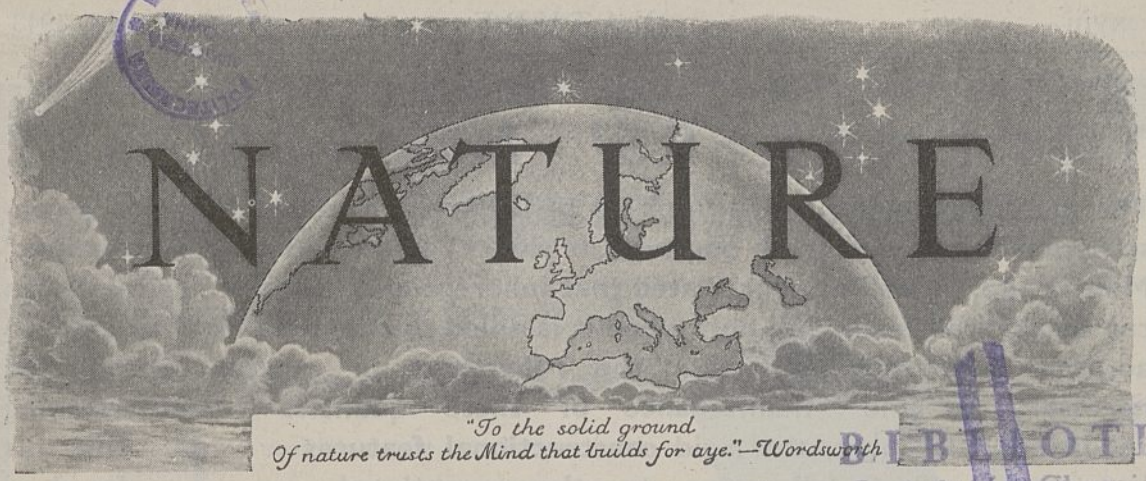

Vol. 151, No. 3820 SATURDAY, JANUARY 16, 1943 ONE SHILLING & SIXPENCE

NATURE

No. 3820 SATURDAY, JAN. 16, 1943 Vol. 151

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MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831
Telegrams: Phusis Lesquare London

Advertisements should be addressed to
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone: Temple Bar 1942

The annual subscription rate is £4 10 0, payable in advance, Inland or Abroad

COAL CONSERVATION IN GREAT BRITAIN

IT would be difficult to overstress the importance of making the maximum use of the available coal in Great Britain ; our survival as a first-class nation may indeed come to depend on the answers we give to some of the fundamental questions concerning the proper use of coal. Individually, they are well understood, and there is no great divergence of opinion as to the facts. Collectively, there is a lack of agreement as to policy, and a strange and fatal apathy on the part of Ministries and the fuel industries. This lack of understanding in the past has in no small measure brought about the present unfortunate and serious state of affairs, where confessedly we are unable to supply the consumer with our only native mineral, albeit the demand is less than in peace-time.

Certain aspects of the problems were referred to by Mr. E. V. Evans, the present technical leader of the gas industry, at a meeting of the Fuel Luncheon Club held on December 17 last. It is perhaps worth while directing attention to them, as the subject above all needs impartial discussion on a platform free from the sectional interests of the various coal-using industries.

Britain's world predominant position was built on coal ; until the War of 1914–18 both coal and transport were cheap and only the very few were concerned to use coal economically. Bad habits persist, and it is a safe guess that at least 20 per cent of the coal used by industry in Great Britain in 1939 could have been saved by attention to methods of fuel economy. A committee of fuel technologists under Dr. E. S. Grumell is known to be at work to effect this saving.

The question before the public is how they shall obtain the heat, light and power they need in their daily life : from raw coal, gas or electricity ? The three forms have been long competitive for the favours of the householder, and the tempting prices charged are not always fair. There can be no justification for price structures that put a tax on consumers who *must* use the commodity in order to subsidize adventure in markets that, in themselves, are uneconomic.

Surely, the various branches of the fuel industry should become complementary parts of one whole. This is the essence of the problem of co-ordination, and the solution can only be achieved by the findings of impartial judgment, sifting and balancing the advice of experts. The fuel industries themselves should be preparing for such comprehensive co-operation, which indeed has been largely achieved in certain American cities, but so far there is no sign of such vision in Great Britain.

The householder of the future will require to use both gas and electricity and perhaps some solid fuel for water and space heating. The old-fashioned coal fire grate, using raw coal and sending all the tar products and most of the heat up the chimney, is an anachronism. Surely it should be forbidden as a

wasteful apparatus under the new fuel order announced on December 28, for only some 20–25 per cent of the heat in the coal reaches the room. It is responsible also for the smoke pall, for fogs and for the decay of stonework, metal and textiles. Until November 11 last, many of the present generation had never seen a London fog and realized what burning raw coal involved. It is criminal also to waste the raw hydrocarbon material present in coal tar. Great Britain has no native oil, a handicap the extent of which we have yet to realize, and it should be insisted that every ounce of tar is recovered and used as the raw material for motor-fuel and chemical industries. Perhaps the day may come when all coal, whether used for domestic or industrial purposes or for making electricity, is carbonized before use. Petroleum may well become scarce or we, as a nation, so poor that we cannot afford to buy it.

Light will be supplied by the electrical industry and should become cheaper, better and capable of decorative development as the lamp improves. Power applied to small units is also a matter for electricity. The cooking and individual heating load is claimed by gas, and the share that electricity is to take requires settlement. Water heating and central heating are best done with coke, for which they provide a valuable outlet. Both gas and electricity claim to heat small quantities of water.

It is quite clear that from the scientific and national point of view the burning of raw coal by the domestic consumer should be discouraged: a point not previously mentioned is that the transport and delivery of solid fuel to each household and the collection of ashes are wasteful factors. Rubber, petrol and manpower are scarce now, but however plentiful they may become they should not be wasted.

Both gas and electricity are 'on tap' in the home; the onus of maintaining an efficient load factor is thrown on the companies. The annual hourly load factor of the gas industry, that is, the relation to the plant required to meet the maximum demand, is of the order of 17–20 per cent. Fortunately, the provision of the gasholder makes it possible to even out the load to 50–60 per cent. The load factor of the electricity companies is 30–35 per cent: they can store steam but not electricity.

Both industries seek to obtain off-peak loads, presumably each from the other. Both have made great strides in economic production. Since 1916 the consumption of coal per horse-power hour for power has dropped from 5–7 lb. to 1¼ lb. The gas industry has increased the thermal efficiency of its process to about 80 per cent and increased the total amount of heat supplied by 13 per cent in the last eighteen years in spite of competition by the electrical industry. The replacement of the coal range by the gas cooker has involved a saving of some 15 million tons of coal a year, besides an enormous relief to the housewife.

As regards the future, the coal industry is endeavouring to design appliances that shall burn coal without smoke; the gas industry is preparing to demonstrate how greatly the interests of the nation and of the consumer will be served by the extended use of gas for space heating and water heating; and the electrical industry, always growing more efficient, is interested to take over such proportion of these loads as can be supplied remuneratively.

Some measure of guidance and of collaboration is necessary. In this, coal conservation must be included as the predominant factor. The appliances and methods that were in common use before the War and are in use to-day show striking differences in the amount of coal that has to be consumed to give *equivalent service* by different methods. According to Mr. Evans, for most domestic uses gaseous fuel shows a saving of some 40 per cent compared with either raw coal or electricity. Clearly we must try to establish and work to a sane national fuel policy, so that the resources of material and man-power in Great Britain are not wasted.

MEDICINE FOR PHILOSOPHERS

Physics and Philosophy

By Sir James Jeans. Pp. vii+222. (Cambridge: At the University Press, 1942.) 8*s*. 6*d*. net.

IF Sir James Jeans finds difficulty in defining philosophy (p. 16), there is no doubt of his qualifications for the task. Emerson, in his essay on Plato as a "representative man", defines philosophy as the account which the human mind gives to itself of the constitution of the world. It has been given to Jeans to participate effectively in our quest for the "constitution of the world"; as physicist, as mathematician, as astronomer, as cosmologist, he has opened windows on Nature—on the origins of planetary, stellar and nebular masses and on the interplay of matter and radiation. Now he attempts what he has earned the right to do: he speaks to us his account of the nature of reality, his views on materialism and what he calls mentalism, on determinism and free-will.

If we define the aim of science, including all utilitarian and humanitarian applications, as the endeavour to live the good life and to see into the mind of God, then at least part of that aim is realized when a mature man of science and thinker approaches the fundamental problems of philosophy by the path of mathematics and physics; and in fact without that background the discussion of philosophical problems tends to remain verbal and scholastic. It is, of course, sadly true that whereas we have had our poet and our man of science with the unmistakable characters of universality and agelessness—our Shakespeare and our Newton: we still await a modern *universal* philosopher, a thinker fully equipped as mathematician, physicist, biologist and psychologist, a new Aristotle. Sir James Jeans modestly states that his acquaintance with philosophy is simply that of an intruder, without any authority on questions of pure philosophy. Nevertheless he gives the pure philosopher a good deal to think about.

Perhaps the pure philosopher will wince most under the thrusts which Jeans gives him in the chapter entitled "The Two Voices of Science and Philosophy". While much of the book, as a survey of recent physical thought, is necessarily not new, in these sections Jeans has something vivid, pertinent and new to say to philosophers; and they may be considered as constituting Jeans's riposte (and an effective riposte they are) to the criticisms which have

been made on him by professional philosophers. He analyses the relation between science and philosophy in terms of differences of language, differences of idiom and differences of method. His main reason for the differences of language is that philosophy "tends to think in terms of facts as they are revealed by our primitive senses, while science thinks of them as they are revealed by instruments of precision"; he illustrates this, in more than one part of the book, by a most engaging account of the differences between what the philosopher thinks he means by 'red' and 'redness' and what the physicist means.

Jeans is still more to the point in his account of the philosopher's *idiom*. He gives three types of this. First, "the philosopher usually thinks in terms of qualities, the scientific man in terms of quantities". Secondly, he accuses philosophers of "depicting the world entirely in black and white, and so ignoring all the half-tones, gradualness and vagueness which figure so prominently in our experience of the actual world", and illustrates by the law of the excluded middle, which has so devastated logic. (A pure mathematician might, however, have something to criticize in Jeans's statement that a fallacy lies in the supposition that quantities can be sharply divided into finite and not-finite.) Lastly, he accuses the philosopher of over-simplification. I confess I found myself uneasy on this point, for though Jeans is happy in his examples, as usual, he must be well aware that progress in a *scientific* problem nearly always attends on the right kind of simplification and idealization; in fact, it may be said that the role of mathematical physics is to make self-consistent statements about non-existent entities. As regards differences of method, Jeans criticizes the philosopher as being more *atomistic* in his thought than the scientific man—treating time as a collection of instants, and so on. Jeans is not, however, fortunate in his example of the scientific man seeing Nature as a theatre of *continuous* change, "as a *cinematograph* show rather than as a series of magic-lantern slides"; indeed, he later dwells on the snare of mistaking apparent continuity for genuine continuity, instancing the staircase at 45° with very small steps, which will always support a particle in equilibrium.

On the science of philosophy, Jeans is good; on the philosophy of science he is less good. In a sentence which I do not understand, Jeans says: "The métier of the philosopher is to synthesize and explain facts already known". Does Jeans exclude from the philosopher's province that of *criticism*? It seems to me that one of the principal differences between philosophy and science is that the problems of philosophy are permanent whereas the philosophical conclusions of science are ephemeral. Recently, indeed, physics has changed almost unrecognizably every twenty years or so, not only in the scope of its content but also in its conclusions about itself. What right have we to regard the present position in physics with the complacency which Jeans almost habitually assumes towards it? He attributes to it a degree of perfectibility which philosophical history teaches can be assigned to no construction of the human mind. In his concluding sentence he admits that the quest, and not the knowledge itself, gives the greater interest to thought; but where, in this volume, is that ceaseless interrogation of current conclusions which it should be the aim of a critical philosophy to conduct?

I fear that professional philosophers could find much to criticize in the current philosophy of physics, if it were wholly as given in this volume. A few instances are all I have space for.

First of all, for the honour of nineteenth century science, I must correct an unexpected slip on Jeans's part. He says that the mere permanence of the atom showed the need for a revision of the classical mechanics, for (p. 124) "the constants known to the classical mechanics cannot be combined to form a length at all"; surely e, m and c combine to give e^2/mc^2, which is not only of the dimensions of a length but also gives the order of magnitude of the radius of the electron in interaction with a proton, a length which is fundamental in recent electrodynamics. That the radius of the atom is of a different order of magnitude no more implies of itself a new constant of Nature than the size of the living cell.

Jeans repeatedly (pp. 139, 193, etc.) speaks of "ordinary physical" space and time as something quite familiar and distinct from the conceptual spaces of the mathematician; in a fundamental analysis we choose some particular conceptual space as convenient for particular physical phenomena. He speaks of "the special properties of *this particular world*" (p. 49) as though philosophically it were legitimate to speak of the totality of things as if these were but a part of a wider whole. On pp. 17 and 96 he describes the world as *unintelligible*, on pp. 82 and 174 he describes it as *rational*; whatever meanings I allow these two attributes, I find them contradictory. He is sweepingly condemnatory of older "aether" theories; but he blandly accepts the four-dimensional space-time "continuum" (a disguised aether) and speaks of Nature's "dodging action at a distance" by "making gravitation act on space" (p. 119), and though he admits that this only "postpones the difficulty" he does not take it up again. He never questions the conservation laws, although that of energy has led to the introduction of an unobservable particle—the doubtful neutrino; and although the conservation of linear momentum, applied to a set of discrete particles, is not without difficulties in the light of the theory of relativity.

Again, Jeans considers electric and magnetic forces as not real at all, but mere mental constructs. One may agree with this, but not for the reason given by Jeans, that they "do not even pass the test of objectivity" (p. 200); a vector or tensor is none the less 'real' because its components depend upon the axes chosen, and if we have to accept a four-dimensional continuum as real, why not a four-vector? He does not criticize the classical theory of relativity on its vulnerable ground, namely, that it ignores the uni-directionality of time for each observer. Lastly, he commits a philosophical error in the clause, "If we know nothing about a particle except that it exists" (p. 201), for we cannot *know* of the mere existence of a particle from our own perceptions; observation of the kind considered in physics could not merely indicate the quality 'existence'; it must make some numerical assertion about that existence.

In a lighter vein, Jeans says he is not clear about $2 + 2 = 4$. He seems to think that because two sea-serpents plus two sea-serpents might remain only two sea-serpents (perhaps by cannibalism?), therefore he is entitled to throw doubt on the proposition $2 + 2 = 4$ (p. 46). Surely this is a proposition not of physics but of pure mathematics, and such propositions, he admits (p. 49), are universal.

Jeans comes to no final verdict, but inclines to the view that phenomena do not form reality but are only an extrusion from a deeper-lying substratum, not

in space-time. This, he thinks, may resolve the apparent conflict between causality and indeterminism. He might well here accept a spoonful of the medicine he hands out to philosophers: the answer to that conflict must surely be that it is falsely couched in terms of conflict, that we must not consider it as an antithesis of black and white but reconsider it in greyer shades, and that what mathematical philosophy might reasonably be asked for is a calculus which intervenes between classical causation and the nescience of probability theory.

E. A. MILNE.

NUMBERS, NUMBERS, NUMBERS

Guide to Tables in the Theory of Numbers

By Derrick Henry Lehmer. (Bulletin of the National Research Council, No. 105: Division of Physical Sciences, Committee on Mathematical Tables and Aids to Computation, Report 1: Report of the Sub-Committee on Section F, Theory of Numbers.) Pp. xiv+177. (Washington, D.C.: National Academy of Sciences, 1941.) 2.50 dollars.

THE U.S. National Research Council has embarked on the ambitious venture of producing a series of reports dealing with mathematical tables and aids to computation in every branch of mathematics, as well as in allied and associated subjects. All the reports are to take fully into account what is important in current research, and are to be written in such a way as to be intelligible for the most part to specialists in other fields. The reports are prepared primarily for scholars and others active in scientific work.

The present report, which is due to D. H. Lehmer, is the first of the series, and it sets a high standard indeed for the others. The book consists of three parts, of which the first is a descriptive survey, or rather some account of what the tables contain, often with a considerable amount of useful explanatory matter. This is written so as to be helpful to those most likely to consult the tables, including the amateur mathematicians who are more often attracted by number-theory than by other branches of mathematics.

The second part contains a bibliography giving the sources of the tables quoted in Part 1, and also some indication of the libraries in the United States and Canada where they are available. The third part contains a list of errata found in the tables, many by Lehmer himself.

Lehmer has produced an eminently readable and serviceable volume. He has brought to bear on his task more than a wide knowledge of number-theory and skill in calculation. Nothing appears to have been omitted that will conduce to ease in consulting the book, whether it is a question of arrangement, of explanation, or of reference. All arithmeticians are sure at some time or other to need this book and to have every reason to be grateful to him.

The volume suggests some reflections. In no other part of mathematics do tables of some kind play so important a part in research. This is not surprising since numbers are so fundamental in the mental development of man. Even in an early stage of civilization, the least curiosity or the slightest manifestation of intellectual activity led to the investigation of the properties of numbers. Then followed experiments with numbers and the gathering of numerical material. This led to empirical and inductive conjectures, some of which were proved in due course; and for many years practically every theorem in number theory was suggested in this way. There is ample evidence to this effect in the works of the great mathematicians Euler and Gauss, both of whom were renowned for their powers of calculation. Those conjectures, however, which were not soon proved, led to the further accumulation of numerical results used in testing the conjectures. Many results, the proofs of which now seem very simple, were very difficult to prove at first, and hence the great variety of tables in number theory.

The reader may be curious as to what has constituted the life-blood, so to speak, of arithmeticians. A glance at Part 1 of this book is most instructive, and I note a little of what is immediately intelligible. Probably the most useful are factor tables. In the early part of this century, D. N. Lehmer, the father of the present author, constructed a factor table for the first ten millions (and a few more numbers) which was published in 1909. No error has as yet been found in the 2,372,598 entries of Lehmer's table. Among the most interesting factor tables are those associated with the Mersenne numbers and giving the factorization of many numbers of the form 2^p-1, where p is a prime less than or equal to 257.

Prime numbers have long occupied the attention of arithmeticians, and there are many tables of various kinds. Empirical evidence suggested to Legendre and Gauss that the number of primes less than a given large integer x was asymptotically equal to $x/(A \log x + B)$, where A and B are certain constants. This was proved with $A = 1$, $B = 0$ by Hadamard and De La Vallée Poussin independently in the early 1890's. D. N. Lehmer utilized his factor tables to publish in 1914 a list of prime numbers up to a little more than ten million.

