of the Prince's reference to the application of scientific study to the problems of the Empire in our Dominions and Dependencies was conclusively demonstrated by the presidential address delivered in the Geographical Section on the following day. The lesson was further driven home by the discussion on the effect on the native races of Africa of contact with European civilisation which arose directly out of Mr. Ormsby-Gore's address, and took place in a joint session of the Sections of Geography and Anthropology.

His Royal Highness spoke as one who had had many opportunities in peace and in war to observe the facts, the necessities, and the possibilities of conditions in the Empire as a whole. In like manner, if in a more restricted field, Mr. Ormsby-Gore laid before his hearers the results of his journeys of observation in East and West Africa—journeys which may become as memorable and as far-reaching in effect as those of Joseph Chamberlain when the latter was Minister of State for the Colonies. Those who have followed the newspaper reports of Mr. Ormsby-Gore's travels with some knowledge of the problems which were then brought before him, will appreciate the acute observation and the balanced judgment which underlie his summary of the situation in regard to the economic development of tropical Africa and its effect on the native population. It is, however, of no little significance that his lucid summary of the needs of Africa and its people is followed by an acknowledgment of the greatness of our opportunities and our responsibilities and an appeal for the continued efforts not only of "officials and unofficials in Africa," but also of "the men of science over a whole range of human experience such as are meeting under the auspices of the British Association." It is pardonable if in these words we think we hear the statesman and the administrator rather than the president of Section E.

It cannot be denied that the need of constructive thinking for which Mr. Ormsby-Gore pleaded is urgent. The situation in Africa was summed up by one speaker in the discussion as one of depopulation and disintegration, and he went on to point out that the African native has passed in a brief space of time from the Stone Age to the present day. The final partition of Africa among

the European powers began in the last decade of the last century. Since then the economic development of the country has proceeded at a rapid pace, but especially in the last few years. Figures are quoted in Mr. Ormsby-Gore's address which are worth repeating. Between 1921 and 1925 the domestic exports of Nigeria increased from 8,250,000*l.* to 17,000,000*l.*; in the Gold Coast in the same period from 6,000,000*l.* to 10,000,000*l.* In East Africa the increase is even more marked, due almost entirely to the development of cotton-growing. In Kenya and Uganda the figures for the corresponding years show an increase from 2,250,000*l.* to 7,820,000*l.*, and in Tanganyika Territory from 1,100,000*l.* to 2,900,000*l.* This sudden accession of wealth would not be without its element of danger in any community; but when it is realised that the greater part represents the earnings either as producers or as wage-labourers of a population to whom 'money' is still novel, and whose ideas of a currency and medium of exchange not so long ago were limited mainly to 'brass rods' or 'cloth,' it must be apparent that the problem is both immediate and grave. It is a problem which demands statesmanship, and a statesmanship which is informed with an intimate knowledge of the African, of his institutions, and of his needs.

It is not possible to set back the clock. For good or for ill, the economic development of Africa is bound to go on under pressure of an increasing world-demand for its raw materials and its market for imports. Apart from certain restricted areas which will be exploited for their mineral wealth, it will be developed as an agricultural country. In tropical Africa, where white labour is impossible, that development will depend upon the native. Even in South Africa it is doubtful if white labour will ever be able to hold its own. Whatever may be the ultimate result in South Africa, in the tropics it seems clear, owing to climatic conditions and the question of prestige, that the function of the white man is to act as an administrator or employer and the guide and teacher of the native.

Up to the present it cannot be said that this rapid development of Africa has been for the good of the native on the whole, even though it be recognised that certain benefits have accrued to him. It is doubtful, indeed, how far these benefits may be for his ultimate good unless steps are taken to neutralise the inevitable disabilities by which they are accompanied. It has also to be admitted, as has been pointed out recently by a resident of many years in the remoter parts of East Africa, that the native does not always accept the advent of the white man who comes to exploit his land as an unmixed blessing. The African has a distinctive culture of his own, in which the cardinal features are the religious beliefs which are interwoven as an essential element in every aspect of his life, and the communal spirit which informs his thoughts and actions as a member of a tribal group. Notwithstanding differences as between tribes and peoples in the form of their political organisation, this is true of all in general terms. Especially is it essential to remember that the ultimate sanction of chiefly and tribal authority is religious. Further, apart from provision for the needs of the family and any contribution due to the chief or the community, the idea of the economic value of labour applied to production from the land or of wage-earning is alien to the native mind. Until recently, and as is still the case in many tribes, wealth consisted exclusively of wives and cattle. One of the reasons for the imposition of a hut-tax on the native population in South Africa was the hope that incidentally it would familiarise the native with the advantages of wage-earning and thus increase the supply of labour.

It is self-evident that the sudden impinging of European civilisation on a culture of this type, and the rapid economic development of the country, are bound to result in an equally rapid disintegration of native institutions. The growth of a class of native producers and of wage-earners has rendered the individual conscious of his individuality as a unit rather than merely as a member of a social organism, while introduction to the tenets of Christianity, an individualistic body of belief, has still further strengthened this tendency. The authority of the chief and the sense of responsibility to the tribe have been undermined, and the religious bond upon which they depend has been loosed. In the coast towns of West Africa, natives have become completely detribalised, and if the process is allowed to go on unchecked the existing tribes are in danger of becoming undisciplined mobs. Again, the native system of land-tenure, about which, incidentally, insufficient is known, is in danger. The economic value of land is beginning to be appreciated by the native, and where land is vested in the chief, this has introduced an entirely new relation of landlord and tenant as between the chief and the individual member of the tribe. Of the importance of a knowledge of the system of land-tenure, the disastrous experience of South Africa up to the passing of the Glen-Gray Act is a sufficient indication. Here, too, notwithstanding the reservation system, detribalisation, except in the case of the Zulu, is proceeding rapidly.

Of the results of this tendency to detribalisation, little need be said. They are obvious. The lack of restraint, and the accompanying break-up of the *morale* of the native, unless checked, are bound in the long run to be disastrous. They must accelerate the depopulation of the country, which, owing to disease and especially infant mortality, is already a serious factor in the

situation. Improved sanitation, a higher standard of nutrition, and increased efficiency in medical service may, however, be expected to cope with disease as time goes on; but an informed and intelligent guidance based upon a sympathetic understanding of native psychology, which will control and direct into safe channels the inevitable modification of the full tribal system, is an essential condition of the well-being of the native, and in the long run of the prosperity of Africa.

The present tendency to unchecked detribalisation is the more to be regretted in that the African native is one of the most adaptable of all the primitive races in the world, when the innate conservatism based on his religious taboos is not affected. This is shown by the readiness with which the native has mastered new arts of life in the course of the opening up of his country. Many of the African natives have beside, as the study of their history and institutions shows, a remarkable instinct for social and political organisation. The genius of Chaka, the great chieftain of the Zulu, is by no means unique in the annals of African tribes. This capacity for organisation and government is not confined to the men but has been displayed on more than one occasion by women, who by some accident or other have attained positions of authority.

A hopeful feature of the situation is the intense desire of the African for education. Hitherto the only form of education available for the native, with the exception of the interesting experiment at Achimotu, has been upon European lines; but education in Africa must take a new orientation. It is clearly of little use to offer the African a system of education which was designed originally to meet the needs of a European environment. Too often it has been the case that the curriculum of native schools has been framed with an eye only to the literary side of education, to the neglect of practical subjects. Yet it is not enough to insist on the need for vocational training. Even while recognising the excellence of much of the work which has been done in this direction, too great emphasis cannot be laid upon the fact that the education of the native must be based upon an intensive study of the culture, the institutions, and the needs of the African population. Much, it is hoped, may yet be effected through the Committee on Education of the Colonial Office. For many years the anthropologists have been collecting the facts, and although they are well aware that these facts may still be incomplete in certain respects, yet in response to Mr. Ormsby-Gore's appeal for the assistance of scientific workers they are ready and willing to place their knowledge at the disposal of the administrator for its practical application in the training and government of the native community of the new Africa.

An Indian Clan in Wales.

The Dialect of the Gypsies of Wales: being the Older Form of British Romani preserved in the Speech of the Clan of Abram Wood. By Dr. John Sampson. Pp. xxiii+230+419. (Oxford: Clarendon Press; London: Oxford University Press, 1926.) 84*s.* net.

THE majority of people are surprised when they are told that in almost every country of Europe, and even in America, there is spoken to-day a language which was brought out of India by a tribe or tribes between twelve and fifteen hundred years ago. This is the language of the people known to us as Gypsies, to themselves as Rom or the like, a word which phonologically is the exact equivalent of the modern Indian Ḍom, a general name for an outcast, so-called criminal tribe, who in many places act as scavengers and burners of corpses, and in all places are ready to augment their earnings by stealing or other anti-social practices. The Gypsies of Palestine and Syria still call themselves Dom, just as with them a spoon, *roi* in European gypsy, is *dowi* (and in modern Hindi *ḍoī*).

It has long been recognised that the speech of the Gypsies, which, as regards the European branch at least, differs comparatively little from country to country, is like the modern Indo-Aryan vernaculars of India—Kashmiri, Panjabi, Sindhi, Gujarati, Marathi, Hindi, Bengali, and the rest—descended from an old language of which we have the literary form in the language of the Rigveda and in Sanskrit. Consideration of its sound-changes and of its vocabulary makes it certain that the Gypsy language, or Romani, originally belonged to the same dialect-group as gave birth to the present central languages of India, such as Hindi. At a comparatively early period, however, which must be dated before the beginning of this era, they had wandered away to live for a time with the ancestors of the wild and little-known tribes of the north-west frontier, among the mountains of the Hindu Kush. Linguistically these tribes are very conservative in certain respects; and, being with them, the Gypsies preserved certain sounds and groups of sounds which were afterwards lost by those they had left behind in India proper. Whereas, for example, in India an original *t* or *d* coming between vowels was altogether lost, it is preserved in some form or other only by two of these north-western dialects and by Gypsy. European Gypsy keeps them under the form of *l*, Syrian Gypsy under the form of *r*. It is then of peculiar interest to note that, of the two north-western dialects which also preserve them, Khowar, spoken in Chitral, has *r*, and Kalasha, spoken farther south, has *l*. Thus the word which in Pali (a later form of Sanskrit) is *deti*, 'he gives,' is Hindi *de*, but Khowar

dōr, Kalasha *dali*, Syrian Gypsy *der*, European Gypsy *del*.

About A.D. 400 this region was disturbed by the Hun invasions of India. By them perhaps the Gypsies were set in motion towards the west. At all events, before A.D. 900 we find them in Persia, where various legends are related to account for their presence. A succinct account of their wanderings from here has been given by Dr. Sampson in a recent number of the *Journal of the Gypsy Lore Society*. Their path can be traced by the words which they picked up and adopted from the languages of the countries through which they passed. From Persia the Gypsies who changed original *-t-* to *r* migrated into Syria, from where some went north into Transcaucasia, others south into Egypt. Those, on the other hand, who changed *-t-* to *l* passed on into Armenia, where some remain until the present day; others, driven forward by the Turk inroads, migrated through Asia Minor into the Balkan Peninsula before the end of the eleventh century; and here it is that we first have definite historical record of this strange people. In Greece they stayed for a long period, to which also the numerous Greek loan-words in their language bear witness. But early in the fifteenth century—again before the threat of the Turkish invasion—they once more began their wandering. Their bands moved rapidly, and in a very short while they had appeared in almost every European country.

Wherever they went they were persecuted, and statutes were passed for their suppression and expulsion. It is therefore easily to be understood that it was greatly to their advantage to have a language which was not intelligible to their enemies. This doubtless was a powerful factor in the preserving of their old Indian tongue, despite the comparative smallness of their numbers and their wide separation both from the land of their origin and among themselves. Of recent times, however, and particularly in England, where they have never been very numerous, their speech has degenerated into a jargon, which is little more than a certain number of Gypsy words set in an English framework, with English grammar and English syntax. We may note, in passing, that the borrowing has not been entirely one-sided, and the number of slang words and phrases taken from Gypsy is probably considerable. One at least has acquired universal use: for the word 'pal' is English Gypsy *phal* (in which *ph* is an aspirated *p*, not *f*), meaning 'brother,' Continental Gypsy *phral*, and direct descendant of Sanskrit *bhrātā*.

Those readers (and fortunately they are many) whom the works of Borrow have acquainted with the Gypsies and their language, though already in a much degenerated form, will be astonished when they study the monumental work now before us on the language spoken by a Gypsy clan in Wales to-day. This is still really an Indian language, not a mere jargon. Students, not only of language and of the Indian languages in particular, but also of culture and folk-lore, owe a great debt to Dr. Sampson, both for his original discovery of Edward Wood, the Welsh Gypsy harper, at Bala in 1894, and for the enthusiasm and perseverance which has carried him through thirty-two years of patient collecting and sifting and arranging of stories and other linguistic material from this little Indian clan among the mountains of Wales, work which has at last resulted in a volume of more than 650 pages. It is by far the most complete and most accurate description of any Gypsy dialect that we possess. The first 230 pages are devoted to a description of the sounds, forms, and syntax of the language; the next 419 to a vocabulary, full of quotations, and precisely indicating the meaning and use of each word. If there is one part more than another to which we would refer as especially valuable, it is the pages which contain a minute and scientific description of the sounds of the language. We regret that it was impossible to include a certain number of texts, but presumably the already great size of the volume forbade a further addition. But those who are interested will find a large number of stories published by Dr. Sampson, with notes and translations, in the *Journal of the Gypsy Lore Society*.

In one respect only do we criticise Dr. Sampson's work adversely. Comparative philology, though almost the first impulse to its scientific study was given by that great English scholar and orientalist, Sir William Jones, has never been a plant of vigorous growth in England; and the languages of India, which Englishmen have had peculiar opportunity of acquiring, have suffered more at the hands of amateur philologists perhaps than any other group of languages. The scientific study of the history of the modern Indian languages is a comparatively recent growth, and the workers are still far too few. Gypsy, like the other Indian languages, has also suffered at the hands of amateurs. Some of its students have been famous linguists; but the greatest of them all, Miklosich, wrote before the fruitful ideas of the "Junggrammatiker" saw the light and changed the whole basis of the science of comparative philology. Dr. Sampson unfortunately yielded to the temptation to combine history with description; and throughout the book he attempts to trace the history of Gypsy from Sanskrit onwards. But though the science of language has made such enormous strides during the last fifty years, Dr. Sampson does not seem to have progressed beyond

the days of Miklosich. Examples of this are to be found in profusion on almost every page. We will take two only, to serve as illustrations of our criticism.

Without a recognition of the principle of the constancy of so-called sound-laws, there can be no science of etymology. This principle is that a given sound in a given dialect will develop in the same way in all words in which it appears under the same conditions. Thus Sanskrit words containing intervocalic *-t-*, if they survive, will in Hindi lose the *-t-* altogether, in European Gypsy show it as *l*. An etymology which neglects this rule is at once suspect; and if it is to be upheld, some special reason must be sought, such as borrowing from another dialect or the like. But Dr. Sampson has no compunction in making etymologies which go contrary to well-established rules of Gypsy, and that without noting the fact or seeking for explanation. Thus it is a sound-law of Gypsy (and of nearly every other modern Indo-Aryan language) that original intervocalic *-k-* is lost: this is admitted by Dr. Sampson, who gives for example the Sanskrit ending *-ako*, which became Middle Indian *-ao* and Gypsy *-o*, or the Sanskrit *yūkā*, 'louse,' which became Gypsy *juv*. Yet without hesitation he derives Gypsy *šukār*, 'quiet,' from Sanskrit *sukṛta-*, 'well done' (which in Gypsy would have become something like **suil*). It is, on the contrary, doubtless from Sanskrit *śukrá-*, 'bright, pure, clear.'

Secondly, Dr. Sampson compares Gypsy words not only with what he considers the Sanskrit originals, but also with their Hindi congeners. Now, just as French contains not only inherited Latin words (like *père*, derived from *patrem*), but also borrowed Latin words (like *paternité*, borrowed from *paternitas*), so too Hindi has both inherited Sanskrit words and borrowed Sanskrit words. If we wish to investigate the history of Latin sounds, say in Italian and French, we must compare the inherited Latin words in one language with the inherited Latin words in the other language, not an inherited word in one with a borrowed word in the other: we must compare Italian *padre* with French *père*, not with *paternité*. But Dr. Sampson, in countless cases, compares an inherited Gypsy word with a borrowed Hindi word: for example, he compares Gypsy *thulo*, 'fat' (connected with Sanskrit *sthūlá-*, 'strong'), not with, say, the inherited Nepali word *ṭhulo*, id., but with the borrowed (and only very literary) Hindi word *sthūl*.

Such an attitude and such mistakes invalidate the whole of Dr. Sampson's comparative work: it cannot be accepted as in any way a trustworthy guide. It is indeed a pity that this fine book, which is otherwise such a splendid monument to the author's scholarship, should be so marred. How far better would it have been if either he had followed his first intention (as expressed in the preface) and left the historical side alone, or by a much profounder study of comparative philology in general and Indo-Aryan philology in particular have fitted himself for the task of comparison with other Indo-Aryan languages. But since perfection is not attainable by man, we may be grateful that Dr. Sampson has given us a work which not many could have accomplished. R. L. TURNER.

Ice Ages.

Ice Ages: Recent and Ancient. By Prof. A. P. Coleman. Pp. xliii+296. (London: Macmillan and Co., Ltd., 1926.) 17*s*. net.

EARLY glaciologists wrote of 'The Ice Age,' next of 'The Great Ice Age,' and when it became obvious that there had been earlier refrigerations not inferior in intensity to the latest, of 'The Quaternary Ice Age'; now we have a glacial history of the earth, and from the hand of a master of the subject. Many of the glacial deposits described have only been discovered within the past few years; it is probable that many more will be found in the future, but Prof. Coleman presents enough material to enable us to form an idea of the distribution of glaciation both in space and time.

Deposits referable to ice are now known or suspected from nearly all the main geological formations, but many of them are of small extent and can be attributed to valley or at most piedmont glaciers. Major glaciations are known from the Lower Proterozoic or Huronian, the Upper Proterozoic to Lower Cambrian, the 'Permo-Carboniferous' and the Pleistocene. Minor glaciations are known or suspected at other levels in the pre-Cambrian (though owing to the difficulties of correlation it is not possible to say how many), in the Ordovician (North America and doubtfully in Europe), and in the Silurian-Devonian (Alaska, eastern Canada, Cape Town). The great 'Permo-Carboniferous' glaciation was manifested in five continents at least, but mainly in the southern hemisphere and in India; in strong contrast was the generally warm Mesozoic, from which only two glacial deposits are described, a tillite from central Africa west of Lake Tanganyika, probably Triassic but possibly older, and a Jurassic moraine from California, both probably formed by piedmont glaciers.

During the whole of the Mesozoic the sea-level temperature remained high, and the great cold-blooded reptiles were able to multiply and dominate the earth. Coleman attributes their sudden disappearance to a "slight dip in temperature at the end of the Cretaceous, too small to be called an ice-age." This slight cooling is indicated by the valley moraines of Cape Hamilton

in the Antarctic and the Cordilleran region of North America; the ice-transported boulders of the Cretaceous of South Australia and England are not mentioned, presumably because they are attributed to shore ice and not to land ice. There may have been mountain glaciers in the Miocene of Iceland and Europe, but these were local, and the next great cooling occurred at the close of the Pliocene and still continues.

These phenomena offer a definite meteorological problem, which the author sets out clearly in words which are worth quoting:

"Under normal conditions the world has a relatively mild and equable climate with no permanent ice at low levels even in the polar regions."

"From time to time . . . there have been relatively short periods of cold accompanied by a great extension of mountain glaciers, and sometimes also by the formation of ice-sheets at low levels. In the most severe visitation of the kind ice-sheets invaded the tropics on three or perhaps four continents."

"Ice ages are, in most cases, broken by interglacial periods of milder climate. Sometimes this occurs two or three or more times, indicating a comparatively rapid oscillation from cold to warm and warm to cold."

"All parts of the world have their temperature lowered during an ice age, the tropics as well as the temperate and arctic zones."

The author then turns to the consideration of causes, but gives only a rather mechanical discussion of the various theories of climatic change which have been put forward from time to time. Wegener's theory of continental drift is mentioned, but without enthusiasm. Elevation perhaps comes nearest to a solution, but fails to account for world-wide cooling. The conclusion is that no single cause suffices; "some combination of astronomic, geologic, and atmospheric conditions seems to be necessary to produce such catastrophic events in the world's history."

The difficulty of the problem is increased by the apparently haphazard way in which glaciations have developed. Time and again the author comments on the paradox of field-work, especially on Permo-Carboniferous tillites, beneath an almost vertical sun in a temperature suggestive of anything but ice. On the other hand, so far as is known at present, the Antarctic continent escaped glaciation until the close of the Mesozoic, though of course the great Antarctic ice-sheet may hide traces of many older glaciers. The north-east of North America, where the Quaternary ice-sheets reached lower latitudes than anywhere else, has suffered glaciation over and over again. In the Upper Carboniferous this region bore glaciers which indeed pale into insignificance beside the contemporaneous ice-sheets of the south, but would be sufficiently remarkable in any other period. The same region was ice-covered in the Devonian, the Ordovician, at the close of the Proterozoic, in the Lower Huronian (a photograph shows the remarkable feature of a Huronian tillite smoothed and striated by a Pleistocene ice-sheet), and perhaps at two horizons in the Archæan —seven or eight glaciations in the same or neighbouring areas. Other regions which have suffered repeated glaciation are Alaska, South Africa, and south-east Australia, though South Africa was not glaciated during the Pleistocene.

It almost seems as if, given certain conditions, and especially a world-wide cooling, glaciers and even ice-sheets can develop in any latitude, but have a preference for certain localities. From this point of view it may be only an accident that the two great ice-sheets of the present day occur in high latitudes. Their formation is not entirely a matter of temperature, since we are faced by the idea that during most of geological time the polar regions were free of land ice even while lower latitudes were being glaciated. Apart from pole-wandering, the only theory which throws any light on this anomaly is Paschinger's, not mentioned by Coleman, that glaciation depends on the relation between the zone of maximum snowfall and the snow-line. It may be profitable to try to fit this theory to the facts before us.

As we go from the lowlands up the slopes of a mountain range, we find that the snowfall increases up to a certain level, above which it again decreases; this level depends mainly on the humidity and the temperature during the wettest season. Quite distinct, depending mainly on the summer temperature, is the snow-line. If the snow-line is above the zone of maximum snowfall, the glaciers will be small; if the snow-line is the lower, the glaciers will be large, and with sufficient snowfall may descend to low levels. In the moist equatorial regions the two zones are close together, and a small depression of the snow-line would produce a considerable extension of the glaciers.

