Editorial & Publishing Offices :
MACMILLAN & CO., LTD.
ST. MARTIN'S STREET
LONDON, W.C.2

NATURE

Telegraphic Address :
PHUSIS, LESQUARE, LONDON

Telephone Number :
WHITEHALL 8831

No. 3529 SATURDAY, JUNE 19, 1937 Vol. 139

Foot-and-Mouth Disease*

THE Foot-and-Mouth Disease Research Committee of the Ministry of Agriculture and Fisheries was first appointed in 1924, and although it has not succeeded in discovering any method of prevention, and the policy of slaughtering all infected and contact animals still continues, it has found out a good deal about the virus and its reaction with the body. The present, fifth, progress report covers the work done in the last five years, mainly at the experimental station at Pirbright and also at the Lister Institute, and the National Institute of Medical Research at Hampstead.

The size of the virus has been more accurately determined by means of Elford's graded filter membranes. It is held up by all membranes with an average pore diameter of 25 mμ or less, whence the diameter of the virus particles is about 8–12 mμ, compared with a molecule of oxyhæmoglobin with a diameter of about 4 mμ. It is indeed about the smallest pathogenic virus known, and is actually smaller than some protein molecules such as hæmocyanin or those recently described by Stanley as causing tumours. Size measurements have also been useful in distinguishing the virus from the much larger agent which causes vesicular stomatitis in horses and cattle, a disease which has similar clinical symptoms. Attempts to cultivate the virus *in vitro* in the presence of guinea pig or calf tissue have been only very moderately successful, and, unlike many viruses, it will not grow at all in the developing egg of the fowl or duck.

One of the most obvious objects which the Committee must have had in view from the beginning is some sort of protective inoculation such as has been used so successfully for cattle plague. An attack of the disease confers an extremely solid resistance on a cow ; but, as has been known for some time, there are several strains or sub-species of virus, and the recovered animal, unfortunately, is resistant only to that strain which caused its illness ; it has, for example, been shown that an animal may be given three successive attacks by using three different strains, and it also follows that a cow which has survived a natural attack is by no means secure against picking up the disease again from another strain of virus. These embarrassing features are now known to be worse than was supposed, and recent work has shown a greater multiplicity of identifiable strains as well as the existence of a number which have uncertain characters ; types hitherto unknown have appeared in Great Britain. Particularly inconvenient is the variation of infectivity for guinea pigs, since these are the standard animals used in testing for the presence of virus. Indeed, the prospect of finding an effective and practical method of immunization does not seem at all good.

A very interesting section of the report deals with the influence of diet on susceptibility, and it may surprise some of those who attribute so many ills to undernutrition to learn that well-fed, rapidly growing rats could be infected with a much smaller dose and took the disease much more severely than those which were fed on a meagre (but far from a starvation) diet. The animals which showed no symptoms after inoculation were in some instances found to be immune on subsequent testing after feeding up, showing that they had really been infected without any obvious illness ; others, however, were susceptible, and in them presumably no infection at all had occurred.

* Ministry of Agriculture and Fisheries. Fifth Progress Report of the Foot-and-Mouth Disease Research Committee. Pp. 386+26 plates. (London : H.M. Stationery Office, 1937.) (7*s.* net.)

Good feeding, especially with such eclectic foods as liver and carrot, produces a high degree of susceptibility in a few days, and it takes a long time for the effect to wear off after the animals return to a more ordinary diet. Similar results were obtained with guinea pigs and hedgehogs, and they are no doubt analogous to the old observation of Arkwright that the inflammatory reactions following certain irritating stimuli are much diminished in underfed animals. It may well be that foot-and-mouth disease was little obvious and did little harm among the scrawny cattle of past times in England, and it is just possible that some sort of vaccination with live virus might be a practical procedure if it was combined with deliberate underfeeding.

The major unsolved problem of the disease is, however, where the infection comes from and how it is spread. In the great majority of outbreaks, no perceptible source of infection can be identified, though for some time past they have been thoroughly examined by people fully alert to the various possibilities. With rare exceptions, each outbreak seems to be a thing of itself, and they are scattered about England in an apparently haphazard manner. Movements of cattle are, of course, continuously going on, and it has been suggested that some of them may be carriers of the virus without showing any signs of illness; the inquiries of the Committee do not, however, lend any support to this idea; nor do they favour the speculation that infection is brought from the Continent by birds, which are beyond the control of the most rigorous Ministry. With the dimming of what used to be the sharp boundary between live and dead, it is theoretically possible that the virus is frequently arising *de novo*, generated in cattle or pigs by some unknown influence. The great and apparently increasing variability of the virus is compatible with this idea, though it would be more orthodox to regard it merely as evidence that all the English outbreaks cannot have a common origin, or that the different sub-species of virus are not very permanent.

Spontaneous generation must, however, be the last resort of baffled epidemiologists, and the facts more reasonably suggest that infection is present in some common wild animal, very likely in a form which does not often cause any conspicuous mortality, as is often the case where an uncontrolled infection and its host come into some sort of permanent balance out of which, for reasons unknown, epidemics may arise. Of this line of thought the Committee has made a reconnaissance, partly by laboratory experiments, partly by trapping animals around the Pirbright Station, and partly by surveys of infected localities by Elton and his colleagues from Oxford. But it has all been on such a slight scale that it can scarcely be called an exploration, and much more work needs doing in the field, where it is none too easy under the conditions of isolation and disinfection which are imposed on infected farms.

Several animals and some birds are capable of being slightly infected by artificial inoculation, but the results are irregular and seem to be of no particular importance. The short-tailed field-vole (at any rate the northern form) is freely susceptible and the infection can be carried on in the laboratory from one animal to another by inoculation; it will not, however, spread from an infected to a healthy animal by contact any more than it will in guinea pigs, which implies that voles cannot be important in Nature from the point of view of infection.

The greatest suspicion attaches to the hedgehog, which by tradition is in the habit of sucking cows' teats and drinking the milk. This may or may not be true—the direct evidence for it is thin—and it may well mean nothing more than that it had been observed that close association between hedgehogs and cows was apt to result in a smaller yield of milk—an obvious symptom of foot-and-mouth disease. Whether they were confusing fact with interpretation or not, our ancestors certainly had such a dislike of the hedgehog as a harmful animal that, as Charles Oldham has shown, churchwardens in the eighteenth century would pay as much (fourpence) for an urchin as for a polecat. These bits of history make a rational tale if we suppose, with G. C. Damant, that the hedgehog is the natural reservoir of the disease. The Committee has shown that it is indeed very susceptible, and takes the disease severely: it is also the only wild animal known in which infection spreads from diseased to healthy animals by contact, and the virus has been demonstrated in the expired air. Moreover, in the small surveys which have been made, a single live hedgehog caught in the neighbourhood of an outbreak near Bristol was found to be infected, although it had no naked-eye signs of disease. At Pirbright a cow was infected by stall contact with a diseased hedgehog, and a hedgehog was infected by contact with a diseased cow. The case against the hedgehog seems strong enough to justify much more extensive and intensive field work.

Science and John Donne

John Donne and the New Philosophy
By Prof. Charles Monroe Coffin. Pp. ix+311. (New York: Columbia University Press; London: Oxford University Press, 1937.) 17*s*. 6*d*. net.

THE author explains in his preface that, while this book was undertaken as an "academic exercise", it fulfils a long-standing desire dating from a time many years earlier when he fell under the spell of Donne's poetry and noticed that none of the numerous and worthy studies of his life and works which have appeared in recent years seemed to touch more than lightly on the subject of his response to the new philosophy; whereas he (the author) conceived the idea that in Donne's familiarity with the "new science" there might be found an explanation of the compelling interest he has had for the late nineteenth and the twentieth centuries. He wished, therefore, by this study to provide a necessary supplement to such books as "The Life and Letters of John Donne", by Edmund Gosse (1899), and the prefaces, introductions and notes to the editions of his poems by Charles E. Norton (1895), E. K. Chambers (1896), and Prof. Herbert J. C. Grierson (1912), as well as "A Study of the Prose Works of John Donne" by Mrs. Evelyn M. Simpson (1924). Professor Grierson had already remarked that "No other poet of the seventeenth century known to me shows the same sensitiveness to the consequences of the new discoveries of traveller, astronomer, physiologist and physician as Donne"; and Mrs. Simpson clearly saw that, as a result of the influence upon Donne of the beginnings of modern science, "the break up of a whole system of thought is reflected in his pages".

Donne was brought up as a Catholic, and was first educated abroad by the Jesuits, who were governed by the Ptolemaic-Aristotelian system as brought by St. Thomas Aquinas into harmony with Christian doctrine. While his instruction by the Jesuits stimulated his interest in many branches of learning, Donne's independent and even heretical spirit chafed under their authoritarian régime. In 1584 he entered Hart Hall, at Oxford, "that refuge for adherents of the old religion", which again meant a curriculum of study scarcely less medieval than that followed by his Jesuit instructors. In 1586, or soon after, he is said to have gone to Cambridge, where the Reformation had taken stronger hold, and the contest was then not so much between Catholic and Protestant as between the National Church and the dissenters. Moreover, rebellion against the medieval scholasticism had been encouraged there by Francis Bacon's denunciation of the too dominant influence of Aristotle at the University, and more specifically by the publication by the Cambridge University Press of an edition of the "Dialecta" of Peter Ramus (Pierre de La Ramée) challenging the whole of Aristotle's logic.

Cambridge had also produced before Donne's time the first champions of the new science of the Renaissance. Among these were Robert Recorde, the author of "The Grounde of Artes", and John Dee, who were both adherents of Copernicus, as well as Thomas Digges (son of the mathematician Leonard Digges), who had (before 1576) made the first English translation of Copernicus and had prepared a map of the heavens according to the new system. Henry Briggs, later Savilian professor of geometry at Oxford, was made fellow of St. John's College in 1588 and was still at Cambridge while Donne was at the University.

Donne belonged, however, to no school and was a disciple of no system; he was greedy of learning and experience of all sorts, regardless of consequences; he speaks himself of his "hydroptique immoderate desire of humane learning." He was most deeply impressed by two things: (1) the refutation of Aristotle's dictum about astronomy (that the heavens are unalterable because in so many ages nothing had been observed to have been altered, "De caelo", i. 3), by the discovery of new stars, and (2) the deposition of the earth from its place in the centre. On the second point we know that Donne was familiar with the Copernican hypothesis before (in 1611) he brought out "Ignatius his Conclave", which not only introduces Copernicus as one of the characters but also mentions Kepler and Galileo, and shows that Donne was versed in the earlier history of the subject and the parts in it attributed to Ecphantus, Heraclides and Aristarchus of Samos. Allusions in the poems are illustrated by the lines in "The First Anniversary" (1610-11), "The sun is lost and th' earth, and no man's wit Can well direct him where to find it", where by "lost" applied to the sun he means lost in the sense of a beneficent satellite as it were. (Incidentally, it is worth noting that Robert Burton, a contemporary of Donne, wrote in "The Anatomy of Melancholy": "Copernicus, Atlas his successor, is of opinion the earth is a planet, moves and shines to others as the moon doth to us. Digges, Gilbert, Keplerus, Origanus, and others defend this hypothesis of his in sober sadness, and that the moon is inhabited: if it be so that the

earth is a moon, then are we also giddy, vertiginous and lunatic within this sub-lunary maze".)

As regards new stars, Donne shows by a marginal note to "Biathanatos" one source of his information, Kepler's "De stella nova" (1606) containing an account of his discovery in 1604 of a brilliant new star in the constellation of Serpentarius. He was acquainted too with Galileo's "Sidereus Nuncius" (1610), the full title of which is, in translation, as follows: "The Astronomical Messenger, containing and setting forth Observations lately made with the aid of a newly invented Telescope respecting the Moon's Surface, the Milky Way, Nebulous Stars, an innumerable multitude of Fixed Stars, also respecting Four Planets never before seen which have been named the Cosmian Stars". The planets mentioned were the four satellites of Jupiter, discovered by Galileo, and are plainly alluded to in "The First Anniversary", "And freely men confesse that this world's spent when in the Planets and the Firmament they seeke so many new . . ." One more quotation from "The First Anniversary" may be permitted, "And now Philosophy calls all in doubt, The Element of fire is quite put out". Cardan had denied the existence of the element of fire ("De subtilitate", which Donne had mentioned in "Biathanatos"), but it was more probably from Kepler ("Dioptrice") that he learnt of the "confutation" of fire by Tycho Brahe and Pena, and by Kepler himself.

The book contains fifteen chapters, of which the following may be mentioned: Poetry and Science (i), The Old Order (iii), The Rise of the new Philosophy (v), The Moving of the Center (vi), The New Heavens (vii), "Figures of Space (ix), The Text Saves Us (xi), in which the editor shows the scholarly habits of Donne, how he searched for ultimate sources, compared texts to test their relative validity, acknowledged his obligations to those who had supplied him with information, and even indulged in footnotes.

Enthusiasts for Donne will find the book a mine of detailed and accurate information about his works and thought; while all who are interested in the history of astronomy will, in the text and the elaborate notes, find many particulars about the original works of Copernicus, Kepler and Galileo, as well as many facts in the history of astronomy (especially that of the Greek pioneers).

Morphogenetic Factors of Bone

Bones:
a Study of the Development and Structure of the Vertebrate Skeleton. By Dr. P. D. F. Murray. Pp. x+203+8 plates. (Cambridge: At the University Press, 1936.) 8*s*. 6*d*. net.

THE study of the factors which determine the growth and form of an organism is the special province of the morphologist. Hitherto this has been mainly pursued by the investigation of the biological history of the organism or structure, and indeed morphology has become more or less synonymous with the historical approach. The other common factor, the influence of function upon structure, has of course been implicit in all sorts of biological studies. Beyond these historical or functional investigations of the determinants of form, there is still the experimental approach to the question of the relation between the structure made visible by anatomical methods and the morphogenetic factors that have brought the structure to the state which has actually been achieved.

It is the especial merit of the Strangeways Laboratory at Cambridge, over which Dr. H. B. Fell presides, that it has become one of the most distinguished places in the scientific world for the prosecution of morphogenetic studies. Here the technical methods, tissue cultivation *in vitro*, tissue grafting, the growth of large explants under a variety of conditions, embryological experimentation, the registration of results by the Canti cinema method and so on have been used abundantly, and, in the process, made more efficient and applicable on a wider scale. Dr. Fell and the Strangeways Laboratory have placed British anatomists deeply in their debt.

The present volume relates the work done there by Dr. Murray and his colleagues as it bears upon the anatomical problems presented by bone. The author has set himself the task of presenting the knowledge available which throws light on the factors determining the position of bone. For example, in the membranous skull of the embryo it may be inquired why the sutural margins run where they do. As a matter of experimental observation, the position of the bone and the limiting sutural lines seem inherent in the cells of the dura mater, for when bone including the sutural line is removed and the dura is left intact, both the bone and the sutural line in its normal position are regenerated. Next the author discusses the differentiation of the architectural structure of developing and adult bone. It has become

almost traditional in anatomical schools to regard this as a precise orthogonal pattern precipitated as it were along the lines of tension and compression. The matter is not nearly so simple, and much further investigation is necessary upon this problem.

The fixing of the form of the bone is perhaps an issue upon which the most spectacular experiments have been performed by Dr. Fell and her colleagues. The growth of a recognizable femur outside the body beginning from its primordial mesenchymatous stage was a great achievement and also prepared one to believe in the potency of the factors inherent in the primordial cells. In later life, however, extrinsic factors have more say in influencing shape than in these earliest stages. Finally, of course, there is the problem of how increase in size is attained with the preservation of the characteristic form of the bone. This problem in bone growth has been long investigated, and Dr. Murray mentions that it is germane to his theme. He omits it, however, from his book in order that he may write more particularly upon the experimental aspect of the other two problems mentioned. The problems raised cover all the bones of the skeleton, and a special chapter is given to cartilage.

Those who study the morphogenetic factors cannot help being impressed by the inherent formative properties of the cells themselves. It is difficult to refrain from endowing them with potentialities that make further scientific investigation impossible. The cure for this seems to be more experiments, for some of the supposed facts which have been the starting point of theories outside the realm of science have been shown later to depend on interpretations which further investigation has proved to be erroneous. Dr. Murray has refrained from any such speculation, and has given us a straightforward account of the problems, the experiments and the results obtained. In thanking the author one may append a remark upon his concluding sentence. The author modestly suggests that his book at least has the merit of raising more problems than it solves; the commentator may justly add that it has the merit of raising them in a form that at least makes solution seem not impossible.

Infectious Exanthemata

The History of the Acute Exanthemata: the Fitzpatrick Lectures for 1935 and 1936, delivered before the Royal College of Physicians of London. By Dr. J. D. Rolleston. Pp. ix + 114 + 10 plates. (London: William Heinemann (Medical Books), Ltd., 1937.) 7*s*. 6*d*. net.

THIS small volume contains the Fitzpatrick Lectures for 1935 and 1936. It is concerned with the history of smallpox, chicken-pox, scarlet fever, measles and German measles.

The study of the history of *diseases* presents special difficulties, and in the case of the infectious exanthemata these difficulties are accentuated by the fact that "it is now generally agreed among medical historians that the acute exanthemata were not distinguished from one another until a comparatively late period of their history". This point is exemplified in many passages. "In spite of the teaching of Heberden, Cullen, Willan, and others, there were not lacking during the nineteenth century writers, including some of high distinction, who maintained the identity of smallpox and chicken-pox". "Richard Morton held the view that scarlet fever was exactly the same as measles." The problems which confront the medical historian are much increased by such diagnostic confusion.

Even more perplexing is the nomenclature. Both German measles and chicken-pox received a multitude of names, out of all proportion to their real significance. Chicken-pox, first described by Ingrassias in 1552 under the name of crystalli, has been rechristened forty times; whilst German measles has at least a dozen names. The author negotiates all such obstacles with a confidence which can only come from practical experience and a wide knowledge of the literature of each disease. He goes further, and makes his subject one of profound interest to the reader.

The importance of medical history as a guide to modern practice is apt to be overlooked. Here, the reader finds no excuse for such neglect. Many a modern 'discovery' has its roots in the distant past. Athanasius Kircher (1601–1680) examined the pus of smallpox lesions, and attributed the disease to the action of micro-organisms. Boerhaave (1668–1773) maintained that smallpox was a specific disease spread by contagion. In the middle of the eighteenth century, Francis Home (1719–1813) anticipated the modern prophylactic use of convalescent serum in measles, by using infective blood as an application to the scarified skin.

History also emphasizes the danger of introducing the acute exanthemata to a virgin soil. One of the earliest examples of this kind is the Amazon measles epidemic of 1749, when 30,000

natives died of this disease. In 1846 a somewhat similar fate befell the Faroe Islands, and in 1875 Fiji, when nearly a quarter of the population died of measles. The lesson was brought home to Great Britain in 1914–15, when a Highland Division in training at Bedford had 529 cases with 65 deaths.