The Pellian Equation $x^2 - Dy^2 = 1$ or -1, where x, y are to be integers, is an equation famous in the history of mathematics since the seventeenth century. The first sizable table was published by Legendre in 1798 and went as far as $D = 1003$. It was continued by Bickmore up to 1500 and published by Cayley. Finally Whitford published in 1912 solutions for $1500 < D \leqslant 1700$, and D. H. Lehmer has produced a manuscript containing the solutions for $1700 < D \leqslant 2000$.

Among the tables which proved particularly useful for theoretical investigations were those dealing with quadratic forms in two variables; for example, the tabulation of non-equivalent quadratic forms $ax^2 + 2bxy + cy^2$ with given determinant $d = b^2 - ac$. This was started by Legendre, but extensive tables were computed by Gauss, the founder of the modern theory, and published after his death.

The study of the important partition function $p(n)$ was also materially influenced by tables. $p(n)$ is the number of solutions in positive integers of the indeterminate equation $x + 2y + 3z + \ldots = n$, and was introduced into analysis by Euler, who tabulated it up to $n = 59$ some time about 1750. This table was not extended until 1917, when the researches of Hardy and Ramanujan led to MacMahon's calculation of $p(n)$ for $n \leqslant 200$, and this was exceedingly important in the interpretation of new results for $p(n)$.

Goldbach's conjecture that every even number greater than 2 is the sum of two primes was propounded nearly two centuries ago. No proof of this has been found, though its truth is supported by many tables.

Finally, we may refer to tables dealing with

Waring's problem and in particular with cubes; for example, the conjecture, proved only recently by Dickson, that every positive integer is the sum of at most nine positive integral cubes. It is thought that only four cubes are required for sufficiently large numbers, but this has not been proved. Many tables give the least number of positive cubes required to represent a number n. Thus in 1835, Zornow gave tables for $n \leqslant 3000$. These were recomputed and extended by Dase to $n \leqslant 12{,}000$ and published by Jacobi in 1851. These were extended by Sterneck to $n = 40{,}000$ and published in 1903. Finally, an unpublished manuscript of Dickson continues the table to $n = 270{,}000$. Other tables of cubes have been computed by Western. Despite all these tables, it is not yet known whether every integer can be expressed as a sum of four cubes of integers of any sign (though the question is very simple with five). I venture to suggest, however, that tables will play a prominent part in answering the question.

L. J. MORDELL.

BRITISH ARCHÆOLOGISTS IN GREECE

The Annual of the British School at Athens
No. 38: Session 1937–38. Pp. xii+154+35 plates.
No. 39: Session 1938–39. Pp. viii+112+30 plates.
(London: Macmillan and Co., Ltd., 1940, 1942.)
42*s*. net each.

THESE handsome volumes render account of the archæological work of the British School at Athens in the two seasons preceding the outbreak of war, and illustrate its range and high standards of scholarship. They differ in contents, the earlier presenting a part only of the results of a single series of excavations; the later, seven shorter papers, of which only one is an excavation report, and the others are studies of inscriptions, museum collections, and the like.

The exploration of the upland plain of Lasithi in east-central Crete was undertaken by the late J. D. S. Pendlebury, with the assistance in 1937 of Miss Money Coutts and Miss Pascoe. In this secluded region the best-known site, the cave sanctuary of Psychro, was visited by Sir Arthur Evans in 1895, and explored by the British School in 1901–2. As its contents ranged in date from early bronze age to archaic Greek times, it was evident that the settlements in the plain below it had likewise a long history, spanning the cultural gulf between Minoan and Hellenic culture, and offering exceptional opportunity for examining the many problems, archæological and historical, of the transition. To this Pendlebury had already devoted several seasons, and the results here described are the reward of a type of intensive regional exploration which will supersede the older raids on isolated and fortuitous objectives, wherever local conditions are favourable, and mature students can be found to devote more than a single season to a 'dig'. To provide the means for such intensive study and prolonged acquaintance is one of the major preoccupations of the British School and similar institutions everywhere. The days of the 'wandering scholar' are not over, by any means—wide and planned travel remains a first pre-requisite—but reconnaissance is only the prelude to excavation as an instrument of scientific advance.

Main results of the work in Lasithi are the discovery of other cave sanctuaries, like Psychro; the examination of a mainly bronze age settlement, Kastellos Tsermiádhon, occupied from Neolithic to Middle Minoan times, when it seems to have been deserted except as a cemetery; and the revelation at Karphi, a strong natural fortress on the edge of the plain, of a 'city of refuge' established when the old Minoan regime collapsed at the beginning of the iron age, and maintained throughout the 'intermediate period', which seems to have ended about 900 B.C. Then, the open country being safer, the inhabitants of Karphi descended once more from the 'peg' to which they had clung for two centuries. Truly Aristotle was not far wrong when he described the Greek city-state as "coming into being to keep men alive", a *pis aller* to which Cretans have recourse again to-day. Here is a real piece of historical spade-work, of which the intricate detail must be sought in this well-written record, fitting memorial of its brave and brilliant author, who was wounded in Crete in 1940, and thereafter murdered by Germans.

Two of the papers in volume 39 are of exceptional interest. Miss Benton's excavation of the cave-sanctuary on Polis bay in Ithaca is part of a concerted exploration promoted and largely maintained by the late Lord Rennell of Rodd, whose judgment as scholar and yachtsman was that the topographical descriptions in the "Odyssey" deserved archæological verification. In previous seasons Mr. W. A. Heurtley, then assistant director of the British School, detected the remains of a bronze age fort and habitation at Pelikáta, commanding all landing places in the northern half of the island, thus confirming the place-name 'City Bay' (Polis) for a cove practically uninhabited in classical or medieval times. On the steep side of Polis bay Miss Benton explored a cave-sanctuary the vogue of which began in the bronze age, and was continuous until late Greek times; and one of its votive offerings was inscribed in Greek "a prayer for Odysseus". In earlier Hellenic times a great dedication of bronze tripod-cauldrons attested the fame of the little shrine, whither gifts came from so far afield as Ionian and Italian cities.

Here, then, was the continuous vehicle of tradition from the days of the bronze age post above the bay to those of the poet of the "Odyssey". The argument is simple and conclusive: only Teutonic perversity could have argued that because Ithaca is now called Ithaca, Homeric Ithaca "must have been" somewhere else: *Sagenverscheibung* most pedantic. But the work was not easy. The cliff had subsided since ancient times, and Miss Benton had to grope for her tripods, knee-deep in a tideless sea.

During Schliemann's excavation at Mycenæ in 1877, a group of gold objects was found, outside the stone-built 'Circle', which commemorated the famous 'shaft-graves', but obviously belonging to the same culture as their splendid equipment. When the British School made supplementary excavations around the 'Circle', it became clear (as Schliemann himself supposed) that these objects came from another 'shaft-grave' which had been broken up when the 'circle' was constructed, or by a drain built soon after. Miss Helen Thomas now shows, by minute study of the gold-work and the site, that these treasures stand rather late in the 'shaft-grave' series, that they were looted from a grave of that period, but that what was found in 1877 had been hurriedly re-buried in the grave itself when the rest of the treasure was removed.

Among the other contributions, a report on the various charcoals found in Miss Winifred Lamb's

excavation of an early bronze age settlement at Therm in Lesbos illustrates the great variety of calls on experts in other sciences, which are unavoidable in archæological work; and also the return which excavation can make, in evidence for the history of vegetation. Miss Bancroft, of the Imperial Forestry Institute at Oxford, identifies no less than seven varieties, including both vine and olive (not demonstrably cultivated) and a climbing plant like Salacia which does not seem to grow now in Lesbos.

JOHN L. MYRES.

SEASONAL RHYTHMS IN MAN

Seasonal Influence on Growth, Function and Inheritance

By A. B. Fitt. (New Zealand Council for Educational Research, Educational Research Series, No. 17.) Pp. xiii+182. (Christchurch, Auckland and Wellington: Whitcombe and Tombs, Ltd.; London: Oxford University Press, 1941.) 10*s*. 6*d*. net.

THE physiological cycles of lower mammals in relation to the seasons of the year must have been included in the earliest biological knowledge acquired by primitive man when he first began to observe the processes of Nature. On the other hand, corresponding functional rhythms in man are too inconspicuous to have attracted attention without deliberate inquiry. Even so, it has for a long time been recognized that the rate of growth of the human body is to some extent influenced by, or correlated with, the seasons. Data bearing on this question, partly the result of personal observations, have recently been collected and analysed by Prof. A. B. Fitt, and published by the New Zealand Council for Educational Research. These data include the weight and height increases of school-children, the weight increases in tubercular patients, seasonal fluctuations in muscular capacity, mental ability, mortality, suicide and delinquency, and the relation of weight, height, intelligence, etc., to the month of conception. The last subject is unfortunately included by the author under the general heading of "Seasonal Influence on Inheritance", a phrase which is clearly misleading, for the relevant data do not include a correlated study of the corresponding characters in the parents.

Prof. Fitt finds that the weight increase in children is at a high level in the autumn-winter half of the year and continues at a fairly low level in the spring-summer half. On the other hand, the height increase maximum coincides with the weight increase minimum. There is a phase of high vitality in the autumn, followed by a phase of low vitality in the spring. Rates of crime and delinquency are relatively low in the autumn and winter and high in the spring and summer, while the rates for suicide and insanity are similar to those for crime except that, instead of diminishing at the end of spring, they increase up to midsummer.

In considering the possible explanations of these periodicities, the author concludes that they reflect fluctuations in the 'stress' to which the growing individual is exposed at different seasons of the year. However, he does not define clearly the meaning of his concept of 'stress', and the reader gets the impression that this is little more than a convenient term for expressing the general results of the investigation. As to the cause of the periodical variations in 'stress', the author is strongly inclined to the view that they have an endogenous origin, that is to say, they are the expressions of an internal rhythm, possibly related to fluctuations in endocrine activity, rather than the result of environmental factors of temperature, light, humidity, diet, and so forth. Here many readers will find that Prof. Fitt proceeds much too fast for their liking. The discussion on hibernation in mammals and its relation to endocrine functions will possibly appear too indirectly related to the main thesis of the book, and the author seems too lightly to dismiss the influence of environmental factors as of little significance. We would suggest, in this connexion, that reference might appropriately have been made to the extensive studies on the effect of light on pituitary activity and thereby on general behaviour, particularly in birds and lower mammals. We note, also, that no reference is made to the detailed studies which have been made on seasonal differences in the growth of separate tissues such as the hair and nails. But perhaps it is a little ungrateful to point out such omissions, for undoubtedly Prof. Fitt's book is a valuable compendium of data of great importance to the sociologist and educationist.

The author concludes by briefly discussing some important implications which arise from his work, particularly in relation to the adjustment of the educational year to the seasonal rhythm of bodily functions. Even if it should be argued that the further analysis of more extensive data will be required before they can be confidently applied to educational policy, it will be agreed that Prof. Fitt has clearly pointed out the need for future research along these lines.

W. E. LE GROS CLARK.

LAPLACE TRANSFORMS

The Laplace Transform

By David Vernon Widder. (Princeton Mathematical Series.) Pp. x+406. (Princeton: Princeton University Press; London: Oxford University Press, 1941.) 36*s*. net.

THE theory of Fourier integrals arises out of the elegant pair of reciprocal formulæ

$$f(x) = \frac{1}{\sqrt{(2\pi)}} \int_{-\infty}^{\infty} F(y) e^{-ixy}\, dy,$$

$$F(y) = \frac{1}{\sqrt{(2\pi)}} \int_{-\infty}^{\infty} f(x) e^{ixy}\, dx,$$

in which either of the functions $f(x)$ or $F(y)$ may be arbitrarily given, and the other is then determined by it, and also forms the kernel of an integral formula which represents the given function. The Laplace formula is

$$f(s) = \int_{0}^{\infty} e^{-st}\, \phi\,(t)\, dt,$$

or the limits may be $(-\infty, \infty)$, with a corresponding reciprocal formula. The two theories are really the same, since one set of formulæ can be reduced to the other merely by a change of the variable.

When I commenced analysis some twenty years ago, the theory of Fourier transforms was little more than a footnote to the more popular theory of Fourier series. There were the classical applications to the solution of partial differential equations, such as those

given in the book of Riemann-Weber. But what is now considered as the fundamental theorem of the subject, that if $f(x)$ has its squared modulus integrable over $(-\infty, \infty)$, then so has $F(y)$, had only just been proved by Plancherel. Little use had been made of the theory in its up-to-date form, and no books on the subject existed.

To-day the position of Fourier integrals might be compared with that of power series in the old theory of functions. A Fourier integral is the natural way in which one represents functions of certain classes, and the various generalizations of the integral, such as the Stieltjes integral, enable us to bring wide classes of functions within the scope of the method.

The subject of the present book is the same as that of a book by G. Doetsch in the Grundlehren der mathematischen Wissenschaften series, but the details are widely different. This work begins with a very useful detailed account of the theory of Stieltjes integrals, and the Laplace integral is mainly considered in the Stieltjes form

$$f(s) = \int_0^\infty e^{-st}\, d\alpha\,(t).$$

The theory of the representation of a function of a complex variable s in such a form is established. Applications are then made to moment problems, to the theory of absolutely and completely monotonic functions, to Wiener's general Tauberian theorems and the prime-number theorem. After a discussion of the bilateral Laplace transform (with limits $-\infty, \infty$) applications are made to the 'Stieltjes transformation'

$$f(x) = \int_0^\infty \frac{\psi(t)}{x+t}\, dt$$

and related topics. Much of the analysis is the author's own original work. This very lucid presentation of it will be welcomed by all students of the subject. E. C. TITCHMARSH.

THE NEW BIOLOGY

Molecular Films, the Cyclotron and the New Biology

Essays by Hugh Stott Taylor, Ernest O. Lawrence and Irving Langmuir. (Rutgers University Publications of the One Hundred and Seventy-fifth Anniversary Celebration, No. 4.) Pp. v+95+24 plates. (New Brunswick, N.J.: Rutgers University Press, 1942.) 1.25 dollars.

THERE are many ways of celebrating an academic anniversary, though some, alas! are not available in war-time. The method adopted by Rutgers University to honour its one hundred and seventy-fifth anniversary has been to commission and publish a series of essays by men of distinction in science and learning.

One is always glad to hear from Dr. Irving Langmuir on any topic he chooses to handle; in this instance it is molecular films. He has a way of making profound things seem obvious which is very flattering to the intelligence of the reader. The remarkable results which are still flowing from the Berkeley cyclotron keep one on the *qui vive* for any new account by its inventor and director, Prof. Ernest Lawrence. There is no doubt that a collection of essays gains much if there is some more vital connexion between them than the mere fact that they happen to be enclosed in the same covers. The theme of the present volume is the interrelation of the physical and biological sciences in the past, and the hopefulness for mankind of still closer co-operation between them in the future. The theme is stated explicitly by Prof. H. S. Taylor in his introductory essay on "Fundamental Science from Phlogiston to Cyclotron". "To go forward to meet the years of difficulty ahead," he writes, "we shall need the effort of all men of good-will among whom the scientist, by the nature of his calling, must certainly be numbered. The processes of mutual co-operation and assistance among the individual sciences must be multiplied. The isolation of one science from another must become progressively less and less even though the degree of specialization within a science becomes perhaps greater and greater. This calls for an increasing breadth of culture and of education among the scientists." Prof. Taylor's excellent survey of the history of science during the past 175 years is in the nature of a commentary on this theme. The essays by Dr. Langmuir and Prof. Lawrence provide, in fuller detail, forcible illustrations of the argument from science actually in the making.

In his essay on "Molecular Films in Chemistry and Biology" Dr. Langmuir deals mainly with the chemical aspect, contenting himself with pointing out that the method is one which must throw very considerable light, when properly applied, on many of the obscurer problems of biology. He is offering a tool which the biologists have still to make use of. The cyclotron has already captured the imagination of the biologists, particularly of the medical biologists, and Prof. Lawrence has much progress to report on subjects as diverse as the treatment of cancer, the action of enzymes and vitamins, the secrets of photosynthesis, and the digestion of proteins.

The book is not addressed specifically to the general reader—it assumes some acquaintance, at any rate, with scientific nomenclature—but it should not be difficult reading for anyone who takes an intelligent interest in the progress of the sciences. Biologists, both medical and lay, to whom it is particularly directed, should find it both fascinating and stimulating; though whether they will consider the subtitle of the volume, "The New Biology", to be, as yet, quite justified remains to be seen. That the new weapons now being forged will bring, as Prof. Lawrence predicts, "exciting new pioneer days of discovery" in biology as well as in physics and chemistry is already certain.

This brief review has, I fear, done rather scant justice to Prof. H. S. Taylor's admirable opening essay. By way of *amende*, I quote its concluding sentences. "The modern world, says Maritaine, by which I mean that world which is coming to an end before our eyes, has not been a world of harmony between forms of wisdom, but one of conflict between wisdom and the sciences, and, he adds, it has seen the victory of science over wisdom. Have not we scientists, so to speak, to surrender that victory? We shall not yield our energy, our courage, our diligence in the search of truth. We shall but renounce the primacy to which a sick world has thrust us; and we shall gain by our renunciation. In the free world to which we still dare to look forward, with the soldiers and statesmen, artists, philosophers and priests we shall integrate our scientific skills with the social and spiritual aspects of human life and nature. Let this, we may pray, be an horizon not too far distant."

J. A. CROWTHER.

POLYGENIC BALANCE IN THE CANALIZATION OF DEVELOPMENT

By DR. K. MATHER

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ONE of the greatest differences between genetics to-day and genetics of thirty years ago is to be found in the changed attitude of geneticists towards the relation of a gene to the character, or characters, which it affects. The early geneticists equated a given gene difference to the character difference from which its existence was inferred. The gene for tallness in peas gave tall peas and its allelomorph gave short peas. The significance of the fact that a tall pea, as Mendel himself observed, could be 6 ft. tall or 7 ft. tall or of intermediate height was overlooked; the variation in height of tall peas was not discontinuous and so was not obviously attributable to a gene or genes detectable by the Mendelian technique. Such an attitude is very understandable because the success of Mendelian analysis lay in its concentration on simple character differences, in its exclusion of all extraneous variation from account. But this outlook carried with it disadvantages too, for concentration on discontinuous variation in experiment led easily to the assumption that the variation by which evolutionary changes were effected was just as sharply and obviously discontinuous. The outcome was the mutation theory of evolution on one hand and the presence and absence theory on the other.

It is true, of course, that after, say, 1906 all geneticists were familiar with the fact that the expression of one gene could be contingent on the presence of a given allelomorph of another gene. Bateson[1] gives an extensive account of the inheritance of complementary and epistatic genes, but the observations could be interpreted so easily in terms of the presence and absence theory that they did little or nothing to shake the idea of what we may perhaps call the characteristic expression of the gene.