It seems probable that glaciers or ice-sheets must always *originate* on high ground, but for a glacier to develop into an ice-sheet a large area of more or less level ground is required at a temperature low enough for the ice to spread out as a piedmont glacier. In high latitudes this land may be low, but in low latitudes it must be initially at a high level. Once the ice-sheet has reached a certain size, however, it imports its own climate, and the initially high plateau may be depressed nearly to sea-level without necessarily destroying the ice-sheet. There are several reasons for this; one of the most important is that a snow surface reflects four-fifths of the solar radiation falling on it, and another is that a large ice-sheet is naturally occupied by an anticyclone with outwardly directed winds. The relations between snow-line and zone of maximum

snowfall probably depend on conditions of storminess and vertical temperature gradient which are due to general causes; when these are favourable, glaciers will form which may develop into ice-sheets in suitable localities, determined partly by configuration, which is independent of latitude, and partly by location relative to storm tracks and oceans. The latter proviso causes the repetition of glaciation in certain localities which are not necessarily the coldest parts of the globe. During the course of an ice-age the most suitable location may change, which brings us back to Coleman's speculation that the Greenland ice-sheet may represent the continuation of the eastward trend of glaciation in America, having commenced later than the American ice-sheets and persisting after them.

The author has done good service by uniting in one volume a large mass of material which was formerly only available in scattered papers or, in the case of his own observations, had not previously been published. The volume maintains the high standard which we expect of the publishers; it is lavishly illustrated by photographs of great interest, and the only error which the reviewer has noticed is the name "Grygalski" on page 286.

C. E. P. BROOKS.

The Sylvester Programme in Algebra.

Matrices and Determinoids. By Prof. W. E. Cullis. (University of Calcutta: Readership Lectures.) Vol. 3, Part 1. Pp. xix+681. (Cambridge: At the University Press, 1925.) 63*s*. net.

WE are all familiar with Cartesian co-ordinates denoted by $[x, y]$, where two numbers written in an assigned order specify the position of a point in a plane. Unless $x=y$, the symbol $[y, x]$ denotes quite a different point. This simple geometrical illustration is enough to show that in pure algebra, quite apart from geometry, a pair of numbers (or indeed a whole row of n numbers) in an assigned order might be considered as a single entity A. Such an A is sometimes called a vector (if $n>1$), but it is a special case of a matrix of rank one.

Yet, curiously enough, the more natural set of numbers to consider as a compound unit in algebra is not a row so much as a *square* arrangement of numbers. Nine numbers put in square formation, three by three, are what Cayley called a matrix of order three. Cayley first saw the value of treating it as a single magnitude. The reason is this: that matrices may be added, subtracted, or multiplied together and the result is always a matrix. This is not entirely true of vectors.

As a square is a special case of a rectangle, one may substitute for the idea of a square matrix that of a rectangular matrix of mn numbers, arranged in m rows and n columns. The author has taken this as his leading idea throughout the series of volumes, the third of which we have now reached. But the arrays

$$A=\begin{bmatrix}1, 2, 3\\4, 5, 6\end{bmatrix}, B=\begin{bmatrix}1, 2, 3\\4, 5, 6\\0, 0, 0\end{bmatrix},$$

show that the oblong case is really included in Cayley's square, since the actual properties of matrix A and matrix B are effectively the same.

The B matrix here may be extended to the fourth or higher order simply by fixing columns and rows of zeros to the right and below the existing square. All such matrices share with A the same rank: it is the *rank* of a matrix which is its most important feature. The rank of A or B here is two, and in general cannot exceed the smaller of m and n.

The work of which the bare elements have just been explained is founded on original ideas of three of our countrymen—Cayley, Sylvester, and H. J. S. Smith—and it dates from about seventy years ago. As so often happens in mathematics, work started in England has been brought to fruition abroad. So the work of Cayley was advanced almost out of recognition by Frobenius, and that of Smith by Weierstrass. Sylvester, who foresaw an important future for matrices, outlined a programme which has been systematically adopted by Prof. W. E. Cullis, who has done a real service to the mathematical world by carrying it out in all its breadth and detail.

The present book runs to seven hundred pages, yet it is only part of volume three. It is conceived in a spacious, leisurely spirit. There is something portentous in the massiveness of the structure. The author believes in his thesis, but is in no hurry to convince the sceptic or the ignorant. He promises in volume four a wealth of practical applications to analytical solid geometry, the theory of groups, dynamics, and the like, which will justify the patient elaboration of the preceding algebra. Everything is thoroughgoing and sound, and in fact volume three covers a larger field than its title implies. It is the only really complete account, in the English language, of many fundamental facts of algebra bearing on polynomials, factors, eliminants, and so on.

The book deals with three great branches of the matrix theory, as grouped round the conceptions of (1) *potent divisors*, usually called invariant factors (*elementarteiler*), (2) *commutants*, and (3) *invariant transformands*. The first of these is the difficult general theory governing the classification of algebraic systems illustrated at their simplest by the conic or the quadric surface, or a dynamical system of small oscillations. The second and third of these are bound up in the study

of the respective equations

$$AX=XB,$$
$$AXB=X,$$

where A, B, X are matrices and X is the unknown quantity. Bearing in mind that ordinary algebra is the study of the simplest possible matrix, where $m=n=1$, we have a clue to the interesting general case. Non-zero solutions exist provided A and B satisfy a specific condition analogous to $A=B$ and $AB=1$ respectively, for this simple case.

Incidentally, a problem of Frobenius, to find the square root of a given matrix, is fully discussed.

The treatment of the work brings out forcibly the propriety of thinking of variables X and constants A in a relation

$$f(X, A, A', \ldots)=0,$$

where $X, A, \ldots$ are matrices. The reader is brought to see how far-reaching are the ordinary conceptions of elementary algebra, such as the notion of solving an equation.

The book is not easy reading, in spite of the exceeding care taken to explain or prove everything. The reason is that the formal general case precedes special instances. Algebra is peculiarly adapted to the converse use: a chess board of nine or sixteen squares suggests most of the properties of a chess board of n^2 squares. Also several crucial results are disguised in small print.

The book has been carefully printed and contains few mistakes: one is only sorry that the Cambridge Press is unable apparently to do it full justice by returning to the use of the quality of paper or ink, or both, which go to make the first volume.

It may be added that the second name in the title is relatively unimportant in this volume. A determinoid bears to the rectangular matrix the relation which a determinant bears to the square matrix.

We are under a real debt to the distinguished author for this latest instalment of a mature and suggestive work, and we look forward to the promised further developments with interest.

Our Bookshelf.

Problems of Philosophy: an Introductory Survey. By Prof. G. Watts Cunningham. (Modern Thinkers' Library.) Pp. xxi+453. (London, Calcutta and Sydney: George G. Harrap and Co., Ltd., 1925.) 8*s.* 6*d.* net.

THIS is a useful book, with a modestly misleading title. When a writer introduces 'problems of' or 'studies in' this or that subject, he is commonly taken to offer his own particular theories on a limited group of more or less connected topics. Prof. Watts Cunningham has a less personal and more generous and catholic intention. He writes, broadly speaking, about all the problems that there are, and with the utmost objectivity and detachment. What he gives us is, in effect, a guidebook to contemporary metaphysics, as clear and simple as it can well be made, and so skilfully compacted that the intelligent use of a table of contents and an index will conduct an inquirer's finger straight to the sections relating to any one of the major issues of current interest, and let him find there just how the controversy stands, and why it is where it is. That is no small performance—it has meant selecting and correlating the significant 'tendencies' of endless recent discussion, indicating the historical background of each question, and making plain the cruces of each decision.

The plan of the book is simple. Part 1 defines, partly by contrast, the scope of philosophy and the nature of its distinctive method. Part 2 examines some central problems in the theory of knowledge. Parts 3, 4, and 5 trace the evolution from matter to mind, taking the widest possible survey of what is involved in these terms. Part 6 discusses the nature and status of our experiences of 'value.' This bare indication of contents is perhaps all that need be given; for, all through, the writer is little concerned to recommend a theory, but rather to expose the issues, to show what considerations are relevant and what are the implications. Plainly enough, Prof. Watts Cunningham's own sympathies are with the idealist tradition; but his survey is thoroughly impartial in spirit and in execution. Nowhere, in the nature of the case, does it cut very deeply; but it very well points the ways.

H. J. W. H.

The Physical Chemistry of Steel-making Processes: a General Discussion held by the Faraday Society and the Iron and Steel Institute, June 1925. Pp. 167-296. (London: The Faraday Society, 1926.) 8*s.* 6*d.* net.

As Dr. W. H. Hatfield has said in the discussion before us, "there is to be found in this collection of papers by far the most weighty and valuable treatment of the subject of furnace reactions that we have had." Almost every phase of modern steel-making is dealt with, and, although the symposium reveals, as the chairman, Sir Robert Hadfield, pointed out, the many important gaps in our knowledge of the reactions which take place at these high temperatures and of the physical data necessary for their elucidation, the general feeling after reading the present volume will be that a distinct advance is being made in this important scientific and industrial subject.

The paper by McCance on "Balanced Reactions in Steel Manufacture," a continuation of earlier work by the same investigator, represents probably the most important single contribution yet made to the subject. Experimental confirmation on an industrial scale is necessarily a slow process, and there are clearly many points on which such proof is required, but the excellent manner in which all the threads hold together and the agreement with experimental fact, so far as has yet been found, offer good reason to believe that in time the confirmation will be obtained. "A Study of the Reactions of the Basic Open-Hearth Furnace," by Mr. T. P. Colclough, is another outstanding contribution. His contention that the influence of temperature is definitely subordinate to that of slag composition is of fundamental importance. Among the other papers,

that on the reactions in the electric furnace, by Mr. F. T. Sisco, and another dealing with the general physico-chemical aspect of steel-making, by Mr. A. L. Feild, are well deserving of mention. To all those interested in any degree in the chemistry of the manufacture of steel, the volume is of the utmost importance and will be read with the greatest interest. F. C. T.

Science: an Introductory Textbook. By E. J. Holmyard. Pp. x+230. (London and Toronto: J. M. Dent and Sons, Ltd., 1926.) 4*s*.

MR. HOLMYARD is well known as one of the most active and vigorous exponents of the humanistic school of science teaching, and his viewpoint finds complete expression in this very entertaining and instructive volume. We could wish for nothing better than that the scoffer at the 'romance of science' should read it. For our part we found ourselves compelled to complete a first reading in one sitting. Mr. Holmyard's style is peculiarly happy and easy, and one feels that he thoroughly enjoyed his task. His object is to present science as a whole to the young beginner. He refuses to admit of barriers as between one branch of the subject and another, and in this he is right. Further, he has shown how it can be done. He enlists to his purpose the framework of the past—the Aristotelian scheme of the four 'elements' of air, water, earth, and fire, and after a historical introduction he deals with these one by one, and makes each the theme for a series of facts and phenomena of Nature. So we find simply and naturally interlocked a number of important and fundamental principles usually detached into separate 'subject' volumes. Finally, passing from the inanimate to the animate, the author presents a brief but interesting account of the phenomenon of life.

Naturally there is a serious danger of 'overdoing it,' but Mr. Holmyard has wisely preferred the errors of omission to those of commission. At the same time, we feel that the book would have been greatly strengthened by some short account of the astronomical scheme of the universe. In our view a general survey of science, even for the young beginner, definitely requires this, and its place is as pertinently at the beginning as is the study of life at the end.

The production by the publishers is, with the exception of some rather crude 'portraits,' very well done, and we have nothing but praise for a book that will commend itself to all interested in the teaching of science. I. B. H.

Life of Plants. By Sir Frederick Keeble. (Clarendon Science Series.) Pp. xii+256. (Oxford: Clarendon Press, 1926.) 5*s*. net.

AN initial embarrassment that confronts one who would become acquainted with the present achievements and aims of botanical science is the large number of books dealing with plants from which a choice may be made. The subject has been approached from so many points of view that curiosity is aroused as to wherein any new volume can differ from its predecessors.

Those who are conversant with the writings of Sir Frederick Keeble—who have read his fascinating "Plant Animals," for example—will not be surprised to find that the present book *is* different from those we already know. Excellent as many of the latter are in providing detailed and accurate information about plants, carefully and clearly though some of them are written, we have met with no book which succeeds in conveying to the same degree as does the present small volume the all-pervading importance of plants in the scheme of living things, or the wonder and romance of their activities.

The information is there also—the amount that has been packed into 250 pages is indeed astonishing—but the reader is given the impression of being led into a new country by roads which permit of ever more and more extensive views, the facts and arguments which border the road and define its direction never being allowed to grow into a hedge tall or dense enough to oppress the traveller or to obscure the surrounding prospect. Therein, perhaps, lies the one danger. The reader may be so enthralled by the scenery around him that he may be tempted to give insufficient attention to the details of the foreground. This omission can be made good, however, when the journey is repeated, as no doubt it will be more than once.

Few are the books which can justly claim to have completely fulfilled their author's hopes: fewer still those in which this or that modification would not seem an improvement to some reader. No doubt some will say that a rather disproportionate amount of space is given to Mendelism, or that the contrast between sporophyte and gametophyte phases, with the dominance of the latter in some groups of plants, has been insufficiently emphasised. Exception may also be taken by some to the wholehearted acceptance of hormones to explain the sensitive reactions of plants. Such, however, are but minor matters and do not affect the picture as a whole, which is surprisingly complete in view of the size of the canvass.

In the preface, the author pleads that we should judge leniently his failure to accomplish the task he set himself. If he has not succeeded in satisfying himself, he has earned the gratitude of his readers by giving them a delightful and stimulating book.

Comparative Philosophy. By Paul Masson-Oursel. (International Library of Psychology, Philosophy and Scientific Method.) Pp. vi+212. (London: Kegan Paul and Co. Ltd.; New York: Harcourt, Brace and Co. Inc., 1926.) 10*s*. 6*d*. net.

"COMPARATIVE PHILOSOPHY," by M. Masson-Oursel, gives the impression of a compilation. There is an introduction by Dr. Crookshank, a notice that Part II. has been translated by V. C. C. Collum, and a dedication to M. Lévy-Bruhl, whether by author or translator or editor does not appear. The book itself deals largely in generalities and is interspersed by a long table of comparative chronology and various bibliographies. There is nothing peculiarly original or even striking in the actual matter of the book, and now and then we come on fairly long quotations from the Greek which are left untranslated, although the book is scarcely designed to appeal only to scholars.

Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor 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 Classification of Research Work.

IT has often been found difficult to discriminate between the different classes of work carried on by research laboratories. This difficulty is intensified when, for such purpose as the founding of an industrial research association, it becomes necessary to explain these differences before persons to whom such work had previously been an unknown quantity. In these circumstances the lack of an exact terminology can cause much confusion; three members of a committee can use the expressions 'fundamental,' 'pure,' and 'applied' research, when all three may nevertheless wish to imply the same thing. Such explanatory terms as 'deep-digging' and 'trouble-curing' are less unmistakeable, but they fail to convey shades of meaning.

One grouping which served a useful purpose was made by separating investigation from research proper. This gave the successive steps of pure research, fundamental research, applied research, investigation, invention, and routine. Here a distinction was intended to be drawn in the second instance between the pure research of a university laboratory, and research which is just as free to pursue its studies to any depth or intensity, without regard to their ostensible usefulness, provided only that they are restricted to material offered by the industry concerned. However, the nomenclature employed was confusing, but the writer eventually realised, while assisting to explain these meanings, that the conception of 'restriction' could be used to provide a very tolerable classification which was implicit in the whole discussion of the topic. Such a classification is almost obvious when research work is looked at from the organiser's view of an industrial research department, with its conjoint laboratories, workshops, and manufacturer's plant.

This classification may be illustrated by the mechanical analogy of degrees of freedom, such as those of a three-point support. The three essentials of any research for our present purpose are the Method, the Subject, and the Aim. Accordingly, as the research worker is left free to pursue his own course in each of these respects, or in so far as he is restricted to a limited choice of their possibilities, so we obtain eight separate classes of research activities, covering a very wide range.

The fundamental relation of the experimental method to the advancement of natural knowledge, observed by Francis Bacon, evidently sets the Method in a position of superiority over the other two. Consequently, such work as is done with its methods under restriction is, speaking scientifically, of a low order; such is the plain routine of works-control laboratories, or of a testing-room. On the other hand, the university laboratory is potentially unrestricted—finance excepted—not only in its methods, but also in the subjects studied, and in its aims; it is free in all three degrees, to use mathematics or glass-blowing, to study nebulæ or tadpoles, and to take its aim no closer than at the advancement of human knowledge. The testing-room is not only restricted to quick routine methods in making its tests, as also in the study of its statistical data, but its subject matter is restricted to such material as is manufactured or used in its own factory, and its aim is equally restricted to narrow and well-defined ends. Between these two lie six other possible classes, and it is interesting to see that they do actually correspond to most of the recognisable classes of research work. We will briefly examine them in regular order, though the reader will best draw his own examples out of his own experience.

(*a*) FREEDOM IN METHOD, AIM, AND SUBJECT.—As already noted, this class is indubitably pure research, typified by that of the university.

(*b*) FREEDOM IN METHOD AND AIM, BUT RESTRICTION IN SUBJECT.—This is what the most enlightened industrialists imply by the term 'fundamental research.' It consists in purely scientific study of such material as possesses industrial importance, and is undertaken to broaden the basis of knowledge upon which effort ultimately rests. A determination of the chromosome numbers in species of Gossypium for the cotton industry will serve as an example.

(*c*) FREEDOM IN METHOD AND SUBJECT, WITH A RESTRICTED AIM.—For this class we might cite most of the work done on behalf of public health, which has one definite aim, though it studies mosquitoes or abattoirs, and uses statistics or string galvanometers.

(*d*) FREEDOM IN METHOD ONLY; AIM AND SUBJECT RESTRICTED.—The everyday research of most industrial laboratories falls into this class, which corresponds to the 'investigation' mentioned previously. It aims to effect paying improvements in specified materials and processes.

The next three classes are all restricted in the methods they may employ, and only possess freedom in the minor degrees. It will be seen that the latter are not in themselves sufficient permanently to characterise work as scientific research, and the examples are correspondingly vague. It is not in human nature to study without some speculation as to 'the good of it,' which provides an aim and alters the class. These three may be termed the 'unstable classes,' where true research merges into technicality, and 'gadgeteering.'

(*e*) RESTRICTED IN METHOD, BUT FREE AIM AND SUBJECT.—The usableness of a new discovery is investigated, such as Röntgen's rays, or the emission of electrons from a hot wire.

(*f*) RESTRICTED IN METHOD AND SUBJECT, BUT FREE TO ANY AIM.—This class might be termed that of intelligent technical benevolence. It is obviously a temporary phase through which much research passes in the course of its development.

(*g*) RESTRICTED IN METHOD AND AIM, BUT FREE IN ITS SUBJECT.—Most patented inventions deal with some particular way of achieving something; the invention itself may be applied to many different industries.

The remaining class is again clear-cut in its severe limitations.

(*h*) NO DEGREES OF FREEDOM.—Testing rooms; works-control laboratories; such routine work as that done by junior assistants.

If it be agreed that these classes cover the whole range of pure and applied research, and that they differentiate between types of research which are not easily distinguished otherwise, it remains to provide them with terminology. Having regard to the varied meaning which has already been given to most of the available English words, it is perhaps better not to attempt to name each class, but to specify it when need arises as 'completely free (or restricted),' or else as 'free (or restricted) in (one respect) only.' This

covers all the eight descriptions, if only one function is specified in the latter form.

For written notation we can use capitals and small letters. 'The MSa class of research' would be our class (*c*) above. It is for this convenience that the words subject and aim are used instead of material and object, or subject and object.

Using these notations it is possible to avoid a great deal of ambiguity when industrial research is under discussion, whether inside or outside the ranks of scientific workers. Further shades of meaning could of course be obtained by defining the amount of restriction, beyond the bare positive and negative here used, but it seems quite needless at present to do so.

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Science and Psychical Research.

PERHAPS I may be permitted to offer a few comments on Dr. R. J. Tillyard's article under this heading in NATURE for July 31. Dr. Tillyard's sympathy for the scientific men who take up the study of psychical research, and thus, as he complains, 'lose caste' and undergo persecution from their fellows, may appear pathetic, and his stated determination, in spite of all consequences, to join the noble army of martyrs, may even seem heroic. He may take comfort, however, in the reflection that, after all, Crookes's spiritualistic activities did not prevent him from attaining to that highest of scientific positions, the presidency of the Royal Society, nor to-day does Sir Oliver Lodge cease to remain highly honoured amongst all scientific men for his physical investigations, and especially for his pioneer work in wireless telegraphy, nor does he cease to be in the greatest request as an exponent of the most recondite theories in modern physics amongst all the best-known scientific societies and institutions.

Dr. Tillyard appears to be surprised at the attitude towards spiritualism adopted by most scientific men, but surely this is to be explained by just such expositions of the subject as Sir Arthur Conan Doyle's "History of Spiritualism." As Dr. Tillyard himself admits, psychical research is therein "most certainly very unscientifically handled." Indeed, this so-called history is no more a scientific book than its imaginative author's recent spiritualistic novel. It is replete with what has been rather aptly described as "determined credulity," and, like most of the fantastic and amazing literature that emanates from psychic bookshops, it trades on the credulous side of human nature, and especially on the emotions of those who, having lost friends who were dear to them, are distressed at the uncertainty of the survival of human personality, and, like the drowning man in desperation will clutch at any floating straw.

Dr. Tillyard makes light of the fraudulent aspect of spiritualism, and says that fraud exists in all branches of human affairs. I can offer no opinion upon the suggestion of biological fraud to which he refers, but speaking for physics, with which I am better acquainted, I cannot remember any case of such a kind worth mentioning during my lifetime. On the other hand, the whole history of spiritualism simply reeks with fraudulent deception. There appears to have scarcely been a single well-known spiritualistic medium who has escaped criticism of this nature. The pages of Sir Arthur Conan Doyle's book are filled with the achievements of spiritualists against whom fraudulent practices have been alleged, as it would seem to the unbiassed critic, on very convincing grounds, and quite a considerable portion of the history is devoted to explaining away these unfortunate lapses, the explanation in some cases consisting of the amazing suggestion that though evidence showed that the medium did cheat on certain occasions, on other occasions no signs of cheating on the part of this particular medium could be discovered, and therefore the manifestations produced must be considered to be genuine!

The fact is that the whole basis of spiritualistic investigation, as usually carried out, puts a premium on fraudulent practices. The so-called mediums that appear to be requisite in order to conduct the experiments, seem for the most part to be persons of inferior intelligence and education. Most of them are also needy, and eke out a precarious existence by payments for their services, which payments will only continue so long as they succeed in producing extraordinary manifestations.

Imagine for a moment research in ordinary physics made under such conditions as these, with the physicist unable to carry out his own experiments and make his own observations without dependence on the aid of assistants whose interests were all the time to fake the experiments and thus obtain startling effects, assistants, moreover, whose fraudulent delinquencies when discovered were excused and explained away, as seems to be the usual practice in the case of mediums caught cheating. Could any one have confidence in the accuracy of physical investigations carried out under such conditions?

But, says Dr. Tillyard, "we who have seen these things done under conditions precluding deliberate fraud, are not fools, but in full possession of keen faculties." Does he not know, then, that the experienced medium, just like the expert conjurer, both of whom prescribe to a large extent their own conditions, will fool the observer, however acute and scientific, nearly every time? Did he never, when young, attend at Maskeleyne and Cook's home of mysteries at the old Egyptian Hall in Piccadilly, and did he ever once find out how the marvellous phenomena there shown, admittedly by pure trickery, were produced?