Another example of the value of history in actual practice is found in the variability of virulence in epidemics. One example out of the many provided will serve as an illustration. It refers to the experience of Bretonneau at Tours with regard to scarlet fever. During the period 1799–1822, he never saw a single death from this disease, which he always found a very mild complaint. In 1824 an epidemic occurred which proved so deadly and refractory to treatment that he came to regard scarlet fever as formidable a disease as plague.

The value of the work is enhanced by a generous list of references, also a series of portraits of those who have contributed to our knowledge on the acute exanthemata. A book which may be recommended to all who are interested in the history of medicine.

S. H. D.

Fundamental Electrical Measurements

Electrical Measurements:
Precise Comparisons of Standards and Absolute Determinations of the Units. By Dr. Harvey L. Curtis. (International Series in Physics.) Pp. xiv+302. (New York and London: McGraw-Hill Book Co. Inc., 1937.) 24*s*.

THERE can be but few physicists better entitled than Dr. H. L. Curtis to write on fundamental electrical measurements. As an associate of Rosa, Dr. Curtis has witnessed the development of high-precision work on electric units at the National Bureau of Standards, Washington, and since then he has never ceased to improve existing methods, and to devise new methods in an effort—and a successful one—to increase the accuracy of determination of electric units.

The first quarter of the book under notice treats of units and standards generally. The descriptions of the most modern types of manganin wire resistance standards and of cadmium standard cells are particularly useful, as are also the details of the methods by which national laboratories maintain their units of resistance and of electromotive force.

The comparison of standards is dealt with next. In this section, as elsewhere, instead of outlining all the accurate methods available, the author selects one or two methods, possibly those with which he is most familiar, and describes them in detail. Among the measurements involving two or more electrical quantities, the determination of capacitance by the Maxwell bridge, in terms of resistance and time, receives very good treatment.

The second half of the work is devoted to calculation and design of inductance, and absolute measurement of resistance and current. It is no simple matter to deal with the computation of self and mutual inductance in a few pages, but Dr. Curtis has performed his task remarkably well; rightly starting from first principles, he introduces the reader without difficulty to the complicated formulæ which represent the solution of practical problems. The next chapter, nominally concerned with design of standards of inductance, is devoted mainly to a description of a particular method of winding a solenoid on a cylindrical former. In this chapter and elsewhere in the course of the work, the author embarks on the risky venture of suggesting, and even describing in detail, methods of procedure which have never been subjected to serious test. In this case, the suggestion refers to the construction of a mutual inductor from two solenoids.

Absolute measurement of resistance comes next. A survey of old and new methods is followed by very complete descriptions of the Lorenz method and of the self-inductance bridge method. In the same way the absolute measurement of current is illustrated by detailed descriptions of the Rayleigh balance, for the improvement of which Dr. Curtis is himself largely responsible, and of the Ayrton-Jones balance of the National Physical Laboratory.

The comparative definitions of units in the electrostatic and electromagnetic systems, given in the second chapter, could easily have been avoided by the use of the M.K.S. system of units recommended by the International Electrotechnical Commission. Automatically, the last chapter would then have received a simpler title, and it is possible that with ideas clarified by a more logical choice of starting-point, Dr. Curtis would not have written (top of p. 219): "the variability of the earth's magnetic field prevents its accurate measurement *in c.g.s. units*".

Printing and diagrams are excellent.

British Trees and Shrubs, including those commonly planted:
a Systematic Introduction to our Conifers and Woody Dicotyledons. By H. Gilbert-Carter. Pp. xv+291. (Oxford: Clarendon Press; London: Oxford University Press, 1936.) 12*s*. 6*d*. net.

DR. GILBERT-CARTER'S aim in writing this sequel to his earlier "Catkin-Bearing Plants" is threefold: to enable students to identify our native woody plants, and many commonly cultivated ones; to illustrate Engler's system of classification and to show, by giving the derivations of all the Latin names used, that botanical nomenclature is a human subject with its roots in the past.

The descriptive treatment of the various groups is, on the whole, excellent, though some of the specific descriptions are too brief for certain identification. Under many genera and species valuable notes are given on distribution, ecological preferences, medicinal and culinary virtues, cultivation and general biology. Readers will very rarely have to rest content with the name of any specimen they identify; some illuminating sidelight is nearly always thrown on one or other aspect of the species concerned.

In his preface, and under many of the classes, groups, orders and families, the author discusses briefly the theory and application of Engler's system of classification. He is sceptical, as was Engler, of the possibility of making phylogenetic speculation the basis of natural classification, and uses throughout the noncommittal term 'affinity' when discussing relationship. Dr. Gilbert-Carter's remarks are a welcome contribution to a subject on which many taxonomists are by no means clear.

The footnotes giving the derivation and pronunciation of Latin names will be appreciated by all who value the historical approach, and are not content merely to repeat, parrot-like, the names that they are taught. The few inaccuracies that have crept into these admirable notes will doubtless be corrected in a future edition. J. S. L. G.

Hardy Californians
By Lester Rowntree. Pp. xv+255+64 plates. (New York: The Macmillan Co., 1936.) 18*s*. net.

THE title of this book may call up visions of the "Old Timers" or "Redskins" of the novelist or of Hollywood, but in fact it deals principally with the hundreds of little-known, but none the less interesting and beautiful flowers of the amazing western State, California.

Mrs. Lester Rowntree takes us with her in her travels from what she calls the "Top of the World", altitudes of 9,000–14,000 ft., down to "Death Valley" 276 ft. below sea-level, and from the heat and glare of the Colorado Desert to the dense shade and humidity of the Redwood Forest; a revelation of the wide range of geographical conditions existing in that State. To the Nature lover or gardener, the book is as thrilling as any Western romance, for it is an introduction on an intimate and personal footing to the "plant personalities" she loves and describes so well.

The wealth of detail given on soils and situations, possible requirements in cultivation, etc., is of course intended to assist the gardener, but it is none the less interesting to the botanically minded, and particularly to the student of ecology. To some of the genera with which we in Britain have a nodding acquaintance, for example, *Penstemon*, *Lupinus* and *Viola*, the author devotes whole chapters, and one chapter is reserved for the wonderful and varied range of bulbous plants for which the West is famed. How many of the plants enumerated will prove hardy in Great Britain is an open question, for the book is written primarily for American gardeners and climatic conditions. A fair proportion will undoubtedly find congenial homes in Great Britain, for where else will they receive such hospitality or obtain climatic conditions so varied? G. W. ROBINSON.

Electrical Engineers' Handbook
(Vols. 4 and 5 of Wiley Engineering Handbook Series.) 4: Electric Power. Prepared by a Staff of Specialists under the Editorship of Dr. Harold Pender, William A. Del Mar, Knox McIlwain. Third edition rewritten. Pp. xiv+1268+37. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1936.) 30*s*. net.

ELECTRICAL engineers' handbooks have become both bulky and inconvenient, and contain much duplicated matter owing to the rapid development of the various branches of engineering. In this series it has been decided to publish the fundamental material which forms the basis of all engineering in a separate volume, and the existing handbooks as they are revised are being issued in several volumes containing material closely connected with the specialized branch considered. The entire new series of handbooks will give much more complete information on all topics of interest to engineers.

The latest developments of filament and discharge lamps, methods of air-conditioning, and ventilation fans are all described and the physical constants of building materials including their thermal conductivities are discussed. To the practical engineer, this book will be useful for reference. The latest information about electric power has been included.

The Cactus Eaters
By Julian A. Weston. Pp. 240+16 plates. (London: H. F. and G. Witherby, Ltd., 1937.) 10*s*. 6*d*. net.

IN "The Cactus Eaters" the author records the results of a stay of four months on the Goajira Peninsula on the southern shore of the Caribbean Sea and a boundary area between Colombia and Venezuela. His purpose was to observe the customs and culture of the Goajiro Indians. Although a stock-raising people, it is evident that in level of culture they have advanced little beyond the hunting stage, and the author discusses the interesting question of the nature of their subsistence in pre-Conquest days, as their stock must have been derived from the Spaniard. In view of environmental conditions and cultural indications, it is suggested that they may have been a people of a fishing culture.

A Taxonomic Problem

By J. S. L. Gilmour

AMONG present-day biologists there is widespread interest in, and considerable disagreement on, the proper relationship between taxonomy* and other branches of their science, especially genetics, cytology and ecology. Should the data provided by these branches be incorporated into the existing taxonomic categories, or should new categories be created to meet their needs ?

In discussing these questions, I believe that the purpose and general principles underlying the process of classification have been unduly neglected and that a consideration of these would help materially to clarify the issues involved. A full discussion of these principles may be found in the standard works on logic and scientific method†, and only those points most relevant to the present problem will be dealt with here.

In its simplest terms, classification consists in grouping individual objects (and, ultimately, sense data, expressed as qualities and relations) into classes, so that all the individuals in one class have certain attributes in common. The use of such general names as book, piano, mountain, etc., involves a process of classification no less than the formation of such classes as mammals or flowering plants. Viewed thus, classification is seen to be a necessary stage in the inductive process by which the human mind obtains an ordered knowledge of the universe. Ritchie (*op. cit.*, p. 79) has expressed this concept of classification as follows: ". . . our general knowledge of the external world as expressed by laws of nature is a product of the interaction of two processes, selection from and classification of what is experienced and the discovery of laws relating to the classes".

Any given collection of objects can, of course, be classified in a great number of different ways, depending on the particular attributes chosen as a basis for classification. Thus mankind can be classified on a basis of nationality into Frenchmen, Germans, etc.; on a basis of occupation into lawyers, doctors, etc.; on a basis of physical characters into the various so-called 'races', and so on. Further, the choice of particular attributes depends on the *purpose* in view in making the classification. Thus if we wish to investigate the distribution of professions among the inhabitants of different countries, we employ classifications based on the attributes of occupation and nationality, and, from an examination of the resulting classes, we formulate laws relating them, such as, for example, that there is a greater proportion of clergymen in England than in the U.S.S.R.

These considerations apply also to biological classification in general. Fundamentally, the purpose of biological classification is the acquisition of ordered knowledge regarding living things, and logically any grouping of plants and animals should be considered a taxonomic process. Such groups as hydrophytes, succulents, hemicryptophytes, ruderals and alpines are, in this sense, 'taxonomic' groups, no less than the families, genera, species, etc., of 'traditional' systematic botany. Why is it, then, that the term taxonomy is usually confined to this latter grouping ? Why are Ranunculaceæ, but not annuals, considered a taxonomic group ? The answer to this question involves a consideration of the difference between a natural and an artificial system of classification.

The term 'natural classification' is a general one, the significance of which is not confined to the grouping of living things. It is usually stated in logic that a system of classification is the more natural the more propositions there are that can be made regarding its constituent classes. For example, a classification of mankind on a basis of nationality is more natural than one based on the initial letter of surnames, because more propositions can be made regarding an Englishman (for example, that he probably speaks English, knows "God Save the King", has a white skin, etc.) than about a man whose name begins with E. Thus a natural classification is one founded on attributes which have a number of other attributes correlated with them, while in an artificial classification such correlation is reduced to a minimum. From the point of view of function, a natural classification can be used for a great variety of purposes, while an artificial one serves only the limited purpose for which it was constructed.

The difference between them can be expressed in another way. The greater number of propositions

* "Taxonomy" is here understood in its ordinary dictionary definition of "the principles and practice of the classification of living things". The discussion concerns taxonomy in general, though I have had chiefly in mind the higher plants. I am grateful for certain suggestions made by those who have been kind enough to read through the paper.

† See especially: "Logic" by J. S. Mill (1843); "Logic" by A. Bain (1878); "The Principles of Science", by W. S. Jevons (1883); "Logic", by Carveth Read (1898); "The English Utilitarians", by L. Stephen, Vol. III (1900, esp. pp. 124–131); "The Use of Words in Reasoning", by A. Sidgwick (1901); "Inductive Logic", by T. Fowler (1904); "Formal Logic", by F. C. S. Schiller (1912); "A New Logic", by C. Mercier (1912); "The Philosophy of Biology", by J. Johnstone (1914); "Scientific Method", by A. D. Ritchie (1923); "Biological Principles", by J. H. Woodger (1929); "Modern Introduction to Logic", by L. S. Stebbing (1930).

that can be made regarding an Englishman depends on the fact that nationality (the basis of the classification) is an attribute connected with a very important factor in human life (namely, the habit of living in territorial groups to which we become emotionally attached), while the initial letter of surnames is not. This point is made clearer if we imagine that a dictator has decided to execute forthwith all those whose names begin with E. This attribute would then become connected with another important factor in human life (namely, the power of a dictator) and immediately the hitherto artificial group of E's would become, at any rate temporarily, a natural one, about which many propositions could be made (for example, that they would soon be dead, were probably frightened, were probably making their wills, etc.). From this rather trivial example, the proposition emerges that a natural classification is one which is based on attributes connected with a factor that has an important influence on the objects being classified : the more important the factor the more natural the classification becomes.

The difference between the two is therefore one of degree only. Indeed, it is impossible to construct a classification that is not to some extent natural. As pointed out by Jevons (*op. cit.*, p. 680), even in so artificial a class as those whose names begin with E, there will probably be an abnormally high proportion of Welshman owing to the presence of a large number of Evanses.

If there is one factor influencing a particular collection of objects which is more powerful than any other, then a classification based on attributes connected with that factor will be more natural than any other. For example, in classifying a number of motor-cars which were manufactured during the last forty years, the most natural classification would be a division based on attributes connected with the period of manufacture, because that is the most important factor determining the attributes of the cars. If, however, there are several factors of nearly equal importance influencing a group of objects, then a number of equally natural classifications is possible. This is the case in the classification of mankind, where, for example, it is difficult to say whether a basis of nationality or annual income gives a more natural classification.

If these conclusions are applied to biological classification as a whole, the reason for the unique position held by traditional taxonomy begins to emerge.

Owing to the method of reproduction and evolution of living things, involving the inheritance of parental characteristics, and to the pre-eminent influence that these factors exert on the attributes of plants and animals, the possibility exists of constructing a series of classifications which are more natural than any others, namely, those based on inherited characters. It is by a constant search for the most natural among these classifications that the present vast structure of traditional taxonomy has been gradually built up. We may say, then, that the unique position held by traditional taxonomy, marking it off from other arrangement of living things, is primarily due to the possibility of constructing a set of peculiarly natural classifications of living things based on inherited attributes.

On this view, a natural classification in biology is a particular example of natural classification in general and not a phenomenon peculiar to living things ; further, a natural classification differs in degree only from other biological classifications. This is in contrast to the concept, widely (though not universally) accepted in post-Darwinian times, of a natural classification as being based on *actual phylogenetic relationship* and thus differing fundamentally from artificial classifications. This view involves the assumption that there exists a criterion of degree of phylogenetic relationship, apart from degree of similarity of attributes, and either that such a criterion should be used in constructing a natural classification, or that degree of similarity of attributes is an invariable indication of such relationship and can therefore be used as a basis for a natural classification.

Now, this criterion of phylogenetic relationship must presumably be the same that leads us to say that two brothers are more nearly related than two cousins—namely, the degree of remoteness of a common ancestor. But in order to judge degree of relationship on this criterion, a knowledge of the genealogy of every *individual* in any group under consideration is essential, and such knowledge, except occasionally in man and in certain domesticated animals and plants, is clearly unobtainable.

Can we, then, fall back on the second alternative and accept degree of similarity of attributes as an invariable indication of degree of relationship ? That such similarity is frequently an indication of relationship is true, but that it is an invariable indication certainly cannot be maintained. For example, two individuals related as cousins may have identical genotypic constitutions, while two sibs may be strikingly different and, further, parallel mutations may occur in two individuals only distantly related phylogenetically but of similar genotypic constitution.

If, then, the criterion of degree of relationship applicable to *individuals* cannot be applied in practice to *groups*, and, further, if similarity of attributes cannot be regarded as a certain indication of such relationship, then it would seem that

the view that a natural classification differs fundamentally from artificial classifications in that it represents phylogenetic relationship cannot be substantiated. A natural classification should rather be regarded, first and foremost, as that arrangement of living things which enables the greatest number of inductive statements to be made regarding its constituent groups, and which is therefore the most generally useful classification for the investigation of living things. Whether or not such a classification does in fact group together individuals who are phylogenetically related is a secondary question which must be answered for any particular case on its merits.

For special purposes, however, additional classifications are essential. As emphasized above, classification is a stage in inductive investigation, and in so far as it is desired to discover laws relating certain attributes of living things, such attributes must be embodied in distinct classifications of greater or less complexity. The need for such additional classifications is obvious when the attributes concerned give an arrangement conspicuously less natural than that of traditional taxonomy, for example, a classification into trees, shrubs, herbs, etc., or on medicinal properties. But when the classification is only slightly less natural than the most natural possible, then its validity becomes obscured and confusion arises between it and traditional taxonomy. Such is the case with many of the attributes that have been investigated during the last thirty or forty years under the headings genetics, cytology, physiology and ecology. For example, a traditional taxonomist may divide a genus into a certain number of species on morphological characters, the result being a good natural grouping. A cytologist may then investigate the same genus and find that, say, sterility barriers in some cases cut right across the taxonomist's groups. If the sterility classification is the less natural of the two, that is, if its groups show a smaller correlation of attributes, it should not, as is sometimes suggested, be dismissed as 'taxonomically useless'; but should be retained as a distinct classification for the purpose of establishing the relationship between sterility and other attributes.

This principle of 'multiple classification' is fundamental to the proper functioning of taxonomy as an instrument for the inductive investigation of living things. How can it be most satisfactorily applied in the present position of biological taxonomy? A few tentative suggestions may be put forward.

The categories and nomenclature of traditional taxonomy should be confined to the most natural classification possible in the existing state of knowledge of any particular group, on whatever attributes it may be based, and such a classification would be the most generally useful for a great variety of purposes, both scientific and non-scientific.

Any exact definitions of the categories within this classification are, in my opinion, an impossibility. The categories, genus, species, etc., are of the same nature as such categories as herd or heap, individual *characters* taking the place of individual animals or stones. A well-known trick in logic known as the 'sorites' illustrates this point. The question is put "Does one stone form a heap?" If the respondent answer "No", it is asked, "Do two stones form a heap?" and so on. Great difficulty is found in deciding when the addition of one stone constitutes a heap. The answer would vary from person to person and also according to the shape and size of the stones. Similarly, in a natural classification, the definition of the categories must vary somewhat according to the mentality of individual biologists and the nature of the material being classified.

If the traditional taxonomy is defined in this way, what should be the aim and methods of the additional classifications necessary for special investigations? Unlike the classification of traditional taxonomy, they should be based on the same attributes throughout, and their categories should have a different terminology from that of traditional taxonomy. A good example of such a system is Danser's classification into commiscuum, comparium and convivium, which is based purely on interfertility criteria[1].