Soon, however, several lines of approach led geneticists to doubt the validity of this simple interpretation and finally to abandon it altogether. Four deserve special mention. Bridges[2] found that the inheritance of sex in *Drosophila melanogaster* could not be explained in terms of the presence or absence of any given gene or genes. The numerical relations, or, as he called it, the balance, of the chromosomes, present in all flies, determined whether they would be supermale, male, intersex, female or superfemale. A little later Fisher[3] pointed out that the genes controlling mimetic patterns in insects must be presumed to have been given their special properties by the selection of other genes. He later concluded that even the dominance relations of one gene must be dependent on other genes of the nucleus, and the existence of such dominance modifiers has since been amply verified by experiment. Muller[4] showed that the expression of sex-linked genes must be supposed to be subject to genetical adjustment, for otherwise no reasonable explanation could be given of the equality or near equality of expression of these genes in the two sexes. There exists a means of dosage compensation. Finally, Timoféeff-Ressovsky[5] was able to demonstrate, by direct experiment, that the expression of certain genes in Drosophila was modified by the action of other genes. The dependence in expression of any given gene on the other genes of the nucleus, on the genetical background as it is often called, is thus beyond doubt.

This change of ideas concerning the relation between gene and expression has had a profound effect on the attitude of geneticists towards evolutionary change, as recent writings have shown. Ford[6], Muller[7] and Huxley[8] have especially developed the application of this new outlook to the better understanding of adaptation and evolution. It is not without significance that the rise of the idea of the dependent action of genes has progressed side by side with a return to Darwinism and the abandonment of the mutation theory.

Some further consequences of this view have now been discussed by Waddington[9]. In particular, he points out that the dependence in expression of one gene on the action of others permits a more co-ordinated response of the organism to its environment. Using both embryological and genetical data he shows that development may be regarded as canalized, that is, that although an organism may follow any one of a number of developmental paths, it is difficult to make it develop along lines intermediate between these possibilities. In genetical language, the integrated genotype acts as a buffering system, in such a way as to limit the variation of the organism's response to environmental fluctuations. Major or switch genes may determine which of the paths will be followed, but systems of other genes, the buffering action of which can be adapted by natural selection, will delimit the possible paths with greater or less precision. The switching action may have originally depended on environmental differences but, as Waddington points out, this function can, and generally will, be transferred ultimately to a genetic difference, and in this way will come to operate with greater efficiency and regularity.

Now, although the distinction between switch genes and buffer genes must not, for reasons which we shall presently discuss, be pressed too far, it is clear that the parts they play in controlling development are quite different. We may then expect them to be detected in different ways, to have effects of different magnitudes and to respond differently to selection. Genetical evidence is now available on these points and with its help we can form a clearer picture of how such co-ordinated systems arise and of how they change under the action of natural selection.

The familiar genes of genetical experiment fall into the category of what we have called switch genes. They are not usually known by this name, being more often called major mutants or qualitative genes, to distinguish them from the minor genes controlling quantitative characters. These two classes have also been called[10] oligogenes and polygenes respectively from the oligogenic and polygenic nature of the variation which they determine. With some important exceptions, which we shall discuss in a moment, the variant types to which switch, major or oligogenes, call them what we will, give rise, are not to be found in wild populations except as rare, and presumably recent, mutations; for unless some important end can be achieved only by diversity of allelomorphs of such genes, one allelomorph will have an unconditional selective advantage over the rest and will, apart from the slight effect of mutation pressure already noted, oust its competitors. Thus although we can only rarely detect the operation of

such a gene by the genetical method of observing the different expressions of at least two allelomorphs, we must assume their action in wild organisms.

As but one allelomorph of any such gene is common in the wild, only those buffer genes which control the expression of this allelomorph will be subject to the action of natural selection. The systems buffering the action of the rare, or mutant, allelomorphs will not be so well adapted through selective action to the better fulfilment of their task. Hence when a mutation occurs in the laboratory, or a rare mutant type is found in and introduced from wild material, we should expect its phenotype to be more variable than the wild type, the buffering system of which is constantly adjusted by natural selection. This expectation is in full accord with the observed properties of mutant types, many of which have highly variable phenotypes. It should be noted that this argument presupposes that the various allelomorphs of a gene guide development into channels the directions of which are determined by unlike buffer genes. This has, in fact, now been verified by Haskell[11] in the case of the gene scute in *Drosophila melanogaster*.

The organization of the system of genes buffering the development of wild type individuals is of paramount importance to the organism. It must primarily determine the production of a relatively uniform type under conditions which may be subject to considerable fluctuations, as indeed is implied by its description as a buffering system. Certain complications may be observed, as, for example, adaptation to show ecological plasticity, but these only serve to emphasize our main point, since they imply buffering in such a way as to produce two or more relatively uniform types according to the action of an environmental switch. But to be successful the system must have some elasticity, even though it is only potential, for the inability to respond to trend changes in the environment would mean that sooner or later the species would die out, no matter how well its buffering system were adapted to coping with non-persistent environmental fluctuations.

The way in which uniformity is combined with potential elasticity has been revealed by Mather's[10,12] analysis of polygenic variability. The buffering system is built up of polygenes having effects which are similar to one another and individually small as compared with environmentally determined fluctuations. Natural selection builds up linked combinations of these genes, in which the constituent members of the combinations balance each other in action. Inter-combinational uniformity of immediate action is combined with the ability to produce new combinations of different action by means of recombination between the various existing combinations. Thus the buffering action depends on polygenic balance, which can and does change as a result of recombination, so permitting the emergence of new combinations which are capable of re-aligning the developmental path to give fresh adaptation to changed circumstances. The polygenic variability is hidden, or potential, in the genotype and is not free in the phenotype. In other words, we can see how, as Waddington puts it, the system has absorbed its own variability. Inasmuch as the maintenance of adequate polygenic balance depends on the regular action of natural selection[10], it is easy to see that the polygenic system buffering the expression of mutant switch genes will be inefficient, for it will not have been selected for inter- and intra-combinational balance.

This concept of polygenic balance, and the storage of variability in its potential form, enables us to approach a number of evolutionary questions. There is, for example, the problem of polymorphism, whether of the kind known in grouse locusts or mimetic butterflies, or the more familiar type, sex, heterostyly, etc., on which the breeding structure of a population depends. These are the exceptional cases mentioned earlier, in which the success of the species depends on diversity of a switch gene. It is of no use having females, for example, if no males are available.

The direct determination of sex depends on the action of the sex chromosome inequality, which is the switch gene in this case. But how is the organism adapted to produce functional females and functional males with but rare exceptional individuals, and how was this sharp difference in type of individual first produced ? Though we have stated the question in terms of sexual dimorphism, this is only a particular example of polymorphism, and the answer to this question will apply to polymorphic species in general.

Clearly this answer must be sought in the ability of the polygenic system to distinguish and delimit adequately the paths into which development can be turned by the operation of the switch gene. The latter may itself be composite and so capable of some modification[13], but, in the main, close adaptation must be polygenically determined. Only a polygenic system is capable of giving all grades of expression between wide limits. The balance achieved by the polygenic combinations will determine the end products, and if this balance is adequate the end products of the developmental paths will be functional male or functional female according to the line into which development was guided by the switch gene. Each type can, and will, be adjusted by the action of selection on the buffering system of polygenes ; and in so far as the types are capable of such adjustment, dimorphism will arise and develop continuously, under the action of selection, from the store of potential variability which lay hidden in the polygenic combinations of the undifferentiated ancestral form. The action of the switch gene, giving so obvious and sharp a discontinuity, is made possible by the continuous adjustment of polygenic balance.

Two predictions follow from this argument. In the first place, it should be possible to change the polygenic balance of a polymorphic system by operating on it with unbalanced combinations from a related system which is not adapted to show polymorphism. The polymorphism need not be lost in such a case : the switch gene will merely determine a less efficient polymorphism after the operation. This has been shown to happen to the incompatibility system in Petunia[14]. In *Petunia violacea* gametic incompatibility, which is a type of polymorphism affecting the breeding system, is determined by a series of *S* allelomorphs of the kind well known in Nicotiana species. The related *P. axillaris* shows no incompatibility. It was possible to isolate, from the F_2 of a cross between these species, plants identical in constitution with the *P. violacea* parent in regard to switch gene (that is, the *S* gene), but which were less strongly self-incompatible than was that parent. Furthermore, the two plants, *P. violacea* and the second generation species hybrid, were reasonably freely inter-compatible, though two plants of like *S* constitution within *P. violacea* would have been quite inter-incompatible. The polygenes from *P. axillaris*, not balanced to give incompatibility, have recombined with the balanced combinations of

P. violacea to give new combinations determining a new incompatibility system, which, however, depends on the same switch gene. As we should expect, this new system is not so precise in action as the old one, for these new combinations have not been fully balanced by the operation of natural selection.

Turning to the second prediction, we can see on the polygenic view that two related species, or populations, may show the same end result, yet reach it by balancing different polygenes of similar effect. Indeed, if the groups are isolated, this will be inevitable, because a polygenic system is in a constant state of flux. Its balance is stable but the constituent polygenes producing this balance are changing by mutation, fixation and so on. Now in such a case the joint balance of any pair of combinations can only be maintained by the continual operation of natural selection, and if two combinations are never present in the same nucleus, that is, are isolated, they will have a poor joint or relational balance, though they may have the same internal balance, and though each may be capable of working harmoniously with other combinations from which it is not isolated. Isolation means divergence of polygenic organization (but not of necessity of intra-group polygenic balance as expressed in the phenotype), because it prevents inter-group balance being maintained by natural selection.

It is to such inevitable cryptic divergence that we must attribute hybrid sterility in species crosses, though, of course, bars to crossing must have a selective origin. In particular, however, we should expect that two related species showing the same polymorphism, operated by the same switch gene, would depend on different sets of balanced polygenes to give this common result. On inter-crossing, therefore, the character in question should lose its sharp definition in later generations after the two sets of polygenes had recombined and so lost balance. This is found to be the case with incompatibility in Nicotiana. *N. Forgetiana* and *N. alata* show pseudo-compatibility only in exceptional circumstances, that is, the actions of the various allelomorphs of the switch gene are always distinctive; but in *N. Sanderæ*, a horticultural type derived by hybridization of the two foregoing species, pseudo-compatibility is rife, though the operative switch locus, *S*, is the same as that of both parental species[15]. Pseudo-compatibility marks the breakdown of the distinction between the types produced by the *S* allelomorphs. We can see that it is not the switch mechanism, but the buffering system of polygenes, to which the breakdown must be attributed, exactly as expected.

Thus the character or reaction, the expression of which is apparently dependent on the switch gene, is in fact conditioned by the buffering polygenes. If the latter are not adequately balanced the operation of the switch gene is partially or even wholly vitiated. The buffering system can also change in such a way that it endows the switch gene with an apparently new set of properties. The path or paths into which the latter directs development are so remoulded and redirected that the outcome is quite a new type.

Such changes can be recognized as having taken place in the evolution of flower colour differences in the genus Petunia[14]. *P. violacea* has magenta coloured, and *P. axillaris* white, flowers. The latter is homozygous for the allelomorph *w*, giving lack of anthocyanin in this species, of a gene the other allelomorph of which, *W*, homozygous in *P. violacea*, results in the presence of anthocyanin. When, however, the species are inter-crossed the F_2 contains coloured plants of the constitution *ww*, and what is more, these plants may have a flower colour indistinguishable, at least by inspection, from that of other plants which prove to be *Ww* when tested. The effects of the gene *W,w* are conditioned by the genetical background of the species. The background of *P. axillaris* is so adjusted that *w* switches flower development into a track leading regularly to white pigmentation. The buffering system of *P. violacea*, which does not carry *w*, is naturally not so adjusted and, in an F_2, affects the path of development so that *ww* expresses itself in a new way, namely, by giving coloured flowers. Thus the discontinuity in effect of *W* and *w* is a reflection of the buffering system. The switch gene has been given its characteristic properties by the adjustment of the genetical background or buffering genes. Clearly the evolution of such a specific difference can proceed gradually by continuous steps, even though the eventual discontinuity between the species is controlled by a few major genes.

This leads us to the problem of the relation of switch genes, major genes, oligogenes or whatever we choose to call them, which have large effects, to polygenes, the effects of which are so small as to be individually unrecognizable. It does not seem reasonable to suppose that the nucleus contains two kinds of genes, having sharply distinct properties (though it must be pointed out that there exist two kinds of chromatin, eu- and hetero-chromatin, the latter of which appears in general to be devoid of major genes but to contain polygenes). We have, however, seen that the apparently large phenotypic effect of a major gene is, at least in part, a property of the polygenes which determine the ultimate result of the major gene's action. In fact we may surmise that the difference in phenotypic expression between the allelomorphs of some major genes could be reduced to nothing by the reverse of that process of polygenic adjustment which has endowed them with the property of conditioning sharp phenotypic discontinuity.

But it would be straining both evidence and reason to suppose that a major gene was originally, in all cases, merely one of a number of like polygenes, any one of which might by chance have had the switching role thrust upon it by adjustment in balance of the rest. Rather it would seem that the switch gene operates at an earlier ontogenetic stage, the later acting genes then having the power of reducing or magnifying the difference in outcome of the paths into which this major gene directs development; and inasmuch as the latter genes do operate later, their own effects are small and, at least in part, interchangeable. We may note, too, that in such a case the organism could, without undue loss in fitness, afford to carry a greater store of variability for the later acting polygenes than for major genes; for their individual disruptive action will not only be smaller, but will also be conditioned by the other polygenes present.

This leads us to the speculation that major, switch or oligogenes were at one time polygenes. The distinction between the two classes is one of time of action, and hence of magnitude of average effect, the apparent discontinuity of type being due to the buffering or enhancing action which the polygenes exert on the effects of the earlier acting major genes. In other respects the two kinds of gene are alike, for both mutate, segregate and show linkage. It then

follows that a gene which is now a polygene acting at a late stage in the development of an organ may, either alone or as part of a complex of linked polygenes, assume the role of a switch gene if and when the developmental history of that organ is extended by its morphological and functional elaboration. A gene which has a minor effect on the corolla structure of a relatively unspecialized flower could have a drastic effect on the corolla of a flower elaborated and specialized in the way observed, for example, in an orchid.

This is, perhaps, an unduly simplified discussion of the problem, and the questions raised, for example, by neoteny require consideration at a length not now possible. But the principle that genes have evolved in function can scarcely be denied. Indeed the evolution of an organism is an expression of the functional evolution of its genes.

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STUDIES OF WILD POPULATIONS

By DR. C. B. WILLIAMS

AT a joint meeting of the Royal Entomological Society and the Genetical Society held on December 3, there was a general discussion on methods of study of wild populations.

Prof. R. A. Fisher, president of the Genetical Society, opened the proceedings with an account of recent developments in the method of estimating the numbers of a wild population by liberating a known number of marked individuals and later recapturing a random sample. Thus if a hundred marked flies are liberated and, after a short interval to allow of their mixing with the wild population, a number of flies are captured at random and found to include 1 per cent of marked individuals, then it can be assumed that the original wild population was approximately ninety-nine times the number of marked flies or 9,900 individuals.

If a series of such observations are made at short intervals, say on successive days or every week, it is possible to extend the mathematical analysis to supply estimates, on one hand of the death and emigration rates, and on the other hand the birth or immigration rates. If several contiguous areas are sampled the effect of birth and death can be separated from the effects of movement.

Since the total number of individuals captured and the total released on different days may vary, it is of value to convert all to a 'recapture frequency' which is the number of marked recaptures to be expected if both the numbers released and the total number recaptured were a hundred.

The method has been used particularly with tsetse flies by Jackson in East Africa and on certain butterflies and moths in England particularly by Ford, and there are interesting differences between the former case, in which the insects are flying over long periods with relatively small changes of number, and the latter, in which the brood rises to a peak and falls away again within a few weeks.

The idea of random sampling, which is the central and typical statistical operation, aims at supplying estimates of the population numbers, and birth-rate and death-rate, together with a knowledge of the precision of these estimates which is seldom available by other methods.

Dr. C. B. Williams dealt with some methods of finding the changes in insect population used at Rothamsted Experimental Station in recent years. Direct sampling had been used by Dr. H. F. Barnes to trace the changes in numbers of wheat midges over a period of fourteen years, and the number of slugs caught in thirty minutes at night had been found to be a fairly accurate method for estimating changes in a slug population. Direct sample counts had been used by K. D. Baweja to demonstrate the return of the insect population to an area of soil previously rendered sterile by heat.

The method of sampling by means of a light trap provided an interesting mathematical problem, as the catch in the trap is directly affected by changes both in activity and in population numbers. By considering the difference between catches at short intervals (for example, successive days) the activity factor became dominant, while by comparing monthly average captures in successive years the population effect was emphasized. It was then found possible to correct average catches for the effect of environment on activity and to have left a more exact measure of the population change. Later it was found possible to forecast these changes from a knowledge of the weather conditions during the previous months.

Dr. Williams also dealt very briefly with a new method, recently developed by Prof. R. A. Fisher and himself, for studying the relative abundance of different species in a mixed wild population. By means of a logarithmic series it is possible, if one knows the number of individuals and the number of species in a random sample of a mixed population, to calculate three sets of information. First the relative frequency of rarer and commoner species, as for example the number of species represented in the sample by one, two, three or more individuals; secondly, the number of species which would have been obtained in samples containing fewer or more individuals from the same population; and thirdly, a numerical measure of the extent to which the population is divided up among species, which has provisionally been called the 'index of diversity'. As the error of this 'index' can also be calculated it is possible to say if two random samples are taken from populations of similar composition or not. The calculated results fit very closely indeed to the observed numbers.

Mr. George Salt pointed out that there are two principal aspects to the study of animal populations. One can ask the question "How many ?" and answer it by making a census; or one can ask "How do there come to be so many, neither more nor fewer ?" The curve of population growth, stated by Malthus on theoretical grounds to be exponential, was found by Pearl, Gauss and others in a variety of experiments to begin as though exponential, but then to change over to a sigmoid form. Three groups of

factors have been suggested as effecting the change: competition for food, conditioning of the medium, and density of population. Owing to its applicability to human populations, the last of these has monopolized the interest of most observers; the second has been the subject of much work by Park; the first, competition for food, has been comparatively neglected. Experiments with blowflies show that, as increasing numbers of maggots compete for a fixed amount of meat, the average weight of the surviving larvæ gradually falls, there is an increasing loss of life in the larval stage, and eventually the number of survivors falls off rapidly. These laboratory experiments have their parallel in wild populations, and Holdaway has shown that, from an initial population of 63,200 Lucilia larvæ competing for carrion in Nature, only thirty reached the adult stage. A similar illustration of the law of diminishing returns has been demonstrated in a parasitic insect. In the case of these animals, and probably of others, it is in the larval stage, the principal feeding period, that the size of the population is largely determined by the available food supply.