How even the most distinguished scientific men can be deluded is evidenced by the well-known case of the "N" rays, for the discovery of which the French Academy of Sciences presented a gold medal to Prof. Blondlot, who, however, was neither a fraudulent medium nor a conjurer, but a well-known and highly respected physicist, who, as is now understood, was at the time of his discovery unfortunately afflicted by incipient insanity, from which he afterwards died. How the "N" ray myth was for ever exploded was recounted by Prof. R. W. Wood in NATURE, and is a case of genuine delusion that in the interests of truth should never be forgotten. It is a warning for all time demonstrating the extreme danger of accepting the objective reality of phenomena which, as is claimed, can only be observed, attested, or produced by particular individuals, such as so-called spiritualistic mediums, and not by all competent persons.

I have recently had some personal experience of spiritualistic methods which show how little reliance can be placed upon the support that Sir Arthur Conan Doyle gives to spiritualistic phenomena. Having read in the *Morning Post* that Sir Arthur had exhibited at the Queen's Hall a photograph purporting to be the ghost of the second Viscount Combermere, who was my uncle by marriage, I remembered that I had seen this photograph shortly after it was taken some thirty-five years ago, and that it bore no recognisable resemblance to the deceased Viscount, whom I had frequently seen and

whose genuine photograph I happened to possess. I therefore publicly challenged Sir Arthur Conan Doyle to reproduce in the *Morning Post* the alleged ghost photograph alongside the genuine portrait, whereupon he appears to have suggested to the editor of the *Morning Post* that the ghost photograph could not be reproduced for technical reasons. This assertion was promptly refuted by the *Daily Sketch*, which—I having meantime obtained a copy of the ghost photograph—reproduced with great perfection both this and the authentic portrait in the issue of that paper for May 28 last. There these reproductions remain as evidence that any one can consult, and as I think all sane persons will admit, form a complete exposure of this particular spiritualistic myth.

Ex uno disce omnes.

A. A. CAMPBELL SWINTON.

40 Chester Square,
London, S.W.1,
August 9.

I WOULD like to thank Mr. Campbell Swinton for his letter criticising my article on "Science and Psychical Research" in NATURE for July 31 last. With what he says on the subject of spiritualism I agree almost entirely; but I had hoped that my article drew a clear distinction between spiritualism and psychical research. Unfortunately, the two are evidently confounded in Mr. Swinton's mind, though they are as distinct as, let us say, astrology is from astronomy, or alchemy from chemistry. If a physicist thought of taking up astronomy, would he read up a text-book of astrology to gain his first ideas of the subject? Or if he desired to study chemistry, would he begin with a history of alchemy? Yet this is just what such a man would be doing who thought to find in a book like Sir Arthur Conan Doyle's the elements of psychical research. Let me recommend to Mr. Swinton instead the careful perusal of Prof. Charles Richet's work "Thirty Years of Psychical Research."

That I in any way make light of the fraudulent aspect of mediumship I must emphatically deny. I think that the last sentence in the concluding paragraph but one of my article supports this denial. Mr. Swinton's remarks about mediums and psychical experiments show an entire misapprehension of the essentials of the problem. Mediums may be good or bad, just like chemical balances or microscopes, Some of them are below the average level of intelligence, others greatly above it; some may be paid for their services (and why not, when, like everybody else, they have to live?), and some never take a penny for the whole of their life's work.

These things, however, are entirely beside the point. In psychical research the medium is not one of the experimenters, as Mr. Swinton seems to think, but takes exactly the same place as the spectroscope in the study of light, or the microscope in the study of minute forms of life; that is to say, *the medium is the instrument through which the phenomena become objective to the experimenters*. Usually the medium is in deep trance and knows nothing of what is occurring. The only difference between the spectroscope and microscope on one hand and the medium on the other is that one is a man-made mechanism, the other a living being (if, as many materialists aver, both are merely mechanisms, then this difference vanishes). It is easier to control the mechanism than the living being, and that is why more stringent precautions are required in psychical research than in other sciences. If a spectroscope is found to give untrue results, it is thrown aside and a more trustworthy instrument is substituted; if a medium is found to be fraudulent, then the genuine psychical researcher will not proceed with him, but will endeavour to find a more trustworthy one. The spiritualists may make his apologia if they wish; that is no concern of psychical research.

Of all the great scientific men who have patiently and untiringly studied these phenomena—Crookes, Lodge, Richet, Flammarion, Wallace, Barrett, and others—can Mr. Swinton name a single one who has not become convinced in the end of their genuineness? On the other side we have either (*a*) some few who, having met with a fraudulent medium at the start, have adopted Mr. Swinton's motto *Ex uno disce omnes*, and have concluded, *without further investigation*, that the whole business was fraudulent, and (*b*) the great majority of scientific men, who have never experimented in the subject at all, but some of whom, nevertheless, consider themselves quite competent to pass a hasty judgment upon it. My article was simply a plea for a more scientific and logical attitide of mind from this second class. *Ex uno disce omnes* may be good Latin but it is bad logic; the hasty generalisation from insufficient facts is still, as always, the curse of modern science. A great teacher once chose twelve disciples; one of them turned out a fraud and betrayed his master. *Ex uno disce omnes*? Were all the apostles frauds because of Judas' defection? Surely not! If we must have a Latin motto, let us have a logical one, such as *Humanum est errare*; then, remembering that this applies equally well to physics, biology, or psychical research, let us make our dispositions for the detection and elimination of fraud and get on with the work.

If Mr. Swinton is really in earnest in desiring to do this, I would advise him to get into touch with my friend Mr. Harry Price, director of the National Laboratory for Psychical Research, 16 Queensberry Place, S.W. 7, and make an appointment to see over the laboratory. If his inspection proves satisfactory, perhaps he might even care to go further and arrange to be present at a sitting with a genuine medium like Stella C., when he might succeed in discovering the real reason for the peculiar behaviour of the thermograph during the production of psychic phenomena accompanied by cold breezes. R. J. TILLYARD.

Zurich, Switzerland,
August 17.

External Capillary Action.

WHEN a glass tube, 6·5 mm. in external diameter, 5 mm. in internal diameter and of any convenient length, one end of which has been drawn out into the form of a cone 55 mm. long with a hair-like apex 0·1 mm. in diameter and a correspondingly small aperture (Fig. 1 (1)) is filled with water containing, say, 1 per cent. of caustic soda, and held with its point downwards at an angle of 35° above the horizontal, a minute stream of water issues from its aperture, turns round underneath its lip and ascends to a distance of 33 mm. on its outer side in the form of a series of minute, disconnected, elongated globules which appear to encircle it. In flowing upwards these globules gradually lose their identity, and finally coalesce with each other to form a substantial drop at a point where the diameter of the cone is about 2 mm.

The drop encircles the cone symmetrically when the tube is vertical, but hangs from its lower side, as shown in (2) when the tube is held at an angle. After the drop has attained a weight of about 0·0113 gm.

with the tube shown, it breaks away from the influence of the force which has been holding it, sweeps swiftly down the lower part of the cone, carrying away the ascending globules, and falls from its apex. Immediately afterwards a similar series of globules begins to ascend and another drop is formed and falls away like its predecessor, and so on continuously. The weights of the drops and the rate at which they are formed vary with the angle of the tube, the magnitude of its aperture, the form of the cone, the magnitude of the head, and so on. With the tube shown in (1) a drop weighing 0·0113 gm. was formed every 2 m. 20 sec. for 12 consecutive hours in one trial. (2) was photographed instantaneously while the globules were in the act of ascending the stem.

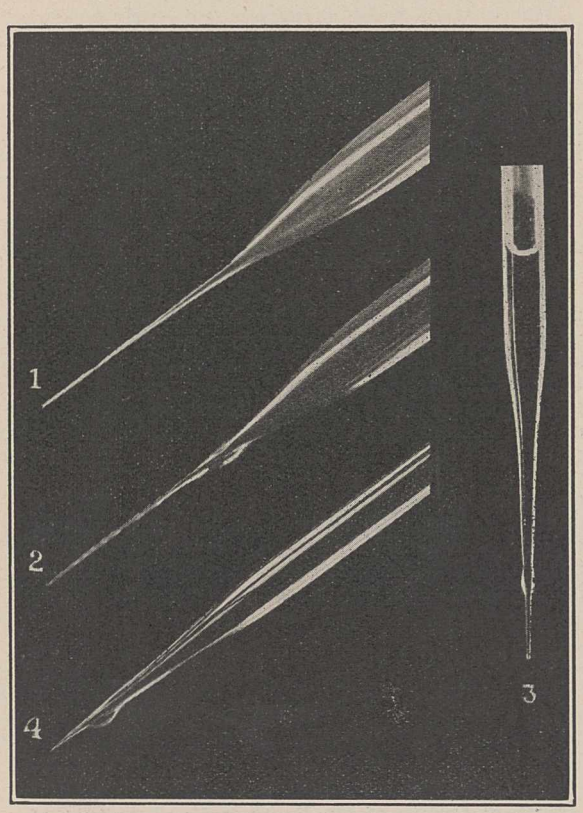

FIG. 1.—Scale, full size.

With some tubes, and some heads, the globules run up the wet surface of the cone so rapidly as to make it quite impossible to count their number; with others, and in different circumstances, they follow each other at distances of several millimetres apart at a comparatively moderate rate, according as the head is greater or less.

(3) shows a tube held in a vertical position, (4) shows it held at an angle. In the former the drop encircles the cone symmetrically, in the latter it has gravitated round to the lower side.

The force which draws the water up on the *outside* of the cone in opposition to the force of gravity is obviously a function of the gradually increasing mass, and consequently of the gradually increasing attraction, of the cone.

The ratio of the weight of the salt to the weight of the decrement in the columns of solution of some salts is a *constant*. The ratio of the square root of the molecular weight of some salts (multiplied or divided by 1, 2, or 4), to the square root of the molecular weight of water multiplied by 4, is equal to the ratio of the weight of each of the same salts contained in its solution in water in a capillary column, to the weight of the decrement in water in the same column.

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Scattering of Electrons in Ionised Gases.

IN the November 1925 issue of the *Physical Review*, Langmuir published an investigation under the above title. From the collector characteristics of a mercury vapour discharge with a hot cathode, it was concluded that, in the tube, electrons must have been present with abnormally high velocities. Langmuir expressly mentions that with these discharges no oscillations could be found. In several experiments which were made by me in consequence of this publication, oscillations could in fact be detected. In accordance with my results, summarised below, it does not seem impossible that the observed "scattering of primary electrons" is always accompanied and caused by these oscillations.

1. A small metal plate, connected to a crystal detector, was placed in the immediate neighbourhood of a tube, similar to the one used by Langmuir. A galvanometer, shunted by the crystal detector, showed a deflexion at the larger current densities, when the electron velocities became abnormal.

2. To screen off the influence of the glass walls a tube was built in which the anode completely surrounded the filament. Only a few small holes (diameter 0·5 mm.) were drilled in it, in front of a collector. In this tube also the velocities became abnormal at the larger current densities, when again simultaneously oscillations could be detected. With appropriate values of emission, anode voltage, and pressure, these oscillations could be brought on a Lecher system. As wave-lengths, values from 40 cm. to 100 cm. were obtained.

3. A similar tube was used for experiments with argon. Here also, under favourable conditions, the Lecher system could be used and showed wave-lengths of the same order of magnitude.

4. With the argon experiments under certain conditions of pressure, etc., it was observed that the steady state of the discharge was only reached a considerable time after the anode voltage was switched on. During the first few minutes, neither abnormal velocities nor oscillations could be observed. Then suddenly the final state was reached in a discontinuous way. At this moment, the electron velocities became abnormal (max. about 20 volts), and simultaneously the detector galvanometer showed a deflexion.

5. Finally, the relation between the abnormal velocities and the distance through which the electrons had gone was investigated. With a tube as described under (2) above, the collector of which could be moved, it appeared that the electron velocities did not become more and more abnormal with greater collector distances, but the reverse happened. This also is not in agreement with the explanation suggested by Langmuir.

A more detailed description of the experiments will be published in the Dutch periodical *Physica*.

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Eindhoven, Holland,
July 27.

On the Law of Radiation.

THE view of physicists on the question of distribution of black-body radiation is that the equipartition principle cannot apply to the problem, and that "each step from matter to ether, or back again, demanded the quantum factor, and does demand it wherever such interaction occurs," as Sir Oliver Lodge recently expressed it in NATURE, June 26, p. 891.

In the session of February this year I presented to the Pontifical Academy of Sciences, Rome, what I think is a new method of attacking the problem, on the basis of equipartition, with only the hypothesis that frequencies are distributed in the same way as velocities in Maxwell's law for gases.

If we express the probability that frequency is between the limits ν and $\nu + d\nu$ by

$$\theta(\nu)d\nu = Ce^{-\alpha^2\nu^2}\nu^2 d\nu,$$

where $C = \frac{4\alpha^3}{\sqrt{\pi}}$, the corresponding number of oscillators will be

$$dn_\nu = N\theta(\nu)d\nu = \frac{4\alpha^3 N}{\sqrt{\pi}}e^{-\alpha^2\nu^2}\nu^2 d\nu,$$

N being the total number in volume unit, and the density of energy in the emitting body, on the basis of equipartition

$$u_\nu d\nu = \chi TN\theta(\nu)d\nu = \frac{4\alpha^3\chi TN}{\sqrt{\pi}}e^{-\alpha^2\nu^2}\nu^2 d\nu.$$

Thence follows the expression for the emitted energy $k_\nu d\nu$; and assuming the Stefan law for totality of energy, it is easy to deduce $N = \frac{8\pi\sigma T^4}{\chi Tc}$, σ being Stefan's constant, and therefore for k_ν the expression

$$k_\nu d\nu = \frac{4\alpha^3\sigma T^4}{\sqrt{\pi}}e^{-\alpha^2\nu^2}\nu^2 d\nu.$$

In order to calculate the constant α we transfer the expression for k_ν in the corresponding E_λ through the relation $E_\lambda d\lambda = k_\nu d\nu$ and introduce Wien's law of displacement. The expression for E_λ becomes

$$E_\lambda d\lambda = \frac{4\alpha^3\sigma}{\lambda^5\sqrt{\pi}}\lambda T e^{-\frac{\alpha^2}{\lambda^2T^2}}d\lambda,$$

where a is Wien's constant multiplied by $\sqrt{2}$.

The law of distribution hence will be

$$F(\lambda,T) = \frac{4\alpha^3\sigma}{\lambda^5\sqrt{\pi}}\lambda T e^{-\frac{\alpha^2}{\lambda^2T^2}},$$

corresponding to Wien's condition, and containing only the Wien's and Stefan's constants. When λT is large the formula reduces to Lord Rayleigh's expression.

The new formula agrees very satisfactorily with the measured energy distribution in the solar spectrum.

G. GIANFRANCESCHI.

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The Electrical Polarity of Molecules.

ON attempting to correlate the electrical double-refraction (Kerr effect) of gases and vapours which has been measured by Leiser, Hansen and Szivessy, with the optical anisotropy of the molecules determined from observations on light-scattering, it is found that electrically polar molecules generally exhibit a Kerr effect which is very large in relation to their optical anisotropy. This indicates that the orientative action of the field on the molecule in such cases is chiefly due to the permanent electric doublet present in it, and is much larger than would be the case if the molecules were non-polar. In the case of molecules having an axis of optical symmetry to which the electric doublet is parallel, or is inclined at some known angle, it is possible to calculate the permanent electric moment from the value of the Kerr constant and the constant of depolarisation of the scattered light. Conversely, if the moment is known, the inclination of the electric doublet to the optic axis can be found. For example, in the case of the simple dipole molecule HCl, we may assume the optic axis to be parallel to the doublet.

The constant of depolarisation as recently measured by Ramanathan is 0·010, and the Kerr constant from the measurements of Hansen = $0{\cdot}90 \times 10^{-10}$. From this, considering the orientative action of the field to be due only to the permanent doublet, we find its moment to be $1{\cdot}06 \times 10^{-18}$ electrostatic units, while if the orientative couple on the induced doublet is also taken into account as in the case of non-polar molecules, the value of the permanent moment comes out to be $1{\cdot}04 \times 10^{-18}$. The recent determination by Zahn from dielectric constant measurements gives $1{\cdot}03 \times 10^{-18}$, thus showing good agreement.

When the optical ellipsoid of the molecule has three unequal axes, measurements of the factor of depolarisation and of the Kerr constant are by themselves insufficient for an accurate determination of the electric moment. But if the moment is known from measurements of the dielectric constant, the data mentioned are of much assistance in fixing the position of the axis of the doublet. For example, if the Kerr constant of a substance is negative, we can assert definitely that the axis of the permanent doublet does not coincide with the longest axis of the optical ellipsoid. It is interesting to note in this connexion that, so far as is known, all substances having a negative Kerr constant are polar.

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Depth of Origin of the Earthquake of August 15.

THE earthquake of Sunday morning, August 15, was one of those for which no method of determining the depth of origin had been devised until recently, and offers an opportunity for applying that which was published in the *Quarterly Journal of the Geological Society* for February last. The extreme limits of the area over which the shock was felt appear to have been Llandrindod Wells and Blackheath, which are about 150 miles apart; the maximum violence seems to have just about reached the lower limit of VI° of the Mercalli scale, or an acceleration of about 150 mm./sec.^{2} Applying the coefficients in the paper referred to, the resulting depth of origin is not far from thirty miles. This estimate is based on the newspaper reports and subject to correction when more precise data are available. The maximum acceleration may have been more than the figure adopted, the limiting value of acceleration, of a shock which is just sensible in England, may be less than the 20 mm./sec.^{2} adopted, and either of these would lessen the resulting depth of origin. On the other hand, the description of the shock at

the limiting stations suggests that it must have been sensible even beyond them, and this would give a greater depth. Taking all these circumstances into consideration, it seems probable that the earthquake originated at a depth of some 25 to 30 miles, say 40 to 50 kilometres, below the surface of the ground.

R. D. OLDHAM.

The Groma: an Ancient Surveying Instrument.

A FEW weeks ago, while looking through some miscellaneous objects at the premises of the Egypt Exploration Society, I discovered a portion of a groma, an ancient surveying instrument, commonly used in Græco-Roman times for setting out straight lines and directions at right angles, in building operations as well as in land instruments.

There are several references to this instrument in the literature, but the only other specimen known was one unearthed at Pompeii in fragments in 1912. This was reconstructed by M. Della Corte and a model is in the South Kensington Museum. There is a representation of a groma on the tombstone of a Roman 'Mensor' found in the neighbourhood of Turin.

The portion now brought to light consists of two roughly shaped pieces each about 12 inches in length, formed of the centre rib of a datepalm leaf, bound together at the centres by a lashing of datepalm fibre, forming a loop for suspension. Near the ends of each piece are in-cuts to locate the plummet strings which were suspended from the ends.

So far as is known, this is the first specimen of the kind known, and special interest attaches to the fact that it came originally from Egypt, having been brought from the Fayum in 1899. Since then it has lain unrecognised among the Museum surplusage in the Society's basement. It probably dates from the Græco-Roman period and may be a tomb model.

The specimen has been acquired by the South Kensington Museum authorities and will shortly be exhibited there.

R. W. SLOLEY.

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The Absolute Density and Coefficient of Expansion of Silicon Tetrachloride.

IN a recent paper on "A Comparison of the Atomic Weights of Silicon from Different Sources" (*Jour. Chem. Soc.*, 1926, 128, 1262) the density of silicon tetrachloride from different sources was determined by means of glass floats. These were calibrated at one temperature and used in the actual measurement at another, but in making the calculation we omitted to take into consideration the alteration in volume of the floats consequent on this change in temperature. After we had instituted inquiries for a trustworthy coefficient of thermal expansion for the 'Durosil' glass used, in order to correct the reported figures, we received a private communication from Mr. A. G. Milligan pointing out this omission, which leads us to take this early opportunity of publishing a provisional correction. Applying the probable value $14{\cdot}1 \times 10^{-6}$ for the cubical expansion of 'Durosil' to the data already published (*loc. cit.*), the mean density and coefficient of thermal expansion of silicon tetrachloride become $1{\cdot}481461 \pm 0{\cdot}000020$ and $0{\cdot}0014048 \pm 0{\cdot}0000022$ respectively. We hope to publish elsewhere a complete résumé of the densities, etc., when our inquiries have yielded a trustworthy coefficient of expansion for this glass.

It should be noted, however, that the application of this correction to the five densities in question makes no alteration in their relative magnitudes, and thus leaves unaffected the essential conclusion of our paper (*loc. cit.*).

P. L. ROBINSON.
H. C. SMITH.

Armstrong College,
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July 30.

The Movements of Molecules.

IN a very interesting little book on phosphorescence by T. L. Phipson, Ph.D., published in 1866, on p. 184 he says: "We have no proof that the molecules of bodies vibrate in straight lines; their motion is more probably circular. Indeed, my ingenious friend, M. Porro, has endeavoured to show the great resemblance which seems to exist between these molecular movements and those of celestial bodies; and it has been supposed by some philosophers that the molecules of matter are as distant from each other, in proportion to their size, as the planets themselves." "But in the present state of knowledge, all these considerations are premature."

Ignazio Porro (1795–1875) was a French physicist who made improvements in the binocular telescope, the telemeter, and other optical instruments. It would be interesting to know if he had any inkling as to the existence of moving particles or electrons in atoms. I have looked through the list of his published papers given in the Royal Society Catalogue, but did not see any titles which appeared to bear upon the subject; perhaps some readers of NATURE may know of some which do.

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Pernicious Grafting.

To reply fully to the question asked by Dr. Grabham in NATURE of July 17 would entail a much greater demand upon the space available than the subject would at present appear to justify.

A study of the question as set forth by Dr. Grabham immediately suggests to the practical cultivator that root control would remedy the evil: nobody expects the best results from peach or nectarine trees grafted on any stock unless systematic root pruning is practised, and from the tendency of the wild 'individuals' in Madeira to flower before the fall of the leaf one adduces the fact that there is a lack of sympathy between stock and scion; therefore root pruning might be the means of modifying the flow of 'incompatible' sap to the need of the cultivated variety at that period. Moreover, a cool moist condition of the soil during the winter being essential to successful peach cultivation, it may be necessary to adopt means of providing these conditions in Madeira, as well as a careful selection of root stocks.

W. M. MACDONALD.

14 Canongate,
St. Andrews, Fife,
July 23.

The Relation between Cultivated Area and Population.[1]

By Sir DANIEL HALL, K.C.B., F.R.S.

RECENT considerations of the problem of the capacity of the world to continue to feed its growing population appear to have begun with the late Sir William Crookes's address as president of the British Association when he discussed the ultimate curtailment of the wheat supply through exhaustion of the soil nitrogen. Crookes's views attracted little more than academic attention at the time (1898) because the great tide of wheat that was setting in from the newer countries still in the process of exploitation was barely slackening; moreover, Crookes had neglected a factor then imperfectly appreciated—the fact that land under any of the conservative systems of farming adopted in the old settled countries does not become exhausted. Generally speaking, a soil will remain itself indefinitely at a certain level of production. Latterly in Europe that level has been raised by the introduction of extraneous fertilisers. In his review Crookes predicted the development of the synthetic processes of bringing nitrogen into combination which are to-day rendering that prime element of fertility so abundant and so cheap.