Many other classifications based on data provided by genetics, cytology and ecology have been proposed during this century[2], but these have for the most part either redefined the categories of traditional taxonomy in such a way as to destroy their general usefulness, or have employed mixed attributes as a basis for new categories. It is greatly to be desired that agreement should be reached on the employment of other classifications similar to Danser's (either new ones, or existing ones modified where necessary), based on other attributes. The number and complexity of such classifications are, of course, questions of meeting the ever-changing needs of biological investigation, and no limits either way can be set.

With regard to nomenclatural technique, it would seem possible that, where necessary, the method of employing Latin words with a prefix or suffix to distinguish them from the Latin names of genera, species, etc., which has already been used with success, for example, for the ecological categories of association, etc., might be extended to classifications based on other attributes.

[1] *Genetica*, **11**, 399 (1920).
[2] See Du Rietz, *Svensk. Bot. Tid.*, **24**, 333 (1930).

The Hammond Electric Organ

THE development of the loud-speaker, and more especially the demonstration of its capability of reproducing all types of music in connexion with the projection of the talking film in the cinemas, has suggested to a number of inventors the possibility of the replacement of the ordinary pipe organ by one which is entirely electric. Many patents have been taken out both in Great Britain and abroad, some utilizing electrically recorded wave forms and a photo-electric cell, and others building up the tone quality from combinations of sine waves; for it is well known that any periodic wave can be analysed into a series of sine waves of which the frequencies are multiples of that of the original wave. Of the latter, the two most successful are that of the Compton Organ Co., in which the waves are generated by a variable capacity, and the Hammond organ.

In the Hammond organ the currents are produced electromagnetically by rotating an iron disk *D* (Fig. 1), about the size of a half-crown, with a serrated edge, in front of the end of a permanent magnet *M* on which is a coil of wire *B*. The change of flux through the coil, caused by the variation of the gap between the serrated edge of the disk and the end of the magnet, produces an alternating E.M.F. in the coil; the edge of the disk and the pole of the magnet are so shaped that this E.M.F. shall follow a sine curve as closely as possible. There are twelve of these disks, each with its own magnet and bobbin of wire, to each octave. The disks of one octave are all mounted on a single shaft and rotate as a whole. The shafts and disks of the successive octaves are all similar and are so geared together that the shaft of each octave shall run at twice the speed of the preceding one.

The number of serrations on the edges of the twelve disks of one of these octaves has to increase progressively so as to give as approximately as possible the notes of the equitempered scale. The number of turns on the bobbins is reduced in the successive octaves to compensate for the increased flux due to the increased speed of rotation, and by this as well as by adjusting the distance of the magnets from the edges of the disks, the intensities of the notes produced are equalized throughout the whole range of the circuits, of which there are ninety-one in all.

There are two keyboards, each with five octaves. To combine the sine waves produced by the rotations of the disks in order to give the organ tones required, each note *K* (Fig. 1) on the keyboard can be connected to nine harmonically related bobbins, and the intensity of each of these circuits can be varied at will. For example, middle C can be connected not only to the bobbin giving the note of middle C, but also to the bobbins giving the fourth and the octave below (G_1 and C_1) and to those giving the octave above, the twelfth, the second octave, seventeenth, nineteenth, and third octave (C′, G′, C″, E″, G″, C‴ .) These connexions are made by means of insulated contacts *E* under the keys, one connected to each bobbin, which are brought down, when the key is depressed, on to nine wires *W* stretching from side to side of the keyboard. The nine wires go to a group of nine draw-bars *DB* situated over the keyboard, each of which can be set at nine positions numbered from zero to eight. All the ninety-one circuits have initially the same resistances, and the draw-bars insert a resistance *R* which varies from infinity to nothing as they are drawn out, and thus each draw-bar adds a determined amount of the corresponding harmonic according to the position at which it is set.

To prevent the current from one bobbin feeding back through a key and the draw-bars to another bobbin and so giving false notes, there is a tuned circuit, consisting of a capacity and an inductance in parallel, between each bobbin and the keyboard.

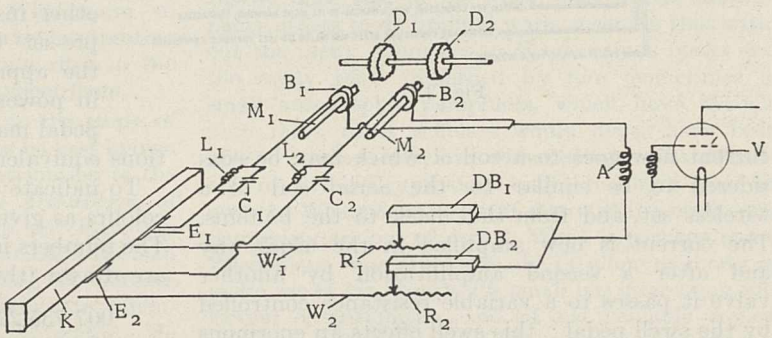


Fig. 1.

DIAGRAM OF ACTION OF THE HAMMOND ORGAN: *A*, COIL; B_1, B_2, BOBBINS; C_1, C_2, CAPACITIES; D_1, D_2, DISKS; DB_1, DB_2, DRAWBARS; E_1, E_2, CONTACTS; *K*, KEY; L_1, L_2, INDUCTANCES; M_1, M_2, MAGNETS; R_1, R_2, RESISTANCES; *V*, VALVE; W_1, W_2, WIRES.

Thus the complete circuit starting from the bobbin passes first through the tuned circuit, then branches and goes to the nine keys connected to that bobbin. Then it goes through the wires stretched across the keyboard to the nine draw-bars and through their resistances. These resistances are all joined together and the combined

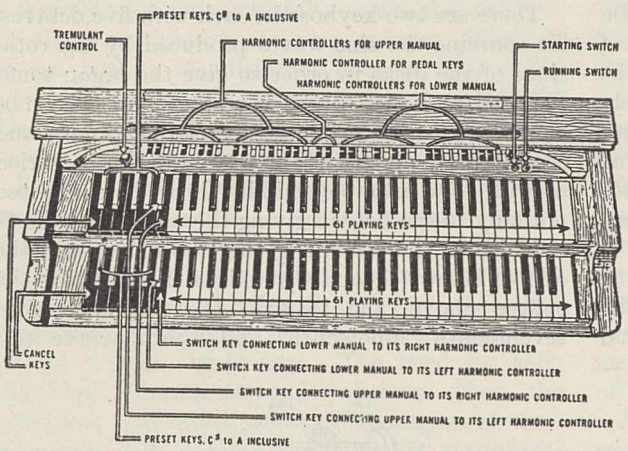


Fig. 2

current now goes to a coil A which may be considered to be similar to the aerial coil of a wireless set, and from that back to the bobbins. The current is now amplified in the usual way and after a second amplification by another valve it passes to a variable resistance controlled by the swell pedal; this swell effects an enormous change in intensity, amounting to a variation of some fifty decibels as compared with about thirty at most of the ordinary organ. It, in fact, is equivalent to the drawing of extra stops in an ordinary organ in addition to the increase produced by the opening of the swell box. From the swell pedal resistance the current is taken by a cable to the power cabinet, where it is amplified by a

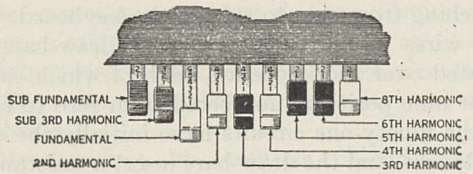


Fig. 3

further range of valves and feeds the loud-speakers, of which there may be two or four or more according to the size of the building for which the organ is required.

As already mentioned, there are two five-octave keyboards (see Fig. 2). Above the keyboards there are four groups of harmonic draw-bars, nine bars to each group; the two left groups are for the upper keyboard and the two on the right for the lower keyboard. One of these groups is shown in Fig. 3. Between these in the middle are two harmonic controllers for the pedals. To the left of the five octaves of playing keys is another group of keys looking like the playing keys except that their colours are reversed. These correspond to the piston buttons in an ordinary organ, and eighteen of them give various combinations of tones which imitate very closely the types of combinations that are obtained on an ordinary organ—the diapasons, the reeds, diapasons and reeds, full organ, certain solo stops, etc.—pressing down one of these keys brings that quality of tone into action, at the same time cancelling the last combination used. Two of the keys bring one or other of the two groups of drawbars over the keyboard into action; thus the player can change from one of these groups to the other instantly, or to any one of the nine pre-set combinations, merely by pressing the appropriate key. The great variation in power of 50 decibels given by the swell pedal makes each of these pre-set combinations equivalent to a large number of organ stops.

To indicate the use of the drawbars a few tone colours as given by the makers are set out below. The numbers indicate the extent to which the bars are drawn (third from left is the fundamental).

007,755,220	Open diapason.
012,221,300	Soft strings.
145,645,553	Full swell.
015,656,342	Diapason chorus with mixtures.
006,470,520	Clarinet.
677,778,677	Full organ.

It is obvious that an almost infinite number of combinations of these harmonics is possible, and thus an immense variety of musical tones can be imitated. The beauty of the quality of the diapason and flute tones is remarkable, and the full pedal notes come out excellently.

There can be no doubt that the loud-speaker electric organ in some form has come to stay. The small compass in which the equivalent of a large organ can be housed—the manual occupies no more room than a piano and the loud-speakers about that of a wireless set—the small cost, and the small running cost, together with the fact that it never requires tuning, are very real advantages which it possesses both for churches and for home use.

We are indebted to Messrs. Boosey & Hawkes, Ltd., 295 Regent Street, London, W.1, for information on which the above article has been partly based.

Obituary Notices

Prof. A. Wiedemann

ALFRED WIEDEMANN, professor of Egyptology at the University of Bonn, died suddenly at the end of 1936 in Bonn, at the biblical age of over eighty years. Both on his father's and his mother's side he belonged to academic families : his father, like his elder brother, Eilhard, was a well-known professor of physics and chemistry, and so was his mother's father, Mitscherlich. Wiedemann himself, although devoted from his youth to Egyptology, felt always a keen interest in natural history and anthropology, and was one of the first among his Egyptological fellow-students to become enthusiastic over de Morgan's theories on Neolithic Egypt. To the latter's book on the tomb of Naqada he contributed an exhaustive study on the methods of burial in the Naqada necropolis, and the origin of the Egyptian people : it was characteristic of Wiedemann to attempt to draw historical conclusions by interpreting Egyptian religious texts and Egyptian rites in the light of recently established archæological facts.

Wiedemann devoted much labour to the study of Egyptian religion, and he will perhaps be best known to the British public through his contribution to the *Proceedings of the Society of Biblical Archæology*, of which he was a member, and through his "Egyptian Religion", an entirely revised translation of a German book by himself. Maspero, on reviewing the German edition, regretted the lack of an elaborate bibliography imposed on Wiedemann by the editor. He alludes evidently to the notes in Wiedemann's "Egyptian History" and in his Commentary to the second book of Herodotus, where an almost incredible mass of information is put together from public and private museums, from publications and accounts of all times and countries, in which the student could find quoted nearly every opinion on any subject treated, every bit of an inscription, every scarab detected anywhere by the author, registered. This tremendous work has rendered great service, but unfortunately Wiedemann declined to make any distinction between important and less important material, and the reader found himself to a certain extent drowned by the flood of monuments big and small, and sometimes difficult of access. Wiedemann was more a sceptic than a critical spirit, and he was neither a philologist nor a historian in the narrower sense of the words. Some of his translations are excellent : his remarks on the age of Memphis against Erman's theory that the city was not founded until the Sixth dynasty, and his opposition to the attribution of the tomb at Naqada to Menes, were sound, but in both cases he missed the real point : the Naqada tomb certainly dates from the beginning of the First Dynasty, and Memphis, although existing before as a settlement, took its name from the pyramid of King Phiops.

Wiedemann disliked the sometimes too systematic way in which Erman, his pupil Sethe, and Eduard Meyer treated the language and history of Egypt. He was unjust to the undoubted achievements of these scholars, and finally resigned from collaboration in Egyptological work, being aware of the gulf which divided his methods from those of nearly all Egyptological scholars in the twentieth century. He devoted himself entirely to the study of the history of Godesberg, the native village (and now town) of his wife, his best companion in life and work.

Wiedemann was the pupil of Lepsius, Ebers and Maspero, and he was strongly influenced by the last. But he lacked the facility with which Maspero connected any new facts with his own knowledge, and he was more of a collector of sometimes very important material than a systematic worker. Maspero rightly once said of his work, that it had allowed many others to do original work, meaning that without the many references in Wiedemann's books and the many texts published by him (sometimes in small autographic pamphlets, which have become very rare), other scholars would never have been able to produce their own dissertations. This is true, and no living Egyptologist ought to forget what he owes to Wiedemann, even if many of his books and pamphlets are out of date. What is perhaps more, Wiedemann was always ready to allow anybody to make use of his library, his small but interesting collection of antiquities, and of his valuable copies, which sometimes contained passages destroyed since Wiedemann had copied them, perhaps so early as 1882–83. I have seen W. Max Müller spending weeks in Bonn in order to take notes from Wiedemann's archives.

A man so sociable as Wiedmann would naturally be a good teacher, he would put everything he knew and had at the disposal of his pupils, he would also open his house to his students, not only giving many of his lectures at home but also inviting his students on his regular Tuesday evenings, and, together with his wife, looking after them whenever they needed help. All who knew Wiedemann in his best years, before the War took his son from him and the inflation annihilated his fortune, will think with pleasure and gratitude of him and his home.

F. W. FREIH. V. BISSING.

WE regret to announce the following deaths :

Mr. R. J. Mitchell, C.B.E., chief engineer and designer of the Supermarine Aviation Works, on June 11, aged forty-two years.

Mr. J. L. Stocks, vice-chancellor of the University of Liverpool, formerly professor of philosophy and public administration in the University of Manchester, on June 13, aged fifty-four years.

News and Views

The Ultra-Centrifuge in Biochemistry

THE substance of lectures by Prof. The Svedberg, delivered in Oxford earlier this year at the inauguration of an ultra-centrifuge in the Department of Biochemistry of the University, is printed as a supplement to this issue of NATURE. The work described represents the culmination of a definite stage in Prof. Svedberg's research with the ultra-centrifuge. By a remarkable feat of engineering, he has succeeded in applying a simple principle to the measurement of molecular weights in a region which seemed inaccessible except through osmotic methods; and since these gave no information as to molecular homogeneity, no idea could be reached of the individual molecular weights of a possible mixture. His ultra-centrifuge, capable of reaching with a rotor of 180 mm. diameter speeds of at least 66,000 revolutions per minute and forces of 300,000 times gravity, seems to be for the moment the only method of getting adequate resolution in the 'mass spectrum' of a mixture of proteins. It is driven by oil turbine and has a horizontal rotor running in hydrogen at a pressure of about 25 mm. Particularly interesting is his mention of the experiments upon the best forms of steel to be used in rotor construction. They indicate all too briefly how much experimental work has been needed to evolve a final form of the apparatus. The studies upon proteins have clearly arisen in Uppsala from the long-continued interest of Prof. Svedberg in colloids. Even before the development of the recent work, he had already made valuable contributions to colloid chemistry; but these must be regarded as of minor importance in the light of the discoveries here summarized.

THE significance for biochemistry of the new work can scarcely be exaggerated. For the first time, it has been possible to know whether a protein solution is homogeneous, and knowing this to define quickly the number of molecular species present in a mixture. The latter enables us to follow the entry and presence of a foreign protein in such a medium as the blood plasma; the implications of this for a study of diseased conditions are clear. It also provides a means of following changes in molecular weight produced by varying treatment of a pure protein such as albumen. In this way it has been shown at Uppsala that slight changes in hydrogen ion concentration (which have always been realized to be of great importance in biochemistry), can cause either reversible or irreversible dissociation of a protein. Further, it is remarkable that in several cases there should be similar changes induced by crystalloids, sometimes present only in traces. A particularly striking instance is recorded for the effect of 0·001 gm. per cent of thyroxin upon a solution of thyroglobulin. Such effects, and there seem to be many of them, can scarcely fail to throw light upon the intimacy of the cell itself, where the proteins in their colloidal relations form one of the most significant features of life. The final table which records the analysis of all the proteins so far studied is remarkable for the regularities that have come to light. With few exceptions, it seems that the molecular weights of the proteins fall into well-defined multiples of 17,600. Here for the first time, we feel that there is some chance of reaching the protein ultimately by the methods of organic chemistry, since these results signify some underlying simplicity of construction.

Agriculture and Industry

IN his recent Mather Lecture to the Textile Institute on "Agriculture as a Potential Source of Raw Materials of Industry", Sir Harold Hartley described the present-day uses of many agricultural products for industrial purposes, and indicated some possibilities of further expansion. His method of approach was that of the short-term extrapolator rather than that of the Utopian dreamer, who, although a more successful prophet as a rule, is apt to disregard the mundane but essential element of cost. Sir Harold left the sphere of social economics severely alone, but he emphasized that development of agricultural industries would promote closer co-operation and better understanding between farm and factory. Only about 12 per cent, by value, of the world's agricultural production is now used for industrial purposes, but the proportion is raised to one third if forest products be included. In spite of the triumphs of the chemist, first in revealing the structure of many organic molecules, and then in synthesizing many natural products, or in processing them, the factory cannot compete with Nature in the cheap production of complex organic compounds; for supplies of cellulose, the key substance of fibrous structures, we must always rely on the plant. The future lies not in competition between Nature and the chemist, but in their closer association to produce the materials needed by man. Such a development of the use of agricultural products will help to conserve our supplies of coal and oil, for whereas these represent wasting capital assets, plant products, ever renewable by solar radiation, represent revenue without debit to capital.

IN the United States the Farm Chemurgic Council is working "to advance the industrial use of American farm products through applied science", and its members meet annually at Dearborn to discuss their problems. Among the many difficulties confronting American agriculture are soil erosion, loss of fertility due to continuous cropping, displacement of the horse by the tractor, and decreasing exports and increasing imports of farm products. It is hoped to combat some of the bad effects of these conditions by growing

new crops to replace imported products, by finding new outlets for established crops, and by better utilization of agricultural waste. Among the new crops are the soya bean, which now covers six million acres. Substances extracted or made from it have manifold uses, and Henry Ford has built a large plant for making plastics out of the meal. Tung oil, valuable for paint and varnish making, is to be derived from extensive plantings of the tung-oil tree; and, also in the Southern States, the quick-growing Southern Pine has been planted over 200 million acres to provide pulp for newsprint and as a raw material for rayon and 'Cellophane'. Among the new outlets for old crops are the use of cotton fabric for reinforcing tarred roads, of inferior cotton and cotton linters for making cellulose derivatives, and of maize for the production of starch, dextrin, corn syrup, dextrose, corn oil and cake. Also under investigation is the utilization of the enormous quantities of straw, cotton stalks, and husks that now run to waste. By promoting agricultural industries on the above lines, it is hoped to put the farmer financially on his feet, and to make him a better customer of the factory.