Owing to the absence of Dr. Julian Huxley, who was to have taken part in the discussion, a communication was read from Dr. Ll. Lloyd on the effect of environment and competition for food on the insect fauna of sewage beds.

The population studied was made up of relatively few species, including three Chironomids, two Psychodids and one Enchytraeid worm, and it was possible in this simple community to see the effects of both intra- and inter-specific competition for food.

The vigorous Chironomid, *Metriocnemus longitarsus*, and the worm *Lumbricillus lineatus* dominate the situation and live in the topmost zone in the beds where the eggs of most species are laid. Cool wet summers are favourable to these dominant competitors, while hot dry summers are adverse to them. A cool June is followed by an abundance of *M. longitarsus* and a consequent reduction of the other Chironomids, *M. hirticollis* and *Spaniotoma minima*. The latter, however, specially counters the Psychodids deeper in the beds, so that these have a more prolonged abundance after a cool June.

M. longitarsus and *Psychoda severina* have the capacity of active winter breeding and one would expect that mild winters would be favourable to them. But the worm intervenes, and in a mild winter pulverizes the surface growth and sooner or later destroys it. Thus conditions are made more unsuitable for the two insects and they tend to become scarcer rather than more abundant in mild winters.

A. N. Barker, in a parallel study of the Protozoa of the beds, found a close negative correlation between the abundance of these organisms in summer and that of the grazing larvæ as assessed by fly trapping.

Dr. U. Phillip said that we can obtain information about the finer structure of free-living populations by studying both genetical and cytological variability. Genetical variability may be investigated by inbreeding insects from the field. It will then be found that every individual is heterozygous for at least one factor, if not for many more. From the occurrence of such factors the structure of the free-living population may be deduced. For the study of structural hybridity the larvæ of the Chironomidæ are very favourable material on account of their large salivary gland chromosomes. By investigating the frequency of various sequences of factors in the chromosomes (inversions) which occur together, it was found that larvæ living together in such a small closed locality as a rainwater butt came from a random mating population of unknown size.

We have so far had only indications of the type of breeding groups that may be found, because our methods of collecting and evaluating our results statistically are not sufficiently refined.

Prof. J. B. S. Haldane discussed the importance of genetic polymorphism in a wild population. He classified polymorphism as (1) manifest, for example as seen in mimetic associations; (2) cytological, in which the animals appear similar but have differences in chromosomes; (3) cryptic, as where recessive characters are normally hidden, but may be discovered to be present by inbreeding.

In the first two cases the population tends to come to an equilibrium in the proportion of the different forms, but not in the latter.

He pointed out that recoveries of individual Drosophila had been made in wild populations at some distance from the laboratories, which showed genes in certain combinations which had first been made in the laboratories. This indicated their origin by escapes.

An analysis of polymorphism throws light on the breeding system of a population, since a small inbred group soon becomes homozygous or nearly so. The study thus enables us to estimate the rough order of magnitude of an interbreeding population.

Mr. E. B. Ford directed attention to the relation between the size of a population and its variability as seen by him in a locality where the butterfly *Melitæa aurinia* occurred over a long series of years. At first the butterfly was rare and rather uniform in appearance. Then followed a period of rapid increase in numbers accompanied by a great increase in variability. Finally the population settled down to more or less stability of numbers at a level much higher than originally, and simultaneously it became much less variable, but not in the same form that had been dominant at the beginning of the observations.

Dr. E. A. Cockayne discussed briefly the problem of melanism and its occurrence in industrial areas. He considered that the melanic forms which became dominant in certain 'industrial areas' occurred as rarities over the rest of the range of the species. He also had evidence that there were frequently very considerable differences in the proportion of melanic forms in some species of moths in localities relatively close to one another, quite independent of any possible effect of the proximity of manufacturing towns.

Dr. W. Ripper expressed the hope that the method of correcting a sample for activity so as to leave a more definite population-number effect, as described by Dr. Williams for his light trap studies, could be extended to other sampling problems, particularly those of immediate agricultural importance.

Mr. Classey remarked that the varying proportion of the sexes in different species caught in a light trap might reduce the value of this as an estimate of populations.

Dr. P. A. Buxton, president of the Royal Entomological Society, in summing up the discussion, emphasized the great scientific and economic importance of the study of populations and said that nearly every problem in economic entomology is a problem of numbers. He suggested that it would be most valuable if someone could produce a critical review of the various methods now in use for obtaining estimates of the number of individuals in wild populations.

LUMINESCENCE AND COLOUR

A FEW years ago luminescence was little more than a curiosity of slight academic importance; to-day it forms the basis of new and important industries. The Colour Group of the Physical Society devoted its tenth science meeting, held on December 11, to its consideration, when four papers were read and discussed.

In the opening paper, on "The Chemical and Physical Properties of Luminescent Materials", Dr. J. W. Strange reviewed the development of luminescence and referred to the alchemical, if not culinary, flavour which still pervades the preparation of phosphors. He declared, furthermore, that the lack of rigid chemical control and co-operation between chemist and physicist has accounted for a good deal of the lack of progress in understanding luminescent phenomena. The words alchemical and culinary might, with some justice, be applied to the early attempts at making luminescent powders, but can scarcely be applied to the preparation of modern highly efficient phosphors, where chemical control is rigid in the extreme. So-called pure chemicals as purchased are rarely good enough for manufacturing luminescent powders, and these are generally subjected to careful purification before use.

It is true that theory lags far behind the practice of luminescence, and there does not appear to be much common ground as yet where the theoretical chemist or physicist and the luminescent powder chemist can meet. Nevertheless, as pointed out in the discussion following the meeting, acknowledgment must be made for the contribution of X-ray analysis to the development and understanding of crystalline phosphors. The way in which X-ray spectroscopy has contributed to the elucidation of luminescent problems has recently been described by Rooksby (*Electrical Times*, 102, 260; 1942).

Dr. Strange described the preparation of crystalline phosphors by firing the precipitated compound or the component oxides with the appropriate activating metal and flux at temperatures between 850° and 1,200° C. Manganese is the most important activator, but copper, silver, bismuth and a few others are also used, there being an optimum concentration for each phosphor.

Phosphors such as calcium and magnesium tungstates and zinc sulphide, which do not require an activator in the accepted sense, appear, at first sight, to conflict with the theory of active centres, which is largely based on the discovery that traces of certain heavy metals in a suitable crystalline matrix produce luminescence. The modern tendency, however, is to regard these apparent exceptions as conforming to the general rule. Thus there is evidence that in pure luminescent zinc sulphide there is a stoichiometric excess of zinc in the lattice which behaves as the activator. The main function of the flux, which is generally a halide, is to speed up the reaction or to bring it about at a lower temperature. Except possibly in certain sulphide phosphors, which require the presence of a halide for maximum efficiency, the flux does not appear to enter into the composition of the luminescent material.

Dr. Strange referred to some of the uses of luminescence in analytical work, atomic physics, electric discharge tubes and cathode ray tubes. In cathode ray tubes the relation between light output and tube current is of particular interest in connexion with theories of the mechanism of luminescence. It is a remarkable fact that the phosphor still continues to show an increase in light output with increase in current even at a power loading as high as 12 watts per sq. cm. of screen.

He concluded his remarks with a brief review of the modern interpretation of luminescence based on the idea that the atoms of the activator form the active centres for absorption and emission of radiation.

Mr. H. G. Jenkins read the second paper of the series, on "Commercially Useful Fluorescent Substances", which he dealt with under the headings: inorganic phosphors, fluorescent glass and fluorescent organic substances. A number of demonstrations were given to illustrate the luminescent characteristics of the various types of substances discussed.

The relation between the luminescent characteristics of the sulphide phosphors and the composition of the matrix, the activating metal and the furnacing treatment were briefly discussed. The most interesting property of the sulphides from the present point of view is their ability to fluoresce strongly when they are excited by near ultra-violet or even visible radiation.

Referring to the very beautiful colour effects obtained with these materials under filtered long-wave ultra-violet radiation, Mr. Jenkins mentioned that luminescent sulphide paints were being used very effectively before the War in conjunction with black-glass lamps for fluorescent posters and displays of great beauty and artistic merit. The black-glass lamp comprises a quartz high-pressure mercury vapour discharge tube rated at 80 or 125 w. in an outer bulb of nickel glass. The transmission of the nickel glass at 3650 A. is about 70 per cent and only a negligible amount of visible radiation is emitted by the lamp, which is one of the most convenient and efficient sources of near ultra-violet radiation available.

With normal paints and pigments, additive mixtures give subtractive mixtures of light. Thus a yellow pigment is yellow because it absorbs blue, and, as everyone knows, a mixture of blue and yellow paints gives green. In mixing fluorescent pigments, however, the artist has to deal with an additive mixture of *lights*, and he finds that blue and yellow no longer give green, but white. It is, of course, necessary for the artist to mix his luminescent pigments and to use them under ultra-violet radiation, with visible light excluded so far as possible. With comparatively little practice the new technique is easily acquired.

Some curious effects are observed with luminescent colours under conditions of scotopic vision; thus yellow luminescent inscriptions are more easily read than are blue, even when the brightness of the yellow is somewhat lower. This is probably due to the use of parafoveal vision for the shorter wave-lengths and consequent inability to focus. The high sensitivity of the periphery of the retina to blue and bluish-green colours makes it possible to see, although not to focus, these luminescent colours at brightness levels too low for normal vision to function. It can in certain circumstances produce a feeling of discomfort in the dark-adapted eye analogous to glare at normal illuminations.

Mr. Jenkins next described phosphors excited by ultra-violet radiation of wave-lengths shorter than 3000A., of which zinc silicate, zinc beryllium silicate and magnesium tungstate are perhaps the best known,

and pointed out that these are commercially much more important than the sulphide types because of the efficiency with which they are excited by the low-pressure mercury vapour discharge. More than 50 per cent of the total input energy in the low-pressure mercury discharge is emitted as resonance radiation of wave-length 2537 A. and below. It is possible to convert a considerable fraction of this energy into visible light by means of fluorescence, resulting not only in sources of high luminous efficiency, but also, what is scarcely less important, in sources in which the spectral luminosity can be controlled.

As might be expected, luminescence in glass is even more complex and difficult to understand than that in crystalline materials. The luminescence centre may be an ionized molecule such as UO_2++, or a covalent molecule such as cadmium sulphide, or neutral atoms such as silver, lead and tin; or the luminescence may be due to a crystalline material such as zinc silicate precipitated in the glassy surround. In the latter case the glass is opalescent due to the presence of undissolved crystalline material. Mr. Jenkins referred to the various types and showed a number of examples. Apart from its use for discharge tubes, the fluorescence of glass activated by rare earth atoms has been used to study the structure of glass and to supplement the information given by X-ray analysis.

Fluorescence has been used by glass manufacturers as a convenient method of identifying their product. Small amounts of cerium give a blue fluorescence and do not affect the colour or physical properties of the glass. Cerium has also been used as an indicator to study the movements of molten glass during manufacture.

Luminescent enamelled surfaces are usually prepared by binding certain sulphide phosphors in a boro-silicate type of enamel frit. By mixing suitable phosphors with certain synthetic moulding resins, luminescent plastics for use as switch covers, name-plates, etc., are prepared.

Referring to organic fluorescent materials, Mr. Jenkins mentioned that commercial anthracene is a characteristic example. This substance fluoresces green in the solid state and blue in solution in benzene, and the green bands reappear if the benzene solution is frozen in liquid air. Very pure anthracene fluoresces blue in both the solid and solution states. It thus appears probable that the green fluorescence is caused by an impurity, stated to be naphthacene, in the crystalline anthracene matrix, and that the blue fluorescence is a property of the anthracene molecule itself.

Many organic compounds are fluorescent only in liquid or solid solution states, or when adsorbed at high dispersion on fibres or on inorganic adsorbents. The fluorescent dyestuffs such as fluorescein, eosin, rhodamine and auramine are well-known examples. Unlike the fluorescent dyestuffs, organic materials such as anthracene, quinine, etc., which fluoresce in the solid state, possess little or no body colour. Some of these colourless substances have all the characteristics of fluorescent dyes and can be incorporated in fabrics like any ordinary dye to give a colourless dyeing which is highly fluorescent. Dyes of this type have found an interesting application for marking linen in laundries, the sorting being done under black-glass lamps.

For spectacular lighting and display effects, fluorescent dyes are often used in conjunction with resins as lacquers and applied by brushing or spraying. When the lacquer is dry, the dye molecules are dispersed in a thin film of resin which serves to isolate them energetically.

Two interesting engineering applications of organic fluorescent substances were mentioned. The first is in connexion with the surfacing of tools, gauges, etc., where the prussian blue used in the normal method is replaced by anthracene. The high spots appear as brightly fluorescing regions. The second application is to the detection of fine cracks in metals—particularly non-ferrous metals where the colloidal iron and powerful magnetic field method cannot be used. The metal part is treated with a strongly fluorescent substance, and after removal of this from the surface the cracks show up as fine bright lines under the black-glass lamp.

A paper on "Fluorescent Lamps: Their Photometric and Colour Rendering Properties and Measurement" was read by Mr. G. T. Winch. High-voltage fluorescent tubes, high-pressure mercury vapour fluorescent lamps and the newest types, the mains-voltage fluorescent tubular lamps, were briefly reviewed. Mr. Winch described the accepted method of visual photometry when colour differences are involved: the field of view is kept down to about 2° usually with a suitable filter in front of the sub-standard tungsten lamp to minimize the colour difference. The transmission factor for the filter is determined from its spectral transmission and the luminosity distribution of the sub-standard lamp. Even when a colour match is achieved, it may be necessary to use a group of observers, owing to the large differences in luminosity distribution which generally exist.

Discussing physical photometric methods, Mr. Winch described his ingenious 'physical eye' photometer, where the light from the source after dispersal in a spectroscope passes through an aperture of special contour before falling on the photo-electric cell. By adjusting the contour of the mask, the apparatus is made to have 'average eye' spectral response without any knowledge of the spectral sensitivity of the photocell.

The difference between the colour of a source and its colour rendering was strikingly demonstrated by showing the wide difference in colour rendering of fabrics which could result when placed under lights of the same colour but of different spectral luminosity distribution. To assess the colour rendering properties of a source, it is necessary to know something about its luminosity distribution. It has been shown that for most purposes it is sufficient to measure the relative luminosity in about eight suitably chosen adjacent spectral bands. Much had already been accomplished in this connexion, but although the method showed considerable promise, the War has interrupted development work, and a good deal remains to be done before it can be applied to commercial fluorescent lamps.

Referring to the variability of natural daylight, Mr. Winch pointed out that the colour temperature of the light from the sun varies over the enormous range of 2,000°–25,000° K. according to conditions. It is for this reason that industrial establishments concerned with colour rendering prefer, for their colour matching work, to use an artificial daylight source corresponding to one of the phases of daylight, usually that of a black-body radiator at a temperature of about 7,000° K. The luminous efficiency of these artificial daylight sources is too low to make more

LEVERHULME RESEARCH FELLOWSHIPS, 1943

Application is invited for Fellowships and Grants in aid of research. The Fellowships and Grants are intended for senior workers who are prevented by routine duties or pressure of other work from carrying out research. They are limited to British-born subjects normally resident in Great Britain. In exceptional circumstances the Trustees may waive the condition as to residence.

The Trustees are also prepared to consider applications from groups of workers engaged upon co-operative programmes of research, particularly from those engaged upon long-distance programmes or in institutions in which the normal facilities for research have been curtailed by the war.

The duration of the awards will not normally extend over more than two years or less than three months and the amount will depend on the nature of the research and the circumstances of the applicant.

Forms of application may be obtained from the Secretary, Dr. L. Haden Guest, M.C., M.P., Leverhulme Research Fellowships. Temporary war-time address: Unilever House, Blackfriars, E.C.4.

Applications must be received on or before March 1, 1943. Awards will be announced in July and will date from September 1, 1943.

UNIVERSITY OF BRISTOL

ENTRANCE SCHOLARSHIPS

EXAMINATIONS for the following SCHOLARSHIPS, each of the value of £100 per annum, will be held in the University on May 5, 1943, and following days:

1. A DULVERTON SCHOLARSHIP, tenable in the Faculty of Medicine.
2. A T. H. GREEN SCHOLARSHIP, tenable in the Faculty of Arts.
3. A FREDERICK WILLIAM GOTCH SCHOLARSHIP, tenable in the Faculty of Arts.
4. A GEORGE ALFRED WILLS SCHOLARSHIP, tenable in the Faculty of Science.

An Examination will be held at the same time for a DAVID STODHART OLIVER SCHOLARSHIP, open to a Bristol born candidate, tenable in the Faculty of Medicine. Value £60 per annum.

THE MARIAN CLARKE ENTRANCE SCHOLARSHIP, tenable in the Faculty of Arts, open to women only, value £25, will be awarded in September to a candidate holding a Higher School Certificate.

Further particulars may be obtained on application to the undersigned.

WINIFRED SHAPLAND,
Secretary and Registrar.

ROYAL SOCIETY—GOVERNMENT GRANT FOR SCIENTIFIC INVESTIGATIONS

Applications to the Government Grant Committee for the year 1943 for grants for scientific apparatus, research expenses and materials, and in certain cases for travelling expenses incidental to research, should be made as soon as possible. They must be made in a manner specified in regulations to be obtained from the Assistant Secretary of the Royal Society, Winforton, Herefordshire.

Applicants must be of British nationality. Grants for purposes of maintenance and publication do not fall within the scope of the committee. No application can be considered which is received later than March 31, 1943.

LONDON COUNTY COUNCIL

Applications are invited for appointment to the position of full time Assistant Physicist (temporary war-time appointment) in the Council's hospitals service. The duties will be mainly in connection with X-ray and radium work at Hammersmith Hospital, Ducane Road, W.12, and Lambeth Hospital, Brook Drive, S.E.11, but the person appointed will be required to undertake any other duties which may be allotted to him from time to time. Salary £450 a year rising by annual increments of £25 to £600 a year (together with cost of living addition —at present confined to salaries not exceeding £500 a year—of 7s. 6d. a week for men and 6s. for women). There are no emoluments.

Application forms giving full particulars, obtainable (stamped addressed foolscap envelope necessary) from Medical Officer of Health (S.D.6), 460 Seven Sisters Road, London, N.4, are returnable by February 1, 1943. Canvassing disqualifies.