Though we no longer fear the exhaustion of soils, of late years certain sociological considerations have revived interest in the old thesis of Malthus. Over-population and unemployment have become terrible realities in Great Britain and other countries; many States are finding themselves under pressure to maintain their standard of living against the intrusion of neighbouring races propagating recklessly down to the barest margin of sustenance. Again, various studies of the course of prices of wheat have led to the conclusion that before the War the real price was rising continuously, and that this tendency is manifesting itself again, however much the true sequence of prices has latterly been obscured by fluctuations of currency.

These considerations led Mr. Keynes to envisage the approach of scarcity: his attitude is very much a return to Malthus. On the other hand, Sir William Beveridge, addressing the Economics Section two years ago, dismisses this fear as regards the world at large; whatever may be the troubles in Britain, "the limits of agricultural expansion are indefinitely far." On the whole that seems a very safe proposition; it has been so amply fulfilled for the last hundred and fifty years—during the greatest expansion of population the world has ever known—that it would almost seem to be necessarily true, especially as it can be buttressed by agricultural experiments showing the enormous potentialities of production from the soil.

There is, however, one aspect of the case that appears to have received insufficient attention: the capacity of agriculture to provide food for the people depends upon the extent of land available as well as upon the pitch of cultivation. To what degree can the tuning-up of methods be made to compensate for a non-expanding acreage? The first step towards a more exact consideration of the problem may therefore be an estimate of the amount of cultivated land that is required to maintain one unit of population—man, woman, and child.

We may make our estimates by either of two methods—abstract or actual. The Food (War) Committee of the Royal Society adopted the figure of 2618 calories as representing the minimal daily energy requirement of one unit of the population, and calculated that the actual United Kingdom consumption in the five years 1909–1913 amounted to 3091 calories per head per day. An average English acre of wheat yielding 32 bushels will produce food, in the shape of wheat, flour, and pig obtained from the offals, of a calorie value of about 2½ millions. As the average consumption was about 1·13 million calories per head per year, we arrive at the conclusion that one acre of wheat would support more than two head, the relationship being more exactly 0·45 acre to feed one unit of population. But this figure is of no service in our more general consideration. The yield of wheat of 32 bushels per acre is far above that of the wheat-producing areas, and is that of only a few selected countries growing but a limited acreage. It is again the produce of land under the plough, and is consumed in the main as a vegetable product.

The great areas of grassland have a lower output of energy than the cultivated land, and the conversion of vegetable into animal food, whether of natural or cultivated fodder crops, is always attended by a great waste of energy. In the most economic production of pig-meat or milk, the energy recovered is only about one-sixth of that consumed, and this represents the machine at the top of its efficiency. The longer period of beef production results in a recovery as beef of only one-eighteenth of the energy consumed, and in practice the actual wastage of fodder and feeding-stuffs doubles or trebles the inevitable losses by conversion. Moreover, just as man is not a vegetarian making the most of the mere sustaining power of the land, so he does not use the land for food alone, but also for drink, for wool and fibre and other industrial materials, and for amenities.

We shall not get far on the theoretical basis, and I have only mentioned it as indicating the order of the superior limit of the maintaining power of land.

THE UNIT OF MEASUREMENT.

We must approach the question in a more empirical fashion and endeavour to ascertain the existing relation between the land in use and the people fed by it. Taking again the estimates of the Royal Society's Committee, it concluded that the United Kingdom production of food for the five pre-War years was 42 per cent. of the food consumed; 46·7 million acres of cultivated land then produced 42 per cent. of the food consumed by a mean population of 45·2 millions, which works out to 2·5 acres to each unit of the population. This figure, however, is somewhat misleading in that it does not do justice to British agriculture, since our farming is to a considerable degree concentrated on the more costly elements of diet like meat or milk rather than upon cereals and sugar. For example,

[1] From the presidential address to Section M [(Agriculture) of the British Association, delivered at Oxford on August 9.

49 per cent. of the food production at home, as against only 24 per cent. of the imported food, consisted of animal products.

The importance of this relation between cultivated area and population is so great, and the calculations by which it can be ascertained are so approximate and subject to so many estimates of a speculative kind, that I may be allowed to set out various results obtained by different methods.

We may begin by comparing population and area of cultivated land for all European countries except Russia, to which we add the United States, Canada, Argentine, Australia, and New Zealand, as the white countries which are also the chief exporters of food to Europe. I exclude all oriental countries because in them the mass of the population possesses a different standard of living, and I have excluded the other South American States and the Union of South Africa and other African colonies because they all possess a very large 'native' population and their exports do not bulk large in the food account of Europe. We must recognise, however, that the errors in the calculation will be loaded on to one side, because all the unenumerated countries, Russia and the tropical lands, are to a greater or less degree exporters and not importers of food. However, with this proviso we find that in the States enumerated there are 464·1 million hectares of land under cultivation and a population of 481·5 million persons, or 2·4 acres per head.

In the United States about 356 million acres are in cultivation: from this may be deducted as producing exported materials, for cotton 24, for wheat 16, for maize 2, for meat products 22 million acres, or 65 million acres in all. Other products are exported but may be regarded as balanced by imports, so that we find 291 million acres of cultivated land devoted to supplying a population of approximately 112 millions, or 2·6 acres per unit of population.

France we know is a country that is largely self-supporting; it has a population of 39·3 millions and 36·3 million hectares under cultivation. To this acreage we must add 0·9 million for imported wheat, 0·5 for other cereals, and 1·1 for imported meat; the exports of wine and fruit we may regard as balanced off by other imports. The net result is approximately 1 hectare, or 2·4 acres, for each head of the population.

A similar calculation applied to Spain, a country in the economy of which neither exports nor imports of food play a large part, gives more than 4 cultivated acres per unit of population; but then the so-called 'cultivated' land includes a considerable proportion of mountain pasture of a very low order of productivity. On the other hand, Denmark, with the most highly developed agriculture of all countries, shows a production well above the average. A much closer calculation of production is possible for Denmark than for other countries—the data are set out in Mr. Harald Faber's paper before the Royal Statistical Society in 1924. Denmark is a country exporting agricultural produce chiefly in its most costly form as meat, butter, and eggs, but the means for equating the export against consumption is supplied in Mr. Faber's paper by the reduction of production and imports to food units. Making the necessary corrections for imports, it would appear that for the years 1909–1913 the population of Denmark was maintained on 63 per cent. of the production of her own land, or 1·82 acres per person.

Putting the various estimates together, we arrive at the conclusion that under the existing conditions of agriculture among the Western peoples, it requires something between 2 and 2½ acres of cultivated land to supply the needs of one unit of population living on the standard of white peoples.

We may confirm this estimate by a consideration of the growth of population during the last century. Between 1800 and 1920 the number of the white peoples increased from about 200 millions to about 700 millions. Data, however, for the land under cultivation in 1800 are very imperfect, and again there was another factor of improved agriculture which came into play in the first half of the nineteenth century. If we take 1870 as our jumping-off point, we may estimate the increase in the white man's numbers up to 1920 as approximately 225 millions. During the same period the addition to the cultivated lands in Europe, United States, Canada, Argentina, Australasia, and South Africa, the countries which have provided the white races with food, has amounted to about 450 million acres. Again we reach a relation between cultivated land and population of between 2 and 2½ acres per head.

This brings me to the central point of my argument, that an increase of population is in the first instance dependent upon an increase in the area of cultivated land. The expansion of the white peoples in the last century was an event unprecedented in the world's history, and was achieved only because of the vast areas of unoccupied land, chiefly in the Americas, which suddenly became available for settlement through the power conferred by the railroad, the steamship, and modern weapons. It will be noticed that the population of Europe previously had become comparatively stable, even as it has become approximately stabilised in France at present—the expansion came with the opening up of the new lands and in proportion to the amount that could be settled.

Energy Value of Produce.

Accepting as a basis for further discussion that under the present system of agriculture something more than two acres of new land will have to be brought under cultivation for each unit of increase in the population, we may examine if any means exist of modifying this relationship before considering its consequences.

I have already suggested that a vegetarian diet is the more economical of the resources of the soil, and that meat and all animal products like milk and eggs are produced with an expenditure of energy which may be so low as seven but also so high as twenty times the energy available from them. It is true that to a certain extent the animal will utilise material otherwise of little service to man, like milling offals and low-grade fodder crops—roots, hay, or straw. None the less, if the maximum of population supported by a given area of land is the objective, vegetarianism becomes increasingly necessary, as we see among the crowded populations of India and China. At the same time, the tillage of lands now given up to the grazing of animals becomes possible because of cheapness of labour resulting from a redundant population. Most

of the beef and mutton supply comes from land left untilled because of the costliness of labour relative to products; the meat may represent a very low level of production from the land and yet a high cash return for the labour expended. Hence the apparent paradox of grazing being general in Middlesex because of the proximity of London.

Another item of waste which would have to be eliminated in case of stern necessity is the conversion of potential food into alcoholic drink. Great Britain ferments the equivalent of one and a half million acres of barley. France devotes 4,000,000 acres, nearly 4·5 per cent. of her cultivated area, to vineyards. Without going so far as to say that beer or wine possesses no food value, it is certainly not half of that which could have been grown from the land thus used for the production of drink. In such matters it is vain to prophesy, but I cannot help feeling that the race (not individuals) which cuts out meat and alcohol in order to multiply is of the permanent slave type destined to function like worker bees in the ultimate community.

Intensification of Production.

The second question that merits very careful consideration is whether the current agriculture cannot be intensified so as to bring about a great increase of production from the existing area of cultivated land. A cursory examination of the average yields of our chief crops in different countries shows what an immense potential increase of production is here open. The average yield of wheat (1921 to 1924) for all the countries of the world collecting statistics was 13·2 bushels per acre; the average yield in Denmark for the same period was 41·4 bushels per acre—more than three times as much. Of course the area devoted to wheat in Denmark is about 200,000 acres in all, or 3 per cent. of her arable land, whereas the wheat acreage of the world amounts to about 250 million acres. The mass production of wheat in the world is from countries of low yield; more than half is grown in countries in which the average yield is less than 13 bushels per acre.

It is from these countries with the low yield per acre that wheat is exported, and their production determines the world market, with the consequence that wheat production has been increasing in these and similar countries, while it has been shrinking in the European countries with a higher yield per acre.

The dominating factor has been cost of labour; speaking broadly, it may be said that increased yields per acre are associated with higher expenditure per bushel for labour, and the great wheat-producing countries with a low yield per acre are the countries with a correspondingly high yield per man employed. It may be estimated that in England a man's labour produces about 960 bushels of wheat, in Australia 1500 bushels. A more exact comparison shows that in England the labour cost amounts to 1*s.* per bushel of wheat, against 8*d.* in Canada; this with an average wage rate of 30*s.* to 36*s.* a week in England as compared with 60*s.* in Canada.

All this goes to show that intensification is only to be purchased at the cost of labour, and that in the past, extending the cultivated area has been a cheaper way of getting the wheat required by the world than higher farming.

This general statement, however, does not tell the whole story; particularly it disguises the intensification of yield that may be obtained without a commensurate increase of labour. For example, the introduction of more heavily cropping varieties, originated by the skill of the plant breeder, may add greatly to the production from a given area without increasing costs other than those of harvesting and marketing.

One must not, however, expect too much of the plant breeder. Over the greater part of the cultivated land of the world the gross amount of production is limited by external factors such as water supply, temperature, available fertility of the soil, etc. For example, the wheats and barleys grown in England had long been subjected to selection and improvement before the scientific methods of plant breeding were evolved, and the further steps in improvement are going to be neither big nor easily won, depending as they do upon altering what Dr. Beaven has called the migration ratio, whereby the plant will convert more of the material obtained from the air into useful grain and leave less as straw. The chief opportunities, in fact, lie in the elimination of susceptibility to disease or destruction by frost, or general tenderness of constitution, by which means the range of the high-yielding cereals, or even of cereal growth at all, may be enormously extended.

Artificial Fertilisers.

The general enhancement of production by processes which induce improvements of the water supply or the temperature, as by irrigation and drainage, soil amelioration, cultivations, etc., suffers from the disadvantage of calling for labour, until it may prove far more costly than the increased produce can repay. Fertilisers appear to offer more promise. It may be recalled that the general level of production from English land was raised by nearly 50 per cent. between 1840 and 1870. At the beginning of the period the average yield of wheat was of the order of 20 bushels per acre, this being the crop the land was capable of maintaining under a conservative rotation with no extraneous source of fertility. But between 1840 and 1870 artificial fertilisers were introduced and became a generally accepted part of British farming, with the result that the yield of wheat had risen to about 30 bushels per acre, though no other marked change in the routine of cultivation had been adopted during the period. The employment of fertilisers still lags far behind the opportunities of employing them to profit.

The various processes of bringing atmospheric nitrogen into combination, to which the War gave such a stimulus, are now being developed on a vast scale in all civilised countries, and will result in an almost unlimited increase in the amount of nitrogenous fertiliser available at low prices compared with the prices of agricultural produce. Here at least is the opportunity for another step up in production from our cultivated lands comparable with the progress that was made between 1840 and 1870. It is not all

plain sailing; the farmer has to study carefully where an increased supply of the cheapened nitrogen can be most suitably applied to his land and what changes in his system of cropping are demanded. The plant-breeders' art is needed; on most of our land any great enhancement of growth of cereals brought about by the use of nitrogenous fertilisers is attended with the danger of lodging. Few of our cereals possess stiff enough straw to remain standing on a soil enriched to the degree even that is reasonably practicable to-day. Thus the more immediate outlet for the new fertilisers would appear to be the fodder crops which are convertible into meat and milk.

In the solution of the main problem under discussion—the possibility of intensification of production from the existing farmed land to meet the needs of a growing population—the development of the synthetic nitrogen fertilisers must play a dominant part. Crookes's prophecy is coming true.

The Economics of Present-day Agriculture.

The present annual increment in the white population may be estimated at about five millions. This, taken alone, would necessitate the taking into cultivation of twelve million acres of new land every year. No process of the kind is going on; indeed, for many crops there has been an actual shrinkage in the acreage since the War. The shrinkage is doubtless no more than a temporary matter, the back-water of the wild fluctuations of prices and values brought about by the War, but it does not promise well for that continued expansion of the cultivated area which the still growing population demands. Indeed, we may detect a new influence at work, the growing disinclination of the civilised peoples to continue in agriculture because of its small and uncertain returns as compared with those of other occupations.

The flight from the land is manifest equally among the wage-earners of large-scale agriculture and among the peasants or family farmers in whose hands resides the greater part of the cultivation, whether in the old settled countries of Europe or the newer exploitations of America. Again and again it must be urged that the determining cause is economic; for the last half-century, save for the abnormal War years, farming has not paid a return on the capital and labour expended comparable with that obtainable elsewhere. It has been said that even the American farmers of the Middle West, who cut prices for all the world, made no profits during the last half-century except those derived from the accretion of land values; and the peasant farmer, who counts neither the capital he has in the business nor the hours of labour he gives to his land, who in Europe is held to the land by secular tradition, finds agriculture unattractive so soon as the growth of industries and the spread of communications render an escape possible. If not the peasant himself, at least the sons look for an easier and less exacting mode of life.

At this stage it would be impossible to begin to diagnose the causes of the comparative unprofitableness of agriculture. Fundamentally it is due to the weakness of the farmer as a commercial unit; the smaller the farmer the more ruthlessly does he compete with his neighbours and reduce prices to a bare level of sustenance for his long hours of labour. Even the large farmers who can put into practice some of the economies of an ordered industry are helpless against the large commercial organisations which pass on their produce to the customers. Always there is the peasant farmer to cut prices.

I cannot, however, pursue this issue. I return to my original text: that if we are to continue to feed the growing population of the world on the present methods a continued expansion of the cultivated area is required; new land is called for year after year. I cannot see where this new land of the necessary quality is to be found in quantities commensurate with the immediate demand. Doubtless the white races will insist on maintaining their rising standard of living and will apply deliberate checks to their fertility, a process we already see in action. But the restriction of increase will not take effect all at once even under economic pressure, and the danger lies in the period preceding the comparative stabilisation.

As it cannot be supposed that the development of the civilised races can be allowed permanently to be checked by lack of food when food is obtainable, it follows that resort must be had to the intensification of production from the area already under cultivation. The means for that intensification are already in sight, more will be supplied with the advancement of research. Intensification, however, is in the main attended by a higher cost of production, and movement in that direction is likely to be slow until it is stimulated by a rise of prices. Organisation will have to be introduced into the industry, and it may be expected that organisation will take one or other of three forms. The farmer may be left as the producing unit, but his methods will be strictly controlled and standardised by the great selling corporations that handle his produce, and these corporations may be either commercial ventures or co-operative associations of the farmers themselves. The co-operative venture appears to imply an even more rigid discipline of the individual than that imposed by the capitalist firm. Alternatively, the capitalist may venture upon the direct exploitation of large areas of land and industrialise farming as he has industrialised other producing businesses. But capital will only be tempted back to farming, whether for the organisation of the business or even to enable the individual to take advantage of the possibilities of intensification, if prices rise to a definitely remunerative level.

I hope I have given reasons for supposing that prices must rise, because the surge in population set up by the unprecedented extension of the cultivated area last century cannot all at once be checked, whereas the new land still available is either inadequate in amount or unsuited to cheap production by the old methods. How close at hand the period of pressure may be it is unsafe to prophesy, but it may be agreed that pressure is sooner or later inevitable and that one of the biggest problems before the world at present is to prevent the pressure developing suddenly or becoming unbearable. The intensification of production is the only remedy, and, again, the only means of rendering intensification practicable is the continued pursuit of scientific research.

The Rate of Work done with an Egyptian Shadouf.

By Dr. J. S. HALDANE, F.R.S., and Dr. YANDELL HENDERSON.

THE shadouf is a man-power apparatus which from time immemorial has been used in raising water from the Nile or from canals, etc., for local irrigation purposes in Egypt. Great numbers of them can be seen in operation throughout all parts of Upper Egypt, and there appears to be little tendency towards their displacement by power-driven pumps.

With a shadouf water is lifted, usually about ten or eleven feet, in a goat-skin bucket, and delivered into a water-channel at the higher level. During low Nile in Upper Egypt, three shadoufs, or pairs of shadoufs, working in series, are commonly employed to lift water from the Nile level to that of the adjoining land. The bucket (Fig. 1) is carried on a wooden hook lashed to a light upright pole of tamarisk wood. This pole is attached at its upper end by rope to one end of a light beam made from a branch, or two branches lashed together, of acacia wood, which is sufficiently strong and rigid to support the weight of the bucket without much bending. At about three-fourths of the distance to the lower end, the beam is pierced by a hole through which passes a wooden pin on which the beam is pivoted. This pin is suspended by short cords from a stout wooden bar, of which the ends rest on two upright pillars consisting of either wood or maize-stalks and dried mud. Round the other end of the beam is plastered a globular mass of dried mud and chopped straw to serve as a counterpoise. Acting on the short end of the beam it is sufficiently heavy (about 230 lb.) to raise a bucket-full of water suspended at the other end.

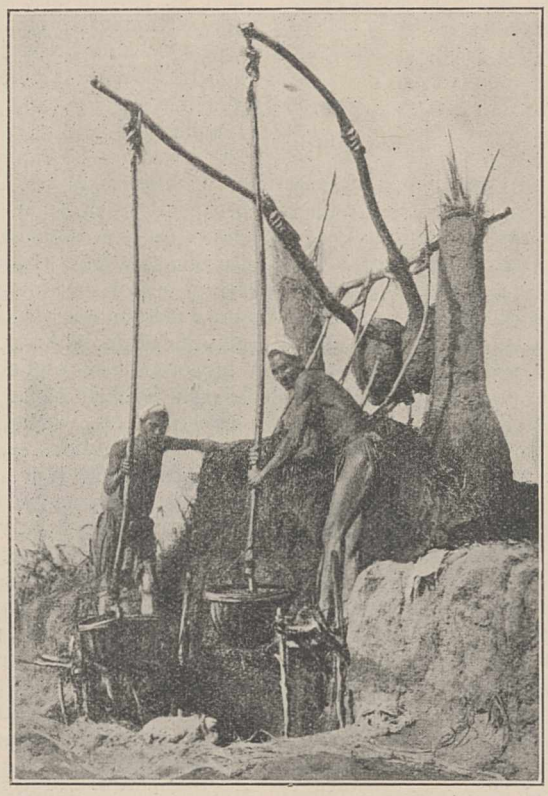

FIG. 1.—Pair of shadoufs working in parallel. After a photograph by Messrs. Gaddis and Seif, Luxor.

The bucket consists usually of goat-skin, although light metal buckets of similar size and shape are used in some places, and is held open by a wooden ring about sixteen inches in diameter, and has a cross-bar to which the wooden hook is attached. Since the counterpoise pulls up the water, nearly all the work done by the man is performed in pulling downwards the upright pole carrying the empty bucket. During this operation his body becomes bent to extreme flexion, and has to be straightened as the bucket ascends. He has also to tip the bucket when it reaches the higher level, and just as it reaches the lower level he gives the pole a slight jerk, so as to make the bucket enter the water edgewise, and thus fill instantly.

During a recent visit to Egypt we took the opportunity of measuring the rate of work done in raising water by means of a shadouf. All shadoufs appear to approximate very closely to the figures here reported. We found that the bucket holds about 60 lb. of water when nearly full, as in the lift, and is raised 11 feet 6½ times a minute, or up to 8 times a minute for a correspondingly less elevation. Thus the work done in raising the water is about $60 \times 11 \times 6{\cdot}5 = 4290$ foot-pounds per minute, or nearly 600 kilogram-metres per minute. Two men, working alternately for about an hour at a time, are employed on each shadouf, and each man works for a total of about 6 hours daily. Thus the work per day is about 1,550,000 foot-pounds or 700 foot-tons. The shifts are measured by means of a simple sun-dial, improvised on the spot. Its essential part is a cord stretched horizontally north and south between the tops of two pegs a few inches above the ground, with marks to indicate the endings of the shifts by the progress of the shadow. The intervals between shifts are devoted to light occupation, meals, and rests.

From other well-known physiological data we may reckon that the gross efficiency of the work during the raising of water is about 20 per cent. As the work done is 1,550,000 foot-pounds, the corresponding amount of energy liberated in the body is therefore equivalent to about 7,750,000 foot-pounds, which is equivalent to almost exactly 10,000 British thermal units, or 2500 calories. This is at a rate of about 417 calories an hour, or 7 calories a minute. During the remaining 18 hours of the 24 the average energy liberated cannot well be less than 80 calories per hour, so that the total liberation of energy will be at least 4000 calories. To cover this expenditure the shadouf worker will, if we make the ordinary allowance of 10 per cent. for waste, require food of the energy-value of at least 4400 calories.