Total Solar Eclipse of June 8–9.

THE fact that the expedition of the National Geographic Society and the U.S. Naval Observatory was accompanied by engineers and announcers of the National Broadcasting Company of America has led to the overlooking of the other expeditions organized to observe the recent total solar eclipse (see NATURE of June 12, p. 993). It is good to report that Mr. C. B. Michie, who led an expedition from New Zealand with the aid of the Royal New Zealand Navy also to Canton Island, shared in the good luck in the form of fine weather that came the way of the American party, and secured good photographs of the corona with several very long streamers. Further, it transpires that the Princeton party to Chembote in Peru—and it is hoped the Japanese party there also—had fine weather for the actual eclipse, though as at Canton Island weather prospects were anything but favourable not long before the eclipse. The value of the results obtained by the various parties (and by the party from Princeton, the Franklin Institute and the Cook Observatory on the S.S. *Steelmaker* near the point of maximum totality) cannot yet be assessed, but in view of the number of experienced observers concerned, one may confidently look forward to results of very considerable importance.

International Peace

THE annual report of the Director of the Division of Intercourse and Education of the Carnegie Endowment for International Peace for 1936 pleads for further support for genuine world organization and collective security through an effective world police force. Dr. Murray Butler refers to the existence of a deep-seated popular sentiment against war and to the necessity of this opinion finding expression not merely in emotional outbursts but also in support of definite policies of social, economic and political co-operation and the substitution of judicial process for the threat of force in settling international differences. The advocates of economic nationalism and of neutrality, he said, are making a most insidious attack upon the foundations of prosperity and of peace, for the first involves ultimate national suicide and world-wide disaster and the latter neglect of the highest international obligations. Dr. Butler pointed out that the wars which are most threatening at the present time are between fundamental philosophies of life and of public order, and he referred to the dangers confronting democratic nations.

THE Inter-American Conference at Buenos Ayres in December was the brightest feature of the year and received support from public opinion in both American continents. The report refers to co-operation with the International Chamber of Commerce and the adoption in August by the Joint Committee of thirteen practical recommendations for improving commercial relations between nations and dealing with monetary stabilization. Reference is also made to the distribution of literature, to the Leadership Training Conference held in Des Moines, Iowa, to the work of the visiting Carnegie professors, to the International Relations Clubs, of which 805 have now been formed, as well as to the work of such associated institutions as the American Academy of Political and Social Science, the Institute of Public Affairs at various universities, the Institute of Foreign Affairs, Earlham College, Richmond, Indiana, and the Institute of Pacific Relations. Details of similar work of the Division in Europe are included, indicating the great extent to which the Division utilizes the opportunities afforded by existing organizations for carrying out its educational work.

Archæological Discoveries in Northern Syria

SIR LEONARD WOOLLEY'S first report on the current season's work of the British Museum's Archæological Expedition to Northern Syria records important discoveries, which throw fresh light on the Hittite occupation of that area and would seem to confirm references in the Biblical narrative to the relations of the Hittite people and the inhabitants of Palestine in the patriarchal age, which hitherto have been regarded as anachronisms. The expedition, Sir Leonard reports (*The Times*, June 12), has completed its first season's work in the Amk plain, inland from Antioch. The time available was brief, as excavations begun last year at Mina had to be completed; but an isolated area about twenty yards square in what was believed to be the aristocratic quarter of the city, opened up to a depth of 13 ft., has revealed a magnificent building, one of the finest as yet found in northern Syria. This structure is Hittite. It was built of basalt, mud-brick and timber. The approach was from a tile-paved area by way of a flight of basalt steps between platform buttresses, and led through a colonnade into a wide entrance court. The building had been destroyed by a fire; but the chambers adjoining the court were rich in finds of pottery, local and imported, including

Cypriote pottery of the Bronze age. An important find consisted of portions of two literary texts, which, as the oldest cuneiform documents as yet found in northern Syria, may be expected to yield results of considerable historical interest. The date of the building can be fixed with tolerable accuracy, as information from the main excavation of the year, which was on a much larger scale, indicates consecutive periods ranging from the twelfth back to the sixteenth or seventeenth century B.C. Here, below cremation graves, was found a house, which on the evidence of Mycenæan pottery belongs to the thirteenth or fourteenth century B.C. Inscribed tablets afford evidence of the existence of a royal library. In the fourth level, dated at the sixteenth century B.C., was found a house which in its details corresponds to the larger building previously described, and being characteristically Hittite, serves also to place the Hittite occupation of northern Syria at a much earlier date than hitherto accepted.

Swanscombe Skull: Committee of Investigation

THE character of the Swanscombe skull and the conditions of its discovery both in themselves and in relation to the Piltdown skull, suggested that a certain suspension of judgment was advisable for further consideration of the evidence, before accepting the find at its face value as inferred by Mr. A. T. Marston on his announcement of the find (see NATURE of October 19, 1935, p. 637 and August 1, 1936, p. 200). A report was also promised on the palæontological evidence, which clearly would have an important bearing on any conclusion to be drawn. So far, anthropologists, while admitting the importance of the discovery as reported by Mr. Marston, have been inclined to caution. An announcement, therefore, is welcome that the Royal Anthropological Institute has appointed a committee to investigate the evidence which Mr. Marston has collected, and to co-operate with him in the further investigation of the site. This committee consists of Mr. M. A. C. Hinton, keeper of zoology, British Museum (Natural History), (*chairman*), Mr. K. P. Oakley, Department of Geology, British Museum (*secretary*), Prof. P. G. H. Boswell, Imperial College of Science, London, Prof. W. E. Le Gros Clark, Department of Anatomy, University of Oxford, Mr. H. G. Dines, Geological Survey of Great Britain, Mr. C. F. C. Hawkes, Department of British Antiquities, British Museum, Prof. W. B. R. King, Department of Geology, University College, London, Mr. A. T. Marston, Dr. G. M. Morant, Galton Laboratory, University College, London, and Mr. S. Hazzledine Warren.

The Empire Cotton Growing Corporation

AT a meeting of the Administrative Council of the Empire Cotton Growing Corporation held in Manchester on May 25, it was announced that the Corporation has recently acceded to a request from the Indian Central Cotton Committee that Dr. T. G. Mason should be permitted to spend some months in India to advise in connexion with an investigation into the causes of the periodic failure of the cotton crop in the Punjab. It was also reported that in letters that had been received from Prof. J. W. Munro, who is making a tour in Africa to advise the Corporation on its work on cotton insect pest control, he has written enthusiastically of the high quality of the work that was being carried out by the Corporation's staff, and recommended that it should continue to receive full support. An addition to the staff in Nyasaland may be necessary. It was naturally impossible to say whether it would prove possible to devise any practical measures for controlling these pests, but pests constituted the limiting factor in cotton-growing throughout considerable areas in Africa, and the Corporation should therefore leave nothing undone which might bring to light any information that might possibly lead to a reduction in the loss of crop thus caused.

Genetic Theory and Practice in the U.S.S.R.

IN a note on genetics in the U.S.S.R. (NATURE, **139**, 185; Jan. 30, 1937), reference was made to the empirical work of Michurin on the hybridization of fruits, and his published work was said not to have been translated into any foreign language. Our attention had been directed to the fact that a translation, in an abridged form, is available for reference in the Bureau of Plant Genetics at Cambridge. The short published abstracts of the Bureau (*Plant Breeding Abstracts*, **5**, 56, 376 and **7**, 122) make the character of Michurin's work fairly clear. Like the recent work of Burbank in the United States, it belongs to the period of Kölreuter. It uses the assumptions and deals with the problems that were in favour in the late eighteenth century. Indifference to the refinements of later work has led Michurin, as it did Burbank, to somewhat fantastic conclusions in physiology and genetics. The reason for Michurin's indifference, however, is peculiar and significant. He states that the Mendelian principles are not in accordance with the dialectic of Engels, and must therefore be disregarded. It seems that Aristotelianism is appearing in a new quarter under a new guise.

Mechanized Farming

THE report on the discussions at the Oxford Conference on Mechanized Farming held in January last has been published. It contains the opening and concluding addresses given by Mr. C. S. Orwin and Mr. Roland Dudley respectively, and full accounts of the discussion that followed the papers dealing with tractor performance and row-crop cultivation, cultivations, the maintenance of fertility, grass drying and combine harvesting. Both the practical and scientific points of view are well represented and the publication is clearly a valuable complement to the papers themselves. The complete Proceedings of the Conference (2 vols.), which includes both the papers and discussions, may be obtained from the Conference Secretary, 10 Parks Road, Oxford, price 2*s*. 6*d*. post paid.

International Congress for the History of Science

THE arrangements for the Fourth International Congress for the History of Science, to be held in Prague on September 22–27, are proceeding. The President of Czechoslovakia, Dr. Eduard Beneš, has agreed to give his patronage, and with him are Dr. Em. Franke, Minister of Education, Dr. Kamil Krofta, Minister of Foreign Affairs, Dr. Josef Zadina, Minister of Agriculture, the rectors of the Czechoslovak universities and corresponding schools, the presidents of the academies of science and of the scientific societies of Czechoslovakia, and the Chief Mayor of Prague. On the Committee of Honour, prominent leaders in industry and science in Czechoslovakia are represented. For the plenary meetings lectures have been promised by Prof. B. Němec, formerly rector of the Charles University, president of the National Research Council of Czechoslovakia; Prof. O. Grosser, formerly rector of the German University in Prague; Prof. K. Studnička, of the Charles University; Prof. Gino Loria, of the University of Genoa, formerly president of the International Academy for the History of Sciences; Prof. Abel Rey, of the Sorbonne, director of the Institute for the History of Sciences and Technics. About a hundred papers, from Czechoslovakia and from Belgium, England, France, Germany, Italy, Poland, Portugal, Rumania, U.S.S.R., and Yugoslavia, have already been received. Members of the Congress will enjoy reductions on the railways of Czechoslovakia and of the other countries interested. Further information can be obtained from the general secretary of the Congress, Prof. Fr. Ulrich, Albertov 6, Praha II.

Institute for Research in Metals, Sendai

PROF. KÔTARÔ HONDA has lately completed his twenty-fifth year as professor of physics in the Tôhoku Imperial University, and the occasion has been commemorated by the publication of a special volume of the Science Reports of that University, contributed by his pupils and by friends from many countries. This substantial volume, of 1,126 pages, is an indication of the prominent part that Prof. Honda has played as teacher and also as director of the very active Institute for Research in Metals at Sendai. As might be expected from the special interests of Prof. Honda, from his work at Göttingen onwards, many of the papers, some sixteen in all, deal with the magnetic properties of metals, but the work of the Institute has covered a wide field in metallurgy, and most branches of the physical study of metals are represented. Another group treats of transformations of alloys in the solid state, including steels. The development of improved steels for permanent magnets has been one of the most important results of the investigations at Sendai, the discoveries made there having had profound industrial effects, through reducing the size of magnets and even of enabling them to take the place of electromagnets in machine tools, etc. Terrestrial magnetism is also represented, whilst other papers describe investigations in chemistry. Many well-known names are to be found among the contributors, and the occasion has been used to present surveys of the position of knowledge concerning several of the properties of alloys of current interest.

Transmission of Electricity in France

AN instructive lecture was given by P. M. J. Ailleret to the Transmission Section of the Institution of Electrical Engineers on April 29, the subject of the discourse being recent developments of electric transmission in France. The French system includes lines operating at 110, 120, 150 and 220 kV. The reason for this difference is partly historical and partly geographical. The grid was begun in France in 1920, the pressure used being 120 kV.; a few years later it was considered necessary to raise it to 150 kV., and the first 220 kV. line was erected five years ago. Every time a new line was proposed which did not interest existing producers, a new company had to be formed, and the whole system was financed by the co-operation between producers, distributors and interested industries. No less than thirty-nine companies were formed to finance the construction of the lines, but the responsibility for operation is entrusted to a fairly small number of them. Another reason for the use of several voltages is that in France the price of coal varies much more from one part of the country to another than it does in England. Hydro-electric generation is concentrated in limited mountain areas and nearly half the total production comes from this source. Some regions which are rich in water power have practically no local consumers, others have an important electrochemical and electrometallurgical load, constant during the day, but with seasonal fluctuations which are advantageously combined with the usual loads of a distribution system. For these reasons a voltage of 220 kV. has in some cases been necessary. An eleven mile underground cable at this voltage was found necessary to transmit the energy from the south-east to the St. Denis power station through a densely populated suburban area. This oil-filled cable can carry 150,000 kilovolt-amperes.

Fishing Gear

THE third edition of "An Account of the Fishing Gear of England and Wales" (H.M. Stationery Office. 6*s*. net), has recently been issued, since the first publication in 1923, a fact which bears full witness to its value. The subject is a vast one, for Mr. Davis's account ranges from the single hook hand-line to the modern otter trawl, from the whelk-pot to the fish weir nearly a quarter of a mile long. The most important modern fishing gears—otter trawl and drift net—are dealt with in detail, and the methods of shooting, fishing and hauling clearly explained. In this connexion it may be mentioned that many east coast drifters now shoot mackerel-nets forward, rather than over the stern. There is a section on the Danish plaice seine, and Mr. C. F. Hickling has rewritten the account of the Vigneron-Dahl trawl. Many of the instruments of the inshore

fisherman described are now disused, or obsolescent, so that parts of the account are chiefly of historic interest. It is interesting to see how similar types of net have been evolved by fishermen on different parts of the coast, and how one type of net grades into another. The author points out that the Saltash tuck-seine is practically a trawl, and the Beer 'fly-backed otter trawl' a seine. The braiding and setting of nets and their preservation is dealt with. Indeed, the use of Mr. Davis's paper would make clear any reference to the methods of fishing around the British coasts, or the description of the shape and construction of any net.

St. Kilda Papers 1931

A PUBLICATION entitled "St. Kilda Papers 1931" has just been issued, and contains, in addition to a foreword, bibliography and large-scale map, reprints of eleven papers previously published in various scientific journals. These papers, which deal with the mice, the breeding birds, the early autumn migration in 1931, the St. Kilda wren, the Coleoptera, the flora and the vegetation of St. Kilda, comprise the chief scientific results of an expedition to the island in the summer of 1931, the year following the evacuation of the islanders. As "St. Kilda Papers 1931" is limited to an edition of only fifty copies, none is available for sale; but as the publication is intended as a basis for any future scientific work on the island, twenty-five copies have been presented to leading public libraries and to the libraries of learned scientific societies for reference purposes. Any further information relative to this publication or to the deposition of the library copies can be obtained from Mr. Malcolm Stewart, Hawridge Court, Nr. Chesham, Bucks.

The World Power Conference

WE have received a summary of the annual report for 1936 of the World Power Conference, prepared by the Central Office, 36 Kingsway, London, W.C.2. The chairman is Sir Harold Hartley (Britain) and the vice-chairmen are O. C. Merrill (United States), G. T. T. Bakker (Netherlands) and M. Kamo (Japan). The plenary conference was held in Washington on September 7–12, 1936, and was attended by about 3,000 members from fifty-four countries. Year book No. 1 was published in October 1936, and it is hoped that No. 2 will be published in September next. Statistics on manufactured gas and coke will be added in this and subsequent year books. The work of the international sub-commission on special cements is going steadily forward, and work on an international technical dictionary in connexion with dams will soon be begun. The International Executive Council has unanimously accepted the invitation of the German National Committee for the second chemical engineering congress to be held in Berlin in 1940. There is little doubt that the fourth World Power Conference will take place in 1942, thus preserving the interval of six years between successive plenary meetings.

University of Lausanne

THE fourth centenary of the University of Lausanne was celebrated on June 4–5, when honorary degrees were conferred on the following, among others: Sir Maurice Amos, Quain professor of comparative law in University College, London (Doctor of Laws); Sir Frederick Gowland Hopkins, Sir William Dunn professor of biochemistry, in the University of Cambridge (Doctor of Medicine, *in absentia*); Prof. G. Barger, professor of chemistry in relation to medicine in the University of Edinburgh (Doctor of Pharmacy); and Prof. G. Rudler, Foch professor of French in the University of Oxford (Doctor of Letters). The University of Lausanne began in 1537 as the first college for the training of Protestant ministers, and other faculties were added during the nineteenth century.

National Baby Week

THE National Baby Week Council announces that National Baby Week will be held on July 1–7. The theme selected for discussion and publicity this year is "Housing and Home in Relation to Maternity and Child Welfare", and a housing manifesto has been issued embodying certain ideals and ideas that may serve as a basis for discussion. This and other particulars may be obtained on application to the Secretary at 117 Piccadilly, London, W.1.

Announcements

THE University of Athens, on the occasion of its centenary celebrations, has conferred on Prof. F. G. Donnan, University professor of chemistry in University College, London, the honorary degree of D.Sc.

MR. EDGAR P. CHANCE, of Bulwell, Burchetts Green, near Maidenhead, has arranged a second exhibition of his collection of British birds' eggs to be held at the above address on June 25–26. The exhibition comprises about 150 drawers or trays selected from Mr. Chance's collection. Admission, from 10 a.m. until 8 p.m., is free.

A CONFERENCE on Magnetism will be held in the Physics Department of the University of Manchester on July 1–2, under the auspices of the Manchester and District Branch of the Institute of Physics. Prof. W. L. Bragg, the chairman of the Branch, will preside over the Conference and the following will give lectures: G. Richer, D. A. Oliver, Prof. N. F. Mott, Dr. C. Dannatt, Dr. E. C. Stoner, and Dr. A. J. Bradley. Visitors will be welcome, and further particulars may be obtained from Dr. C. Sykes, Research Department, Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

THE fifty-sixth annual meeting of the Society of Chemical Industry will be held at Harrogate on July 5–9 under the presidency of the Right Hon. Lord Leverhulme. Prof. G. G. Henderson, recipient of the Society's Medal, will give an address entitled, "A Retrospect; Notes on some Development in the

(*Continued on p.* 1063)

NATURE

SUPPLEMENT

No. 3529 SATURDAY, JUNE 19, 1937 Vol. 139

The Ultra-Centrifuge and the Study of High-Molecular Compounds

By Prof. The Svedberg, University, Uppsala

Introduction and Theory

An atomic weight determination of a 'natural' mixed element by chemical methods gives only a mean value. It does not furnish any information about the individual weights of the different atomic species or isotopes constituting the mixture. Such data may be collected by mass-spectroscopic studies.

Molecular weight determinations by osmotic pressure and viscosity methods likewise give only mean values. Now in the case of high-molecular compounds, there are often present in the same solution a number of different molecular species differing in mass and shape. The properties of the solution as well as of the dried substance depend to a great extent upon the distribution of the different molecular species. A molecular weight analysis is therefore of considerable importance when studying high-molecular compounds. The ultra-centrifuge enables us to carry out such an analysis.