UNIVERSITY OF BIRMINGHAM

CHAIR OF MINING

Applications are invited for the Chair of Mining, rendered vacant by the death of Professor K. Neville Moss.

The salary offered is £1,100 to £1,800 per annum.

The Mining Department deals with the following subjects: Coal Mining, Coal Treatment and Utilisation and Metal Mining. While it is intended to maintain all these activities, it is not necessary that candidates should have an intimate knowledge of all of them. The University wishes to appoint a man who is able to take a special interest in the coal industry.

Ten copies of applications, together with the names of three referees, should be sent before March 1, 1943, to the undersigned, from whom further particulars can be obtained.

The University,
Edmund Street,
Birmingham, 3.
December, 1942.

C. G. BURTON,
Secretary.

WEEK-END COURSE FOR INDUSTRIAL MEDICAL OFFICERS

A week-end course on Faculty Medical Services and Industrial Diseases will be held at the London School of Hygiene and Tropical Medicine, Gower Street, W.C.1, on Saturday and Sunday, February 27 and 28, 1943. The course will be a practical one and primarily for Works Medical Officers. Fee: One Guinea. Apply to the Secretary for further information.

PRINTED IN GREAT BRITAIN BY FISHER, KNIGHT AND CO., LTD., ST. ALBANS

than localized lighting with them possible, and it was not until the introduction of high-voltage fluorescent tubes that general lighting at high illuminations with a light of daylight quality became an economic possibility. The more convenient mains voltage fluorescent tube which was introduced later has made this form of lighting much more generally available.

Mr. Winch described how, by a process of repeated interchanges of lamps and measurements between the leading lamp manufacturers, and elaborate colour-rendering tests with many observers, the luminosity distribution of the present 5 ft., 80 w. fluorescent lamp was evolved. The colour of the tube is fairly close to that of illuminant *C* specified by the C.I.E. (6,500° K.), and the colour rendering is adequate for nearly all purposes except those concerned with the most critical discrimination of colour. The daylight colour of these lamps has proved of considerable psychological importance in war-time factories and other situations where natural daylight is largely or completely excluded and where work is carried on for twenty-four hours of the day.

Mr. F. W. Coppin read an interesting paper on "The Use of Fluorescent Pigments in Colour Printing". Owing to the impossibility of ensuring that the printing inks used in photomechanical colour reproduction processes have the theoretically correct hue, compensating corrections have to be made at some stage in the process. For relief printing these correctives take the form of local adjustments to the dot size in the plates, or 'fine etching' as it is called, and for photolithography, hand re-touching of the screen. These operations are highly skilled and somewhat uncertain, and many attempts have been made to introduce the corrections by mechanical methods.

In the fluorescence process blue and green fluorescing materials are included in certain of the paints, and the colour separation negatives are made by mixing with the normal copying light some additional near ultra-violet radiation. The special paints comprise a set of eighteen water colours which are used by the artist under normal lighting conditions. Slight modifications in the normal technique are necessary to produce different hues by mixing colours, in order to avoid upsetting the fluorescence balance.

Arc illumination is used for making the colour separation negatives. For the yellow and magenta printing negatives, the arcs are shielded by special hoods fitted with filters which allow only ultra-violet, blue violet and green light to reach the copy. The correct ratio of ultra-violet to visible light is obtained by adjustable slits and compensating filters, using control patches on the copy-board. The blue-green printing negative is made using a panchromatic plate with the direct light of the arc on the copy and a Wratten No. 29 filter over the lens. For the black printing negative an infra-red sensitive plate is used and an infra-red filter over the lens.

Mr. Copping showed examples of colour charts prepared with the special paints and reproduced by the method described. For completely faithful reproduction, the hues of the four colour-printing inks should correspond to those for which the fluorescent paints have been balanced, but almost any good set of four colour inks will yield results which are sufficiently accurate for commercial purposes.

OBITUARIES

Prof. Franz Boas

PROF. FRANZ BOAS, who died on December 21 last, was born at Minden, Westphalia, in 1858, and did most of his scientific work in North America, becoming instructor in anthropology at Clark University in 1882 after university studies at Heidelberg, Bonn and Kiel. He worked in physical anthropology, linguistics, evolution of material cultures and social characteristics and ceremonial, besides writing suggestive essays on questions of wide interest and making a notable attack upon the racist theories of Nazidom. Though he thus clearly belonged to what in Britain is sometimes called the Huxley-Haddon tradition of general practice in anthropology, he yet showed, as did Huxley and Haddon, a capacity for detailed observation as well as wide generalization. Among the outstanding features of his scientific work were his studies of the Eskimo in Baffin Land (1883–4) and his plan for and conduct of the Jessup North Pacific Expedition (1897 onwards) to study the relationships of peoples of North America and Northern Asia. As professor of anthropology in Columbia University (1899 onwards), as well as for a time curator of ethnology at the American Museum of Natural History (1901–5), Boas found opportunities to co-ordinate the researches of different workers, and he became a central figure in the field of North American, and especially Eskimo, ethnology.

Boas's observations were much valued even if at times his theories were set aside; in such a field, theory is inevitably in a high degree provisional. He emphasized cultural similarities—the kayak, umiak, harpoon, household utensils, rituals and hero-tales, pictographic art and realistic carvings—between the Eskimo on one hand and the Chukchee and Koryak of north-east Asia on the other. But he rejected the view that the Eskimo peoples and their cultures had originated in Asia and spread to America. The findings of his Jessup expedition led him to think of the Eskimo of Alaska as comparatively new arrivals there from farther east in America. Indeed, he thought that several Palæ-Asiatic peoples of Siberia should be considered to have been immigrants from America. Needless to say, he shared the general view that the original peopling of America was due to movements from Asia; all he added to this was the idea of a backwash. Subsequent work has revealed evidence of older cultures in Alaska; and it is increasingly realized that diffusions of culture and movements of peoples in arctic America and the region around the Bering Sea have been complex, and probably by no means all in one direction; but ancient drifts from Asia to America are universally thought to have been fundamentally important. An Asiatic cradle for Eskimo culture is nevertheless not generally accepted, and Stefansson, for example, has the view that from the forests north of Lake Superior the ancestors of the Eskimo drifted northwards to the Barren lands and thence went on both eastwards to Greenland and westwards to Alaska. It seems established that the arctic Eskimo culture, which has an obvious unity throughout, came into the Arctic two thousand or more years ago, and was once more prosperous than it has been in recent centuries.

Boas believed that the peoples of the extreme south and south-east of South America and those of the north-west of North America must be considered fringing groups imperfectly imbued with the culture

which had developed, in the main, on the American continent, though the roots might be Asiatic ; he thus emphasized here again the importance, in his view, of cultural evolution in America. He believed that there were cases of similarities between peoples, due not to borrowing but to psychological factors working parallel to one another. He would, however, have nothing to do with necessarian theories. Totemism, for example, seemed to him to be a term covering a wide range of associated ideas and customs ; but neither are the widespread similarities proof of a unitary origin, nor is totemism a necessary expression of thought of a particular stage in human evolution. After suggesting that the Northern Kwakiutl of the Northern Pacific were in a stage of transition from mother-kin to father-kin, he later went over to the opinion that from a father-kin system they were influenced towards a mother-kin scheme and division into totemic clans by borrowing from more northerly neighbours. Sir James Frazer held that the facts agree better with Boas's earlier view.

Deeply aware of the interdependence of all aspects of human life and work, Boas felt that as a teacher he could not easily neglect any. We thus have his comments and contributions in several fields. He thought of primitive art as arising from technical execution and also from the stylized expression of emotions and thought. Stylization seemed to him to give a measure in this field of work, provided it is understood in its broader sense of controlled form. He disagreed with the theory that geometric ornament develops through degeneration of perspective, or symbolic designs because of slurring and inaccuracy ; and he emphasized the borrowings of forms and the changes in their interpretation as they pass from one people to another, or from one generation to another. Among one and the same people there may be two or more distinct styles, especially if these are associated with different industries carried on by distinct sections of the group. The desire for artistic expression, in his view, is universal.

In the field of physical anthropology Boas concerned himself to show the rapid mutability of head form, and he published elaborate statistics concerning descendants, of even the first generation, of immigrants from Europe to the United States of America. Some anthropometric workers accepted his conclusions, but some found difficulties in his analysis of the measurements he gathered ; and it may be said that mutability of a rapid type is by no means a general feature, if it ever occurs, which is doubtful.

Boas's broad knowledge of material culture, linguistics, social organization, religious ideas and physical characteristics of human groups gave strength and cogency to his fiercely valuable attack on Nazi racism, and on all attempts to trim and distort scientific truth to suit dogmatic schemes in politics or in any other field of expression. He is one of those who have enriched the knowledge and understanding of mankind in more ways than can be specified by giving a list of special discoveries or theories or publications.

H. J. FLEURE.

WE regret to announce the following deaths :

Dr. George Washington Carver, director of the Research and Experimental Station and consulting chemist at Tuskegee Institute, Alabama, the distinguished Negro botanist, aged eighty.

Prof. R. G. Collingwood, F.B.A., late Waynflete professor of metaphysical philosophy in the University of Oxford, on January 9, aged fifty-three.

Dr. C. Tate Regan, F.R.S., lately director of the British Museum (Natural History), on January 13, aged sixty-four.

Dr. Nikola Tesla, the well-known electrical engineer and pioneer of radio telegraphy, on January 7, aged eighty-five.

Prof. Arthur Willey, F.R.S., emeritus professor of zoology in McGill University, on December 26, aged seventy-six.

NEWS and VIEWS

An American Steam-Boat Pioneer

ON January 21 occurs the tercentenary of the birth of John Fitch, the American pioneer of the steam-boat, who while other inventors were struggling with costly and inconclusive experiments built several working steam-boats, formed the first steam-boat company in the world and for a period carried passengers on the Delaware according to a time-table. Fitch was born at East Windsor, Conn., and after working on his father's farm, pursued various callings, including those of a brassfounder and a silversmith. He suffered many misfortunes, made an unhappy marriage, and during the War of Independence was taken prisoner. In 1780 he became a surveyor in Kentucky and later on took to map-making. On a journey in 1785 he conceived the idea of propelling vehicles and boats by mechanical means. Quickly visualizing the value of his ideas, he made models and drawings, secured favourable opinions from public men and during the years 1786–90 made three or four boats which ran with varying success on the River Delaware. In 1791 a French patent was secured and two years later Fitch visited France to further the exploitation of his invention in Europe. The Terror, however, was then at its height and he soon returned home, having exhausted his means. From that time onwards he strove unsuccessfully against an unkind fate, and died at Bardstown, Kentucky, in 1798, at the age of fifty-three. His merits have not gone unnoticed in the United States, and in 1926 Congress erected a memorial to him where he died.

Pamphlets in War-time

As in the War of 1914–18, so in this one, pamphlets are much in evidence. There is a saying of John Selden, who flourished in the seventeenth century, that "more solid things do not show the complexion of the times so well as ballads and libels". By "libels", however, Selden meant what we mean by pamphlets, for, as Archbishop Trench remarked, the extent of meaning which a word covers is often gradually narrowed. Any little book (*libellus*) was a "libel" once ; now, only such as is scurrilous or injurious. The truth of Selden's saying is seen in the fact that pamphlets were plentifully produced until

far into the nineteenth century, when popular magazines tended to replace them. Now they become plentiful again at times of great public excitement. The Oxford pamphlets of 1914–18 are still fresh in the memories of people who have reached or passed middle age. Pamphlets are with us again. They cover many subjects—scientific, geographical, historical, biographical, and all that relates to the Fighting Forces. For the most part they are authoritatively written, and "show the complexion of the times" very effectively.

Recent additions to the Oxford pamphlets (Oxford University Press, 3*d*. net) include Lieut.-Col. Casson's "Greece", written by one who is both a scholar and a soldier, and describing the character and traditions of the Greek people. Sir John Pratt, writing from an intimate knowledge of the Far East, describes in "Great Britain and China" the chief episodes in our relations with China since 1715, when the East-India Company set up its factory in Canton ; and Admiral Sir Herbert Richmond, distinguished alike as naval officer and writer, in his "War at Sea To-day" makes clear to the layman the new difficulties of naval warfare, and the means adopted to meet them.

The latest addition to Federal Tracts, published by Macmillan and Co., Ltd. (6*d*. net), for Federal Union Research Institute, is Prof. George Catlin's valuable pamphlet on "Anglo-American Union as a Nucleus of World Federation"—a title which explains itself. The author's distinguished record as a student of politics, and as an exponent of this particular subject, marks him out as a high authority. World federation is for him the ultimate aim, but Anglo-American Union is the first step. Cultural autonomy is the due of all nations, even the smallest, but national sovereignty is not. Lord Balfour's reference to "an English-speaking method of looking at the great affairs of mankind" is recalled and enforced—that sense of a common culture which needs to be made more articulate. Prof. Catlin regretfully points out that the whole issue has received far less attention and publicity in Britain than in the United States and the Dominions.

"The Body as a Guide to Politics", by Dr. W. B. Cannon, formerly professor of physiology at Harvard, afterwards of the British Military Service, and later of the U.S.A. Medical Corps, is more directly scientific in tone. His general thesis, which may sound fanciful at first hearing, is that the external and internal relations and activities of the body are so marvellously organized by Nature that they may throw light on the present defects of organization by man. When danger threatens the body, stabilizing agencies act on the instant to guarantee security, but when danger threatens a nation disruptive factors have full sway. The pamphlet is an elaboration of the epilogue to Dr. Cannon's popular work "The Wisdom of the Body", published in 1932. It is included in the series "The Thinker's Forum", published by the Rationalist Press Association. In the same series appears Muriel Jaeger's "Wars of Ideas", expounding the claim that Nazi-ism is a new religion, with Hitler as its Messiah.

Geographical Names

THE vexed problem of geographical place names is raised again in an article in the *Geographical Journal* for October in which the Permanent Committee on Geographical Names of the Royal Geographical Society, Kensington Gore, S.W.7, enumerates certain principles which are offered for criticism. The whole memorandum is too long for extensive quotation but some of the main principles may be noted. Generally speaking, names should be those used by the responsible government or official survey of the country concerned, in the case of countries that use a Roman alphabet. In names of features or places in lands not using a Roman alphabet, transliteration, with certain qualifications, is recommended. But exceptions to these general rules are allowed. In popular, text and small-scale maps, English names of conventional usage are allowed ; in learned works and large-scale maps conventional English names are allowed for marine features outside territorial limits and features of international interest, with the recommendation that the foreign official name, if it differs markedly from the English, should be given in brackets. Other exceptions are in favour of English or international postal names of important places that differ markedly from official names, and, in historical context, the use, either of the name or narrow transliteration of the name that prevailed at the time under consideration, or the name conventionally known to English scholars. It is emphasized that these principles do not necessarily represent the considered views of the committee but are put forward as a basis for discussion.

Russian Scientific and Technical Periodicals in Great Britain

ON the recommendation of the Anglo-Soviet Scientific Collaboration Committee, the British Council requested the Association of Special Libraries and Information Bureaux to undertake a survey of the war holdings of Russian scientific and technical periodicals available in Great Britain. The survey, covering the years 1939–42 inclusive, has just been completed, and summaries of the results may be obtained from A.S.L.I.B., 31 Museum Street, London, W.C.1 ("Wartime Guides to British Sources of Specialised Information, No. 4", 1*s*. 6*d*. to members of A.S.L.I.B., and 2*s*. 6*d*. to non-members, postage inclusive). More than two hundred specialized libraries participated in the survey, which covers three hundred and thirty-four periodicals. From the summarized results it is possible to tell at a glance whether complete series of each of the periodicals for the last four years may be consulted in the Science Library or Patent Office, whether complete series have been located in other libraries, or whether the series located are incomplete. For further detailed information concerning the location of incomplete sets and odd numbers of periodicals, application should be made to A.S.L.I.B., where an index showing the particular issues received, their location, and the conditions of their accessibility is maintained. It is apparent from the survey that very few of the 1942 issues have so far been located, but attention is directed to the considerable time-lag in transit.

Potato Tips as Seed

THE importance of the potato, not only as human and animal food but also as a raw material for the manufacture of starch, alcohol and synthetic rubber, has greatly increased in the U.S.S.R. since the War. At the beginning of the War a big increase in the potato crop was ordered by the Government, but to achieve the goal set, a large addition to the amount of seed potatoes available was necessary. Lyssenko claims that the problem can be, and to some extent already has been, solved by utilizing as seed small pieces of tuber weighing about half an ounce and containing one of the upper eyes. The rest of the

tuber—about 90 per cent of the whole—can be used as food. It is said that tips yield as well as whole tubers and that their produce is less subject to disease. In 1942, in the U.S.S.R., 250,000 acres were sown with potato tips, and it is anticipated that ten times this area will be thus sown in 1943. This would mean an additional 8 or 9 million tons of potatoes in 1943 without having appreciably reduced the quantity available for food and industry in 1942.

Methods of Clearing Derelict Land

THE clearing and reclamation of derelict land has become an urgent problem on many farms in Britain to-day. In view of the recent developments in the mechanization of British agriculture, the new edition of Bulletin No. 101, "Hedge and Tree-Stump Clearing", by T. Swarbrick, recently published by the Ministry of Agriculture (price 6*d*.), should prove of great help to farmers faced with probably unfamiliar operations. The methods recommended fall into four groups: hand methods, the use of power, chemical agents and explosives. The means selected depends upon a variety of circumstances. Much can be done with timber jacks and monkey winches, especially when isolated trees are the chief problem. If hedges also need removing and no tractor is available, the use of a monkey winch in conjunction with explosives is suggested, for horses can then pull out the small stuff. As regards power methods, the track-laying type of tractor is undoubtedly most suitable for land clearing, but it is essential that full use be made of the dead weight of the tractor, its drawbar pull and the leverage exerted by making a high hitch on the tree and a low hitch on the tractor. Other forms of power such as steam tackle, gyro-tillers and bull-dozers can also do most valuable work, if the size of the job justifies the use of expensive equipment. Explosives, particularly gelignite, offer a simple means of removing tree stumps and hedges; full details are given in the bulletin as to how they should be employed. Farmers requiring further information or help are recommended to get in touch with the machinery sections of the county war agricultural committees, who are in possession of the necessary tractors and employ full-time machinery officers to organize the equipment.