The men working on the shadoufs are erect and finely developed, looking a picture of health and physical grace, and doing the work without signs of fatigue. They take several meals daily between shifts. These meals consist usually of cakes made fresh each day from maize or wheaten flour, with cheese and sour milk. Hot meals, with lentils or

beans, and occasional meat, are taken at home. The work could not be kept up day after day if the food were not abundant. We were told that this food is almost entirely the produce of the land the men are irrigating and cultivating. The actual men who work the shadoufs and do the other work on the land are joint farmers. They thus work jointly for themselves and pay the rent jointly, taking all the produce and profits from its sale after the rent has been paid. The rents seem enormous by British or American standards, but the land, as actually worked, is extremely productive. It is very improbable that if the men were working on daily or weekly wages they would work so effectively or obtain the same net earnings. It seems also to be for essentially the same reasons that modern power-driven appliances have not displaced the shadouf. A shadouf is not only extremely efficient mechanically, but can be made from materials on the spot, and can be at any time repaired by the men who use it. To judge from carvings on a tomb near Luxor, the shadouf was practically the same more than three thousand years ago as it is now.

The work done on a shadouf is of special physiological interest, because it is so well standardised, employs so many muscles, and is so easily measured directly. In most kinds of standardised work we can only measure the work indirectly from the oxygen-consumption. In the late Mr. Jervis Smith's book on "Dynamometers" (edited by Prof. Boys) a description is given, on page 10, of another easily measured form of standardised human muscular work. This form of work was employed early last century in raising the earth needed in the construction of forts round Paris. The earth was loaded into a bucket attached to a rope passing over a pulley, and was then drawn up by the action of a counterpoise consisting of a man, whose work consisted in continuously ascending a ladder and coming down as a counterpoise to the ascending earth. It was found that the work done in this way amounted to 4230 foot-pounds per hour—a figure very close to ours for the shadouf worker as regards the rate per hour, though the French navvies kept up this rate during eight hours daily.

There can be no doubt that where the motive is adequate a man in good physical training, and fed in correspondence with the work, can keep up day after day, for say eight hours, a considerably greater rate of measured work than corresponds to these figures; and for short periods far greater rates are possible. Thus Henderson and Haggard (*Amer. Journ. of Physiology*, 72, p. 264, 1925) found that over a four-mile race in 22 minutes each oarsman of a university crew did average measured work at a rate of 0·45 horse-power, or 15,000 foot-pounds a minute, with a total energy-expenditure of 19 calories a minute, or at the rate of 1140 calories per hour. This rate is 3½ times that of the shadouf workers, but, of course, could not be kept up nearly so long. In a 1¼ mile rowing race the rate rose to 0·57 horse-power, or 18,770 foot-pounds a minute. For very short periods of less than a minute, still higher rates are possible, even for an untrained man. For example, Douglas and Haldane, with the view of producing maximum discharges of lactic acid from muscles during their temporary lack of oxygen, used short bursts of climbing work at a rate of 30,000 foot-pounds per minute (*Journ. of Physiology*, 38, p. 431, 1909). The rates of work of the shadouf men and of the French navvies are, however, worthy of record, as these rates could, without unusual effort, be maintained day after day throughout the working period.

We have pleasure in acknowledging the help we received from Mr. George Gattas, of Luxor, a chief dragoman on Messrs. Cook's Nile Service steamers.

Audibility of Explosions and the Constitution of the Upper Atmosphere.

By F. J. W. WHIPPLE.

PHYSICISTS who are interested in the problem of the temperature and constitution of the upper atmosphere have been awaiting with some impatience the publication of the official reports on the audibility of the experimental explosions arranged by the International Commission for Investigations on the Sound of Explosions. The first experiment was made (at Oldebroek in Holland) in October 1922, but the full report on the second experiment or series of experiments has appeared first. This report[1] has been prepared by Prof. Charles Maurain, head of the Institut de Physique du Globe at Paris. Some idea of the mass of evidence that has been digested may be gathered from the facts that 405 observations were plotted on the map showing the audibility of the first explosion, 360 and 240 on the maps for the second and third.

The site of the explosions was at La Courtine; this place is about half-way between Paris and the Pyrenees; as it is more than 250 km. from the nearest sea, the audibility in all directions could be investigated. There were four explosions, on May 15, 23, 25, and 26, 1924. In each of the first two, about ten tons of melanite was spent, in each of the others, five tons. Observers did not receive sufficient warning in the last case, and M. Maurain's report is practically confined to the other three.

The great advantage of organisation is manifest throughout the report. When explosions have occurred by accident, the places at which they were heard have in many cases been mapped successfully, but accurate records of the time have been rare. With an experimental explosion the observers are ready to note the time to a second at which the sound reaches them. In many of the places from which Prof. Maurain received reports, the agreement between the observers was excellent. Perhaps the best example of precision is provided by the observations at Bordeaux on the first occasion. In the observatory and near by, four observers gave the time as 19 h. 44 m. 5 s., two gave 19 h. 44 m. 4 s., and one 19 h. 44 m. 3 s.

Another advantage is that full information can be obtained as to the meteorological conditions. There were at least two soundings of the upper air in France on each of the three 'La Courtine' days, and the stratosphere was reached on each occasion. Special

[1] Annales de l'Institut de Physique du Globe. Fascicule spécial consacré aux expériences de La Courtine sur la Propagation des ondes aériennes. Paris, 1926.

pilot balloon ascents gave the direction of the air currents in the lowest three or four kilometres.

In the discussion of the observations, Maurain distinguishes between normal and abnormal audibility; for normal audibility the quotient of distance and time is approximately equal to the velocity of sound near the ground, whereas for abnormal audibility the quotient is considerably smaller. In each of the three La Courtine experiments there was a well-defined zone of silence separating zones of normal and abnormal audibility. The maps illustrating the last two experiments are comparatively simple and remarkably consistent. In each, the zone of normal audibility extends about 100 km. N.E. from La Courtine (with the wind), but barely 25 km. in the opposite direction. The zone of abnormal audibility occupies a quadrant to S.W., the minimum distance being about 160 km.

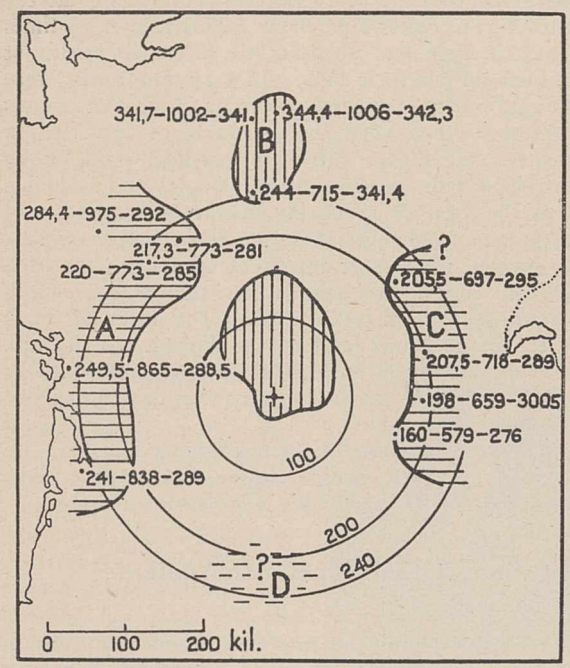

FIG. 1.—The numbers against the dots representing reporting stations are:—The distance from La Courtine in kilometres, the time after the explosion in seconds, and the quotient in metres per second. The circles are not in the original.

Two or three small detached areas of audibility are also shown to the east and north. The map for May 15, which we reproduce (Fig. 1), is of special interest on account of its remarkable symmetry. There were zones of abnormal audibility to east and west of the explosion. A detached region of normal audibility is also mapped in the neighbourhood of Paris, but it is to be noted that the observations in this area were instrumental. The records suggest waves of long period, beyond the range of the ear. With the favouring wind, the long waves travelled better than short ones through the lower atmosphere. As evidence for the favouring wind, it may be mentioned that the Upper Air Supplement of the Daily Weather Report shows that there was a current from the south crossing the English Channel at the cirrus level; the velocity deduced from nephoscope observations was about 100 miles per hour.

In a report of this kind the presentation of the observations in a convenient way is the main issue; it is to be regretted, however, that in the theoretical discussion the author has ignored details and adopted very rough approximations. Although he has been at pains to record the distribution of wind and temperature in the lower atmosphere, he boldly assumes that the sound rays in that region are straight. Moreover, he assumes that the stratosphere is uniform in temperature and composition up to 50 km. above ground, and does not test alternatives. His conclusions are that the high temperature postulated by Lindemann and Dobson for the atmosphere at 60 km. and above (say 300° A.) is not high enough to account for the recurving of the sound rays, and that Von dem Borne's hypothesis of the hydrogen atmosphere must be invoked. He goes so far as to hazard the estimate of 92 per cent. of hydrogen in the constitution of the atmosphere at 116 km., the height suggested for the apex of the path of the sounds heard at Bordeaux.

Fortunately, the observations provide us with a simple criterion by which such statements can be tested. Prof. Wiechert has reminded us recently that there is a close relation between the rate at which the intersection of a sound wave with the earth progresses and the velocity of sound at the apex of the trajectory. In the case of absence of wind and uniform stratification, these are equal. If there is a wind at the level of the apex, the component of the wind velocity in the direction of propagation of the sound must be allowed for. Now, in the La Courtine experiments there are three cases in which the radial velocity of the disturbance in the zone of abnormal audibility can be estimated.

In the first experiment there were well-supported observations to the north-west of La Courtine, at Chinon, and at Angers.

	Distance from La Courtine = X.	Time after explosion = T.	ΔX.	ΔT.	ΔX/ΔT.
Chinon . .	220 km.	773 sec.	..	..	..
Angers . .	284·4	975	64·4	202	0·319.

On May 23 there were observations at Angoulême, Rochefort, and Bordeaux, and as the straight line from La Courtine to Angoulême when produced bisects approximately the line from Rochefort to Bordeaux, we may take the average of the co-ordinates of those two stations for comparison.

	X.	T.	ΔX.	ΔT.	ΔX/ΔT.
Angoulême . . .	162 km.	614 sec.	..	..	..
Bordeaux and Rochefort	244	845	82	231	0·355.

On May 25 there were observations at Vélines between La Courtine and Bordeaux.

	X.	T.	ΔX.	ΔT.	ΔX/ΔT.
Vélines	191 km.	690 sec.	..	..	..
Bordeaux . . .	241	843	50	153	0·327.

It will be seen that in each of these cases the sound travelled across the zone of abnormal audibility with a speed differing but little from the ordinary speed of propagation, which for the temperature 17° C. is about 341 metres per second. In each case the sound was travelling against a light surface wind and would be retarded thereby.

Two deductions may be made:

(1) In the outer part of the zone of abnormal audibility the wave fronts were nearly vertical, the rays nearly horizontal.

(2) Unless the apexes of the sound rays were in a region of strong wind, they must have been at a level where the velocity of sound was about the same as at ground level.

Prof. Maurain's hypotheses are at variance with these deductions from the observations. He contemplates rays, the inclination of which at the ground is only 22° from the vertical, and the velocity of sound at the apex of such sound rays is said to be 786 metres per second. It is clear that further discussion of the observations is called for.

In our diagnosis of the conditions, we start with the known facts with regard to the state of the atmosphere on May 15. As a good approximation we take the temperature of the surface air as 290° A., the lapse rate of temperature $6\frac{2}{3}$° per km. up to 12 km., and assume a uniform temperature 210° from 12 km. upwards.

The region of uniform temperature may be supposed to extend to a height H_2. Above H_2, temperature is higher. It may be supposed that at the height H_3, temperature is the same as on the ground, 290° A., the inverted lapse rate being the same from H_2 to H_3 and beyond. With these assumptions, wind being ignored, a sound ray consists of arcs of cycloids in the troposphere and the upper atmosphere and of straight lines in the stratosphere.

For a ray starting with a given inclination to the horizon, the range, etc., can be expressed as linear functions of H_2 and H_3. For example, for a ray starting with the inclination $\psi = 15°$, we have the formulæ:

Range in kilometres $= X = 17{\cdot}8 - 5{\cdot}46H_2 + 8{\cdot}35H_3$.
Time of passage in seconds $= T = 36{\cdot}54 - 14{\cdot}55H_2 + 26{\cdot}64H_3$.
Height of apex in kilometres $= Z = 1{\cdot}26H_3 - 0{\cdot}26H_2$.

The observations of audibility give values of X and T and, if the inclination of the sound ray is assumed, such formulæ can be used to determine H_2 and H_3.

Four examples are quoted in the following table:

	X.	T.	ψ.	H_2.	H_3.	Z.	θ.	V.
1.	220	773	15	32	45	48·6	311	0·354.
2.	220	773	5	33	44	44·1	292	0·343.
3.	284	975	0	34	51·5	51·5	290	0·341.
4.	160	579	20	30	37	40·7	328	0·363.

ψ = initial inclination of ray; θ = temperature at height Z; V = corresponding velocity km./sec.

In the first two, the values of X and T are those appropriate for Chinon on May 15; the alternative values 15° and 5° are assumed for the inclination.

In the third example, the figures for Angers are used, this being a case of a very long range, and in the fourth example, the figures for Unieux are selected to illustrate a very short range.

It will be seen that in each of these cases it is indicated that the region of high temperature begins at about 30 km. above ground. The apex of the specified ray is between 40 and 50 km. above ground, and the temperature there is in the neighbourhood of 300° A.

Values of H_2 and H_3 having been determined, we can compute the values of X and T for rays of various inclinations. Thus, if H_2 is 32 and H_3 is 45·2, we obtain the following table:[2]

ψ_0.	X.	T.	ΔX.	ΔT.	ΔX/ΔT.
0	247·5	853·7	..	..	..
5	234·4	815·4	13·1	38·3	0·342.
10	225·3	789·0	9·1	26·4	0·345.
15	220·3	774·8	5·0	14·2	0·352.
20	219·8	773·3	·5	1·5	..
25	224·3	785·6	−4·5	−12·3	0·370.

It will be seen that the range is a minimum for an inclination about 18°. The figures in the last column illustrate Wiechert's principle.

The course of the rays in this example is illustrated in Fig. 2. The figure shows how the rays which return to earth are distributed over a rather narrow zone. That the zone of abnormal audibility is actually wider in observed cases is no doubt to be explained by the complication introduced by wind. The computation of the exact forms of rays with the influences of wind and temperature both taken into account is very cumbersome. To discover a hypothetical distribution of both elements consistent with all the reported observations would therefore require much laborious arithmetic. It is to be hoped that some one will carry this through. It is not likely, however, that the general result, that the observations imply a region of high velocity and high temperature between 30 and 50 km. above ground, will be modified. That this was probably the interpretation of the La Courtine observations was noticed when the preliminary account was published (F. J. W. Whipple, *Meteorological Magazine*, 1925, p. 16). Wiechert has come to the same conclusion as the result of the study of all the available evidence with regard to abnormal audibility (*Met. Zeitschrift*, March 1926, p. 90).

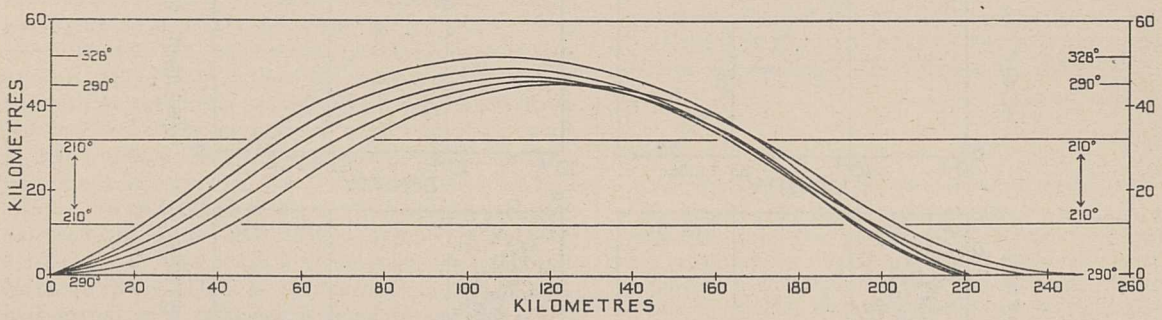

FIG. 2.

The existence of high temperatures at great heights was deduced by Lindemann and Dobson from the evidence provided by observations of meteors (*Royal Soc. Proc.* A, vol. 102, 1922, pp. 411-437). That this hypothesis would explain the 'abnormal' audibility of explosions was seen at once. There is, however, an apparent discrepancy. Lindemann and Dobson considered that the stratosphere with its uniform temperature might be regarded as reaching nearly to

[2] The figures quoted for 15° elevation do not tally precisely with the formulæ for X and T in which the coefficients have been rounded.

60 km., and credited the higher temperature to the region above that level. The discussion of audibility brings the transition down to 30 km. It seems, however, that the meteor observations are not inconsistent with this modification of the hypothesis.

In Fig. 3A, which is reproduced from part of Fig. 3 of Lindemann and Dobson's paper, the density of the air at different levels is shown by crosses and dots. Each cross shows the density computed for the point of appearance of a meteor, each dot that for a point of disappearance. The curve shows the density calculated on the assumption of a uniform temperature 220° at all levels above 12 km. The curve runs from 220° to 300° occurs between 30 km. and 40 km. The fit is now a little better. Finally, in Fig. 3D, I have made the rise of temperature begin at 30 km. and assumed a regular increase up to 50 km. At that level and beyond, the temperature is 380°. The assumptions are now in reasonable agreement with the observations.

It is difficult to believe that the atmosphere at 60 km. is really at a temperature above the normal boiling-point of water. That seems, however, to be the logical conclusion from the theory of Lindemann and Dobson. For our present purpose the essential point is that the meteor observations do not

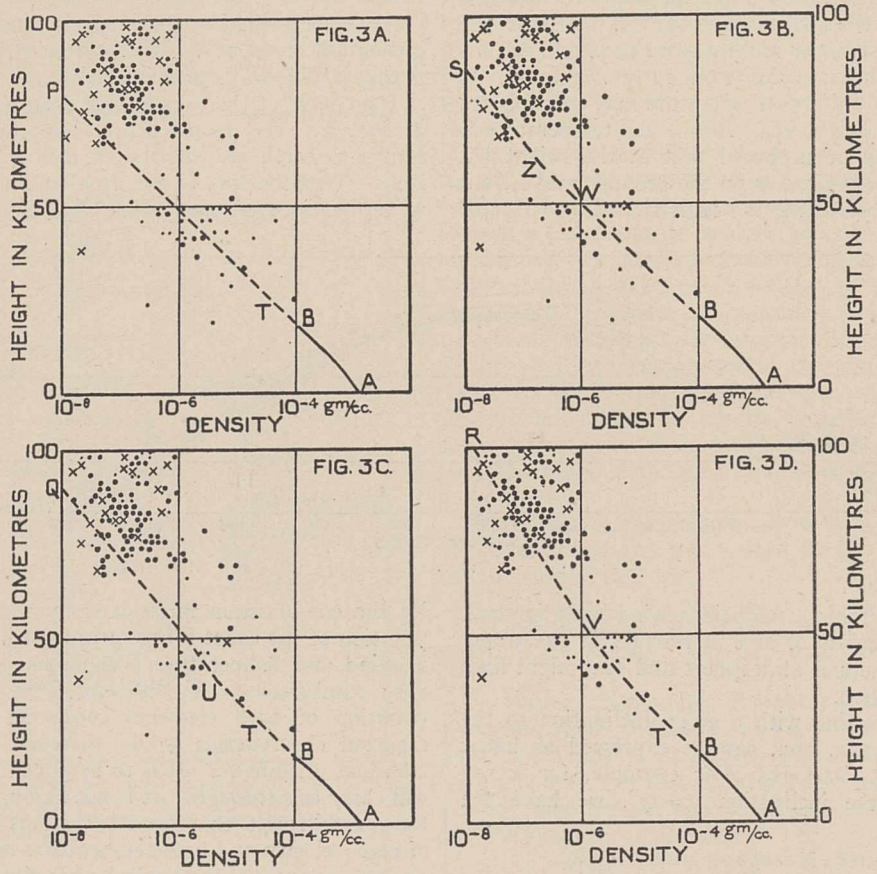

FIG. 3.

fairly through the points representing meteor observations below 60 km. As Lindemann and Dobson point out, above 60 km. the meteor observations "all indicate densities very much greater than those calculated on the assumption of a uniform air temperature of 220° A., but consistent with a considerably higher temperature." They state that the rate of change of density with height shows that the temperature is probably about 300° A., but how this estimate is reached is not clear. I have shown in Fig. 3B the curve which represents the relation between density and height on the assumption that temperature is 220° from 12 km. to 50 km., that there is a uniform gradient to 60 km., and that temperature above 60 km. is 300°. It will be seen that the curve does not represent the meteor observations at all well. In Fig. 3C I have adopted the hypothesis that the transition conflict with the hypothesis suggested by the phenomenon of abnormal audibility, *i.e.* that temperature is about 220° up to 30 km., about 300° at 40 km., and possibly higher above that level.

The apparent inconsistency between the theory of Lindemann and Dobson and their conclusions was pointed out recently by C. M. Sparrow, who interprets their diagram as implying a temperature of 480° (*Astrophysical Journal*, 63, March 1926, pp. 90-110). Sparrow does not accept the theory, and puts forward one of his own, which does not require high temperatures at all. The reply of Lindemann and Dobson to Sparrow's arguments has not yet appeared.

Realisation of the probability that the transition from the uniform temperatures of the stratosphere to much higher temperatures begins at the comparatively modest height of 30 km. makes it desirable to extend

the range of soundings by free balloons to that height, and beyond. By the proper choice of balloons that should be possible.

Another line of attack is also open. We are familiar with the fact that, during the War, gunfire was heard regularly at distances exceeding 100 miles. Why should not similar observations be made systematically in peace time? I should like to inquire whether gun practice at Portland is heard in South Wales. If there is any quiet spot in that region where the sounds are heard frequently, observations should be timed and, with a little organisation, valuable information would be obtained. The advantage of frequent observations of this kind as compared with the occasional 'big bang' is obvious.

Since this article was written I have had an opportunity of testing the possibility of timing the passage of the sound of gunfire. Listening at Grantham on June 28 for the discharge of guns at Shoeburyness, 115 miles away, I found that the time of passage increased gradually from $10\frac{3}{4}$ to $11\frac{1}{4}$ minutes and then began to decrease. Details have been published in the *Meteorological Magazine* for August.

Obituary.

DR. J. F. HALL-EDWARDS.

WE regret to record the death on August 15, at the age of sixty-seven years, after many years of suffering due to extensive X-ray injuries, of Dr. J. F. Hall-Edwards. He was educated at King Edward's School and at Queen's College, Birmingham, and after qualifying in medicine he went into practice. Soon after the discovery of X-rays, Dr. Hall-Edwards took up their application in medical work and was one of the earliest authors in radiography. He served in the South African War as surgical expert in X-ray work to the Imperial Yeomanry Hospitals at Deelfontein and Pretoria, receiving the Queen's medal with four clasps. In spite of disabilities which might well have deterred him from any further executive work, he applied for and received a commission as temporary Major in the R.A.M.C. at the outbreak of war in 1914, and served in a radiological capacity to such effect that official recognition of his services was made on two occasions. He was an honorary member of the Röntgen Society and the author of several original papers in the journals of this Society and of the Electro-therapeutic Section of the Royal Society of Medicine.