The interest in high-molecular compounds has been rapidly growing during recent years. The role of proteins in the organism is a matter of life and death, and the elucidation of the constitution and physico-chemical properties of these substances is therefore an urgent task. Certain industries dealing with proteins are also interested in progress in this field. For our understanding of the properties of polysaccharides, such as starch, glycogen, cellulose and their derivatives, as well as the behaviour of the associated hydrocarbons and the high-molecular dyestuffs, it is necessary to study their molecular size under various conditions. The ultra-centrifuge offers a possibility of solving many of the problems in question.

What we aim at in ultracentrifuging is an accurate determination of the molecular sedimentation in a strong centrifugal field. Two lines of approach are possible. We can measure the rate of settling of the molecules—the sedimentation velocity—or we can measure the competition between settling and diffusion—the sedimentation equilibrium—which is finally reached after prolonged centrifuging. In the former case we need an independent determination of the diffusion constant in order to calculate the molecular weight. The latter method furnishes directly the molecular weight[1-7].

The sedimentation velocity reduced to unit centrifugal field and to standard frictional conditions represented by water at 20° C. is called the sedimentation constant.

$$s = \frac{dx}{dt} \cdot \frac{1}{\omega^2 x} \cdot \frac{\eta}{\eta_0} \cdot \frac{1 - V\rho_0}{1 - V\rho} \quad . \quad . \quad . \quad (1)$$

where dx/dt is the observed translational velocity, x the distance from centre of rotation, ω the angular velocity of the centrifuge, η and ρ the viscosity and density of the solution, η_0 and ρ_0 the same quantities for water at 20° C., and V the partial specific volume of the solute.

From the sedimentation constant s and the diffusion constant D, we get the molecular weight

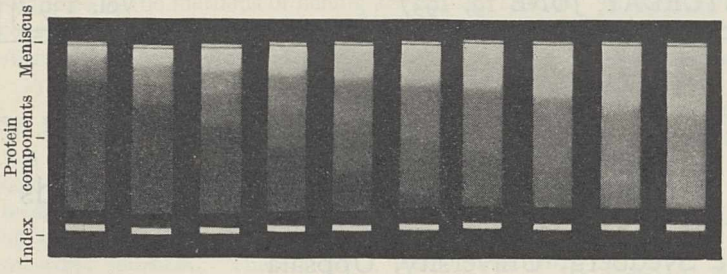
$$M = \frac{RT\,s}{D(1 - V\rho)} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where R is the gas constant and T the absolute temperature.

The knowledge of the distribution of concentration c with distance from centre of rotation in equilibrium enables us to calculate the molecular weight from the following formula :

$$M = \frac{2\,RT \ln c_2/c_1}{(1-V\rho)\omega^2(x_2^2-x_1^2)} \quad . \quad . \quad . \quad (3)$$

In both cases a small quantity of the solution to be studied is enclosed in a sector-shaped cell provided with plane-parallel ultra-violet transparent windows and rotated at constant (or but slightly changing) temperature. Freedom from convection currents is an essential feature of the procedure. Given the height and thickness of the column of solution and its distance from the centre of rotation, all other characteristics of the ultra-centrifuge can be unambiguously derived. The dimensions of the sample of liquid determine the size of the observation windows of the cell and its outer diameter. The dimensions and situation of the cell holes determine the size of the rotor and its shape, as well as the maximum speed attainable with given rotor and cell materials.



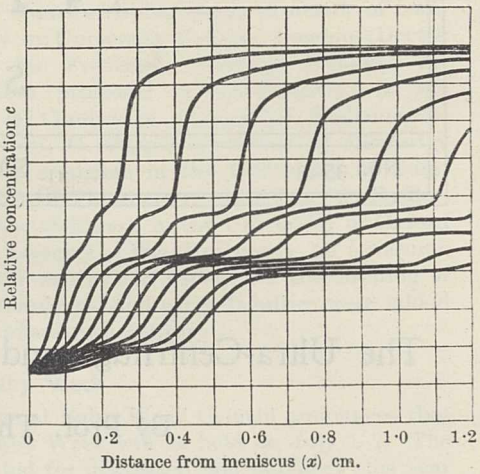


Fig. 1.

(*Left*) SEDIMENTATION PICTURES OBTAINED BY MEANS OF THE LIGHT ABSORPTION METHOD ; AND (*right*) CURVES OF CONCENTRATION DISTRIBUTION FOR *Limulus* HÆMOCYANIN AT *p*H 6·8 ; SEDIMENTATION CONSTANTS OF COMPONENTS, $56{\cdot}6 \times 10^{-13}$, $34{\cdot}6 \times 10^{-13}$, $16{\cdot}1 \times 10^{-13}$, $5{\cdot}9 \times 10^{-13}$; CENTRIFUGAL FORCE 120,000 TIMES GRAVITY ; TIME BETWEEN EXPOSURES 5 MIN. (I.-B. ERIKSSON-QUENSEL[20]).

If the substance is electrolytically dissociated, the disturbing influence of the charges may be eliminated by the addition of a non-sedimenting electrolyte.

APPARATUS AND EXPERIMENTAL PROCEDURE

In order to determine molecular sedimentation velocities, centrifugal fields of high intensity have to be used so as to shorten the time of observation, thus avoiding undue blurring of the boundary due to diffusion. In sedimentation equilibrium measurements, the centrifuging is carried on long enough at a comparatively low speed so as to attain an equilibrium between sedimentation and diffusion.

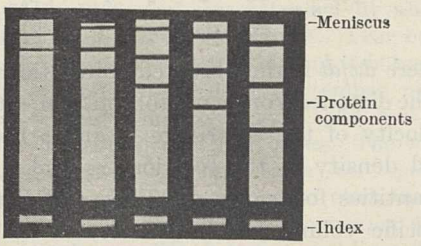


Fig. 2.

SEDIMENTATION PICTURES FOR *Limulus* HÆMOCYANIN OBTAINED BY MEANS OF THE TÆPLER *Schlieren*-METHOD AT *p*H 6·8, SHOWING THE FASTEST THREE SEDIMENTING COMPONENTS OF $s = 56{\cdot}5 \times 10^{-13}$, $34{\cdot}6 \times 10^{-13}$, AND $16{\cdot}1 \times 10^{-13}$; CENTRIFUGAL FORCE 120,000 TIMES GRAVITY ; TIME BETWEEN EXPOSURES 5 MIN. (I.-B. ERIKSSON-QUENSEL[16]).

The diameter of the rotor should be large enough to allow of the cell being placed at a suitable distance from the centre of rotation. In velocity measurements, the accuracy is decreased if the sample of solution studied is rotating with too small a radius. The part of the liquid where the concentration is independent of distance becomes impoverished too quickly, decreasing with time inversely as the square of the distance from the centre of rotation.

For low-speed runs, the rotor may be made with cylindrical outline, which has the advantage of good heat-exchange with the surrounding casing. At high speed, an oval shape with two cell holes—one for the solution cell and one for the balancing cell—must be chosen in order to reduce the strain. A vane of proper diameter screens off false light.

As rotor material chromium-nickel steel has proved the best. The highest centrifugal forces (1,000,000 times gravity) were reached using hard steel, but at the same time accidents during the test runs were often met with. Soft steel has been found more reliable, especially in the case of big rotors.

To diminish friction, the rotation has to take place in a medium of low viscosity. Vacuum is advisable only when the construction is such that practically no heat from the bearings is transferred to the rotor. An atmosphere causing some friction but possessing a high heat-conductivity is preferable. In those circumstances, the heat generated will be conducted away so quickly that satisfactory thermal conditions can be permanently maintained and convection currents avoided. For low-speed runs, hydrogen at normal atmospheric pressure may be used. For higher speeds, the hydrogen pressure should be cut down to about 25 mm. in order to reduce the friction without diminishing the heat-conductivity of the gas.

Up to speeds of about 20,000 r.p.m. or even somewhat higher, the rotor can be supported by ball-bearings. At high speed (20,000–160,000 r.p.m.) they become unreliable and have to be replaced by journal bearings. In the Uppsala machines oil-lubricated white-metal was chosen. With good balancing, the bearing pressures are very low, hence the surface of the bearings may be kept small and the heat-production and energy loss by friction low. For a recent type of our rotors it is 0·7 kW. at 60,000 r.p.m.

If the rotor is not self-balancing, it is of considerable importance not only that it should be in perfect balance, both statically and dynamically, but also that provision should be made for some sort of damping device to take care of small accidental irregularities in the movement and to prevent such disturbances from building up dangerous vibrations. A special type of damping bearings was therefore developed at Uppsala. The bearing surface is divided into six parts, three of which are fixed and three others form the ends of moving pistons acted upon by oil pressure. The movement of one of the pistons can be adjustably limited by means of a micrometer screw.

In the air-driven self-balancing ultra-centrifuge developed by Beams[8], Bauer[9], and Wyckoff[10], a light duraluminium rotor is hanging on a thin steel shaft and supported by an air-film bearing. The friction, and consequently the energy consumption, are therefore very low. The air-turbine is sealed off from the vacuum chamber in which the rotor moves by surrounding the vertical shaft with an oiled gland-shaped bearing.

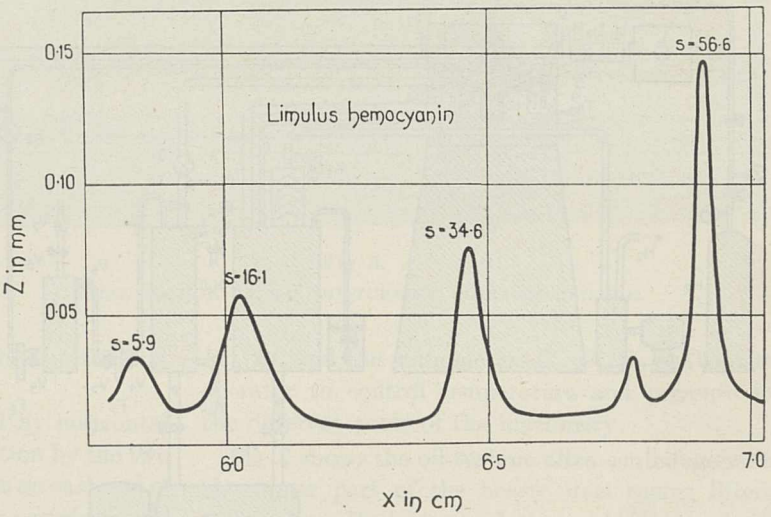


Fig. 3.

SEDIMENTATION DIAGRAM FOR *Limulus* HÆMOCYANIN OBTAINED BY MEANS OF THE REFRACTIVE INDEX METHOD AT *p*H 6·8 SHOWING THE SAME FOUR MAIN COMPONENTS AS IN FIG. 1 AND ALSO A SMALL AMOUNT OF A FIFTH ONE; CENTRIFUGAL FORCE 120,000 TIMES GRAVITY; TIME AFTER REACHING FULL SPEED 35 MIN. (K. O. PEDERSEN).

Direct electric drive with a heavy rotor self-balancing on top of a vertical shaft has proved very good for speeds up to 20,000 r.p.m.[11]. Beams has succeeded in spinning electrically a hanging duraluminium rotor supported by an air-film bearing up to 60,000 r.p.m.[12]. For driving a heavy rotor at high speed, turbines appear to be the best means[13,14,15]. Oil-turbines have been chosen by us for the following reasons. There is no danger of contaminating the atmosphere around the rotor by gas from the turbine. The same compressor may be used for delivering the lubricating oil and the oil operating the damping bearings. The output of our oil-turbines compares favourably with that

of air-turbines of similar power dimensions. In recent constructions the energy consumption of the oil compressor motor at a centrifuge rotor speed of 60,000 is 2·8 kW.

For the calculation of sedimentation constants and molecular weights, knowledge of the temperature in the rotating sample is necessary. In low-speed runs the temperature of the cell may with sufficient accuracy be taken as equal to the temperature in the thermostat bath surrounding the rotor chamber. In high-speed runs with the oil-turbine centrifuge, a radiation thermocouple placed very close (0·15 mm.) to the surface of the rotor near the cell hole registers the actual temperature of the cell.

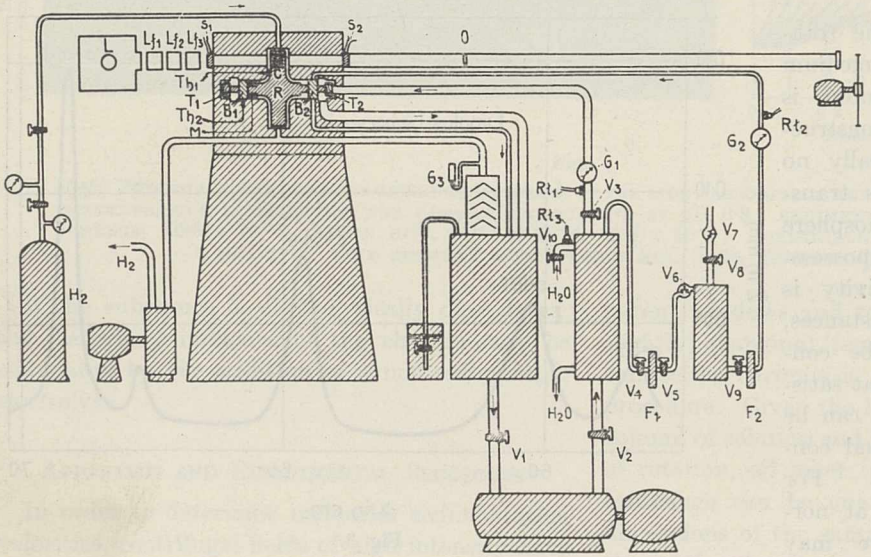


Fig. 4.

DIAGRAM OF THE HIGH-SPEED OIL-TURBINE ULTRA-CENTRIFUGE EQUIPMENT.

The angular velocity enters to the second power in the formulæ for sedimentation constant and molecular weight. The accurate determination of this quantity is therefore of great importance in ultra-centrifugal technique. In the case of direct drive by an A.C. motor, a measurement of the frequency of the electric current suffices, because with ball-bearings and the rotor running in hydrogen there is no noticeable slip. For the high-speed oil-turbine centrifuge, a stroboscopic tachometer was at first used. A more convenient magneto-electric method for speed measurement has recently been worked out. Part of the shaft of the centrifuge rotor is magnetized and surrounded by a two-pole soft iron armature provided with coils. This device constitutes a magneto-electric generator which produces an A.C. current of the same frequency as the revolutions per minute of the rotor. After amplifying, this current is fed to a vibration frequency meter or to an oscillograph.

The process of sedimentation is followed by optical means. Two different properties of the solute may be utilized for the determination of the concentration distribution in the rotating solution, namely, the light absorption and the refraction. In both cases the thickness of the layer of liquid studied necessitates long-focus lenses in order to avoid parallactic errors. When using the absorption method, photographic exposures of the sedimenting column are made from time to time by light of a wave-length absorbed by the solute. These pictures are then measured by means of a microphotometer and give the relation between concentration c and distance x from centre of rotation. Each molecular species is brought out as a step on the c–x curve (Fig. 1). The change in refractive index can be made use of in various ways. The simplest way is to apply the Tœpler *Schlieren*-method (A. Tiselius and K. O. Pedersen[16]). The different molecular species present are then recorded on the plate like the lines of a mass-spectrum (Fig. 2). A more accurate procedure to obtain the real concentration distribution in the sample studied is to take pictures of a finely ruled scale through the sedimenting column of solution by light of a wave-length which is not absorbed (O. Lamm[17]). By measuring the displacement of the lines, we get the concentration gradient dc/dx as a function of the distance from the centre of rotation. Each molecular species is therefore shown as a maximum on a curve (Fig. 3).

The resolving power of the ultra-centrifuge is given by the expression $\omega^2 xh$ where ω is the angular velocity, x the distance from centre of rotation and h the height of column of solution in the cell. Insufficient centrifugal force, $\omega^2 x$, may be compensated, therefore, by high column of solution, and vice versa. The method of rotor construction limits the maximum value for $\omega^2 xh$

attainable to $5{\cdot}8 \times 10^8$, which corresponds to a speed around 65,000–75,000 r.p.m., a rotor diameter of about 180 mm. and a height of column of solution of about 18 mm.

The high-speed oil-turbine ultra-centrifuge equipment devised for sedimentation velocity measurements on substances of high molecular weight (in the case of proteins from 15,000,000 down to about 1,000) and for sedimentation equilibrium measurements on low-molecular substances is represented diagrammatically in Fig. 4. A detailed section of the centrifuge through the axis of rotation is shown in Fig. 5, and a photograph of rotor and cell in Fig. 6.

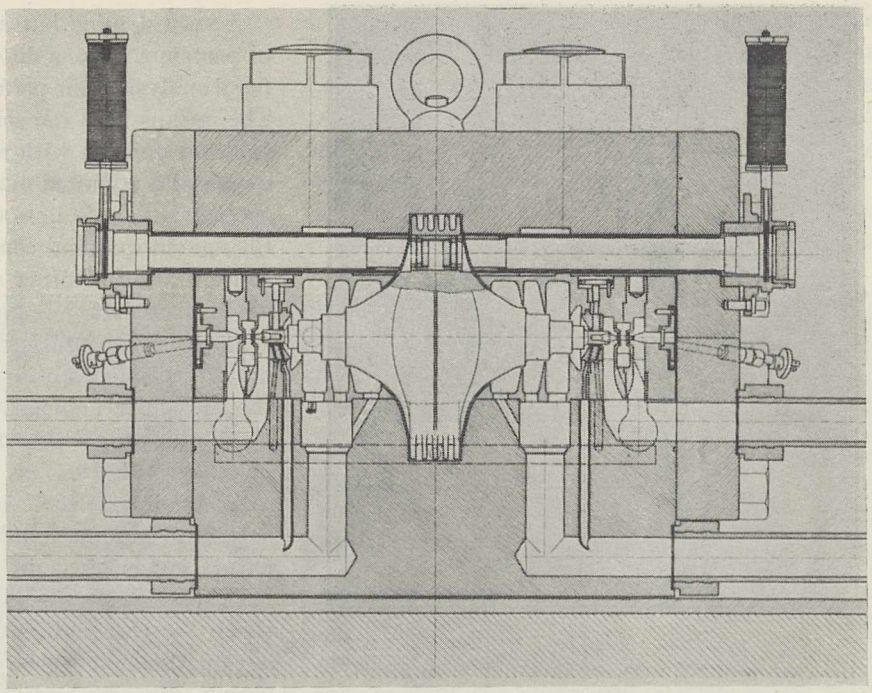


Fig. 5.
AXIAL SECTION OF THE OIL-TURBINE ULTRA-CENTRIFUGE.