School Science Teaching

THE recent issue of the *School Science Review* (No. 92, Nov. 1942) contains an interesting article, "School Science Teaching after the War", by Mr. E. T. Harris. Mr. Harris points out that science teaching before the War was greatly affected by economic and social conditions which, in some cases, created a hostile attitude. But now, due to its contribution to the war effort, science is valued and appreciated. The changed social conditions likely to prevail after the War should give impetus to the modern movement to stress the applications of science, but the principles should not be omitted. ". . . Science is a social phenomenon, and is only to be understood in relation to the human society in which it has developed and is developing. Its principles and its applications are closely interrelated aspects of the same social phenomenon, and they must be studied in conjunction." In discussing how this principle may be applied in teaching, Mr. Harris cites the introduction of general science and the greater attention which biology is receiving nowadays (see NATURE, 149, 456; April 25, 1942). There are two aspects to the study of science, (1) its historical and logical development and its social uses, and (2) its application to the pupil's life—his home, body, food, etc. Later in the science course should come a broadening of these early ideas, so that science is regarded as a struggle of mankind to master Nature for knowledge, power, and freedom.

A New Universal Bevel Protractor

MESSRS. E. R. WATTS & SON, LTD., 123 Camberwell Road, London, S.E.5, have designed and introduced a new type of bevel gauge which should prove a most valuable tool in the engineering workshop for the convenient and accurate measurement of angles. The instrument consists essentially of two straight-edges hinged together by means of the protractor head and capable of being set at any desired angle. The principal feature of this bevel gauge is the circular scale, which is divided accurately on a glass annulus mounted inside the head. The graduations on this scale are read by means of a high-power magnifier attached to the head and giving a wide field of view. The scale is most conveniently observed by looking through the eyepiece when the instrument is held in front of a source of artificial light, and under these conditions angles can be measured to within one twelfth of a degree. The straight-edges or blades are made of hardened steel and one of them is capable of sliding, an arrangement which greatly extends the range of the instrument, and two sizes of blade are provided—6 in. and 12 in. The sliding blade is secured by an eccentric operated by a lever extending from the centre. When fitted with the short sliding blade, the dimensions of the gauge, closed, are $6\frac{1}{2}$ in. × $2\frac{3}{8}$ in. × $1\frac{3}{4}$ in. and its accuracy in measurement is 5 minutes of angle. The blades are secured in angular position by means of a knurled ring concentric with and surrounding the protractor head so that, in all respects, this tool lends itself to rapid and convenient operation.

The Royal Observatory, Cape of Good Hope

THE 1941 report of H.M. Astronomer at the Cape, though showing only too clearly the impact of the War on South African astronomy, contains much of interest. The reversible transit circle has been fairly fully employed in making 7,234 transit observations, including fifty-seven of the moon, which were undertaken in view of the fact that lunar observations have perforce been dropped from the restricted programmes of many European observatories. With the Victoria telescope the stellar parallax programme has been continued, 2,642 plates having been secured during the year. A new determination of the parallax of Proxima Centauri, the star closest to the sun, gives $0{\cdot}763'' \pm 0{\cdot}007''$, in good agreement with the previously accepted figure of $0{\cdot}762'' \pm 0{\cdot}005''$; this should be compared with the value $0{\cdot}756'' \pm 0{\cdot}007''$ for α Centauri. It is interesting to note that during recent years the number of plates used for a parallax determination has increased to thirty, taken over three years or more: this change is fully in accord with the experience gained in the cloudier weather (but better seeing) at Greenwich.

The photoheliograph record of the sun's disc has suffered somewhat from the shortage of fine-grain plates, but a record, either on lantern plates or faster emulsions, was obtained on 311 days. Observations of occultations by the moon indicate a correction of $0{\cdot}77''$ to its ephemeris longitude, which is of course based on Brown's Tables. This correction is expected to reach zero in 1943. Cometary

observations included the photographing of Comet 1941c (de Kock), which reached the second magnitude, and of Comet Cunningham, which did not live up to expectations and only just reached naked-eye brightness. The weather at the Cape over the year was cloudier than usual, rainfall being 40 per cent above normal, as the result of considerable falls on a large number of days rather than excessive falls on a few days. Substantial observing losses through cloud were recorded in the programmes of the Victoria telescope and of the photoheliograph, but in spite of the weather the increased efforts of a war-depleted staff actually raised the number of observations made with the transit circle.

A New Telephone Set for Partially Deaf Persons

AN article by A. Herckmans (*Bell Lab. Rec.*, **21**, No. 2; October 1942) describes a new amplifying set which recently has been developed for use with the regular telephone set to assist the hard of hearing, and which permits all the added equipment except a small 4½-volt battery to be incorporated in the base of the telephone. The gain of the amplifier is adjusted by turning one of the switchhook plungers, and the amplifier can be disconnected by a second switch controlled by this same plunger. The switchhook plunger at the right of the set gives gain control and it may be turned to any one of three positions to give low, medium or high gain. Vertical motion of the plunger removes the amplifier from the circuit entirely. The very small amplifier unit consists of a granular-carbon microphone the diaphragm of which is actuated by a bipolar receiver element using permanent magnets. A soft rubber mounting prevents it from picking up vibrations from the surface on which the set is resting. When the amplifier is in use its receiver element is connected in place of the regular handset receiver, while its transmitter element is connected to the handset receiver in series with a 4½-volt battery which may be placed in any convenient location and connected to the set by two wires. With this arrangement the handset receiver is operated by the amplified speech from the transmitter element of the amplifier.

To prevent 'singing', the amount of gain around the closed path from the receiver to the transmitter through the air path and then back to the receiver through the induction coil must be less than the total loss. A maximum of 25 db. gain is provided by the amplifier used and 'singing' will not occur in normal use. A person is not conscious of impairment of hearing for ordinary room conversations until his loss is about 25 db., and only about 5 per cent of the population would be conscious of the need for a hearing aid. This percentage would be smaller for telephone conversations because the average speech level received is approximately 10 db. higher than that of normal direct conversation. With the additional 25 db. provided by the new set, persons with as much as 60 db. loss will receive adequate volume. Since only 0·5 per cent have a loss greater than this, the new set provides the help needed for about 90 per cent of those conscious of hearing impairment and would undoubtedly give considerable assistance to many with losses in excess of this.

Application of Electricity in Mine Pumping

G. B. Alvey and N. Tetlow, in a paper on this subject read before the Institution of Electrical Engineers on December 10, give a good deal of useful information upon electrically driven mine-drainage pumps, which may be of the centrifugal or of the positive displacement reciprocating type. Since the characteristics of the driven pump have a considerable bearing on the choice of the most suitable driving motor, the first portion of the paper deals with operating and design characteristics of the two types of pump. The remainder shows how, by a study of these operating characteristics, the most suitable type of driving motor may be chosen.

Control of Venereal Diseases in Peru

LAWS concerning the medical care of patients suffering from venereal diseases in Peru have recently been promulgated by the President (*J. Amer. Med. Assoc.*, October 17). A national department dealing with these diseases has recently been established with its headquarters in Lima. Treatment during the contagious stage is obligatory. If the patients are minors or mentally deficient, the parents are made responsible for their treatment. Drugs for the treatment of venereal disease are now sold only on medical prescriptions, and the sale of specific medicine by unauthorized persons and treatment by correspondence are prohibited. Wet nurses must have a certificate of health, which is given free of charge in the dispensaries and hospitals. Five per cent of all the beds in public hospitals are to be reserved for venereal diseases.

Edinburgh Geological Society: Clough Memorial Medal and Fund

THE Clough Memorial Medal for the years 1941–1942 has been presented to Mr. James L. Begg, of Mount Vernon, Glasgow, for his outstanding contributions to Scottish palæontology. He has worked for many years on the Ordovician rocks of Southern Scotland and has discovered more than a hundred new species of trilobites, mollusca, brachiopods, and other organisms, many of which belong to new genera. The majority of the specimens have been obtained from the classical sections of the Girvan region. Mr. Begg, who is a past president of the Geological Society of Glasgow, has also served as its honorary treasurer for the past twenty-five years.

The Clough Memorial Fund was instituted in 1935 for the purpose of encouraging geological research in Scotland and the north of England. The north of England is defined as comprising the counties of Northumberland, Cumberland, Durham, Westmorland, and Yorkshire. Under the terms of the administration of the fund a sum of approximately £30 is available annually. Applications for grants are invited for the period April 1, 1943–March 31, 1944. These should be sent to the Secretary, Clough Research Fund Committee, Edinburgh Geological Society, Synod Hall, Castle Terrace, Edinburgh.

Greetings from Russian Physiologists

PROF. A. V. HILL, joint secretary of the Royal Society and foreign secretary of the Physiological Society, has received a cable of New Year greetings from the All-Union and Moscow Societies of Physiologists, Pharmacologists and Biochemists, expressing their confidence in complete victory during 1943 for the democratic countries. In his reply, Prof. Hill said he looked forward to joining with them in holding the Congress of Physiologists deferred from 1941 in Great Britain during 1944.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A World Language

SIR RICHARD GREGORY, in his recent address to the Association of Special Libraries and Information Bureaux (ASLIB), reported in NATURE of November 28, refers to the importance of developing a world language for international use after the War. He mentions the British Association Committee's investigations in 1919 which directed attention to the three alternatives :

(1) The use of a dead language, for example, Latin.

(2) The use of a national language, for example, English.

(3) The development of an artificial language such as Esperanto or Ido.

I venture to suggest that a fourth alternative should now be considered, namely, the use of a systematic sign language, as was proposed, nearly twenty years ago, by Prof. Daniel Jones, of University College, London.

I would exclude the instinctive pantomimic gesture language, as developed by all deaf mutes, for this language is *not* built up of separate signs equivalent to spoken words, and it is therefore almost as unfamiliar to all users of spoken language as spoken language is to the uneducated deaf. The natural pantomimic gesture language of deaf mutes represents in fact a different and altogether more primitive way of thinking from that used in normal speech.

The sign language for international use would be one (like the Red Indian sign language) in which every sign is the equivalent of a spoken word—so as to represent a unit of thought—but in which every sign is also pantomimically related to the meaning which it bears.

I have suggested elsewhere[1] that the spoken languages of primitive man were, in the main, derived from pre-existing sign languages of this type, the simple cause being that (as Darwin pointed out[2]) man's mouth and tongue tend to copy the movements of his hands.

From this it followed that *all* sign language was inevitably accompanied by gestures of articulation, while the equally natural urge of man to express emotional states by laryngeal sounds supplied the acoustic energy needed to convert gestures of articulation into audible speech sounds[3].

The advantages which may be claimed for a systematic sign language are :

(1) That every sign will appear natural to all nationalities alike.

(2) That—as experience has shown—the individual signs will be easily and quickly learnt and remembered.

(3) That the symbolism—being essentially pantomimic—will be more direct than that of any spoken or invented language.

(4) That the language will lend itself especially to use by children and the rising generation—as a form of play—and will give them at the same time a datum line from which to judge and compare the spoken languages.

(5) That the sign language will be at once simpler, more concise, and more unambiguous than any spoken language—owing to the much greater versatility and precision of the human hands as compared with the human organs of articulation (lips, tongue, etc.).

(6) That the sign language will be very easy to teach—on a world scale—by means of educational films and television, and that it will be free from all difficulties of pronunciation.

(7) That there is already available a vocabulary, of just under two thousand words, which any interested student of average intelligence might expect to acquire within a month. A longer period of practice would, of course, be necessary for gaining speed in signing and reading.

On the other hand, sign language has certain disadvantages, namely :

(1) It is at present unfamiliar—except to the born deaf.

(2) There is not, at present, any available script by which the hand gestures can be recorded and read—unless a cinema film of the person signing can be considered as a script of his signs.

Unfamiliarity of sign language is almost certainly not a serious objection—as witness the fact that all nationalities communicate by signs when the intending communicators cannot understand each other's spoken language.

The absence of a script, on the other hand, is a serious disadvantage, and the invention of an efficient script would be an essential factor in the development of sign language as an auxiliary international language.

Shortly before the present War broke out, that great master of script, Eric Gill, had begun to interest himself in the problem of devising a script for sign language. His premature death was a heavy blow not only to sculpture and the arts generally but also to sign language.

If any readers of NATURE—or their friends—should be disposed to investigate the problem of recording the three-dimensional movements of sign language by means of a simple and artistic two-dimensional script, I would gladly give them any help in my power.

Miss Margaret Morris has devised a script for recording all the bodily movements in dancing[4]—the problem is much simpler in the case of sign language, where (in effect) only hand movements are concerned.

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Dec. 16.

[1] NATURE, Feb. 23, 1929, p. 281 ; "Human Speech", Sir R. Paget, Kegan Paul, 1930, p. 133 ; NATURE, May 14, 1938, p. 882.
[2] "The Expression of the Emotions", Chap. 7.
[3] "Human Speech", p. 37–39.
[4] "The Notation of Movement", Kegan Paul, 1928.

Control of Potato Blight (*Phytophthora infestans*) by Spraying with Suspensions of Metallic Copper

IN 1807 Bénédict Prévost found that germination of the spores of the wheat bunt fungus (*Tilletia caries*) in water was inhibited by the presence of submerged pieces of clean metallic copper[1]. It has long been known that water contained in copper vessels becomes toxic to some species of algæ and bacteria. Since about 1885 many compounds of copper have been used in spraying plants for the control of fungus diseases, but in an extensive search of the literature[2], I have not found a single reference to the trial of finely divided metallic copper itself, for this purpose

Following the work of Horsfall, Martin, Marsh[3] and others, cuprous oxide has recently come into wide use as a general fungicide, but the mechanism of its action remains obscure. It is possible that in presence of some exudate '*E*' from the fungus itself, one of the steps in the reaction may be :

$$2Cu_2O + E \rightarrow Cu_2 + 2CuE,$$

and it therefore becomes of much interest to examine the fungicidal effect, not only of the free cupric ion, but of the molecular copper that may be deposited.

The conduct of comparative trials of Bordeaux mixture, cuprous oxide, copper oxychloride and other copper compounds for the control of potato blight in Devon and Cornwall this year, gave me the opportunity of including plots sprayed with suspensions of finely divided metallic copper. Among the methods used in preparing these suspensions were : (*a*) reduction of copper sulphate with sodium hydrosulphite, (*b*) treatment of cuprous oxide with sulphuric acid, followed by repeated washing to remove the ionic copper, (*c*) precipitation of copper metal in dispersible form from copper sulphate solution with zinc dust, and (*d*) simple dispersion of fine electrolytic copper, or technical (B.D.H.) hydrogen-reduced copper metal. Methods (*a*) and (*b*) gave copper particles mostly of about 1 μ, and methods (*c*) and (*d*) mostly of 2–5 μ in diameter. Small-scale trials showed, as was to be expected[4], that suspensions of the smaller particles were the more effective, but for the main trials, on randomized plots, suspensions made by method (*d*) were chosen, to put metallic copper to the severer test, and to avoid the possibility of including traces of soluble copper compounds through incomplete washing out of the other materials.

Dispersal of the copper particles to obtain preparations in convenient practical form for application to the plants was secured by trituration of the reduced copper, in a dry or moist state, (*a*) with sulphite cellulose extract ('Sulphite lye'), or (*b*) with a mixture containing 97 parts of bentonite, 2 parts of aluminium sulphate, and 1 part of soda ash, by weight. Bentonite was used to ensure good adhesion to the foliage, as well as to stabilize the copper suspension. The small addition of aluminium sulphate and sodium carbonate in the above proportions was found to overcome the difficulty previously experienced when using bentonite with spray materials, due to its 'balling' into very slowly dispersible, sticky masses on addition to water. The method is an improvement on others I have used for this purpose[5], and its underlying principle is to prevent swelling of the bentonite when the preparation containing it is creamed with a *little* water, without causing flocculation of the fully diluted suspension. The same additions to the bentonite were made in preparing both the metallic-copper and the yellow cuprous-oxide suspensions referred to in the table below.

The chequer-board spraying trials were carried out on Arran Banner at Bude (1), and on Majestic at Dartington (2) and Kentisbeare (3). There were three replications of each treatment at each trial. All the spray fluids were made up to the same copper content, namely, 0·25 per cent copper by weight, and two applications were given, the first at the rate of 110 gallons per acre, the second at 140 gallons per acre, using a knapsack sprayer. Detailed assessments of the percentage of the foliage area affected by blight, on each individual plot, were made at frequent intervals. Full particulars of the trials will be published elsewhere, but, in short, at all three centres the blight attack, though late, was severe, and the metallic copper sprays, though not quite so effective as Bordeaux mixture, kept the plants green for three weeks after the unsprayed were dead, and throughout gave such good control of blight on the foliage as to indicate beyond doubt that metallic copper has very marked fungicidal activity, at any rate against *P. infestans*.

The effect on the yield of tubers was as follows :

	Mean total yield in tons per acre		
	Arran Banner (1)	Majestic (2)	Majestic (3)
Bordeaux mixture	14·4	14·3	16·1
Cuprous oxide plus bentonite	15·4	14·3	14·7
H-reduced copper plus bentonite	13·8	14·6	14·3
Control, unsprayed	10·6	11·1	11·6
Significant difference between treatment means (P=0·05)	1·4	1·7	1·8

The deposits on the leaves of the plants sprayed with finely divided copper appeared to retain the colour of the metal throughout the trials, but the possible occurrence of oxidation of the metal on exposure remains to be investigated. It also remains to be ascertained whether the fungicidal action of metallic copper, or of oxides resulting from the application of copper in metallic form, is specific to *P. infestans* or of wider application. If metallic copper sprays prove effective against the apple scab fungus (*Venturia inæqualis*), for example, they may be of great value on the copper-sensitive varieties, as there would appear to be less likelihood of scorch with metallic copper than with its more soluble or reactive compounds.

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Dec. 17.

[1] Prévost, B., "Mémoire" (Montauban, 1807).
[2] Large, E. C., "Advance of the Fungi" (Cape, 1940).
[3] Horsfall, J. G., Marsh, R. W., and Martin, H., *Ann. App. Biol.*, **24** 867–82 (1937).
[4] Cunningham, G. H., "Plant Protection" (Palmerston North, 1935).
[5] Large, E. C., British Patent No. 493,148 (1938).

Loss of Thiamin from Cooked Potato

IN the course of assays of thiamin (vitamin B_1) in potato by the Phycomyces method[1], which involves cooking the potato samples in the process of sterilization, the method of sterilization was varied from time to time. One of these variations was of sufficient culinary interest to be briefly reported.

The normal method of conducting the Phycomyces test is to grow the fungus on small cylinders of potato in a liquid medium (*p*H 6·4) ; medium and potato are sterilized together by steaming for 45 minutes on three successive days. This process does not destroy the vitamin, for determinations by this method gave concordant results with those made at the same time on raw potato by the thiochrome method[2]. If, however, the medium is poured off from the potato after the three steamings, and replaced by fresh sterile medium, the loss in vitamin

LOSSES OF THIAMIN FROM MAJESTIC POTATOES.