Dr. Hall-Edwards made a great fight for many years against the insidious damage which he had suffered when using X-rays in his medical work. Like other pioneers he suffered because protective methods were unknown. His services in the public cause which so unhappily affected him, were recognised by the award of a Civil List pension in 1908, and later, in 1922, he received the Carnegie Hero Trust Medallion with an annuity.

S. RUSS.

WE regret to announce the following deaths:—

Dr. Charles W. Eliot, for forty years president, and since 1909, president emeritus of Harvard University, who was largely responsible for raising Harvard to its present high position among the universities of the world, on August 22, aged ninety-two years.

Dr. D. E. Flinn, formerly medical inspector of the Local Government Board, Ireland, editor of the *Health Record* and author of works on public health and hygiene in Ireland, on August 18, aged seventy-six years.

News and Views.

SIR ARTHUR EVANS'S paper on "The Shaft Graves of Mycenæ and their Contents in Relation to the Beehive Tombs," which was read before the Anthropological Section of the British Association at Oxford, was something in the nature of a bomb-shell, of which the effects will be far-reaching. The relation of the great beehive tombs at Mycenæ, which were found empty of their sepulchral contents, to the shaft-graves, so rich in sepulchral relics, found by Schlieman within an extension of the Acropolis wall, has always been a puzzle to archæologists. Sir Arthur's paper revived a theory, first put forward by Prof. Gardner and arrived at independently by himself, that at a time of danger the royal burials had been transferred from the mausolea outside the walls to a site which could be included within the enceinte. This theory has not found favour among archæologists, and the view generally held is that the two classes of tombs correspond to earlier and later dynasties at Mycenæ. Mr. Wace recently has carried the matter further and suggested that the two finest shaft-graves, the "Treasury of Atreus" and the "Tomb of Clytemnestra," belong to the latest groups, making them contemporary with a time when the Palace of Knossos was in ruins and the civilisation of Crete on the downward path. Sir Arthur Evans's latest discoveries render this theory untenable. He has found decorative sculptures, not later in date than the end of the Third Middle Minoan period and in vogue about 1700 B.C., which run parallel with those of the façade of the "Atreus" tomb. Vases characteristic of the same epoch were found in the "Tomb of Clytemnestra." He was able to demonstrate archæologically that the finest of the beehive tombs belong to the same date as the earliest elements in the shaft graves, and that both are equally Minoan. On this view their culture, with the exception of certain intrusive barbaric elements, can no longer be regarded as a 'mainland' culture and, as Sir Arthur pointed out, the term 'Helladic' as applied to it becomes a misnomer.

SIR FREDERICK KEEBLE, Sherardian professor of botany in the University of Oxford, has accepted an

appointment with the Synthetic Ammonia and Nitrate Co., which is associated with Messrs. Brunner, Mond and Co., for the promotion of research in the application of synthetic nitrogen compounds to agricultural purposes. He will probably be released from his chair at Oxford at the end of next term, and start upon his new duties in January. This appointment marks a further step in the movement towards a closer association of fundamental scientific research with commercial enterprises in connexion with agriculture. The growing use of artificial fertilisers renders it imperative that possible fresh sources of supply should be investigated and the value of the products thoroughly tested. As a measure of economy and as a means of protecting agriculturists from loss that might be incurred by using new and comparatively untried fertilisers, research with regard to their economic application is essential, and it is this that Sir Frederick Keeble will endeavour to foster. His wide and varied experience has already brought him into contact with certain aspects of the problem, for on the practical side he has served as controller of horticulture to the Food Production Department of the Board of Agriculture, as assistant secretary to the Board of Agriculture, and as director of the Royal Horticultural Society's Gardens at Wisley, and on the scientific side as professor of botany at Reading and at Oxford. The possibilities in connexion with the use of synthetic nitrogen compounds as fertilisers are of great importance to agriculture, as was pointed out by Sir Daniel Hall in his presidential address at Oxford to Section M (Agriculture) of the British Association, which appears elsewhere in this issue, and the development of this line of work will be followed with much interest.

FURTHER records of the British earthquake of August 15 show that the disturbed area is much larger than was at first supposed, for it was felt at King's Lynn, Gainsborough and Harrogate, so that the total area shaken may amount to 60,000 square miles. This is a high estimate, but it must be remembered that the shock was felt chiefly in upstair rooms and at a time when there were few disturbances to hinder its observation. The position of the epicentre is still uncertain, but it is probably nearer Ludlow than Hereford. That the depth of the focus was considerable is clear from the slow decrease outwards in the strength of the shock in the central district, and from the large area shaken. The shock seems to have been registered at most British stations. The interesting record obtained at Kew is reproduced in the *Daily Express* for August 17. At Stonyhurst, according to the Rev. J. P. Rowland, S.J. (*Times* for August 20), the first preliminary tremors began at 3h. 58m. 46s. A.M. (G.M.T.), and the second at 3h. 59m. 5s., implying that the origin was 103 miles from the observatory or close to Ludlow. "The chief element of uncertainty," he adds, "lies in the determination of the time of commencement of the preliminary tremors, which are very small and difficult to read."

WHAT was probably the first important geological discovery from the air was made in 1920 by Dr. P. Chalmers Mitchell in the course of *The Times* African aeroplane flight. Between Khartum and Wady Halfa the Nile follows an S-shaped course. Flying over the unexplored country within the southern loop of the S, Dr. Mitchell observed a great plain of lava diversified with a number of craters and resembling, as he said, "an enlarged view of the moon." Part of this previously unvisited volcanic field has now been explored by motor car by Mr. H. C. Jackson (*The Times*, August 18). South-west of Sani Wells two conspicuous extinct volcanoes were found; one of the somma type, and the other, graphically called "the Place of Gloom," with an apparently complete crater "of awe-inspiring dimensions." Dr. Mitchell thinks that these craters lie to one side of those over which he passed, and states that Dr. Grabham, the Government geologist of the Sudan, hopes soon to make a survey of the area. Geologists will await with interest the petrological and tectonic description of the field, for its situation is in a line with the western branch of the Rift Valley system, though far to the north of any hitherto suspected continuation of that branch. It is clear from this example alone that many parts of the world may still hold surprises, even for geographical explorers.

THE president of the Board of Trade has appointed a standing committee to consider and advise on questions connected with the economic use of fuels and their conversion into various forms of energy, having regard to national and industrial requirements and in the light of technical developments. The members of the committee are: Sir Alfred Mond, M.P. (chairman), Mr. J. Baker, M.P., Mr. Mark Brand, Sir John Cadman, Sir Arthur Duckham, Sir William Hart, Mr. Frank Hodges, Prof. F. A. Lindemann, Sir David Llewellyn, Mr. M. Mannaberg, Mr. C. H. Merz, Sir Alexander Walker, and Mr. D. Milne Watson. The secretary of the committee is Mr. W. Palmer, and the assistant secretary Mr. R. J. Moffatt. All communications should be addressed to the secretary, National Fuel and Power Committee, Board of Trade, Great George Street, S.W.1.

PROF. ELLIOT SMITH, in the *Morning Post* for August 23, again raises the question of the origin of American culture, apropos of the articles by Dr. T. W. Gann on his discoveries on ancient Maya sites in Central America, which appeared in that journal in the early part of the year. Prof. Elliot Smith now offers the interesting suggestion that the remarkable stone causeways of the Maya found by Dr. Gann are distinctive of work of that period in Indo-China and Java, where there were definite reasons for their construction, and that they were introduced from those countries into Central America, where, however, the reasons for their construction no longer existing, they continued to be constructed from force of habit. He goes on to refer to the arguments recently advanced by Dr. C. Handy that the Maya temple and the Polynesian oracle-house were both copies of the Cambodian temple. A third class of evidence to

which Prof. Elliot Smith directs attention is connected with the cultivation of the sweet potato. The methods of cultivation employed are identical not only in New Zealand by the Maoris and in America, but also throughout Oceania, Cambodia, China, and Japan. Further, it is held that *Kumara*, the Maori word for the sweet potato, also occurs in Ecuador and Peru as *Kumar*, but in addition, F. W. Christian has recently suggested that the word itself is to be derived from the Sanskrit word for the white lotus.

MAJOR FRANCO and Capt. Ruiz de Alda have published a book "de Palos al Plata" giving an interesting record of their adventurous voyage in a seaplane across the South Atlantic from Palos in Spain to Buenos Ayres. They make it clear that an important factor in their success was due to the Marconi direction finder and the radio telegraphic apparatus they carried. On several occasions the direction finder prevented them from making unnecessary detours. There was a fog when approaching Las Palmas. They signalled the radio station there to send continuous signals so as to ensure a good descent. This was immediately done, the signals increasing in loudness until they were directly over Las Palmas, and a good descent was made. They experienced bad visibility again when approaching San Vincente, and again the direction finder proved to be of the greatest value. During their flight they were frequently in communication with passing ships, which sent them their bearings and sometimes sent radio messages announcing their progress to their next stopping place. The authors conclude that the direction finder enabled them to navigate with a maximum inaccuracy of about 3°. This is equivalent to efficient dead reckoning navigation and even to very fair astronomical navigation. They consider that radio telegraphy is indispensable for flights over the sea or sparsely populated countries.

RESULTS of meteorological observations made at the Radcliffe Observatory, Oxford, in the five years 1921–1925, prepared under the direction of Mr. H. Knox-Shaw, Radcliffe Observer, have recently been published by order of the Radcliffe Trustees. The work consists of five annual parts which deal with the observations for the several years. Commencing with 1925, changes in the routine of observation have been introduced; the numbers of eye-readings have been reduced from three to one each day, and the photographic barograph and thermographs which have been in use since 1881 have been superseded. Various other alterations of smaller detail have been introduced, but they are clearly stated. Now that observations have been recorded for seventy-five years or thereabouts, the mean results of barometer, temperature, and rain are as accurate as they will ever be. The mean of the maximum or day temperatures is 70°·8 F. in July, which is the warmest month of the year, and the mean of the day readings in January, the coldest month of the year, is 43°·7 F. The mean of the minimum or night readings for the corresponding months are respectively 53°·3 F. and 34°·5 F. The rainfall for seventy-five years gives the annual average 25·99 in. The wettest month is October, with an average fall of 2·84 in., and the second wettest month is July, with 2·58 in. The driest month is February, with 1·65 in., and the next driest March, with 1·73 in.; but making allowance for the different lengths of the two months, less rain falls on a March day when the average daily fall is 0·056 in., while in February it is 0·058 in. The sunshine records cover forty-five years; the sunniest months are May and June, each with average sunshine for 194·5 hours; the least sunny month is December, with the average sunshine 43·8 hours.

ACCORDING to a despatch of the Cairo correspondent of the *Times*, which appears in the issue of August 16, Mr. Alan Rowe, field director of the Palestine Expedition of the University Museum, Philadelphia, has succeeded in identifying the two temples of the Philistines mentioned in the First Book of Chronicles, x. 10. Of the four temples at Beisan (Beth-shan) built during the Egyptian occupation, two belong to the reign of Rameses II., and of these the southern is identified with the 'Temple of Dagon,' which was dedicated to the warrior god Resheph; the northern, which was dedicated to the warrior goddess Antit-Ashtoreth, was the 'House of Ashtoreth.' It is conjectured that a sanctuary was established in one or other of these temples by David after he had destroyed and partially reconstructed them. A consideration of the results of the season of 1925, and the examination of the archæological objects then obtained, has afforded material for suggestion as to the relation subsisting between Crete, Anatolia, and Philistia before the driving out of the Philistines by King David. The Egyptian mercenary troops who occupied Beth-shan appear to have included an Ægean-Anatolian element before the coming of the Philistines. The walls of the temples of Seti I. and Rameses II. apparently were built by the mercenaries themselves. Some bricks bear signs identical with certain Minoan signs, and not only are the cylindrical cult objects and ring flower-stands Minoan, but also they do not appear on the site before the time of Seti I. The presence of Cretans among the mercenaries had not previously been recognised.

IN the July issue of the *Quarterly Review* Mr. Robert Steele has an illuminating article on the early days of chemistry. He points out that in the Dark Ages of Europe there were two great civilisations, still at the height of their powers, with a foothold in Europe, namely, the Byzantine and the Arab. Byzantium was, however, cut off from Atlantic Europe, whereas the Arab civilisation seems from the first moment of reviving curiosity as to science to have been that to which all eyes turned, in spite of the difference of religion and language. By the middle of the twelfth century a learned world had come into being in Europe, but this renaissance was literary: it knew nothing of science. A century later, however, science

was beginning to come into its own, through the efforts of such translators as Adelard of Bath, Gerard of Cremona, Robert of Chester, and Plato of Tivoli. Among the other Greek sciences which thus came to Latin Christianity by way of the East was alchemy, which had been studied widely and enthusiastically by the Muslims. Mr. Steele's sketch of alchemy in Islam is brief but clear, and by basing it upon recent investigations into this subject he has avoided the errors and misconceptions which are commonly met with. His unrivalled knowledge of medieval Latin alchemy has enabled him to present the salient features of an interesting period in a way which the general reader will find easy to follow and the specialist extremely suggestive.

MR. THOMAS SHEPPARD, director of the Hull Museum, has issued (*Hull Museum Publications*, No. 87) a catalogue of the various exhibits relating to shipping and fisheries which are permanently housed in a special building presented by the late Mr. C. Pickering and situated in Pickering Park, Hull. At one time the whaling trade at Hull was of immense importance, and from it has sprung the present fish and oil trades of that port, which have now grown to an enormous size. It is, therefore, a fitting centre for an exhibit of this kind, and much trouble has been taken to bring together all relics of the old whaling industry which was connected with Hull so early as 1598. The collections are of remarkable interest, embracing as they do an historical series of whaling implements and many valuable old prints and paintings representing the gradual growth of the shipping and fisheries industries. There are many other things in the museum, which is by no means confined to whaling, but all are connected with shipping, fisheries, or exploration in some way, and there is a nucleus of a good library on these subjects. We note that the Adélie penguin (No. 174), brought by the *Terra Nova* from Capt. Scott's last Expedition, is unfortunately described as coming from the Arctic, instead of the Antarctic. Mr. Sheppard is to be congratulated on the catalogue, which adds very much to the value of this interesting little museum.

THE Board of Education has issued a "Report on the Science Museum for the Year 1925." Our copy is marked "For Official Use"; at the same time it is said to be published by H.M. Stationery Office at 1s. net. The restriction of the report to 24 pages does not permit elaborate treatment, but enough is said to show that many objects of considerable interest were placed on exhibition during the year. The more important among them were mentioned in NATURE at the time. The value of this museum may be inferred from three classes of visitors. School children come in large numbers, both on their own account and under the guidance of their own teachers. Students make much use of the collections. Officers and technical experts have found here alone the evidence that enabled judgment to be passed on various claims arising out of the War. The space allotted to the exhibition galleries is therefore fully justified. At the close of 1925 it amounted to 155,000 square feet, and the addition of galleries giving 22,000 square feet was authorised by the Government. Even this, however, will not suffice, and of it 45,000 square feet is in old buildings not considered sufficiently fire-proof. "The construction of the centre block, to provide about 100,000 square feet, is therefore an urgent need." The War, while retarding the building operations, gave a great impetus to invention, and thus, on both counts, enhanced the congestion. The Science Museum, it should be remembered, is only one of a number of rapidly expanding institutions in a limited area.

IT is stated in *Science* that the gold medal of the American Geographical Society has been awarded to Dr. Erich von Drygalski, professor of geography in the University of Munich and leader of the German South Polar Expedition of 1900 to 1903.

THE following have been elected officers of the Röntgen Society for the session 1926–1927: *President*, Mr. N. S. Finzi; *Vice-Presidents*, Dr. Robert Knox, Prof. A. W. Porter, Prof. S. Russ; *Hon. Treasurer*, Mr. Geoffrey Pearce; *Hon. Editor*, Dr. G. W. C. Kaye; *Hon. Secretaries*, Mr. Russell J. Reynolds, Prof. F. L. Hopwood.

A QUANTITY of palæolithic implements, stated in the *Times* of August 17 to number more than 200, has been obtained from a gravel pit, at a depth of 12 feet, on the City of Norwich sewage farm at Whitlingham. The discovery is due to Messrs. H. H. Halls and J. E. Sainty, who, in examining the material thrown from the pit by workmen, found two well-made examples of the hand-axe. Mr. J. Reid Moir has examined the deposits and the implements. He has pronounced them to be of Acheulean type, and considers that the gravels in which they were found were laid down just before the third glacial epoch. The implements exhibit a brownish-yellow patination and some exceed 1 ft. in length.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—An assistant bacteriologist in the department of pathology and bacteriology of the University of Sheffield—The Registrar (September 11). A lecturer in mathematics at University College, Nottingham—The Registrar (September 14). A junior technical officer in the aerodynamics department of the Royal Aircraft Establishment—The Employment Department, R.A.E., Farnborough, Hants (September 18, quoting Reference A. 122). An engineer to take charge of the Wood Preservation Section of the Forest Products Research Laboratory of the Department of Scientific and Industrial Research—The Secretary of the Department, 16 Old Queen Street, S.W.1 (December 1). A teacher of biology at Gordon College, Khartoum—The Sudan Government London Office, Wellington House, Buckingham Gate, S.W.1. A part-time lecturer in mathematics at Birkbeck College—The Secretary, Birkbeck College, Breams Buildings, Fetter Lane, E.C.4.

Research Items.

MUSIC OF THE SAN BLAS INDIANS.—Advantage was taken of the opportunity afforded by the presence of Tule Indians of Panama in Washington in 1924, to investigate their physical characters and certain aspects of their culture. It will be remembered that the chief point of interest about these Indians, who were brought to the States by Mr. R. O. Marsh, centred in the question whether there was among them a truly 'white' element, as Mr. Marsh claimed. Observations on their music were made by Frances Densmore, and these are now published as No. 11, Vol. 77 of the *Smithsonian Miscellaneous Publications*. The "official musicians," with the chief and the doctors, are the most important people in the villages. Of these the chief may act as a doctor, but not the musician. There are four musicians, two "Chief" and two "Assistant Musicians," in each village who know the songs and teach them for pay. Social gatherings, weddings, etc., are attended by one chief and one assistant musician, never more, for the entertainment of the people. In addition to the songs sung for entertainment there are songs with a definite purpose, such as the treatment of the sick, and songs sung as "charms" which are sold by the doctors. The principal instruments are the flute and the panpipes. The man from whom the songs in the present record were obtained was an amateur who had learnt his songs, some thirty in all, from the official musician. The first song he had learnt was that which brought success in catching a turtle. He also learnt the medicine man's songs, though not himself a medicine man. These include songs to make medicinal herbs effective, to cure headache and other ailments, and the songs that were sung after a man's death. The vocal and instrumental music of the Tule Indians is a form not hitherto recorded. It appears that though the substance of the words and the general character of a song is learnt, each performance is an improvisation. The tone is artificial and extremely difficult to acquire. It is very hard, with a pinched forced quality. The principal occasions for singing were the treatment of the sick, the scene after a burial, the maturity of a young girl and her wedding.

THE AUSTRALIANS AND SOUTH AMERICA.—In No. 18 of the *Compte rendu sommaire de la Société de Biogéographie*, Dr. Paul Rivet discusses the possible routes which might have been followed by the Australians in the migrations postulated to account for the Australian linguistic elements which he claims to have discovered in the language of the Ona of Tierra del Fuego. The sea route across the Pacific is out of the question in view of the scanty equipment of the Australian for navigation. No evidence can be brought forward to support the view that the Australians entered America from the north as did the immigrants from Asia. A third hypothesis was suggested by Mendez-Correa, namely, that they came by the south. The journey might have been performed by making use of the islands of Auckland, Campbell, Macquarie, Esmeralda, Wilkes Land, King Edward VII. Land, and Grahamland as stages. The powers of endurance of cold displayed by the Ona, which surpass those of the Eskimo, might be a result of a prolonged sojourn in these inhospitable regions. In present conditions, however, it is difficult to admit that the islands and shores of the Antarctic are habitable. It is, therefore, desirable to investigate whether there has been a change in climate in this area sufficiently recent for linguistic resemblances to survive, or whether there has been a glacial extension sufficiently marked to shorten the crossing by sea and on which the people could have found game for their subsistence. In discussion it was suggested that the zoological evidence pointed in the direction of this hypothesis and possibly to an extension of Tasmania to the Antarctic, while the geographical and bathymetric distribution of echinoderms suggested a more temperate climate and warmer water at one time in the Antarctic area.

EARLY DEVELOPMENT OF HUMAN EMBRYO.—In the latest volume of "Contributions to Embryology" (Vol. 17, 1926, *Carnegie Institution Publication*, No. 362) Profs. G. W. Bartelmez and H. M. Evans have published a detailed account of the development of the human embryo during the period of somite formation, including embryos with two to sixteen pairs of somites. The material dealt with comprises twenty-five embryos belonging mostly to the collections of the Department of Embryology of the Carnegie Institution and the Department of Anatomy at the University of Chicago. The memoir, which is illustrated by a fine series of plates, deals with many points of interest. It is shown that the cranial flexure is present from the beginning of somite formation, and is due primarily to the more rapid growth of the dorsal as compared with the ventral lamina of the mid-brain folds. The asymmetry, which in the case of the neural folds is a striking feature of the external form, is quite as marked in other systems. It is interpreted as due to localised differences in the rate of growth on each side. Differentiations in the ectoderm foreshadow certain regions of the head, and definite parts of these contribute to the formation of certain of the cranial ganglia in the 16-somite stage. The closure of the neural folds begins at the level of the fourth pair of somites in the 6- to 7-somite stage, and the neural crest is proliferated at about the same time. The origin and early development of many other structures are described in detail, and their phylogenetic and physiological significance are pointed out. Owing to the comparatively large amount of material available, the time-sequence in which the various parts appear has been traced far more fully than in any previous accounts of early human development.

NEUROGLIA CELLS.—Those who are interested in the study of neuroglia will welcome the paper by Dr. C. Da Fano in the current (June) issue of the *Journal of the Royal Microscopical Society*, in which the recent methods for demonstrating the neuroglia cells are carefully described. These methods were devised by Cajal and Del Río-Hortega, but Dr. Da Fano has given due weight in his account to his personal experience gained chiefly through a short stay in Del Río-Hortega's laboratory in Madrid. It is impossible to give a summary of the methods; the paper, which is illustrated by eight figures, should be consulted for the details of the several processes.

SOUTH AFRICAN MOLLUSCA.—Two papers on mollusca from South Africa appear in the *Annals of the Natal Museum*, vol. 5. Mr. J. R. le B. Tomlin contributes a paper on marine forms, including the description of eleven supposed new species, and one new genus belonging to the Tectibranchiata. This last, *Alexandria natalensis*, n. gen. et sp., the author places in the Acteonidæ on account of the shell apex, the radula and operculum. The paper is illustrated by one of Miss G. M. Woodward's excellent plates. Mr. H. C. Burnup supplies Part 2 of his memoir

"On some South African Gulellæ, with Descriptions of Some New Species and Varieties." The genus Gulella was formerly reckoned as a section of the genus Ennea, under which name most of the numerous species were formerly described. The fascinating little group, which externally calls to mind the British 'chrysalis shells,' is remarkable for the armature of the mouth, which in some is so studded with teeth that the occupants must be seriously incommoded when issuing or retreating. Twelve species are dealt with in this instalment, of which four are described as new, and the whole illustrated by the author on a plate of 39 figures.