The rotor R (Fig. 4) is supported by horizontal bearings B_1 and B_2, and kept in rotation by the two small oil twin-turbines T_1 and T_2, one on each end of the shaft. Hydrogen is let in at the periphery and constantly pumped off so as to maintain a pressure of about 25 mm. Thermocouples Th_1 and Th_2 serve for temperature determinations of the bearings and the rotor. A beam of light from a mercury lamp L filtered through Lf_1, Lf_2, Lf_3 passes the cell C in the rotor on its way to the camera. The exposures are timed by means of the electromagnetic shutters S_1 and S_2. The stroboscope or the magnetic generator M enables the observer to measure the speed of the rotor. The pressure oil which feeds the turbines is produced by a special oil-compressor and cooled to a suitable temperature before entering the turbine chambers. The lubricating oil for the bearings passes through an oil filter and is controlled by the valve V_5. By changing the speed of the motor which drives the compressor and by operating the valve V_3, the pressure of the oil entering the turbines may be regulated so as to make possible measurements at any desired speed between 20,000 and 140,000 r.p.m. (corresponding to centrifugal forces 30,000–700,000 times gravity). The resistance thermometers Rt_1, Rt_2, Rt_3 and the manometers G_1, G_2, G_3 enable the operator to control temperature and pressure in the different parts of the machinery.

Fig. 7 shows the oil-turbine ultra-centrifuge with the upper part of the heavy steel casing lifted, laying bare the rotor and the turbine chambers. The cell with its sector diaphragm is in the vertical position, upside down. Behind the centrifuge is the lamp house and the filters. The two halves of the thick steel casing are held together by bolts of chromium-nickel steel firmly anchored in a

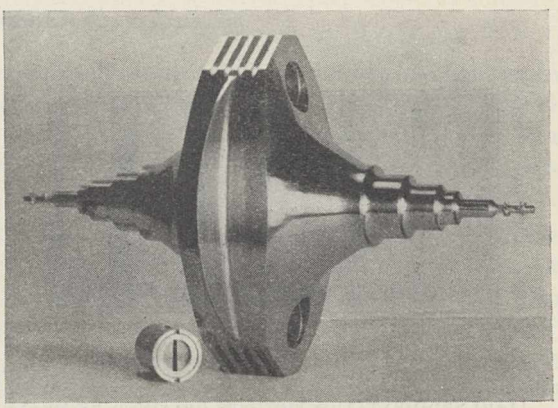


Fig. 6.
ROTOR WITH TURBINES AND CELLS FOR THE OIL-TURBINE ULTRA-CENTRIFUGE.

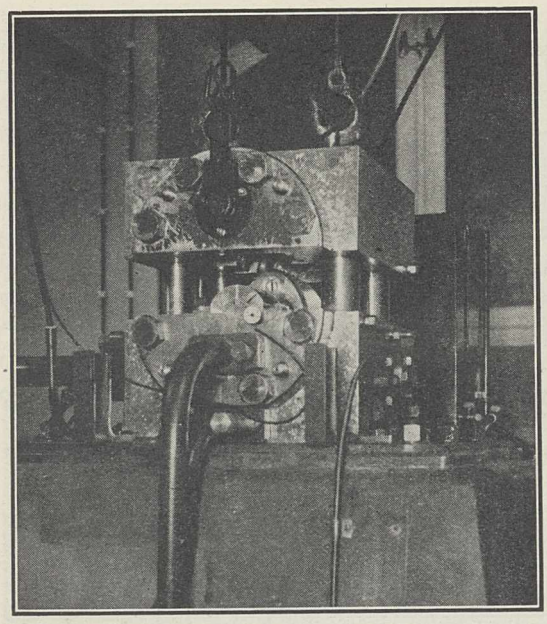


Fig. 7.

THE OIL-TURBINE ULTRA-CENTRIFUGE WITH THE LID RAISED.

concrete foundation. Fig. 9 is a photograph of the whole installation showing, from right to left, the lamphouse, the centrifuge on its foundation, the camera and the oil-coolers and containers ; in the foreground are the steps down to the machine pit where the oil-compressor, the oil filters and the vacuum pump are mounted.

INVESTIGATIONS ON PROTEINS

Among the various groups of high-molecular compounds the mass analysis of which has been attempted by means of the ultra-centrifuge, the proteins stand out as an especially interesting and peculiar class[7,18,19].

A very striking but rather unexpected property of protein solutions discovered by the ultra-centrifugal analysis is the perfect molecular homogeneity. This means that the solution of a certain protein is either uniform with regard to molecular weight or contains a limited number of different molecular species, as a rule in equilibrium with each other. Change in protein concentration, in *p*H, or in concentration of other solutes present may bring about dissociation or association.

If the sedimentation proceeds so quickly that no appreciable diffusion takes place during a run, the molecular homogeneity can be tested simply by studying the degree of sharpness of the receding boundary (Fig. 8).

An example of the behaviour of a high-molecular substance become non-homogeneous by slight denaturation is given in Figs. 10 and 11.

In cases where the sedimentation proceeds more slowly, so that noticeable diffusion occurs during a run, the homogeneity can be tested by comparing the theoretical sedimentation-diffusion curves with the observed ones (Fig. 12).

A homogeneity test may also be performed by means of sedimentation equilibrium measurements (Fig. 13). Here the molecular weight values should be independent of distance from centre of rotation.

The dependence of a protein on *p*H is exemplified by the stability diagram of *Helix* hæmocyanin (Fig. 14). At the isoelectric point the protein contains only one component, but on lowering or raising the *p*H, points are reached where a very small change in *p*H causes a great change in the

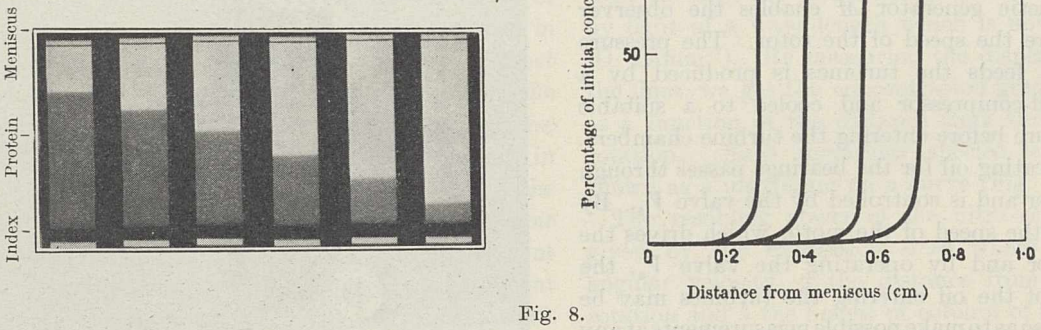


Fig. 8.

(*Left*) SEDIMENTATION PICTURES OBTAINED BY MEANS OF THE ABSORPTION METHOD ; AND (*right*) CURVES OF CONCENTRATION DISTRIBUTION FOR *Helix* HÆMOCYANIN at *p*H 5·5 (M = 6,740,000, s = 98·9 × 10^{-13}) ; CENTRIFUGAL FORCE 45,000 TIMES GRAVITY ; TIME BETWEEN EXPOSURES 5 MIN. THE SHARPNESS OF THE BOUNDARY AND STEEPNESS OF THE CURVES DEMONSTRATE THE HIGH DEGREE OF MOLECULAR HOMOGENEITY OF THIS PROTEIN (I.-B. ERIKSSON-QUENSEL[20]).

molecular state. The original molecule of weight 6,740,000 ($s=98{\cdot}9\times10^{-13}$) dissociates step-wise into halves ($s=62{\cdot}0\times10^{-13}$), eighths ($s=16{\cdot}0\times10^{-13}$) and sixteenths ($s=12{\cdot}1\times10^{-13}$). The *p*H-dissociation products represent perfectly homogeneous components[20]. The presence of divalent ions ($Ca^{\cdot\cdot}$, $Mg^{\cdot\cdot}$) causes a considerable change in the stability diagram of *Helix* hæmocyanin. Measurements of the Tyndall effect gave the first indication of this interesting phenomenon (J. Brosteaux[21]). An analysis by means of the ultra-centrifuge (I.-B. Eriksson-Quensel) has shown that upon addition of 0·01 molar calcium chloride, the dissociation on the alkaline side of the isoelectric point does not become noticeable until a *p*H of about 9·5 is reached, where splitting of the molecule into halves and eighths takes place. Without $Ca^{\cdot\cdot}$ the dissociation starts already at *p*H 7·4.

The reversibility of the dissociation-association process influenced by hydrogen ion concentration is demonstrated by the following experiment. A solution of *Helix* hæmocyanin at *p*H 6·8 of sedimentation constant $98{\cdot}9\times10^{-13}$ (molecular weight 6,740,000) was brought to *p*H 8·0, where it contains three components with the sedimentation constants $98{\cdot}9\times10^{-13}$, $62{\cdot}0\times10^{-13}$, $16{\cdot}0\times10^{-13}$ (molecular weights 6,740,000, 3,370,000, and 842,000). The *p*H was then changed back to 6·8 and a sedimentation analysis performed. It was found that all the fragments of dissociation had completely united to form the original component of $s=98{\cdot}9\times10^{-13}$ (molecular weight[20] 6,740,000).

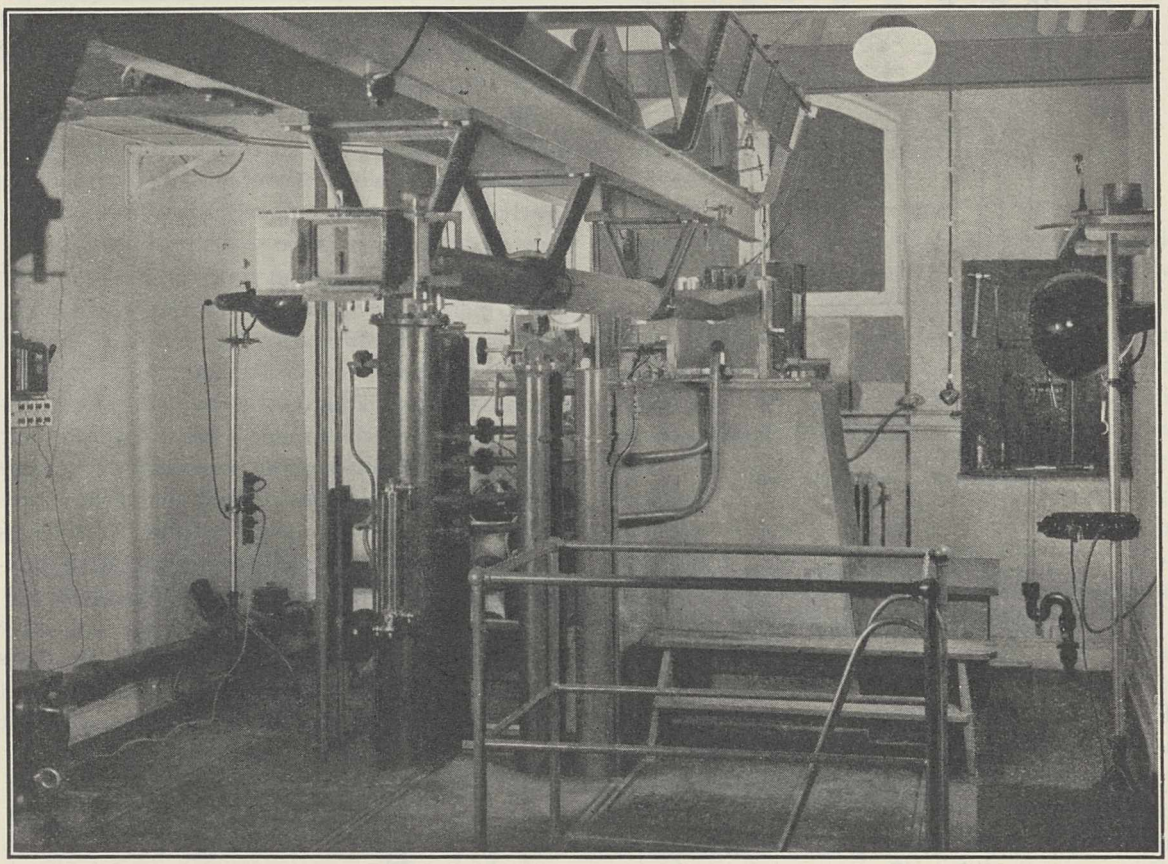


Fig. 9.

THE OIL-TURBINE ULTRA-CENTRIFUGE INSTALLATION.

High dilution often causes dissociation. Thus hæmoglobin is partly dissociated into half molecules upon dilution[29]. In dilute solutions of thyroglobulin there are present several dissociation products[23]. The addition of an amino acid or another protein often causes dissociation. Thus serum albumin may be split by adding clupein[42].

In certain cases even extremely small amounts of foreign substances may cause appreciable dissociation. Thus the addition of 0·001 per cent thyroxin gives rise to an appreciable dissociation of thyroglobulin (Fig. 15)[23].

The action of a dissociating compound on a protein is more or less specific. An amino acid which acts strongly upon a certain protein may have no effect on another protein, and vice versa.

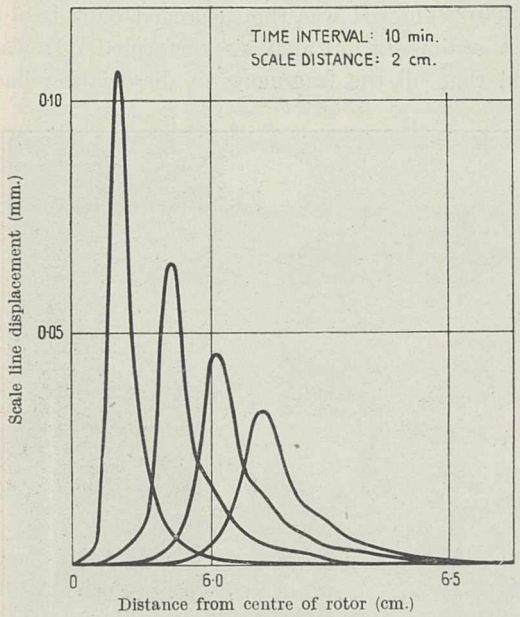


Fig. 10.

SEDIMENTATION DIAGRAM OBTAINED BY MEANS OF THE REFRACTIVE INDEX METHOD FROM SLIGHTLY DENATURED TOBACCO-MOSAIC VIRUS PROTEIN AT *p*H 9.5; CENTRIFUGAL FORCE 10,000 TIMES GRAVITY; TIME BETWEEN EXPOSURES 10 MIN. (I.-B. ERIKSSON-QUENSEL [20a].

Thus arginin plus ammonium chloride dissociates serum albumin but not *Helix* hæmocyanin, while lysin plus ammonium chloride splits the latter protein but not the former. Guanidin chloride affects *Helix* hæmocyanin very strongly but has only a very slight effect on serum albumin. Clupein splits both, and arginin without ammonium chloride has no effect on either of them (K. O. Pedersen, I. B. Eriksson-Quensel).

High salt concentration may cause dissociation or association. In solutions of thyroglobulin ($s=19{\cdot}2\times10^{-13}$; $M=640{,}000$), the addition of 4 molar sodium chloride gives rise to a homogeneous association product of $s=196\times10^{-13}$, corresponding to a molecular weight[23] of about 16,000,000.

The above survey has aimed at giving a general picture of the physico-chemical properties of the protein molecules, especially with regard to the influence of environment. In the following, a short summary of some of the results obtained in Uppsala for special groups of proteins will be presented.

The serum proteins are among those which have been most fully studied, but which still present notable difficulties. Serum albumin ($M=67{,}000$; $s=4{\cdot}5\times10^{-13}$) is found to be homogeneous both in sedimentation and electrophoresis. Serum globulin is complex. Molecules ($s=7{\cdot}1\times10^{-13}$) of mass double that of serum albumin and reversibly dissociating into halves make up the bulk of it. Usually there is also present components of larger mass, among which the most prominent one has a sedimentation constant of 17×10^{-13} (v. Mutzenbecker[24], McFarlane[25]).

Fig. 16 shows the sedimentation pictures (*Schlieren*-method) for a pathological serum (amyloid-nephrosis) with three protein components clearly resolved and a fourth just beginning to show up at the meniscus.

In antitoxic sera the amount of globulin is very much increased. This rise in globulin content may be due to formation of molecules of the normal globulin mass ($s=7{\cdot}1\times10^{-13}$) or molecules of mass corresponding to the sedimentation constant 17×10^{-13}. The former is the case with rabbit antibody globulin against pneumococcus type specific polysaccharides. The analogous horse antibody globulin is composed entirely of molecules sedimenting with the high constant (M. Heidelberger, K. O. Pedersen, A. Tiselius[26]).

The milk proteins are very complex and have not yet been completely disentangled. In cow's milk there are two albumins, the α-lactalbumin, of molecular weight 17,600 and sedimentation constant

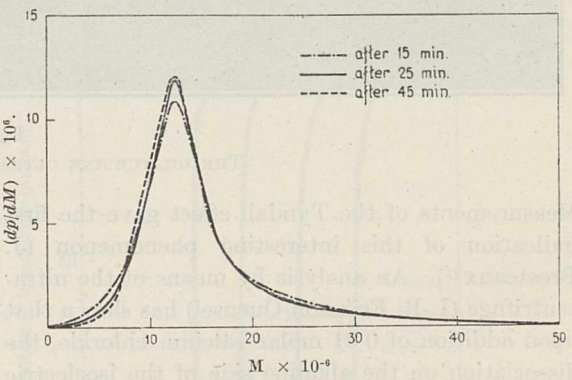


Fig. 11.

MOLECULAR WEIGHT DISTRIBUTION CURVES FOR A SLIGHTLY DENATURED TOBACCO-MOSAIC VIRUS PROTEIN AT *p*H 9·5 (I.-B. ERIKSSON-QUENSEL [20a]).

$1{\cdot}9\times10^{-13}$ and β-lactalbumin (also called Palmer's lactoglobulin) with $M=39{,}000$ and $s=3{\cdot}12\times10^{-13}$. Then there is a typical globulin of probably the double molecular weight, and several caseins[27].

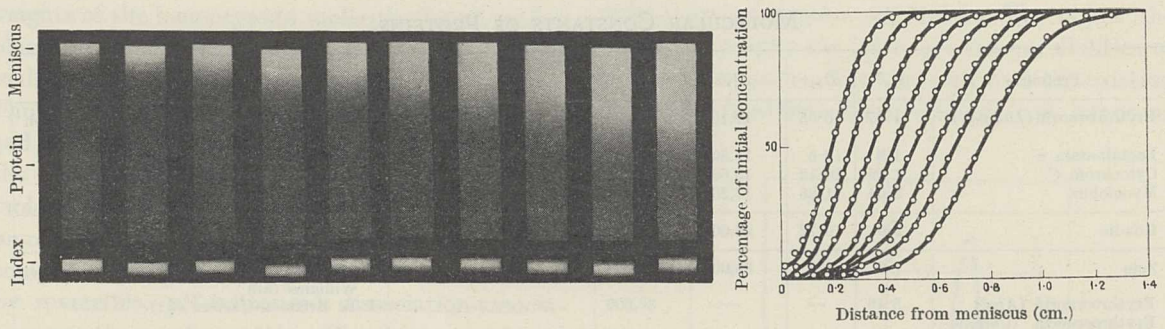


Fig. 12.