Date	Thiamin in sample sterilized normally (μ gm./100 gm.)	Thiamin (μ gm./100 gm.) remaining	
		After pouring off medium	After sterilizing at *p*H 9
Nov. 1941	103	34	26
Jan. 1942	179	11	21

is considerable. It is comparable with the loss incurred by sterilizing the potato at *p*H 9 instead of *p*H 6·4, as is shown in the table.

It would appear that the greater part of the vitamin is washed out into the medium in the process of steaming. These figures afford an additional argument in favour of always cooking potatoes in their skins.

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[1] Schopfer, W. H., and Jung, A., *C.R.Ve. Cong. int. Tech. Chem. Indust. Agric.* Schéveningue, 22 (1937).
[2] Pyke, M. A., *J. Soc. Chem. Ind.*, **58**, 338*T* (1939).

Effect of Hexœstrol and of Alpha Methyl Stilbene on the Insulin Content of the Pancreas of the Rabbit

CONSIDERABLE evidence accumulated during the past two years shows that administration of natural and synthetic œstrogens increases the amount of insulin in the pancreas of the rat[1,2,3,4].

Further experiments on the action of the synthetic œstrogen hexœstrol, 4 : 4′ dihydroxy - α, β - diethyldihydrostilbene, on the insulin content of the pancreas of the rabbit have been carried out in this laboratory. Some experiments using α methyl stilbene, of which Dodds, Fitzgerald, and Lawson[5] have found that even very large doses are non-œstrogenic, have also been carried out. The results are summarized in the following table.

The two substances were dissolved in arachis oil and injected intramuscularly, over periods of 4–10 weeks.

TABLE 1.

Number of rabbits	Substance injected and average total dose	Body weight grams		Blood sugar mgm.%	Liver wt. grams	Testis wt. (2) grams	Adrenal wt. (2) grams	Insulin content in units gram of pancreas
		Init.	Final					
5 (1 female)	—	—	2,215	102	53·0	4·28	0·32	5·20
5 (1 female)	40 mgm. hexœstrol	2,386	2,306	98	44·2	1·27	0·31	8·85
3	320 mgm. of α methyl stilbene	2,190	2,323	84	66·0	4·35	0·47	24·49

From this table it is seen that the hexœstrol brings about atrophy of the testes and a moderate increase in the amount of pancreatic insulin. α methyl stilbene, on the other hand, increases the amount of pancreatic insulin to a marked degree, but has no effect on the testis weight, which result substantiates the finding of Dodds, Fitzgerald and Lawson that it is non-œstrogenic.

This report will be published shortly in the *Proceedings of the Linnean Society of New South Wales*.

I wish to take the opportunity of acknowledging my indebtedness to the Society for a scholarship grant, and to Prof. C. G. Lambie for his interest in this work.

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[4] Conrat, H. L. F., Herring, V. V., Simpson, M. E., and Evans, H. M., *Proc. Soc., Exp., Biol. and Med.*, **48**, 333 (1941).
[5] Dodds, E. C., Fitzgerald, M. E. H., and Lawson, W., NATURE, **140**, 772 (1937).

A Census of Atmospheric Pollen

THE pollen content of the atmosphere is of interest in relation to general plant biology, the pollen analysis of peats and the study of allergic diseases such as hay fever and asthma. This subject was first investigated by Blackley[1] in Great Britain and has since been pursued on a wide scale in the United States[2]. So far as is known to us, however, it has received attention from only a very few workers on the Continent of Europe[3,4,5] and no such researches made in Great Britain (other than Blackley's) have been published.

We have recently completed a continuous investigation of the day-to-day changes during twelve months in the pollen rain at Llandough Hospital, Cardiff. Microslides previously coated with glycerine-gelatine containing fuchsin as described by Wodehouse[6] have been exposed, one every twenty-four hours, in a horizontal position under conditions which allowed reasonably free passage of air over them while affording protection from rain. Each slide was then mounted and all pollen grains under a $\frac{7}{8}$ in. coverslip were identified so far as possible and counted.

The effective pollen season was found to extend from the middle of February to the end of October and to fall into three main phases, dominated by trees, grasses and herbaceous dicotyledons respectively. Of the trees, birch (Betula) gave by far the highest pollen count, 315 (63 per sq. cm.) on April 28–29, and yew (Taxus) gave the next highest, 142 (28 per sq. cm.) on March 26–27. Oak (Quercus) had a medium value, 92 (18 per sq. cm.) on May 16–17, as did elm (Ulmus), 83 (17 per sq. cm.) on March 27–28, and hazel (Corylus), 63 (13 per sq. cm.) on March 20–21, while alder (Alnus), 29 (6 per sq. cm.) on March 25–26, was relatively low and ash (Fraxinus), 12 (2 per sq. cm.) on April 11–12, was very low.

The grass pollen, from being negligible at the beginning of June, reached 386 (77 per sq. cm.) on June 11–12 and a maximum of 482 (96 per sq. cm.) on June 22–23. It was still 395 (79 per sq. cm.) on July 5–6, but toward the end of this month the number fell rapidly.

The phase of herbaceous dicotyledons, including chiefly the genera Urtica, Plantago and Artemisia and the family Umbelliferæ, gave low values only : Urtica 27 (5 per sq. cm.) on August 27–28 and 10 (2 per sq. cm.) on September 6–7, Umbelliferæ 10 (2 per sq. cm.) on August 27–28, Plantago 5 (1 per sq. cm.), and Artemisia 12 (2 per sq. cm.) both on August 20–21, while 10 grains (2 per sq. cm.) of the Compositæ—(Aster type)—were found on October 4–5. Pollen of some of these genera was found in larger quantities, however, during the grass season, namely, Urtica 58 (12 per sq. cm.) on June 19–20, Plantago 28 (6 per sq. cm.) on June 6–7 and Umbelliferæ 24 (5 per sq. cm.) on May 27–28.

Certain entomophilous pollens appeared in sur-

prising numbers; for example, Cruciferæ 90 (18 per sq. cm.) and elder (Sambucus) 21 (4 per sq. cm.). In all, some sixty types of pollen have been recognized on the slides.

The detailed results of the year's work will be published elsewhere.

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Dec. 16.

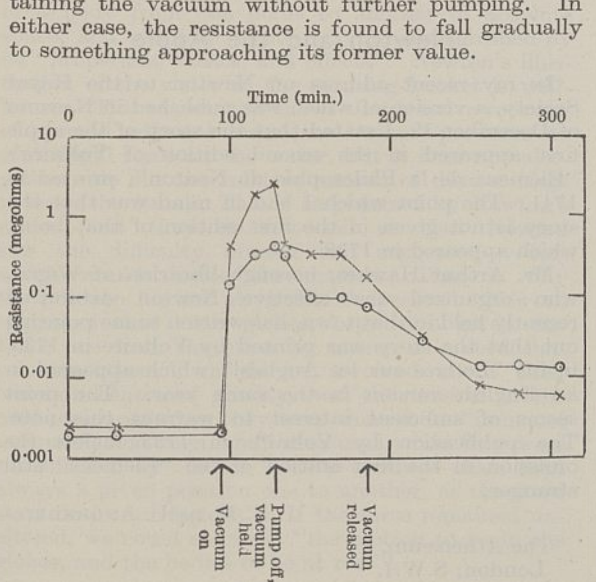
[1] Blackley, C. H., "Experimental Researches on the Cause and Nature of Catarrhus Aestivus" (London, 1873).
[2] Summarized by Vaughan, W. T., "Practice of Allergy" (London, 1939).
[3] Bertsch, F., *Beihefte zum Botanischen Centralblatt*, **54**, Abt. B, 185–243 (1935).
[4] Lüdi, W., and Vareschi, V., "Bericht über das Geobotanische Forschungsinstitut Rübel in Zürich", 1935 (Zürich, 1936).
[5] Lüdi, W., "Bericht über das Geobotanische Forschungsinstitut Rübel in Zürich", 1936 (Zurich, 1937).
[6] Wodehouse, R. P., "Pollen Grains" (London, 1935).

Electrical Resistance of Wood

THE electrical resistance of wood increases very rapidly with decrease in moisture content (grams of water present per 100 grams dry weight), so that, if two probes about 2 cm. apart are driven into the centre of a drying board, the resistance between the probes can be used as an indication of moisture content.

When beech wood is heated to just over 100° C. in a confined space at atmospheric pressure and the space suddenly evacuated, we have found that, for moisture contents between 30 and 40 per cent, the resistance between the probes increases by a factor of as much as 200 : 1. This is shown in the figure, where the resistance is plotted logarithmically. The increase might be interpreted as a rapid and large reduction in moisture content, but direct measurement shows, as one would expect, only a small reduction due to loss by evaporation.

That the apparent decrease in moisture content is not real is proved by readmitting air, or by maintaining the vacuum without further pumping. In either case, the resistance is found to fall gradually to something approaching its former value.



These observations suggest that the current path in moist wood is principally along the interior surfaces of the cells. If the current path were through the body of the cell walls, the sudden drying of the interior surfaces on evacuation could only cause an insignificant increase in the average resistance, whereas the observed resistance increases between one and two hundred times.

The effect appears to be confined to initial moisture contents below 30–40 per cent, that is, to the condition where the small local drying is not at the expense of the 'free' water present in the cell cavities, but has the chance of reducing the moisture in the surfaces themselves.

Measurement of the change in resistance of the wood as it is being heated up prior to evacuation shows that the temperature coefficient of resistance is negative, which indicates that the conduction is ionic as in a solution. The temperature coefficient is, however, too small to account, in terms of local cooling, for the large resistance change on evacuation.

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Human Activities and Soil Characteristics

ADDITIONAL evidence to that given by K. L. Robinson in NATURE of July 4 of changes in soil profiles of the New Forest since its occupation by early man has latterly come to light from under tumuli in the New Forest. These have been investigated archæologically by Mrs. Stuart Piggott, to whom I am indebted for the opportunity of seeing some of the exposures and discussing her findings, the early publication of which is anticipated.

The tumuli date, I am informed, from the Bronze Age, probably 1500–1200 B.C., and I know of no evidence of any earlier human occupation of this district. The sections were of pedological interest for their indications of changes of soil profile during the succeeding 3 to 3½ millennia of human occupation. Certainly throughout written history, and almost as certainly throughout pre-history, the hand of man has lain but lightly upon this hunting preserve cum free-range pastoral district, and it can have been subjected to nothing like the several drastic alterations of ecology implicit in the farming history of more normal agricultural districts.

One sectioned tumulus had a massive core of neatly piled sods of thick black heath peat, 3–4 ft. in thickness, above the old soil line and the central interment. These sods apparently represented the A_0 horizon from a mature and fully developed podsol profile, and adherent to each was its thick and well-developed bleached horizon (A_1); the core comprised quite two thirds of the volume of a cast or central mound about 40 ft. in diameter, and was topped over with 2–2½ ft. of sandy gravel. This latter appeared identical with the plateau-gravel subsoil underlying this heath. I should estimate the mound to have contained 90–100 cubic yards of compacted soil, probably more when loose and newly piled. This considerable weight of material was transported, one assumes, by hand in baskets, and therefore collected from a local source, in the narrowest sense of the word.

The present vegetation of this plateau site is Calluna, well scattered with ill-grown *Erica tetralix*, pervaded with dwarf *Molinia cœrulia* and a scatter of *Agrostis setacea*, all short of stature. Its modern profile, while podsolic, is unorthodox and not comparable with the ancient clear-cut and well-developed podsol beneath the tumulus, or of the sods at its core. It presents anomalous features as to which, since my war-time circumstances denied facilities for the necessary analyses, I cannot be at all particular. The differences most apparent to the eye are first, that the surface peat, A_0, is but $\frac{1}{2}$–$\frac{3}{4}$ in. thick instead of 1–2$\frac{1}{2}$ in., and secondly, in place of a well-marked pale bleached layer it has for A_1 an inch or two of black humic sand next below, passing fairly sharply into a dull medium yellow pebbly sand. To-day, therefore, it would not be possible to duplicate the sod-core of the tumulus within any reasonable carrying distance. One deduces that the ancient podsol profile has been robbed of its A_0 and A_1 horizons, and maybe of its B horizon during the thirty or so centuries of human occupation. The periodic heather burnings to freshen the grazing, and the now vanishing local manner of paring thin surface peats for domestic fuel, are probably responsible.

I agree with Robinson's conclusion that we have here a range of formerly mature podsols, mainly truncated through man's activities in the human era, and now in various phases of immaturity, undergoing regrading of a podsolic character.

A similar tumulus from a southern New Forest parish presented a different question in that the present conditions of the surroundings are of a moist heath with impeded drainage and gleyed subsoils of variable character, even more in contrast to the clear-cut podsol profile suggested by the sod-core, and the old soil-line beneath the tumulus. The original bottom of its surrounding ditch proved on excavation to be considerably below the present water-table of the site. The subsidence which flooded the vales of the Solent and Spithead rivers and made Wight into an island is believed to have occurred in middle or later Bronze Age times, so it may be that earth movements or minor foldings related to that subsidence are responsible for this revolution in drainage conditions.

If a district by comparison so lightly pressed by the hand of man can present profile immaturity problems of this degree, how much more complex the undeciphered sequence of partial regradings confronting the pedologist in the soils of farming England with their history of transformations: from forest cover to open-field manor, from this to grass at the Black Death, thence to enclosed arable for the Napoleonic War, and so on. This profile immaturity due to centuries of relatively dense human occupation and changing land-utilization seldom receives adequate allowance in considering the late start and the difficult progress of pedological survey in Great Britain.

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A Modified Calomel Cell for *p*H Measurements

THE present shortage of potassium makes it necessary that chemists should take every care that there is no undue waste of this material, and it seems to us that with the large number of workers using the saturated calomel electrode[1] for making *p*H measurements, there must be a considerable loss of potassium chloride resulting from the frequent flushing of the liquid junction. The use of normal and decinormal potassium chloride cells would do much to avoid this waste, but they are neither so quickly prepared nor is the conductance of the cells so good as that of the saturated type.

We have experimented with a saturated calomel cell in which the potassium chloride has been replaced by sodium chloride, and it was found that well-defined potentials are obtained. The potential of the sodium chloride type of cell referred to the normal hydrogen electrode is a little lower than the potassium chloride cell, but there is not likely to be any inconvenience arising from this difference.

Saturated sodium chloride cells were made up by us and tested independently against saturated calomel cells of the conventional type. The sodium chloride cell had a potential of 245·8 mv. at 20° C.

It is well appreciated that for precise work in physical chemistry the potassium chloride cell is better, but there must be many hundreds of workers making routine *p*H measurements of a lower standard of accuracy where slight errors due to the difference in ionic mobilities are unimportant; further, there is the saving of potassium chloride and also of expense.

Further work on the potential and the temperature coefficient of the cell is being undertaken to assess the value of this cell for more precise work.

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[1] Clark, W. H., "The Determination of Hydrogen Ions", 3rd ed. (Baltimore: Williams and Wilkins Co., 1928).

Newton and the Apple

IN my recent address on Newton to the Royal Society, a version of which was published in NATURE of December 19, I stated that the story of the apple first appeared in the second edition of Voltaire's "Elémens de la Philosophie de Neuton", printed in 1741. The point which I had in mind was that the story is not given in the first edition of that book, which appeared in 1738.

Mr. Arthur Hawkes, borough librarian of Wigan, who organized the effective Newton exhibition recently held in that town, has written to me pointing out that the story was printed by Voltaire in 1733, in his "Lettres sur les Anglais", which appeared in an English version in the same year. The point seems of sufficient interest to warrant this note. The publication by Voltaire in 1733 makes the omission in the first edition of the "Elémens" still stranger.

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ABSOLUTE TIME AND SPACE

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"Yet the thing is not altogether desperate."
—NEWTON.

SINCE the last centenary of Newton's birth, his philosophy has been assailed with more vigour than in any other period since the first. Those who defended him against the Continental mathematicians of that time used the robust language of their day: James Bernoulli was a "boasting mathematical bully"; Leibniz "as dogmatical as if he had been originally one of God Almighty's privy council", and so on. In the tercentenary year, it may be worth while to inquire anew into the position of two of Newton's postulates which have come most under fire from Continental attack.

Absolute time, Newton thought it necessary to distinguish because the "vulgar" were liable to associate time only with the periodic behaviour of certain material systems. But the sensation of the passage of time is independent of the motion of any particular object and so the definition of time could not be made in terms of such a motion. Periodically recurring mechanical phenomena had, of course, to be used in order to introduce numbers as symbols for time intervals experienced in consciousness (Newton mentions the day and year, and Galileo used his pulse and water clocks); but these intervals were corrected according to theory built upon the assumption (in the case of the large time intervals) and the conscious awareness (in the case of the shorter ones) that the corrections, if any, would be very small. In this way laws were discovered which enabled a time scale to be developed which is independent of the behaviour of any particular body in the universe. This is the time scale which we still use to-day, and is possibly what Newton had at the back of his mind when he distinguished between "absolute, true, and mathematical time" and "relative, apparent, and common time".

Absolute space was postulated by Newton as existing, like absolute time, "without regard to anything external". Absolute motion is the translation of a body from one point to another in absolute space, and absolute motion may be distinguished by its "properties, causes, and effects". Newton's illustration of the water in the rotating bucket is well-known. This experiment shows that relative rotation of a small adjacent mass (the bucket) produces no centrifugal force on the water, but it does not altogether rule out the relative motion of distant large masses (the stars). This is emphasized by Newton's critics, but they do not tell us that Newton saw the difficulty himself and suggested a test which would decide the matter. That is why the position "is not altogether desperate". Newton suggested that "two globes, kept at a given distance one from the other by means of a cord that connects them", should be revolved about their common centre of gravity, and the tension in the cord measured when they were alone in an "immense vacuum", and then again measured when they were surrounded by "some remote bodies—that kept always a given position one to another, as the fixed stars do in our regions". If the force remained unaltered, we could conclude "the motion to be in the globes, and the bodies to be at rest"[1].

Physicists may vary in their opinion as to the result of such a test, but although the experiment is impracticable (unless the recession of the galaxies were to produce some change over a long period), it is not meaningless. It is curious, therefore, that Mach should quote pages from the "Principia" and yet stop quoting at the very point where the description of the crucial experiment above begins[2]. Continental relativists have followed Mach in ignoring this part of the "Principia" and they advance an epistemological argument saying that only "observable facts of experience" can be used as causes[3]. This would seem to rule out most of the causes used in physical theory, including the electron and the Heaviside layer, but without pursuing this point let us see what cause is put in the place of Newton's absolute space.