COPEPODS IN THE BAY OF BISCAY.—In his account of the Copepoda from the collections made by Dr. G. H. Fowler on board H.M.S. *Research* in the Bay of Biscay in 1900, Mr. G. P. Farran (*Journal of the Linnean Society* (*Zoology*), vol. 36, April 1926) not only enumerates the various species but also gives most valuable data concerning their diurnal and nocturnal movements; thus treating the subject in a somewhat similar manner to that employed by Dr. Fowler himself for the Ostracoda in the same collections (1909). The samples were all taken in July, approximately in the centre of the Bay of Biscay, mainly along a diagonal line about 65 miles in length from the N.W. to the S.E. corner. The soundings taken lay between 1219 and 2341 fathoms, and the author divides his material into the epiplankton hauls made chiefly down to 100 fathoms with horizontal non-closing nets which lasted an hour or more, and the deep water hauls, almost all of which were made with closing nets hauled vertically. The former could not be treated quantitatively, but in the latter all the copepods were counted. The copepod population from the surface to 100 fathoms was found to be approximately doubled during the night by an upward migration consisting mainly of *Metridia lucens*, *Pleuromamma robusta* and *P. gracilis*, and from 50 fathoms downwards, *Undeuchaeta minor*, several other species joining in the migration. In the deep water hauls a number of little-known forms are noted whilst the new genus Bathyidia and fourteen new species are described, three of which belong to Calocalanus and five to Scolecithrix. The view that *Aegisthus dubius* is the male of *A. mucronatus* has been rejected by Sars, but the present author seems to have good cause to regard the question as still an open one.

FISHERIES AROUND GREENLAND AND ICELAND.—The report of the North-western Area Committee (*Conseil Internat. Expl. Mer*) for the years 1924 and 1925 contains seven papers dealing with the hydrographical and biological researches undertaken in Greenland and Iceland waters. Hydrographical observations in the Faroe-Shetland Channel on May 3-14, 1924, showed that the water at the surface was composed of Atlantic water, while that at the bottom was bottom water from the Norwegian Sea. Between the two there was an intermediate layer formed by the mixing of Atlantic and bottom water with water introduced from the east Icelandic Arctic current. The biological part of the report deals with the five species of fish under the Committee's observation, namely, cod, halibut, herring, haddock, and plaice. It seems now beyond doubt that a particular stock or population of cod exists in Greenland which is indigenous to the waters of western Greenland. In Iceland, however, an almost unparalled density of young cod is experienced off the north and east coasts, in spite of the fact that very few cod-eggs are spawned there. Thus, the stock is recruited by drift, and the quantity must depend on the success of this drift. Faxe Bay, at the south-west part of Iceland, has proved to be a most important nursery-ground for the halibut, and there is little doubt that an enormous destruction of undersized halibut is caused by trawling operations in this area. The herring investigations are said to establish the fact that there are two distinct races of herrings in Icelandic waters, a spring herring and a summer herring, and that, as yet, no characters are known by which the Iceland spring herring can be distinguished from the Norwegian spring herring. Interesting figures from the estimations of age of haddock in Icelandic waters, in material collected over a number of years, show the way in which certain year-classes dominate. Thus, material of 1908–1909 showed an absolute dominance of the 1904 year-class, while that of 1924 indicated the predominance of the 1922 year-group. The study of the growth of haddock reveals the fact that growth is greatest off the south coast. Samples of plaice from Faxe Bay and Skiálfiandi Bay in Iceland were examined as to their age composition, and important conclusions were drawn from the analyses of catches at intraterritorial and extraterritorial trawling stations.

A NOVEL CURRENT METER.—In No. 2 of the *Journal du Conseil International pour l'Exploration de la Mer*, Mr. J. N. Carruthers describes a current measuring instrument which, lowered from an anchored raft or vessel, records the direction and velocity of the current. It is an advance upon the customary form of meter in that it may be left working for several days, when the velocity and direction of the residual current or drift of the water, over and above the tidal oscillations, can be found. The instrument has been put to fairly extensive use and has already provided very interesting information. It will undoubtedly prove of considerable value for purposes of fishery research in relatively shallow areas such as the North Sea and eastern end of the English Channel, where the drift of water carrying the egg and larval stages of fish plays an important rôle.

PROPORTIONS OF KRYPTON AND OF XENON IN THE ATMOSPHERE.—The values obtained in 1898 by Ramsay and Travers, shortly after the discovery of the above gases, and those obtained by Ramsay in 1903, differ greatly from one another. In the *Comptes rendus Acad. Sci.*, Paris, July 19, Messrs. C. Moureu and A. Lepape describe measurements made by the spectrophotometric method previously used by them. The two gases were fractionated from commercial argon by means of coconut charcoal cooled to suitable temperatures. The volumes obtained per unit volume of air were, kypton $1{\cdot}0 \times 10^{-6}$, xenon 9×10^{-8}.

SWEDISH RAINFALL.—The Swedish rainfall statistics for 1925 are already published in fairly considerable detail in Part 7 of *Årsbok* of the Swedish Meteorological and Hydrographical Institute. The greater part of a considerable volume is occupied with the data from 705 rainfall stations. In each case and for every month the figures given are the total, the heaviest fall in twenty-four hours, the number of days with precipitation of various stated amounts, and the days with hail and snow. The depth of the snow and its rainfall equivalent is added for certain stations. For the various departments of Sweden the duration of snow covering on the ground is given in another table. There are small scale rainfall maps for each month and a somewhat larger scale map for the year. The volume is very complete in the data it affords, but contains no discussion of the figures nor comparisons with the mean or any previous year.

Eu. 61.

CLIMATE OF NEW YORK STATE.—This subject is discussed by Mr. R. A. Mordoff in Bulletin 444 of the Cornell University Agricultural Experimental Station, Ithaca, New York. It is mentioned that the first organisation for local climatic observation in America was that inaugurated in 1825 by the New York Board of Regents. This was continued until 1863, when it was abandoned owing to the Civil War. In 1870 the National Weather Service was organised and five weather-observing stations were established in New York. Later, under the administration of the United States Weather Bureau, the number was increased to nine regular stations. It is said that New York State has a diversity of climate not usually encountered within an equally restricted area. Charts are given for each month showing the average temperature over the State. The temperature is greatly influenced by the proximity of the Lake Ontario and Lake Erie. Charts are also given showing the highest and the lowest temperatures recorded. During the summer months the maximum temperature often reaches 90° F. or above, and in winter temperatures of −40° F. are experienced in exposed localities. Frosts are dealt with and the periods when killing frosts occur. Precipitation over the State is shown by monthly rainfall maps; the heavy summer rains are largely due to thunderstorms. There is a good distribution of rainfall throughout the growing season. A serious drought affecting the State as a whole is of rare occurrence; the two most serious in recent years occurred in 1889 and 1908. Winds, sunshine, and humidity are discussed. Analysing past records, it is asserted that no change of climate can be traced.

THE INHIBITION OF THE GLOW OF PHOSPHORUS.—It is now fairly certain that the propagation of the glow that accompanies the slow oxidation of phosphorus is a process comparable with the passage of flame through a combustible gas mixture. It is therefore possible to determine the rate of propagation by measuring the blast of gas necessary to maintain the glow in a fixed position. H. J. Emeléus describes the application of this method to experiments on the inhibition of the glow of phosphorus by ethylene, in the *Journal of the Chemical Society* for June 1926. Measurements of the effect of temperature on the action of the inhibiting substance at constant volume and constant pressure are included, and the mechanism of inhibition is discussed.

THE ATOMIC WEIGHT OF SILICON.—The apparent variation of the atomic weight of boron with the source of supply, and the discrepancies between the published values of the atomic weight of silicon, have led P. L. Robinson and H. C. Smith to redetermine the atomic weight of silicon in materials from different sources. In order to make the comparison it was decided to determine the densities of silicon tetrachloride with great accuracy. The tetrachloride was prepared by chlorinating ferrosilicon manufactured from silicon from different sources, and was carefully purified by fractionation, shaking with mercury, sodium amalgam, and finally fractional distillation in a vacuum. A full description of the density determinations is contained in the *Journal of the Chemical Society* for June 1926, the measurements involving the use of glass floats, calibrated in a standard liquid (bromobenzene) with properties similar to those of the tetrachloride. It appears from the results that there is no variation in the atomic weight greater than 0·005 of a unit. (See letter by authors in the present issue of NATURE, p. 303.)

ELEMENT 61.—Moseley's work on X-ray spectra showed definitely that an element with an atomic number 61 should exist between neodymium and samarium. Its isolation and X-ray analysis are the subjects of two papers by J. A. Harris and B. S. Hopkins, and by these two authors and L. F. Yntema, published in the *Journal of the American Chemical Society* for June 1926. When suitable rare earth minerals are fractionally crystallised using the double magnesium nitrates, element 61 concentrates between neodymium and samarium, but the ratio of the quantities of the new element and its neighbours is such that X-ray analysis fails to show its presence. Detection by absorption spectra, although more sensitive, fails on account of the width of the neodymium and samarium bands. If, however, the fractionation is carried out with the bromate series, element 61 concentrates with terbium and gadolinium, the former having one absorption band and the latter having none. By continued fractionation of this series the presence of a band was revealed which had always been regarded as due to neodymium. The crystallisation was continued until a fraction was obtained which contained sufficient of the new element for X-ray analysis. The *L*-series was investigated, and lines were obtained corresponding closely to the theoretical values for L_α and L^β of element 61. It is proposed to call the element illinium (Il), in honour of the state of Illinois and of the University (*v.* also NATURE, June 5, p. 792).

COSMICAL CREATION OF MATTER.—The issue No. 15 of the *Sitzungsberichte Acad. Sci.*, Vienna, for 1926 contains a suggestion by Dr. A. Haas as to the possibility of the creation of matter at any point of the universe at which, at a given instant, radiation is excessively concentrated. If at such a point an incandescent gas is present having a mean molecular speed of the order of one-half or one-third of that of light, about a hundredth of the molecules will have speeds equal to that of light, and energies equal to that of a proton and an electron. The observations of the Compton effect show that it is possible that a light quantum impinging on such a fast-moving molecule may have its frequency increased, and a repetition of the impacts may so raise the frequency of the quantum that its energy becomes equal to that of a proton and electron, and it is transformed into these two constituents of matter.

A MUMETAL MAGNETIC SHIELD.—A paper by Prof. A. V. Hill, describing an effective magnetic shield for a moving needle galvanometer, is published in the July number of the *Journal of Scientific Instruments*. The shield is constructed of 'mumetal' strip, wound alternately with copper strip on a copper cylinder. At each end it is closed by two mumetal plates separated by a copper plate. Although only two pounds of actual magnetic material is used in the device, a screening ratio of 1000 to 1 is obtained, which is a great advance on the screens in ordinary use. It seems highly probable, therefore, that moving needle galvanometers, after being neglected for some thirty years, will again come into favour. The sensitivity of these instruments is far higher than that of moving coil instruments, and the coils used can have a much lower resistance as they are not limited by the resistance of the suspension. Their only drawback is their liability to magnetic disturbance, and this has proved most troublesome in the past. It can now be almost wholly prevented by this shield made of a nickel-iron alloy. The editor of the *Journal* makes the useful suggestion that a shield could be employed as the case of a chronometer watch, and doubtless other uses can be found for it. It seems certain that cobalt steel permanent magnets and the use of nickel-iron shields will raise the sensitivity and greatly widen the sphere of usefulness of moving needle instruments.

The Recently Discovered Gibraltar Skull.

AT the Oxford meeting of the British Association the first authoritative account of the discovery by Miss D. A. E. Garrod of a human skull associated with Mousterian implements at the Devil's Tower, Gibraltar, was given in a session of the Anthropological Section. The discovery was made on a site which first attracted the attention of the Abbé Breuil in 1917, who observed fragments of bone breccia in a cleft facing an old signal station known as the Devil's Tower. From this he obtained a few Mousterian implements and bones of a variety of animal species, including hyæna and panther, which are now extinct in Spain.

Miss Garrod, who undertook the excavation of the site at the suggestion of the Abbé Breuil, found that the cave contained a succession of seven deposits, which emerge from the mouth of the cave and spread fanwise in a succession of steps. All levels of the deposits contained a large number of animal bones, some broken and burnt by man, some evidently the relics of an animal's lair. As the cave faces north, it was probably occupied by man in summer only and by animals in the intervals of human occupation. The animal bones included deer, wild goat, boar, and rabbit in abundance, and, rarely, horse and ox. Resting on the raised beach which formed the seventh and lowest deposit was a carpal bone of an elephant. Implements of Mousterian type were found at all levels down to the fifth, those of the second level being definitely assignable to the upper Mousterian; but no implements of a later industry and no pottery were found.

The removal by dynamite of a large block of limestone in the hard travertine of the fourth level opened up a number of fissures and led to the discovery of a human frontal bone at a depth of 15 cm. from the surface of the deposit. The left parietal was discovered half a yard away, but, whereas the frontal bone had been loosened from its matrix, the parietal was firmly embedded in the travertine and had to be brought away in a mass of that material for reduction in the laboratory. As explained by Mr. L. H. Dudley Buxton, to whom that task was entrusted, the freeing of the interior from the mass of deposit with which it was filled proved a particularly difficult and tedious operation. Implements of quartzite and flint definitely of Mousterian type, but less well made than those of the overlying levels, were found near the skull. The fact that the skull and the implements were found embedded in the travertine in a manner allowing no possibility of disturbance places the Mousterian age of the skull beyond question.

The anatomical characters of the skull were described by Mr. L. H. Dudley Buxton. Owing to the fact that the greater part of the month which had elapsed since the skull had been brought to England had been taken up by the task of freeing the fragile bone from the travertine in which it had been embedded, it was possible to put forward tentative conclusions only; but an attempt had been made to reconstruct the upper part of the skull. There is no doubt that the two fragments belong to the same skull. From various characters it would appear to be that of a very young person; but the exact age and the sex are difficult to determine. A comparison with the three skulls of Neanderthal man of immature age available—a skull of a child of five from La Ferrassie, the skeleton of a youth found at Le Moustier, and fragments of the skull of a child, perhaps of eight years of age, from La Quina—shows that it agrees with them in the characters in which they differ from those of modern skulls of corresponding age. The measurements, which, however, must at present be regarded as entirely provisional, indicate that the skull is broader in its proportions than would have been expected, nor are the eyebrow ridges and temporal fossæ developed in the manner distinctive of Neanderthal man. The most striking feature in the parietal bone is the fact that the parieto-squamous suture, which is more or less straight in the apes and the human infant and bowed in the adult man, in the Devil's Tower skull is most markedly bowed; but instead of a regular squamous suture, with a bevelled edge, the actual edge of the bone is only recessed very slightly—a condition which is to be attributed to age and not to race. On the provisional measurements which have been made the cranial index works out at 80, a high figure which further consideration may make it necessary to correct.

In view of the very tentative character of the conclusions put forward by Mr. Buxton, it would be premature to offer any comment. Opportunity to appreciate the bearing of the discovery will occur later when the skull has been examined more carefully and the results have been made public at a meeting to be held by the Royal Society. It may be pointed out, however, in the meantime, that its importance is two-fold. It affords some degree of corroboration of the Mousterian date of the Gibraltar skull discovered in 1848 not far from the Devil's Tower site—a corroboration much needed in view of the fact that the collection of implements made at the time of the earlier discovery has disappeared; and secondly, it adds another to the number of skulls of the Neanderthal race, and, what is most important, the specimen is of an age which will add much needed information to our knowledge of the process of growth in that interesting and peculiar variety of early man.

Adhesives and Adhesive Action.[1]

IN reviewing the first report of the Adhesive Research Committee, the present writer had occasion to remark on the extreme persistence of the three main types of adhesives, which documentary evidence shows to have been quite familiar to craftsmen of the eleventh century. Believers in proverbial wisdom may incline to the opinion that this familiarity, continued through generations, has indeed bred the contempt with which the subject of adhesion—with or without adhesives—is generally treated in the literature of physics. In this respect the second report breaks entirely new ground in Appendix IV., entitled "Adhesives and Adhesive Action," by Prof. J. W. McBain and Dr. D. G. Hopkins, in which the authors attempt, with a considerable measure of success, to develop rational theories of the mechanism of adhesive action.

The first important conclusion at which they arrive is that there are two fundamentally different types of joints: those between porous surfaces and those between smooth, non-porous ones. In the first type the penetration of the adhesive, while liquid, into the pores of the surfaces to be united is an essential part of the effect. This view is borne out strikingly, apart from much other evidence, by comparison of the strengths of glued joints, made between plain and stained specimens of the same woods; the latter are

[1] Second Report of the Adhesives Research Committee, Department of Scientific and Industrial Research. Pp. iii.+128. (London: H. M. Stationery Office, 1926.) 3s. net.

considerably weaker, as the stain (a spirit varnish) fills the pores and prevents the penetration of the adhesive. It is in complete accord with this explanation that the diminution of strength is less marked with a very porous wood, like deal, than with a closer grained one, like walnut.

For the second kind of joint, that between smooth, non-porous surfaces, the authors postulate some specific action between material and adhesive, and refer to Hardy's views on lubrications. They arrive at the conclusion that any liquid which wets the surfaces and can somehow be transformed into a solid will act as an adhesive for these surfaces. As soon as the statement is put in this form, it would seem to follow quite naturally from considerations of continuity, which does not lessen its novelty or importance. Very remarkable examples of such 'specific' joints are given; *e.g.* shellac joints between metal surfaces with a tensile strength of more than two tons per sq. in. Space does not permit more detailed discussion of the paper, which will be read with profit not only by those interested in adhesives, but also by any one who derives pleasure from seeing a complex problem attacked by the whole armoury of research.

Prof. Schryver briefly describes his attempts to isolate a pure standard gelatin or, incidentally, to decide whether a body of uniform composition answering to this description exists; the results are not conclusive. Dr. J. C. Kernot and Miss N. E. Speer have achieved a result of technical and economic interest by producing from suitably treated fish skins a glue quite free from "an ancient and a fish-like smell," such as in ordinary fish glues is disguised—or, as sensitive people might say, accentuated—by various additions. The same authors in another paper suggest improvements in the manufacture of bone glue. Appendix V. deals with the mechanical tests of adhesives for timber used by the Royal Aircraft Establishment; the general conclusion is reached that the causes of the large variations in the results of timber tests remain obscure, and that "until the degree of these variations has been reduced the present forms of test-piece are unsuitable for experimental or even inspection purposes."

Readers of the report will learn with regret, though without surprise, that important investigations on the manufacture of glue have had to be abandoned owing to lack of financial support from manufacturers—a position which is perhaps explained, though scarcely justified, by the great fall in the price of glue.

E. H.

Herrings along the Baltic Coast of Sweden.

IN *Publications de Circonstance* of the Conseil Permanent International pour l'Exploration de la Mer, No. 89, Chr. Hessle surveys the herring investigations which have been carried on during the past few years along the Baltic coast of Sweden. Nets, both drifting and anchored, land-seines, and big traps are all used for the fishery, but the main part of the total catch is fished by nets. Although the bulk of the fish is landed between July and November, considerable quantities are taken during the winter and early spring. Ice on the water is a severe hindrance to the net fishery during the colder months, and in some places it may put a stop to fishing when, by all evidence, herrings are still present. In the archipelagos nets are sometimes used actually under the ice.

Baltic herrings are characterised by their small size, the low average number of vertebræ, and of the keeled scales behind the ventral fins. In contrast to these, the average number of the first vertebræ with closed hæmal arches is rather high. Both autumn-spawning and spring-spawning herrings occur, the former being of the greater economic value. Catches of autumn-spawners nearly always contain a percentage of spring-spawners, the proportion varying with the season and from year to year. In these catches of mixed fish the spring-spawners are generally smaller in size. This is due partly to the greater percentage of smaller fishes among the spring-spawners, but also to the fact that the rate of growth of the spring-spawners is inferior. In both classes the rate of growth is exceedingly slow after the second or third year. Spawning would seem to occur in the same places for both autumn and spring fish, the former spawning at a temperature of 11°-14°, and the latter at 6°-10°.

In the innermost parts of the archipelagos, and especially in the fjords which penetrate deep into the country of the Middle Baltic, there is a fishery which is based on stationary local races in waters so closed and isolated that sea herring do not enter them. The size and rate of growth of these isolated fjord herrings show a very great variability. Gudingen and Gamlebyviken are two fjords separated only by a narrow strip of land: in Gudingen the rate of growth is quite normal, but in Gamlebyviken sexually ripe fish of only 10 cm. in length have been taken.

Along the coast of the Gulf of Bothnia herrings are caught in traps, fishing commencing as soon as the ice breaks up in the spring, and lasting until midsummer. The bulk of these 'ice herring' are spring-spawners, and a typical feature of the catches is the great number of remarkably large fish which show a peculiar mixture of characters and habits typical of one or another of the races previously dealt with. Altogether Hessle has provided us with a most interesting and instructive paper.

University and Educational Intelligence.

ABERYSTWYTH.—Dr. W. Robinson, senior lecturer in the department of cryptogamic botany in the University of Manchester, has been appointed to the chair in botany in University College, Aberystwyth, in succession to Prof. Lloyd Williams, who retires under the age limit in September.

CAMBRIDGE.—The University Commissioners have published a number of regulations that they have made for bringing into action next term the new statutes governing the General Board and the various faculty Boards. They have also published further regulations which they propose to make—after discussion by the Senate—on the election of members of the Council, degree committees, the Buildings Syndicate, and University finance. The chief point on which discussion is likely to take place is the proposal that members of the Council shall be elected by the method of the single transferable vote. So far as the election of ordinary members of the Regent House is concerned, where four members are elected at a time, this provision is probably suitable, as it will ensure representation on the Council of different groups of electors. It is doubtful, however, whether this method secures the most effective result in the case of the election of the other two groups—(*a*) heads of colleges, and (*b*) professors and readers. Here only two members are elected at a time in each class. So far as University politics is divided into two fairly even parties, this method generally means the election of one candidate from each party—not by any means necessarily the best way of electing an executive body.

Mr. A. Hopkinson, Emmanuel College, has been reappointed demonstrator in anatomy.

THE Air Ministry announces further appointments to short-service commissions in the Royal Air Force to be made in September. Applications are specially welcome from young men who have had some engineering training or have shown a bent towards mechanical matters in their private amusements, as well as from those who are keen sportsmen and have a leaning towards travel and adventure. Short-service officers are taught to fly and at the same time receive instruction in aeronautical engineering, armament, navigation, etc. Service in the R.A.F. counts in part towards the period necessary to become associate members of the Institute of Mechanical Engineers. Applications for regulations should be addressed to the Secretary, Air Ministry, Adastral House, Kingsway, W.C.2. Candidates must be between 18 and 25 years of age, should have received whole-time education at least up to the age of 16 years, and should possess good physique and eyesight.