(*Left*) SEDIMENTATION PICTURES OBTAINED BY MEANS OF THE ABSORPTION METHOD; AND (*right*) CURVES OF CONCENTRATION DISTRIBUTION FOR α-LACTALBUMIN (M = 17,600; s = 1·9 × 10^{-13}; D = 10·6 × 10^{-7}); THE OBSERVED AND THE THEORETICAL VALUES AGREE, WHICH SHOWS THAT α-LACTALBUMIN IS HOMOGENEOUS WITH REGARD TO THE MOLECULAR WEIGHT; CENTRIFUGAL FORCE 310,000 TIMES GRAVITY; TIME BETWEEN EXPOSURES 40 MIN. (K. O. PEDERSEN).

The respiratory proteins are of great interest not only because of their unique physiological importance but also from a physico-chemical point of view. With regard to the nature of the prosthetic group, these proteins may be divided into four groups; red pigments (erythrocruorins, hæmoglobins), green pigments (chlorocruorins), brown pigments (hæmerythrins), and blue pigments (hæmocyanins). The first three types contain iron, the last one copper.

One of the most striking points is the fact that low sedimentation constants, and therefore, comparatively small molecular weights are (with one exception) only found for pigments enclosed in blood corpuscles, while the respiratory proteins which occur dissolved in the plasma are characterized by high sedimentation constants and consequently by large molecular weights. The corpuscles of all the vertebrates, with the exception of the species belonging to the lowest class, the Cyclostomata, contain a pigment of the same molecular weight 68,000 (hæmoglobin) with four atoms of iron per molecule. The protein from the Cyclostomata corpuscles has a molecular weight one quarter of that of hæmoglobin, and certain invertebrates have corpuscle erythrocruorin of one half the hæmoglobin weight (A. Hedenius[10]). The mammalian hæmoglobin dissociates reversibly into half molecules upon addition of certain amino-compounds such as urea, acetamide, formamide (J. Steinhardt[29]). As shown by Anson and Mirsky, it is possible to resynthesize hæmoglobin from globin and hæme, and this synthetic pigment has proved identical with the native protein with regard to molecular mass. The isoelectric point is slightly lower and the chemical processes used seem, therefore, not to have left it entirely unchanged (N. Gralén). Erythrocruorins of high molecular weight occur in the blood plasma of the crustacean *Daphnia* (M=400,000), the snail *Planorbis* (M=1,600,000) and certain worms, *Arenicola*, *Lumbricus* (M=3,200,000)[30,31].

The hæmocyanins form an interesting class with a number of inner connexions. The molecular

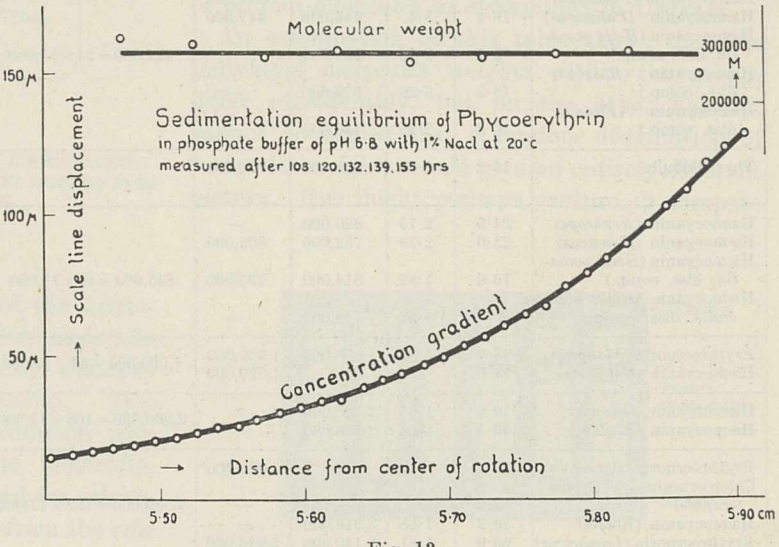


Fig. 13.

RELATION BETWEEN MOLECULAR WEIGHT AND DISTANCE FROM CENTRE OF ROTATION FOR PHYCERYTHRIN (M = 290,000) AT pH 6·8; THE CONSTANCY OF THE MOLECULAR WEIGHT THROUGHOUT THE WHOLE X-REGION DEMONSTRATES THE HOMOGENEITY OF THIS PROTEIN (I.-B. ERIKSSON-QUENSEL).

Molecular Constants of Proteins.

Protein	s_{20}*	D_{20}†	M_s	M_e	$M_{calc.}$	
Erythrocruorin (*Lampetra*)	1·87	10·65	17,100	19,000		I.-B. Eriksson-Quensel (31), A. G. Polson (32)
Lactalbumin α	1·9	10·6	17,500	—	17,600	R. A. Kekwick (33), A. G. Polson (32)
Cytochrom *C*	1·89	10·13	15,600	—		K. Andersson and K. O. Pedersen (22)
Myoglobin	2·04	11·25	17,200	17,500		A. G. Polson (32)
Gliadin	2·0	6·72	26,000	—		S. Arrhenius (34), A. G. Polson (35)
Zein	1·9	4·0	35,000	—		C. C. Watson, S. Arrhenius and J. W. Williams (36)
Erythrocruorin (*Arca*)	3·46	—	—	33,600		I.-B. Eriksson-Quensel (31)
Erythrocruorin (*Chironomus*)	2·00	—	—	31,400		I.-B. Eriksson-Quensel (31)
Lactoglobulin	3·12	7·27	41,800	37,900		K. O. Pedersen (37)
Pepsin	3·3	9·00	35,500	39,200		J. St. L. Philpot (38), A. G. Polson (32), I.-B. Eriksson-Quensel (39)
Insulin	3·47	8·20	40,900	35,100	35,200 = 2 × 17,600	B. Sjögren (40), A. G. Polson (32)
Bence-Jones α	3·55	—	—	35,000		B. Sjögren (41)
Bence-Jones β	2·85	7·33	37,700	—		K. Andersson and K. O. Pedersen (22), A. G. Polson (32)
Egg albumin	3·55	7·76	43,800	40,500		K. O. Pedersen (42), A. Tiselius and D. Gross (43)
CO-Hæmoglobin (horse)	4·5	6·3	69,000	68,000		T. Svedberg and R. Fåhraeus (44), A. Tiselius and D. Gross (43)
CO-Hæmoglobin (man)	4·5	6·9	63,000	—	70,400 = 4 × 17,600	K. O. Pedersen (42), A. G. Polson (35)
Serum albumin (horse)	4·5	6·17	70,200	66,900		P. v. Mutzenbecker (24), I.-B. Eriksson-Quensel (39), A. G. Polson (32)
Yellow Ferment	5·76	6·28	82,800	77,800		R. A. Kekwick and K. O. Pedersen (45), A. G. Polson (32)
Serum globulin (horse)	7·1	4·05	167,000	150,000		P. v. Mutzenbecker (24), I.-B. Eriksson-Quensel (39)
Phycocyan (*Ceramium*, diss. comp.)	6·2	4·58	131,000	146,000	140,800 = 8 × 17,600	I.-B. Eriksson-Quensel (39), A. G. Polson (32)
Phycoerythrin (*Ceramium*)	12·0	4·00	290,000	292,000		I.-B. Eriksson-Quensel (39), A. Tiselius and D. Gross (43)
Phycocyan (*Ceramium*, main comp.)	11·4	4·05	272,000	273,000	282,000 = 16 × 17,600	I.-B. Eriksson-Quensel (39), A. Tiselius and D. Gross (43)
Edestin	12·8	3·93	309,000	—		A. G. Polson (32)
Excelsin	13·3	4·26	294,000	—		A. G. Polson (32)
Amandin	12·5	3·62	329,000	—		A. G. Polson (32)
Erythrocruorin (*Daphnia*)	16·3	—	—	—		I.-B. Eriksson-Quensel (31)
Hæmocyanin (*Pandalus*)	17·4	—	—	397,000		I.-B. Eriksson-Quensel (20)
Hæmocyanin (*Palinurus*)	16·4	3·4	446,000	447,000		I.-B. Eriksson-Quensel (20), A. G. Polson (32)
Hæmocyanin (*Helix pomatia*, diss. comp.)	12·1	2·23	503,000	—	422,000 = 24 × 17,600	I.-B. Eriksson-Quensel (20), A. G. Polson (32)
Hæmocyanin (*Busycon*, diss. comp.)	13·5	3·29	379,600	—		I.-B. Eriksson-Quensel (20), A. G. Polson (32)
Hæmocyanin (*Eledone*, diss. comp.)	10·6	2·25	440,000	—		I.-B. Eriksson-Quensel (20), A. G. Polson (32)
Thyroglobulin	19·2	2·65	628,000	650,000		M. Heidelberger and K. O. Pedersen (46), A. G. Polson (32)
Hæmocyanin (*Nephrops*)	24·5	2·79	820,000	—		I.-B. Eriksson-Quensel (20), A. G. Polson (32)
Hæmocyanin (*Homarus*)	22·6	2·78	752,000	803,000		I.-B. Eriksson-Quensel (20), A. G. Polson (32)
Hæmocyanin (*Helix pomatia*, diss. comp.)	16·0	1·82	814,000	797,000	845,000 = 48 × 17,600	I.-B. Eriksson-Quensel (20), A. G. Polson (32)
Hæmocyanin (*Helix nemoralis*, diss. comp.)	16·6	1·92	799,000	—		I.-B. Eriksson-Quensel (20), A. G. Polson (32)
Erythrocruorin (*Planorbis*)	33·7	1·96	1,636,000	1,539,000	1,690,000 = 96 × 17,600	I.-B. Eriksson-Quensel (31), A. G. Polson (35)
Hæmocyanin (*Calocaris*)	34·0	—	—	1,329,000		A. Hedenius (28), I.-B. Eriksson-Quensel (20)
Hæmocyanin (*Octopus*)	49·3	1·65	2,785,000	—	2,960,000 = 168 × 17,600	I.-B. Eriksson-Quensel (20), A. G. Polson (47)
Hæmocyanin (*Eledone*)	49·1	1·64	2,790,000	—		I.-B. Eriksson-Quensel (20), A. G. Polson (32)
Erythrocruorin (*Arenicola*)	57·4	—	—	3,000,000		I.-B. Eriksson (30)
Chlorocruorin (*Spirographis*)	55·2	—	—	—	3,380,000 = 192 × 17,600	I.-B. Eriksson-Quensel (39)
Hæmocyanin (*Rossia*)	56·2	1·58	3,316,000	—		I.-B. Eriksson-Quensel (20), A. G. Polson (32)
Erythrocruorin (*Lumbricus*)	60·9	1·81	3,140,000	2,946,000		I.-B. Eriksson (30), A. G. Polson (32)
Hæmocyanin (*Helix pomatia*, main comp.)	98·9	1·38	6,630,000	6,680,000		I.-B. Eriksson-Quensel (20), A. G. Polson (47)
Hæmocyanin (*Busycon*, main comp.)	101·7	—	—	—	6,760,000 = 384 × 17,600	I.-B. Eriksson-Quensel (20)
Hæmocyanin (*Busycon*, aggr. comp.)	130·4	—	—	—		I.-B. Eriksson-Quensel (20)

* In units of 10^{-13} † In units of 10^{-7}

weights of the hæmocyanin molecules found in the blood of a certain species are always simple multiples of the lowest well-defined component. Thus for the Malacostraca the relationship is 1 : 2 and for the Gastropoda 2 : 8 : 16 : 24. Moreover, the weights of all the well-defined hæmocyanin molecules seem to be simple multiples of the lowest among them. In most cases the hæmocyanin components of a certain species are interconnected by reversible, *p*H-influenced dissociation-association reactions. At certain *p*H values a profound change in the number and percentage of the components take place. The shift in *p*H necessary to bring about reaction is not more than a few tenths of a unit. Consequently the forces holding dissociable parts of the molecule together must be very feeble[20].

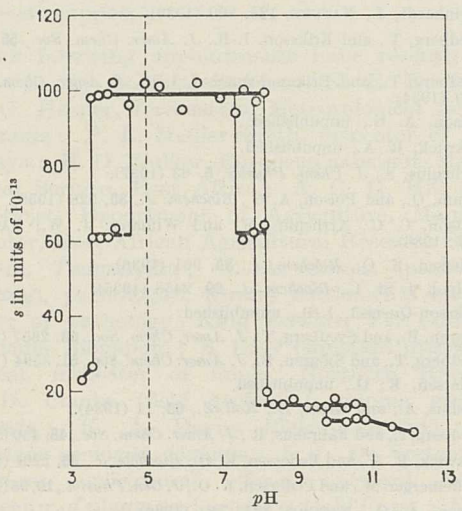


Fig. 14.

THE *p*H-STABILITY DIAGRAM FOR *Helix* HÆMOCYANIN; THE ISOELECTRIC POINT IS INDICATED BY THE DOTTED LINE (I.-B. ERIKSSON-QUENSEL[20]).

Not only the molecular weights of the hæmocyanins but also the mass of most protein molecules —even those belonging to chemically different substances—show a similar relationship. This remarkable regularity points to a common plan for the building up of the protein molecules. Certain amino acids may be exchanged for others, and this may cause slight deviations from the rule of simple multiples, but on the whole only a very limited number of masses seems to be possible. Probably the protein molecule is built up by successive aggregation of definite units, but that only a few aggregates are stable. The higher the molecular weight the fewer are the possibilities of stable aggregation. The steps between the existing molecules therefore become larger and larger as

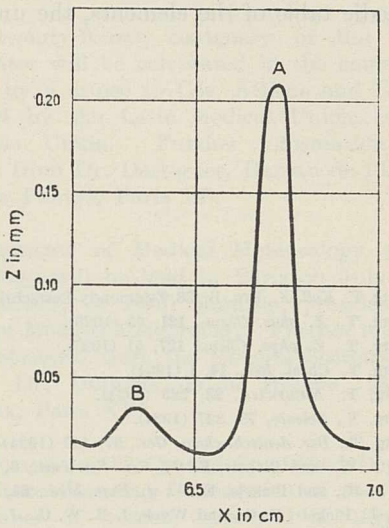


Fig. 15.

SEDIMENTATION DIAGRAM OF THYROGLOBULIN IN 0·001 PER CENT THYROXIN SOLUTION; THE RAPIDLY SEDIMENTING MAXIMUM, *A*, REPRESENTS NORMAL THYROGLOBULIN, *B* and *C* THE DISSOCIATION PRODUCT (H. LUNDGREN[23]).

the weight increases. These statements are born out by the accompanying table (p. 1060), in which are collected recent data for the various constants of protein molecules as determined in Uppsala.

An examination of this table shows that the individual molecular weights within the groups differ considerably, but on the other hand it cannot be denied that a random distribution of molecular weights would give an entirely different picture. One might perhaps venture to compare

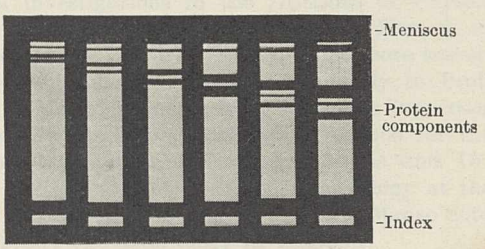


Fig. 16.

SEDIMENTATION PICTURES FOR AN AMYLOID-NEPHROSIS SERUM OBTAINED BY MEANS OF THE *schlieren*-METHOD SHOWING THREE PROTEIN COMPONENTS (K. O. PEDERSEN).

the regularities of this table with the whole number tendencies shown by the table of the atomic weights of the elements. In both cases there is an unmistakable regularity partly obscured by obvious deviations. As in the case of the periodic table of the elements, the underlying simple principle was not understood until quite recently (Aston's work on the isotopes); so perhaps the future will give us the key to a better understanding of the table of the molecular weights of the proteins and furnish the explanation for the regularities disclosed.

References

[1] Svedberg, T., *Koll.-Z.*, Erg.-B., **36**, Zsigmondy-Festschrift 55 (1925).

[2] Svedberg, T., *Z. phys. Chem.*, **121**, 65 (1926).

[3] Svedberg, T., *Z. phys. Chem.*, **127**, 51 (1927).

[4] Svedberg, T., *Chem. Rev.*, **14**, 1 (1934).

[5] Svedberg, T., *Naturwiss.*, **22**, 225 (1934).

[6] Svedberg, T., *Science*, **79**, 327 (1934).

[7] Svedberg, T., *Ber. deutsch. chem. Ges.*, **67**, 117 (1934).

[8] Beams, J. W., and Pickels, E. G., *Rev. Sci. Inst.*, **6**, 299 (1935).

[9] Bauer, J. H., and Pickels, E. G., *J. Exp. Med.*, **64**, 503 (1936),

[10] Biscoe, J., Pickels, E. G., and Wyckoff, R. W. G., *J. Exp. Med.*, **64**, 39 (1936).

[11] Svedberg, T., and Sjögren, B., *J. Amer. Chem. Soc.*, **51**, 3594 (1929).

[12] Beams, J. W. and Snoddy, L. B., *Science*, **85**, 185 (1937).

[13] Svedberg, T., and Lysholm, A., *Nova Acta*, Uppsala, 1927.

[14] Svedberg, T., and Nichols, J. B., *J. Amer. Chem. Soc.*, **49**, 2920 (1927).

[15] Svedberg, T., Boestad, G., Eriksson-Quensel, I.-B., NATURE, **134**, 98 (1934).

[16] Tiselius, A., Pedersen, K. O., and Eriksson-Quensel, I.-B., NATURE **139**, 546 (1937).

[17] Lamm, O., *Z. phys. Chem.*, A, **138**, 313 (1928); A, **143**, 177 (1929).

[18] Svedberg, T., *Koll.-Z.*, **67**, 2 (1934).

[19] Svedberg, T., *Chem. Rev.*, **20**, 81 (1937).

[20] Eriksson-Quensel, I.-B., and Svedberg, T., *Biol. Bull.*, **71**, 498 (1936).

[20a] Eriksson-Quensel, I.-B., and Svedberg, T., *J. Amer. Chem. Soc.*, **58**, 1863 (1936).

[21] Brosteaux, J., *Naturwiss.*, **25**, 249 (1937).

[22] Pedersen, K. O., and Andersson, K., unpublished determinations

[23] Lundgren, H. P., NATURE, **138**, 122 (1936).

[24] v. Mutzenbecker, P., *Biochem. Z.*, **266**, 250 (1933).