According to these critics, the cause of the bulging of rotating bodies must be distant masses. The use of the word 'must' looks as if they have left the inducto-deductive empiricism of Bacon and Newton and have returned to the compulsive categories of medieval logic. Misunderstanding Newton's famous "Hypotheses non fingo", some accuse him of not carrying out his own precepts. It is interesting to examine how far their own procedure is better in this respect. Passing over the almost universal use of unobservable space-time as a cause and saying that the motion of bodies is due to the curvature of space-time, let us ask whether these 'distant masses' can be observed. There are, of course, the 'fixed' stars, and the critics seem to conclude immediately that they are the distant masses the presence of which is compelled by their 'law of causality', and the relative motion of which produces centrifugal force.

Now Einstein's law of gravitation allows us to calculate the effect of relative motion on the force between masses, so that the next step was obviously to see whether the hypothesis of the relative motion of the known stars was sufficient to account for the bulge of the earth's equator. But for an examination of this point we have to turn to one of Newton's countrymen, and it leads to the conclusion that "the centrifugal force could not be produced by the motion of the stars, so far as they are known"[4].

Newton's absolute space is, therefore, not so easily dismissed, and the rather superficial epistemological 'principle of the law of causality' leads to the postulation of great masses for which there is no evidence in observation. It is true, of course, at the present time, that the larger the telescope the greater the number of distant stars seen, and thus it can be imagined that this number will increase, but those who hold such a law of causality cannot employ imaginary causes.

A choice philosopher in the tercentenary year of Newton's birth, when seeking for the reason for the bulging equator, must therefore choose between the following hypothetical causes: (1) The absolute space of Newton. The test which prevents it from being a physically meaningless concept cannot be performed. (2) The 'distant masses' of the relativists. The quantitative test which general relativity theory suggests shows that these distant masses are not the known fixed stars. These distant masses, therefore, are not 'observable facts of experience'. (3) The known stars. If the experimentally observed stellar masses are the cause, then the law of gravitation is not that of the general theory of relativity.

The problem of centrifugal force remains a fascin-

ating one, and if the third cause above is ultimately adopted, it will certainly take a good deal of believing. This is because, if relative motion of masses be the cause, then masses at millions of light-years distance must be supposed to be effective whereas neighbouring masses produce no observable change. The behaviour of a gyrocompass in a submerged submarine is quite unaffected by the large masses of sea-water with various relative motions by which it is surrounded, and yet we must suppose it sensitive to the spiral nebulæ, α Piscium, β Leonis, γ Cygni, δ Herculis, ε Tauri, plus old Ursa Major and all !

To Newton, God was the origin of all things and "by existing always and everywhere, he constitutes duration and space". In Newton's mind the notions of absolute time and absolute space were undoubtedly mixed with pious considerations which no longer enter natural philosophy. Yet if absolute time means time the intervals of which are independent of the motion of any one body in the universe, and absolute space means a referent which is not obtained by taking any one body of the universe as being at rest, then absolute time and space are still the foundation of physical measurement to-day.

[1] Newton, "Principia", 1, 13 (Motte's Translation, 1803).
[2] Mach, "The Science of Mechanics", 229 (1902).
[3] Einstein, "The Principle of Relativity" (Translated by Saha and Bose, 1920).
[4] Eddington, "Space Time and Gravitation", 153 (1920).

A NATIONAL SCHEME FOR HOLIDAY CENTRES

IN the broadsheet "Planning for Holidays" (No. 194), Political and Economic Planning directs attention to a problem which may easily become acute, if not dangerous, immediately after the War, unless at least some effort is made to handle it now. The subject of holidays with pay enters into industrial relations, education and the social services, as well as forming an important part of a national health policy.

Only about four million out of about 18½ million insured workers in Britain in 1937 were entitled to holidays with pay, with about 750,000 salary earners with more than £250 per annum, but by March 1938 the number of insured workers with paid holidays had risen to about 7¾ millions, and when the Holidays with Pay Act was passed in July 1938, the Government's policy was that, after an interval to allow the extension of holidays by collective agreements, legislation should be passed in 1940 or 1941 making paid holidays compulsory throughout industry. The number of persons actually taking a holiday of one or more weeks away from home in 1937 has been estimated at about 15 millions out of a population of 46 millions. For the immediate post-war period, an estimate of 30 million holiday-makers in the first year after the War and towards 45 millions in successive years is not unreasonable. To meet this demand, holiday accommodation must be increased and an effort made to alter both the custom and the necessity which now concentrate the holiday exodus from the towns in the months of July and August, and especially in the Bank Holiday week. The potential peak of five millions seeking accommodation at one time could, it is estimated, be reduced to between 2 and 4 millions by spreading holidays between May and October.

The staggering of holidays is also important in its bearing on the cost of accommodation, but staggering is primarily a matter for industrial co-operation and for the help of the education authorities in timing school holidays. Moreover, forethought and planning will also be required if the greater demand for holidays is to be prevented from doing irreparable harm to the countryside and seriously interfering with the enjoyment of all. The War, by halting the spoliation of the coast of Britain, for example, has offered an opportunity of checking it permanently.

The urgency of this aspect has been stressed in the second report of the Coastal Preservation Committee, which appeared last October. The preservation of the coast is regarded as an essential item in a national policy for maintaining the beauty of the country; the scientific interest of the coast is an additional reason for its protection. Such preservation cannot be effectively carried out by the local authorities, and the report is in full agreement with the Scott report as to the necessity for immediate national planning, and that coastal preservation should be primarily a responsibility of the State. Coastal planning should include a belt extending sufficiently far inland to preserve the natural features of the general coastal landscape. There should be adequate provision for public access both to and along the shore and coast. Further, the right of the public to the free enjoyment of the foreshore for general recreation should be legally and practically established. Due allowance in planning the coastal belt should be made for probable losses through erosion, and the interference with public access to coastal areas for national defence purposes terminated as soon as military necessity allows.

According to the Planning broadsheet, the immediate post-war problem of holiday accommodation could be met by the conversion into holiday centres of some of the industrial hostels and other suitable war-time Government sites. The former include the Royal Ordnance Factory hostels, with a possible maximum of more than 41,000 places; the industrial hostels controlled by the National Service Hostels Corporation, with nearly 40,000 projected places in fifty-eight hostels; the temporary hostels outside target towns to house temporarily bombed-out workers and families with more than 50,000 places in seventeen hostels; and the three hundred rural hostels for agricultural workers with about 12,000 places. Although much of the accommodation will be in places not well chosen for holidays, more than half may be in suitable districts, and while other claims of comparable social importance may be advanced, it is hoped that a fair proportion will be allotted for holiday centres.

It is estimated that the Service camps have a capacity considerably exceeding that of any other type of war-time accommodation. Some of this will be retained for Service use, but some of the land occupied will be too valuable to retain for camps. Of the rest, much will be unsuitable for holiday requirements, but there should be a considerable useful residue adapted for temporary or permanent holiday use. Another possible source is in the large country houses no longer inhabited by their traditional owners, the expense of upkeep of which may prove progressively onerous. If the State were to acquire them, they could be maintained as people's holiday centres, a house forming a nucleus with annexes in the grounds if necessary.

The new holiday centres might be placed under the management of a semi-public body of the type of the National Camps Corporation or the National Service Hostels Corporation. Such a National Holiday Centre Corporation would be responsible for maintaining good standards of holiday provision at minimum prices at the centres under its control. Various forms of management might be tried experimentally, including indirect management through non-profit holiday organizations which would be free to run the centres in their own way, subject to inspection and to general conditions as to charges and standards. The Corporation might be assisted by an advisory committee representing the consumers and the experience of voluntary bodies concerned with workers' holidays.

COLONIAL RESEARCH IN THE BRITISH EMPIRE

THE survey of Colonial research in the British Empire prepared by Dr. Lucy Mair (*Agenda* for October) is of particular interest at the present moment. Under the Colonial Research Committee appointed in June 1942, a comprehensive survey is at present being made, as the first work of the Committee, of the facilities existing in Great Britain and the Colonial Empire, both for research and for the training of research workers. Pointing out that research in the Colonial field has tended in the past to be directed to the overcoming of practical difficulties that have already been encountered, Dr. Mair emphasizes that the present demand for a planned and consciously directed welfare policy is not a demand for something entirely new, but for more effective measures in the pursuit of aims already accepted. In regard to research by administrative officials, while those responsible for the conduct of policy in the Colonial Empire are fully aware of the need for knowledge of every aspect of the lives of its native populations, such inquiries, often limited in scope by the difficulty of finding time for them amid the pressure of other work, and carried out by those who have no specialized training in research in the relevant subjects, have not had a scientific value on a level with that of work done by trained specialists devoting their whole time to research.

In social anthropology, the London School of Economics, where B. Malinowski held the chair from 1926 until 1942, is the centre for this work in Great Britain. A great expansion in research was made possible by the Rockefeller Foundation which, after adding social anthropology to the subjects qualifying for its research fellowships, made a generous grant to the International Institute of African Languages and Cultures. The latter body from 1931 until the outbreak of war played a leading part in financing the training of social anthropologists and research by them in Africa. Chairs of social anthropology have been founded at Cape Town and Sydney, and research workers trained at these universities, and also at the Department of African Studies of the University of the Witwatersrand, have undertaken field-work in the adjacent Colonial areas of Africa and the Pacific. While such field-work is in suspense, a special advisory board in Colonial studies constituted in 1941 has undertaken a review for the University of London of the achievements and potentialities of the various social sciences in regard to Colonial research.

At the London School of Economics a Colonial Research Division has been set up to co-ordinate work on the various subjects which have Colonial aspects. Linguistic research in Colonial areas of a most practical kind is the work of the School of Oriental and African Studies (University of London), while the Colonial Department of the University of London Institute of Education has as its primary object the training of teachers for work among Colonial peoples but has also encouraged research on educational problems. The Oxford University Social Studies Research Committee organized in 1938 a co-operative expedition to Kenya, in which two anthropologists, an expert in Colonial administration, an economist and a geographer collaborated. The principal centre at Oxford for sociological research on Colonial questions is now Nuffield College, where a programme of research has been organized including a study of the economic problems of Nigeria and the Gold Coast, a comparative study of the various political institutions which have been developed under British rule in tropical Africa, and a study of the institutions, official and unofficial, through which economic policy is formed and executed.

In addition to the universities, the International Institute of African Languages and Cultures was also in peace-time an important institution for the organization of sociological research in Africa, and the war has prevented the completion of a plan to establish in Northern Rhodesia a Rhodes-Livingstone Memorial Institute as the first centre in Africa itself for the special study of problems arising out of the relations between local peoples and other races. Dr. Mair's survey also includes a brief reference to the London School of Hygiene and Tropical Medicine and the Liverpool School of Tropical Medicine, as well as to other medical research institutes in the Colonial empire where research in tropical medicine, in nutrition and in other health matters is carried out.

There are numerous institutions in the Colonies and in Great Britain which are concerned with agricultural and veterinary research and assist Colonial research workers with information and technical advice. Fishery departments have made surveys of local resources in Palestine and in West Africa, while in Malaya the Fisheries Department has concentrated its attention on raising the efficiency of this native industry. In the Colonial empire the most extensive forestry research has been done in Malaya by a well-equipped Forest Research Institute. The principal centre for forest research in Great Britain is the Imperial Forestry Institute at the University of Oxford, while research on the utilization of forest products is carried out by the Forest Products Research Laboratory, Princes Risborough, and the Colonial Forest Resources Development Department. A considerable amount of research has been carried out on the mineral resources of most Colonies by the geological departments, as well as by mining and oil companies, and this work has the assistance of the Mineral Resources Department of the Imperial Institute. At the present time, research on technical subjects has run far ahead of the study of social and economic problems, and Dr. Mair suggests that the disproportion may be corrected by the influence of the new Colonial Research Committee, on which both the social and the natural sciences are represented.

EDDY CURRENT LOSSES IN SINGLE-CONDUCTOR LEAD-COVERED CABLES

IN a paper entitled "Eddy Current Losses in Single-Conductor Paper-Insulated Lead-Covered Unarmoured Cables of a Single-Phase System" (*J. Inst. Elec. Eng.*, 89, Pt. 2, No. 12; December 1942), Dr. A. H. M. Arnold gives the results of an experimental investigation made at the National Physical Laboratory on cables carrying A.C. at power frequencies. Measurements were made with single-phase current on two parallel, 1·4-sq. in. cables forming go and return conductors. The total eddy-current losses are divided into four parts, namely, skin effect in the core, proximity effect in the core, proximity effect in the lead sheath, and circulating-current losses in the lead sheath when they are bonded together. Each of these is dealt with separately on a theoretical basis, and formulæ are then put forward for estimating the A.C. resistance of a cable from the design data; these formulæ are shown to give good agreement with the experimental figures.

The report is an official communication (Ref. *F/T78a*) from the British Electrical and Allied Industries Research Association and, together with an earlier one (Ref. *F/T55*), permits the following general conclusions to be drawn.

The losses in the core due to spirality effect and in the sheath due to skin effect can be neglected. The loss due to skin effect in the core is substantially the same as that due to skin effect in a solid round conductor of the same D.C. resistance per unit length, and was found to be calculable to within 1 per cent of the total losses by means of a well-known formula. The loss due to proximity effect in the core is less than that due to proximity effect in a solid round conductor having the same D.C. resistance per unit length on account of the higher resistance offered to the proximity eddy currents in a cable which have to flow from strand to strand. A previous formula for proximity effect in solid rods may be used for stranded conductors, provided a conductivity lower than the true conductivity of the copper is assumed; a figure of about 75–80 per cent of the true conductivity should be assumed.

A theoretical formula by H. B. Dwight for the losses due to proximity effect in the lead sheath was found not to be sufficiently accurate on account of its neglect of the modification due to the proximity effect in the core. An empirical factor has been added to Dwight's formula which increases its accuracy considerably. The loss due to circulating currents in the lead sheath was found to approximate closely to that obtained from the formula given in the report, except for cables very close together. At close spacings, the actual loss is less than that calculated, on account of the reduction of the mutual inductance between core and sheath due to proximity eddy currents in the core. This loss reduction can be allowed for largely by assuming that the proximity loss in the lead sheath is non-existent when the sheaths are bonded together.

The complete formulæ put forward for estimating the total losses in a cable, with the sheaths bonded or unbonded, give good agreement with the experimental results. At a frequency of 50 c./s., the maximum discrepancy between the computed and measured losses is less than 1 per cent for a 1·4-sq. in. cable, and at 100 c./s. the maximum discrepancy is 3 per cent. Tables are given by means of which the ratio of A.C. losses to D.C. losses of any standard cable can be read at a glance for the standard frequency of 50 c./s.

FORTHCOMING EVENTS

Monday, January 18

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 8 p.m.—Capt. W. E. D. Allen: "Ethiopian Highlands".

Tuesday, January 19

INSTITUTION OF CIVIL ENGINEERS (RAILWAY ENGINEERING DIVISION) (at Great George Street, Westminster, London, S.W.1), at 2 p.m.—Mr. George Ellson: "Modern Trend of Railway Engineering Practice".

Wednesday, January 20

FOLK-LORE SOCIETY (at the Royal Anthropological Institute, 21 Bedford Square, London, W.C.1), at 1.30 p.m.—Dr. J. D. Rolleston: "The Folk-Lore of Children's Diseases".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Prof. W. E. S. Turner, F.R.S.: "New Uses for Glass".

INSTITUTE OF PHYSICS (at the Royal Institution, Albemarle Street, Piccadilly, London, W.1.), at 6 p.m.—Dr. R. K. Schofield: "The Distribution of a Liquid in a Pore-Space."

Thursday, January 21

INSTITUTE OF FUEL (JOINT MEETING WITH THE CHEMICAL SOCIETY, THE INSTITUTE OF CHEMISTRY AND THE SOCIETY OF CHEMICAL INDUSTRY) (in the University Chemical Department, Woodland Road, Bristol), at 5.30 p.m.—Dr. E. W. Smith: "Fuel Economy and the Chemist".

Friday, January 22

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. S. A. Couling: "Practice and Experience in the Production of High-Speed Helical Gears, with special reference to the Elimination of Transmission Noises".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER TO TEACH CHEMISTRY in the Department of Chemistry and Metallurgy, Coventry Technical College—The Director of Education, Council House, Coventry (January 20).

EDUCATIONAL PSYCHOLOGIST—The Secretary, Royal Victoria and West Hants Hospital, Bournemouth (January 22).

SPEECH THERAPIST for Speech Clinic in Harrow—Mr. C. W. Radcliffe, 'R.2', Clerk to the County Council, Guildhall, Westminster, London, S.W.1 (January 23).

TEACHER OF MECHANICAL ENGINEERING—The Principal, Wolverton Technical College, Wolverton, Bucks (January 25).

BOROUGH ELECTRICAL ENGINEER AND MANAGER—The Town Clerk, Municipal Offices, Grimsby (endorsed 'Borough Electrical Engineer and Manager') (January 28).

SPEECH THERAPIST—The Director of Education, Peel Street, Huddersfield (January 30).

EDUCATIONAL PSYCHOLOGIST—The Secretary-Superintendent, Belfast Hospital for Sick Children, 180 Falls Road, Belfast (February 1).

ASSISTANT TO TEACH MATHEMATICS—The Registrar, Wimbledon Technical College, Gladstone Road, London, S.W.19 (February 1).

SPEECH THERAPIST—The Acting Director of Education, Education Offices, Becket Street, Derby.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Proceedings of the Royal Society of Edinburgh. Section A: Mathematical and Physical Sciences. Vol. 61, Part 3, No. 21: Sylvester's Unravelment of a Ternary Quartic. By W. L. Edge. Pp. 247–259. (Edinburgh and London: Oliver and Boyd.) 1*s*. [2812

Transactions of the Royal Society of Edinburgh. Vol. 60, Part 2, No. 18: The Conducting System of the Marsupial Heart. By Prof. D. M. Blair, Prof. Francis Davies and Dr. E. T. B. Francis. Pp. 629–637+2 plates. (Edinburgh and London: Oliver and Boyd.) 1*s*. 9*d*. [2812

The Stammering Child and How he can be Helped. Pp. 4. 2*d*. Should we have a Baby in War-time? Pp. 2. 2*s*. per 100. (London: National Baby Welfare Council.) [2912

Other Countries

Commonwealth of Australia: Council for Scientific and Industrial Research. Bulletin No. 149: Production of Dried Grapes in Murray Valley Irrigation Districts, 2: Irrigation, Drainage and Reclamation. By A. V. Lyon and A. L. Tisdall. Pp. 35. (Melbourne: Government Printer.) [2812

Printed in Great Britain by FISHER, KNIGHT & Co., LTD., The Gainsbo rough Press, St. Albans, and published by MACMILLAN & Co., LIMITED. at St. Martin's Street, London, W.C.2, and THE MACMILLAN Co., 60-62 Fifth Avenue, New York—Saturday, January 16, 1943.