THE Ramsay Memorial Fellowship Trustees have made the following awards of new fellowships for the session 1926–27 :—A British Fellowship of 300*l.*, tenable for two years, to Dr. R. F. Hunter, for work at the Imperial College, London ; a Glasgow Fellowship of 300*l.*, tenable for two years, to Mr. J. D. Fulton, for work at the University of Manchester ; a Swedish Fellowship of 307*l.*, to Mr. Gunnar Hägg, for work at University College, London ; a Swiss Fellowship of 300*l.*, tenable for one year, to Dr. Max Brunner, for work at the University of Cambridge. The Trustees have renewed the following Fellowships for a year ; Mr. G. A. Elliott (British Fellowship)—at University College, London ; Mr. T. Corlett Mitchell (Glasgow Fellowship)—University of Cambridge ; Dr. D. McKay Morrison (Canadian Fellowship)—University of Cambridge ; Mr. W. G. Burgers (Netherlands Fellowship)—Royal Institution, London; Dr. Ekonomopoulos (Greek Fellowship)—University College, London ; Dr. P. Misciattelli (Italian Fellowship)—University of Oxford ; Mr. Erik Rudberg (Swedish Fellowship)—King's College, London.

THE League of Nations Committee on Intellectual Co-operation has received from its sub-committee of experts recommendations concerning the instruction of children and young people in the existence and aims of the League. These recommendations raise questions of principle of the highest importance. It is proposed to request Governments to include the subject in their programme of studies and to ensure that the relevant text-books mention it, that education authorities should arrange that in examinations, questions on the League should be set whenever practicable, and that universities should organise special courses of at least six lectures which all students might attend. In addition numerous devices are recommended for propagating knowledge of the League and its gospel, such as the dissemination of books and periodicals, lantern slides, kinematograph films and radio broadcast addresses, special courses for teachers, celebration of League Days at schools, essay competitions, inspirational lectures, and national conferences. The exact place which this instruction will occupy in the curriculum and the time to be allotted to it are, the sub-committee remarks, questions which should be left for the national or local authorities to decide, but it is recommended that it should be correlated with the lessons in " geography, history or civics." Where civics is included in the school curriculum a teacher may fairly be expected to give some instruction about the League of Nations, but where it is not, it is open to question whether such instruction should be smuggled in as " geography " or " history."

Contemporary Birthdays.

August 27, 1865. Prof. James Henry Breasted.
August 28, 1858. Prof. Roland Thaxter.
August 30, 1871. Sir Ernest Rutherford, O.M., P.R.S.
September 1, 1877. Dr. F. W. Aston, F.R.S.
September 1, 1859. Dr. Walter Gardiner, F.R.S.
September 2, 1877. Prof. Frederick Soddy, F.R.S.
September 3, 1882. Dr. William Lawrence Balls, F.R.S.

Prof. J. H. BREASTED, the accomplished American Egyptologist, was born at Rockford, Illinois. His interests early centred in the University of Chicago. Since 1905 he has been professor there in Egyptology and Oriental history. In 1894–95 he was collecting in Egypt for the University, and, later, director of its Egyptian Expedition. In 1920 he was in charge of an archæological survey of Mesopotamia. Prof. Breasted is an honorary fellow of the Society of Antiquaries of London, and D.Litt., Oxford.

Prof. THAXTER, who was born at Newton, Mass., U.S.A., graduated at Harvard. Assistant professor of cryptogamic botany there from 1891 until 1901, he later occupied the chair, and he has been, since 1919, emeritus professor. He is the author of many papers on the fungous diseases of insects. Prof. Thaxter is a foreign member of the Linnean Society.

Sir ERNEST RUTHERFORD, president of the Royal Society, Nobel laureate in chemistry, 1908, was born at Nelson, New Zealand. He was educated at the University of New Zealand and Trinity College, Cambridge. After prosecuting research work at the Cavendish Laboratory, he left England in 1898 to occupy the chair of experimental physics in McGill University, returning in 1908. His record of accomplishment in the domain of radioactivity and atomic structure is world known.

Dr. ASTON, Nobel laureate in chemistry, 1922, was born at Harborne, Birmingham, and educated at Malvern College and the University of Birmingham. In 1910 he became one of Sir J. J. Thomson's research assistants at the Cavendish Laboratory, Cambridge. Here it was, under stimulating associations, that Dr. Aston engaged in his classical researches on isotopes. In 1922 the Royal Society awarded him its Hughes medal for his " discovery of isotopes of a large number of the elements by the method of positive rays."

Dr. GARDINER was educated at Bedford, graduating at Clare College, Cambridge. Sometime a science lecturer at Girton, and University lecturer in botany, he received one of the Royal Society's Royal medals in 1898, at the hands of Lord Lister. His researches in vegetable histology established that the protoplasm in the tissues of plants is continuous from cell to cell. Other work of his dealt with the function of tannin, protoplasmic contractility, and the phenomena accompanying stimulation in insectivorous plants.

Prof. SODDY, Nobel laureate in chemistry, 1921, a graduate of Merton, was born at Eastbourne. Early, at McGill University, Montreal, he was working under the inspiring guidance of Sir Ernest Rutherford, engaged in researches on radioactivity ; afterwards he was with Sir William Ramsay at University College, London, a period when proof was obtained with the spectroscope of the production of helium from radium. Occupant of the chair of chemistry in the University of Aberdeen from 1914 until 1919, he left to become Lees professor of chemistry in the University of Oxford.

Societies and Academies.

CAMBRIDGE.

Philosophical Society, July 26.—P. A. M. **Dirac**: On quantum algebra. In this algebra the commutative law of multiplication no longer holds, but the other axioms of ordinary algebra are still valid. A general definition of a function is proposed, and the differential coefficient is defined without introducing the idea of a limit.—Miss B. **Swirles**: The polarisabilities of atomic cores. The polarisabilities of the cores of several atoms are calculated from the terms of their spectra by means of a formula due to Born and Heisenberg. The values so obtained agree with those given by a modification of the dispersion formula of Kramers and Heisenberg.—J. R. **Oppenheimer**: On the quantum theory of the problem of the two bodies. (Preliminary communication.) In addition to the Balmer terms derived by Pauli, Schrödinger and Dirac, the line intensities are computed; for example, the first Balmer emission line is 12·2 times as intense as the second Lyman line, and the first Balmer absorption line is 5·37 times as intense as the second. The probabilities of transition and capture are derived, and a method of obtaining the deflexion spectrum is sketched. The argument is based throughout on Schrödinger's theory.—G. P. **Thomson**: An optical illusion due to contrast. A blackened strip on a photographic negative sometimes has the appearance of being blacker at the edges than the centre, though the reverse is found to be the case when measurements are made by a photometer. The edges are narrower and clearer the more rapid the transition from light to darkness, but become too narrow to be seen when the transition is made as abrupt as possible. The eye appears to see rapid change of blackness as enhanced blackness. A converse effect appears for a light strip on a blackened ground.—M. H. A. **Newman**: Integral invariants of the affine field.—A. **Young** and H. W. **Turnbull**: The linear invariants of ten quaternary quadrics.—G. S. **Mahajani**: A contribution to the theory of ferromagnetism.—E. B. **Moullin**: On some resistance properties of a certain net-work containing inductances and capacities, and their analogies in a mechanical system. If the net-work is in acceptor resonance at a certain frequency when excited from a particular member, then it will also be in resonance when excited from any other member, but then the resonance may be either acceptor or rejector.—J. C. **Burkill**: On Mellin's inversion formula.—Major P. A. **MacMahon**: The elliptic products of Jacobi and the theory of linear congruences.—R. **Hargreaves**: Geodetic and dynamical principles, a comparison and connexion.—J. R. **Oppenheimer**: On the quantum theory of vibration-rotation bands. The dynamical problem of the diatomic molecule is solved on the new mechanics. The quantum numbers, chosen to give a normal state, are $n=\frac{1}{2}, \frac{3}{2}\ldots$; $m=-\frac{1}{2}, -\frac{3}{2}\ldots, \frac{1}{2}, \frac{3}{2}\ldots$; $r=-m+\frac{1}{2}\ldots,+m-\frac{1}{2}$. The frequencies differ from the classical frequencies for half integral vibrational and rotational quantum numbers in having $m^2-\frac{1}{4}$ for m^2 in the coupling term. The weights of the m states are $2m$. The intensity of the central line of the band vanishes. The intensities of the lines are worked out to the second order in $\nu_{rot.}/\nu_{vib.}$.—P. A. **Taylor**: An approximation to the motion of two rotating electrical doublets in a plane.—D. R. **Hartree**: Some relations between the optical spectra of different atoms of the same electronic structure. (ii.) Aluminium-like and copper-like atoms. For penetrating orbits of the series electron, the quantum defect can be expressed as the sum of contributions from the groups of core orbits of different principal quantum number. Based on this, relations are obtained between the values of the quantum defect for corresponding terms of the spectra of an atom of a given element in different states of ionisation, and of different atoms in such states of ionisation that they have the same electronic structure.—J. P. **Gabbatt**: Note on the extension to higher space of a theorem of Wallace.—J. B. S. **Haldane**: A mathematical theory of natural and artificial selection (Pt. iii.).

ROME.

Pontifical Academy of Sciences (Nuovi Lincei), June.—**Gemelli**: Perception of the position of the body in relation to the sensation of equilibrium of an aeroplane pilot. The importance of muscular, cartilaginous, and tactile sensations, in opposition to those of the semi-circular channels of the ear, is emphasised. Anile, however, reaffirms the importance of such channels with reference to the equilibrium, and states that these studies necessitate consideration of the vast and complex relationships between the vestibular nerve and the nervous centres.—**Luigioni**: A case of trifid antenna in *Demetrias atricapillus*, a small coleopterous insect of the scarab family.—**Teofilato**: Motion of a weight in a medium with viscous resistance.—**Pagnini**: Hypotheses serving as foundation for the undulatory theory.—**Gianfranceschi**: De momento theoriae physicae circa quanta. The bases and the results of the quantum theory are examined and those of real value indicated.—**Scatizzi**: The demonstration of formal generality by means of differential equations of a typical case of the ideal problem.—**Colonnetti**: Experimental investigations on elastic co-actions. Results are given of the study of a rectilinear beam and of a ring subjected to the action of a source of heat which induces in them a state of co-action.—**Giorgi**: Unsolved questions in the fundamental theories of electromagnetism.—Isabella **Biasi**: The extension of Birichbet's theorem to the general typical case of impulsive function.

SYDNEY.

Linnean Society of New South Wales, June 30.—R. J. **Tillyard**: Upper Permian insects of New South Wales (Pt. ii.). The orders Mecoptera, Parameco-ptera and Neuroptera. These fossils are from Belmont and Warner's Bay and belong to three closely allied holometabolous orders. The Mecoptera are represented by no less than two families, five genera and eighteen species, this being the largest fossil Mecopterous fauna yet discovered, though the Lower Permian of Kansas comes fairly close to it with six genera and fourteen species. This order is also the oldest of the three, as it can be traced back into the Upper Carboniferous. The most abundant genus is Permochorista Till., of which eleven species are described. Fragments of the wings of this genus are the commonest fossils in these beds. The order Paramecoptera is not known outside these beds, and there are only two species; they are interesting as being the early ancestral types from which the orders Diptera, Trichoptera and Lepidoptera have evolved. The Neuroptera are represented by one family, four genera and eight species of the suborder Planipennia.—A. P. **Dodd**: New species of Australian Proctotrypoidea, with revisional notes. One new genus in the family Scelionidæ and ten new species in the families Scelionidæ, Belytidæ and Diapriidæ are described.—G. H. **Hardy**: A new classification of Australian robberflies belonging to the subfamily Dasypogoninæ (Diptera, Asilidæ). Eighteen genera of the Dasypogoninæ are recognised and are divided into three tribes, Brachyrrhopalini (4 genera), Saropogonini (10) and Phellini (4).—May M. **Williams**: Contributions to the cytology and

phylogeny of the siphonaceous Algæ. (2) Oogenesis and spermatogenesis in *Vaucheria geminata*. The young oogonia and antheridia are multinucleate, the ultimate uninucleate condition of the oogonium resulting from the degeneration of the supernumerary nuclei. These latter are regarded as being potential gameto-nuclei, and potential and functional gameto-nuclei are homologous. There is no mitosis occurring in the oogonium or antheridium in connexion with the development of these organs. The Vaucheriaceæ are regarded as being derived from a Cladophora-type with gametangia liberating free gametes. They probably represent an end line of development.

Royal Society of New South Wales, July 7.—A. R. **Penfold**: The essential oils of *Leptospermum lanigerum*, Smith (Pt. 1). This Myrtaceous shrub is widely distributed, and is especially plentiful in the southern districts of New South Wales, where it follows the water courses. The chemical results obtained by an examination of material collected at Monga, near Braidwood, New South Wales, points to the separation of two extreme forms of this shrub. The type has silvery leaves, and yields 60-75 per cent. of aromadendrene and eudesmene, 16-20 per cent. d-a-pinene, with smaller quantities of citral, geraniol, geranyl-formate and cinnanamate, etc. The leaves of form A are bright green, and it yields 40-60 per cent. d-a-pinene, 40-45 per cent. darwinol and its acetate, with smaller quantities of sesquiterpene and its alcohol.

Official Publications Received.

Proceedings of the Cambridge Philosophical Society. Vol. 23, Part 3, July. Pp. 191-335. (Cambridge: At the University Press.) 7*s.* 6*d.* net.

Museo Nacional de Historia Natural "Bernardino Rivadavia," Buenos Aires. Memoria Anual de 1924. Por M. Doello-Jurado. Pp. 118+44 plates. (Buenos Aires.)

The Rockefeller Foundation: a Review for 1925. By George E. Vincent. Pp. 59. (New York City.)

The Memoirs of the Imperial Marine Observatory, Kobe, Japan. Vol. 2, No 2: A Note on the Characteristic Movement of Spots, Faculæ and Flocculi of the Sun. By Rikiti Sekiguti. Pp. 83-110. (Kobe.)

Memoirs of the College of Science, Kyoto Imperial University. Series B. Vol. 1, No. 2: Notes on the Volcanic and Seismic Phenomena in the Volcanic District of Shimabara, with a Report on the Earthquake of December 8th, 1922, by Prof. Takuji Ogawa; Notes on a Fossil Elephant from Sahamma, Tôtômi, by Prof. Jirô Makiyama. Pp. 201-264+plates 6-16. Vol. 1, No. 4: Studies on the Surface Characters of Minerals. i: Electro-chemical Behavior of the Crystal Surface of Pyrite. By Atsushi Matsubara. Pp. 285-332+plate 19. Vol. 2, No. 1: On the Structure of the Anaphasic Chromosomes in the Somatic Mitosis in *Vicia Faba*, with special reference to the so-called Longitudinal Split of Chromosomes in the Telophase, by Yoshinari Kuwada; A Study of the Mycorrhiza of *Abies firma*, S. et Z., with special reference to its Mycorrhizal Fungus, *Cantharellus floccosus*, Schw., by Koki Masui; On the renewed Growth of the Mycorrhizal Root, by Koki Masui. Pp. 92+6 plates. Vol. 2, No. 2: Contributions to the Knowledge of the Intestinal Secretion of Insects. i: Mid-Intestinal Secretion of Lepidoptera, with an Appendix: Behavior of Mitochondria in the Mid-Intestinal Epithelium of the Silk-worm *Bombyx mori*, L., by Osamu Shinoda; Einige Beobachtungen über die Ernährungsbiologie der wilden Seidenraupe, *Dictyoploca japonica*, Moore, von Osamu Shinoda. Pp. 93-128+plates 7-10. Vol. 2, No. 3: Studies on the Surface Characters of Minerals. ii: The Distribution of Tarnish Colours on the Crystal Surface of Pyrite, by Atsushi Matsubara; Studies on the Surface Characters of Minerals. iii: a simple Method for the Determination of the Surface Stability of some Minerals, by Atsushi Matsubara; Tertiary Fossils from North Kankyô-dô, Korea, by Prof. Jirô Makiyama. Pp. 129-160+plates 11-13. (Kyoto.)

U.S. Department of Agriculture. Farmers' Bulletin No. 1489: The Green June Beetle Larva in Tobacco Plant Beds. By K. B. McKinney and Joe Milam. Pp. ii+6. (Washington, D.C.: Government Printing Office.) 5 cents.

Proceedings of the Society for Psychical Research. Part 99, Vol. 36, July. Pp. 171-343. (London: Francis Edwards.) 7*s.* 6*d.* net.

Conseil Permanent International pour l'Exploration de la Mer. Bulletin Statistique des Pêches maritimes des Pays du Nord et de l'Ouest de l'Europe. Rédigé par D'Arcy Wentworth Thompson. Vol. 13, pour l'année 1923. Pp. 113. (Copenhague: Andr. Fred Host et fils.)

Carnegie Institution of Washington: Eugenics Record Office. Bulletin No. 25: The Families whence High Intelligence Springs. By Grace Allen. Pp. 39. (Cold Spring Harbor, Long Island, N.Y.)

Royal Botanic Gardens, Kew. Picture Postcards. Set 12: Stove and Greenhouse Plants. 6 cards in colour. Set 14: Roses (Rosaceæ.) 6 cards in colour. Set 15: Orchids (Orchidaceæ.) 6 cards in colour. Set 16: Decorative Plants. 6 cards in colour. (Kew: Royal Botanic Gardens.) 1*s.* per set.

Mitteilungen der Naturforschenden Gesellschaft in Bern aus dem Jahre 1925. Pp. xxx+82. (Bern: K. J. Wyss Erben.)

Diary of Societies.

SATURDAY, AUGUST 28.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS (Associates and Students' Section) (at Newcastle-upon-Tyne), at 3.—Capt. W. Ridley: The Mineral Wealth of the British Empire.

CONGRESSES.

AUGUST 27 AND 28.

IRON AND STEEL INSTITUTE (Autumn Meeting) (at Stockholm).—F. Adcock: The Effect of Nitrogen on Chromium and some Iron Chromium Alloys (Alloys of Iron Research, Part IV.).—J. H. Andrew and H. A. Dickie: A Physical Investigation into the Cause of Temper Brittleness.—Prof. C. Benedicks, H. Bäckström, and P. Sederholm: Anomalies in Heat Conduction, with some Determinations of Thermal Conductivity in Iron and Carbon Steels.—Prof. C. Benedicks and R. Sundberg: Electrochemical Potentials of Carbon and Chromium Steels.—G. F. Comstock: The Treatment of Steel with Ferro Carbon-Titanium.—G. A. Hankins, D. Hanson, and Miss G. W. Ford: The Mechanical Properties of Four Heat-Treated Spring Steels.—Prof. K. Honda: Is the Direct Change from Austenite to Troostite Possible?—A. Johansson and R. Von Seth: The Carburisation and Decarburisation of Iron and Some Investigations on the Surface Decarburisation of Steel.—A. Johansson and A. Wahlberg: The Development of the Swedish Iron and Steel Industry during the last thirty years.—E. Kinander: Notes on Jernkontoret.—A. Lundgren: The Testing of Hardened Steel.—W. Petersson: Notes on the Development of the Swedish Mining Industry during the last twenty-five years.—G. Phragmen: The Constitution of the Iron-Silicon Alloys.

AUGUST 29 TO SEPTEMBER 1.

SOCIÉTÉ HELVÉTIQUE DES SCIENCES NATURELLES (at Fribourg).—In Sections devoted to Mathematics, Physics, Geophysics, Meteorology and Astronomy, Chemistry, Geology, Mineralogy and Petrography, General Botany, Special Botany and Geographical Botany, Zoology, Entomology, Anthropology and Ethnology, Palæontology, Medical Biology, History of Medicine and Natural Science.

AUGUST 31 TO SEPTEMBER 8.

WORLD POWER CONFERENCE (at Basle), Technical Programme of Sectional Meeting:

Utilisation of Water Power, and Inland Navigation.
Exchange of Electrical Energy between Countries.
The Economic Relation between Electrical Energy Produced Hydraulically and Electrical Energy Produced Thermally: Conditions under which the two systems can work together with advantage.
Electricity in Agriculture.
Railway Electrification.

SEPTEMBER 1 TO 4.

INSTITUTE OF METALS (Autumn Meeting) (at Liége).

Wednesday, September 1, at 8.—Dr. W. Rosenhain: Ancient Industries and Modern Metallurgy (Autumn Lecture).

Thursday, September 2.—L. Boscheron: An Account of the Non-Ferrous Metals Industry in the Liége District.—Dr. A. G. C. Gwyer and H. W. L. Phillips: The Constitution and Structure of the Commercial Aluminium-Silicon Alloys. With an Appendix upon The Properties of the Modified Aluminium-Silicon Alloys, by Dr. D. Stockdale and I. Wilkinson.—J. D. Grogan: Some Mechanical Properties of Silicon-Aluminium Alloys.—B. Otani: Silumin and its Structure.—H. J. Gough, S. J. Wright, and Dr. D. Hanson: Some Further Experiments on the Behaviour of Single Crystals of Aluminium under Reversed Torsional Stresses.—P. Chevenard: Thermal Anomalies of Certain Solid Solutions.—W. T. Cook and W. R. D. Jones: Preliminary Experiments on the Copper-Magnesium Alloys.—Dr. K. Honda: A Comparison of Static and Dynamic Tensile and Notched-Bar Tests.

Friday, September 3.—Dr. C. J. Smithells, H. P. Rooksby, and W. R. Pitkin: The Deformation of Tungsten Crystals.—A. Pinkerton and W. H. Tait: Season-Cracking in Arsenical Tubes.—Dr. C. S. Smith and Prof. C. R. Hayward: The Action of Hydrogen on Hot Solid Copper.—F. W. Rowe: Bronze Worm-Gear Blanks produced by Centrifugal Casting.—Kathleen E. Bingham: The Constitution and Age-Hardening of Some Ternary and Quaternary Alloys of Aluminium containing Nickel.—Capt. F. R. Barton: Development of the Use of Nickel in Coinage.—C. H. M. Jenkins: The Constitution and the Physical Properties of the Alloys of Cadmium and Zinc.—G. B. Phillips: The Primitive Copper Industry of America. Part II.

SEPTEMBER 6 TO 11.

AMERICAN CHEMICAL SOCIETY (at Philadelphia).—In eighteen Divisional Gatherings, dealing with various branches of Pure and Applied Chemistry.

SEPTEMBER 12 TO 18.

INTERNATIONAL CONGRESS FOR APPLIED MECHANICS (at Federal Technical University, Zurich).—Lectures by Prof. P. W. Bridgman, Prof. P. Debye, Prof. T. Levi-Civita, Prof. L. Prandtl, and Prof. G. I. Taylor.

SEPTEMBER 13 TO 17.

INTERNATIONAL CONGRESS OF PHILOSOPHY (at Harvard University, Cambridge, Mass.).

SEPTEMBER 19 TO 26.

GERMAN SCIENTIFIC AND MEDICAL ASSOCIATION (at Düsseldorf).

SEPTEMBER 22 TO 24.

GERMAN RÖNTGEN SOCIETY (at Düsseldorf).—Discussions on X-ray Treatment of Inflammation, the Compton Effect, and Irradiation of the Ovary and Offspring.