[25] McFarlane, A. S., *Biochem. J.*, **29**, 660 (1935).

[26] Heidelberger, M., Pedersen, K. O., Tiselius, A., NATURE, **138**, 165 (1936). Heidelberger, M., and Pedersen, K. O., *J. Exp. Med.*, **65**, 393 (1937).

[27] Pedersen, K. O., *Biochem. J.*, **30**, 948 (1936).

[28] Svedberg, T., and Hedenius, A., *Biol. Bull.*, **66**, 191 (1934).

[29] Steinhardt, J., NATURE, **133**, 800 (1936).

[30] Svedberg, T., and Eriksson, I.-B., *J. Amer. Chem. Soc.*, **55**, 2834 (1933).

[31] Svedberg, T., and Eriksson-Quensel, I.-B., *J. Amer. Chem. Soc.* **56**, 1700 (1934).

[32] Polson, A. G., unpublished.

[33] Kekwick, R. A., unpublished.

[34] Arrhenius, S., *J. Chem. Physics*, **5**, 63 (1937).

[35] Lamm, O., and Polson, A. G., *Biochem. J.*, **30**, 528 (1936).

[36] Watson, C. C., Arrhenius, S., and Williams, J. W., NATURE. **137**, 322 (1936).

[37] Pedersen, K. O., *Biochem. J.*, **30**, 961 (1936).

[38] Philpot, J. St. L., *Biochem. J.*, **29**, 2458 (1935).

[39] Eriksson-Quensel, I.-B., unpublished.

[40] Sjögren, B., and Svedberg, T., *J. Amer. Chem. Soc.*, **53**, 2657 (1931).

[41] Svedberg, T., and Sjögren, B., *J. Amer. Chem. Soc.*, **51**, 3594 (1929).

[42] Pedersen, K. O., unpublished.

[43] Tiselius, A., and Gross, D., *Koll.-Z.*, **66**, 11 (1934).

[44] Svedberg, T., and Fåhraeus, R., *J. Amer. Chem. Soc.*, **48**, 430 (1926),

[45] Kekwick, R. A., and Pedersen, K. O., *Biochem. J*, **30**, 2201 (1936).

[46] Heidelberger, M., and Pedersen, K. O., *J. Gen. Physiol.*, **19**, 95 (1935).

[47] Polson, A. G., NATURE, **137**, 740 (1936).

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

Theory and Practice of Chemistry in the last Half Century"; Prof. R. V. Wheeler will read a paper on "The Problem of Dust in Coal Mines; and the Food Group will hold a symposium on "Fruit Juices", when papers will be read by A. Charley, Long Ashton Research Station, T. N. Morris, Low Temperature Research Station, Cambridge, and J. A. Reavell.

THE Eugenics Society has set up a Population Investigation Committee with Prof. A. M. Carr-Saunders as chairman and representatives from various societies, including one from the British Population Society, Mr. D. V. Glass acting as research secretary. He and Dr. C. P. Blacker have produced a pamphlet of thirty pages which discusses "The Future of our Population", issued by the Eugenics Society, 69 Eccleston Square, S.W.1, at the price of 6*d*. This introduces the subject on the basis of material supplied in the books of Carr-Saunders and Kuczynski, pointing out how present trends will affect future population decline. This is followed by a discussion of the reasons why families are being curtailed in the present generation, and ends with an appeal for financial support.

THE following appointments have recently been made in the Colonial Service: N. E. Davis, and W. G. Harper, forecasters, Meteorological Services, Bermuda; P. L. Mellier-Smith, inspector of mines, Malaya; H. O. Walker, European assistant, Meteorological Service, East Africa; A. G. G. Hill (senior geneticist, Department of Agriculture, Mauritius), director, East African Agricultural Research Station, Amani, Tanganyika; J. A. Cowan (pathologist, Penang), pathologist, Straits Settlements and professor of pathology, King Edward VII College of Medicine, Singapore; S. Bray (assistant inspector of mines), inspector of mines, Northern Rhodesia; A. D. Combe (field geologist), mining geologist, Uganda; K. A. Davies (field geologist), senior assistant geologist, Uganda; L. L. De Verteuil (late assistant agricultural officer, Leeward Islands), inspector of plants and produce, Gold Coast; A. E. C. de S. Gunasekera (assistant irrigation engineer), irrigation engineer, Ceylon; H. P. Rowe (district surveyor), chief surveyor, Survey Division, Lands and Mines Department, Tanganyika; F. G. Taylor (telegraph engineer, Railway Department), wireless engineer and broadcast officer, Sierra Leone.

PROF. OTTO HAHN, director of the Kaiser Wilhelm Institute for Chemistry in Berlin, has been made a corresponding member of the Bavarian Academy of Sciences.

PROF. A. CHEVALIER, professor of colonial agronomy in the National Museum of Natural History, Paris, has been elected a member of the Section of Botany of the Paris Academy of Sciences in succession to the late Prof. J. Constantin.

THE annual congress of the German Society of the History of Medicine, Natural Science and Technique will be held at Coblenz on September 3–6. Further information can be obtained from Dr. Artelt, Universitätsstrasse 3 b, Berlin, N.W.7.

A TRAFFIC clinic has recently been set up at Detroit for the elimination or improvement of dangerous drivers. Among the first hundred accidents studied, fourteen chauffeurs were too disabled to drive properly, seven were suffering from various psychoses and ten were mentally deficient.

THE twenty-fourth centenary of the birth of Hippocrates will be celebrated in the course of the summer by a cruise to Cos, Athens and Epidaurus organized by the Latin Medical Union, commonly known as Umfia. Further information can be obtained from Dr. Dartigues, Bureau de l'Umfia, 81 rue de la Pompe, Paris 16e.

A CONGRESS of Medical Meteorology and Biometeorology will be held in Paris on July 4 under the presidency of Prof. Maurain, president of the Society of Medical Meteorology. Further information can be obtained from the General Secretary of the Society, Dr. Dujarric de la Rivière, 28 rue du Dr. Roux, Paris XVe.

ACCORDING to the Central Statistical Department of the State Planning Commission of the U.S.S.R., the number of women employed in 1936 in the factories, in agriculture, transport, trade, public catering, health protection, education, etc., was 8,492,000, forming thirty-four per cent of the total number of employed workers. There were 15,338 women scientific workers, or little less than half the total medical practitioners in the country.

THE anti-noise campaign in New York, in which the Mayor, Mr. La Guardia, has taken an active part, began more than a year ago. In April 1936, the police issued 9,288 warnings, while summonses and arrests totalled 547. In May, legal enactments were adopted providing fees for offending. In November the police issued 15,661 warnings, and the number of arrests and summonses rose to 1,012. Motors continue to be the worst offenders, and radios come next.

THE Argentine Society for the Progress of Science awarded travelling fellowships during the year 1935 to Dr. Juan Carlos Speroni, to study the technology of wool in England, Dr. Santiago A. Celsi, for electrochemical investigations in the Institute of Physics and Chemistry at Madrid, and Dr. Jorge Thenon, to study psychiatry in Paris. In 1936 four more travelling fellowships were awarded respectively to Prof. Marcos A. Morinigo for studying American linguistics in Paris, Dr. Rodolfo Schwartz of Cordoba for the study of the bacteriology of tuberculosis and Dr. Ignacio Pirosky for the study of immunology at the Institut Pasteur in Paris, and Dr. Alberto Manso Soto for the study of bacteriology in England.

IN NATURE of May 29 a request was made for copies of NATURE for a boys' secondary school in London. Several offers have been received and the headmaster of the school informs us that his needs are now met.

Letters to the Editor

The Editor does not hold himself responsible for opinions expressed by his correspondents. He cannot undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.*

NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 1072.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

Sidereal Time Periodicity of Cosmic Rays and its Phase Shift

WITH a coincidence apparatus—aperture in north-south direction 10°, east-west direction 40°—we have since July 1934 recorded continuously the intensity of the cosmic radiation (hourly records, sidereal time). The counters were arranged in the first series vertically one above the other, and later with 36 cm. lead between the counters in vertical position of the plane of the counter axes, and the plane inclined 24°, 50° and 64° towards the south. The material of the total number, 720 days of observation was subjected, after reductions for barometer and terrestrial magnetic field effects, to harmonic analysis, whereby we determined the time and the amplitude of the first harmonic wave. Arranging the time of the occurrence of the maximum in accordance with the total thickness of the absorbing matter, we get as a first approximation a straight line connexion (Fig. 1). The equation of the line of regression has the following form :

$$y = 29^{h}\ 40^{m} - 0{\cdot}90\,E \pm 1^{h}\ 10^{m}$$

(where E is the thickness of the absorbing material in metres of water), for the measurements in which the counters were filled with air (efficiencies about 27 per cent) ; and

$$y = 33^{h}\ 4^{m} - 0{\cdot}94\,E$$

for counters filled with argon plus alcohol (efficiency about 95 per cent).

We are most probably confronted with a maximum, corresponding to a definite direction, and with its phase shift under the influence of the earth magnetic field. From the inclination of the line it can be deduced that negatively charged particles are involved in it.

The inclination of the line of regression for air-filled counters is nearly the same as for argon plus alcohol-filled counters, but is displaced sideways with respect to it. This is probably due to the argon plus alcohol-filled counter reacting in a higher degree upon the softer components. The circumstances that the maximum for directions so widely different fits so well a straight line relationship and, moreover, that the amplitudes are on the average nearly equal, suggest the conclusion that the wave is not caused by anisotropy in outer space (for example, a greater density of radiating matter away from the direction of the Milky Way) but that its source should be looked for in an effect of the galactic rotation pointed out by Compton and Getting[1]. In this case the time of the maximum for undeflected rays would be at $20^{h}\ 40^{m}$ of the foregoing day. They have calculated the magnitude in the increase of the intensity, which one should expect for a coincidence apparatus through the increase in the number n of the incoming particles:

$$\frac{\Delta n}{n} = \left(\frac{1}{(1-\beta)^{3}} - 1\right) F,$$

where $F = \frac{1}{2}(\cos\dot{\varphi}_{\text{max.}} - \cos\dot{\varphi}_{\text{min.}})$, $\dot{\varphi}$ is the angle between the observer's zenith and the direction of motion and $\beta = 0{\cdot}001$ speed of the motion. In our latitudes (47° 30′ N.) and with the inclinations used—if we neglect the deviation in the north-south direction caused by the earth's magnetic field—we find for the average value of F, 0·6 ; and hence for the amplitude of the wave to be expected, ± 0·18 per cent. The experimental results, however, lead to a value of about ± 0·9 per cent. This disagreement can probably be met by the following considerations. From our measurements of the diurnal variation[2], performed with the same counter arrangements, an increase in the horizontal intensity of the earth's magnetic field by 10^{-5} gauss involves a decrease in the intensity of the radiation of about 0·06 per cent. For every point along the path of any charged particle in the earth's magnetic field, the radius of the curvature is (for high energies) proportional to E/H, where E is energy of the particle, and H is intensity of the magnetic field. So long as the relative changes are small, the effect of the decrease of the magnetic field is identical with an effect caused by an increase in the energy of the incoming particle :

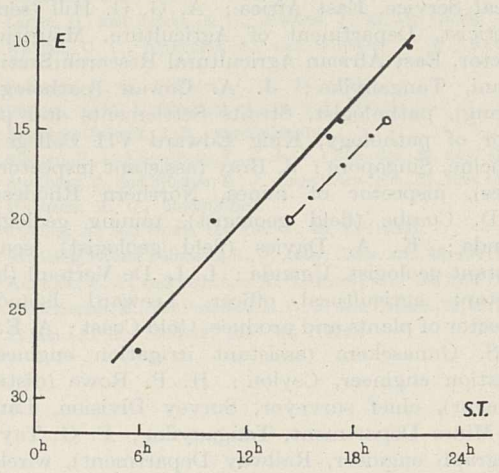


Fig. 1.

RELATION OF TIME OF THE MAXIMUM OF THE FIRST HARMONIC WAVE (SIDEREAL TIME) TO THE THICKNESS OF THE ABSORBING MATERIAL (E). SOLID CIRCLES FOR AIR-FILLED COUNTER, OPEN CIRCLE FOR ARGON PLUS ALCOHOL-FILLED COUNTER.

$$\frac{d(\Delta J/J)}{d(\Delta H/H)} = -\frac{d(\Delta J/J)}{d(\Delta E/E)} = -12\,; \quad \frac{\Delta J}{J} = 12\,\frac{\Delta E}{E}$$

due to the galactic-rotation effect the change in the energy is of the order

$$\frac{\Delta E}{E} = \frac{1}{1-\beta} - 1 = 10^{-3}\,;$$

so that the amplitude of the sidereal-time wave will be :

$$\frac{\Delta J}{J} \cdot F = 12\,\frac{\Delta E}{E} \times 0{\cdot}6 = 0{\cdot}7 \text{ per cent.}$$

Adding to it the expected amplitude according to the calculations of Compton and Getting ($\pm$ 0·18 per cent), we get as a result an amplitude of about $\pm$ 0·9 per cent, in good agreement with the experimental values.

It should be mentioned that for other counter arrangements, or for an ionization chamber—since the sidereal time wave depends largely on the magnetic effect—the amplitude is as likely to be smaller as larger. By coincidence apparatus the predominant part of the amplitude is proportional to the magnetic effect ; for harder rays (greater filtering) the magnetic effect will be smaller, and in accordance with it, the amplitude of the sidereal time wave should also be smaller; this conclusion seems to be detectable also in our measurements, as the amplitude in the direction 64° was only $\pm$ 0·5 per cent (but the deflection in the north-south direction should also be taken into consideration in determining the value of F). In the case of the ionization chamber, the diurnal variation[3], and hence the magnetic effect, is much smaller, so that here the effect calculated by Compton and Getting is predominant, and the sidereal time wave will have a much smaller amplitude.

The measurements were made through the kindly assistance of the Hungarian Council for Natural Science and the Széchenyi Scientific Society.

J. BARNÓTHY.
M. FORRÓ.

Institute for Experimental Physics,
University of Budapest.
April 13.

[1] Compton, A. H., and Getting, I. A., *Phys. Rev.*, **47**, 817 (1935).
[2] Barnóthy, J., and Forró, M., *Z. Phys.*, **104**, 534 (1937).
[3] Hess, V. F., and Graziadei, H. Th., *Ter. Mag. Atm. Elec.* (March 1936).

The Continuous β-Ray Spectrum

QUANTUM mechanics deals with object systems composed of only a few particles out of the total number of particles in the universe. The particles of the local object system, which may be an atom or atomic nucleus, are supposed to be incapable of dropping into vacant energy levels in the background consisting of the unspecified particles of the universe. Also an unspecified particle of the background is supposed to be incapable of falling into one of the vacant levels of the local specified system. As Eddington[1] has pointed out, this means that quantum mechanics *postulates* that the levels of the background are all below the ground-level of the local object system, and further, that all the levels in the background are occupied by one particle, a neutral scalar particle in Eddington's theory, in each level in accordance with the exclusion principle. The *limit* energy of the unspecified background particles corresponds to the *threshold* energy of the local specified system. The background forms a uniform isotropic 'comparison fluid' which is postulated by our statement of the quantum theory.

The disintegration β-particles are believed to arise from the transformation of a neutron into a proton and an electron inside the nucleus. In order to conserve spin and energy, since the β-particle spectrum is continuous, the existence of a neutrino has been assumed.

Let us suppose that a neutron in an upper energy level of the nucleus reverts to an unspecified particle of the background. To make room in the background for this particle, one of the unspecified background particles must be specified, and so it becomes a particle in the object system, that is, the nucleus. Let the background particle be specified as a proton in a lower energy level of the nucleus. The energy lost by the nucleus is now resident in the background and can be employed in raising an unspecified particle of the background to the limit energy (that is, the threshold energy of the object system), where it becomes specified as an electron and is endowed with kinetic energy equal to the energy change in the nucleus less the amount of energy required to raise the particle to the limit level.

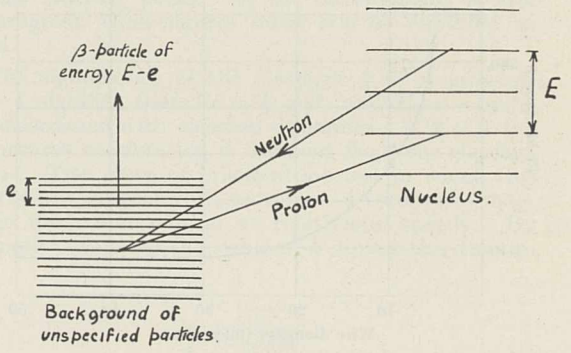


Fig. 1

Since the energy levels in the background just beneath the limit energy are practically continuous, for they have quantum numbers of the order of 10^{26}, the β-particle spectrum will be continuous. Since the electron comes from the background it will have the requisite spin. The process suggested above is shown diagrammatically in Fig. 1. It should be added that Eddington has shown[2] that the emission of an electron does not leave a vacant level in the background.

F. L. ARNOT.

University,
St. Andrews.
April 28.

[1] Eddington, "Relativity Theory of Protons and Electrons", p. 261 (Cambridge, 1936).
[2] Eddington, *ibid.*, p. 267.

Supraconductors of Small Dimensions

MENDELSSOHN[1] has suggested that the high threshold value of supraconductive alloys and impure metals might be confined to regions of very small dimensions. In connexion with subsequent experiments[2], it was pointed out that for thermodynamical

reasons there might exist a causal relation between small dimensions and high threshold value, and that supraconductivity might persist to a higher field strength in sufficiently fine wires than in the massive metal at the same temperature. This assumption is supported by results obtained in Toronto[3] on supraconductive films deposited on another metal. Owing to the possibility, however, that in this case the phenomena may have been influenced by the formation of an alloy at the boundary of the two metals, definite proof cannot be obtained by these experiments.

Conductivity experiments on fine lead wires in a longitudinal magnetic field at 4·2° K. have now been carried out. The specimens were made by the Taylor process from pure lead (99·999 per cent) and annealed. The largest diameter at which a change of threshold value (that is, the field strength at which the first resistance appears) was found is 14·2 μ. From this size downwards, however, the threshold value

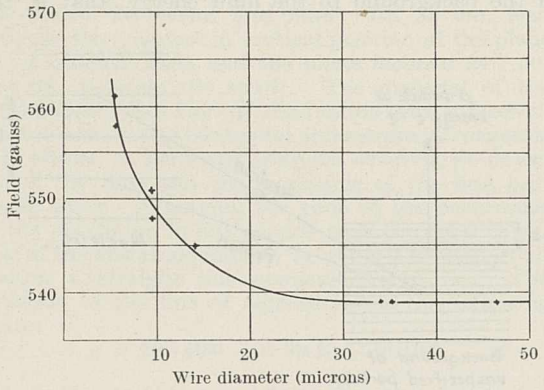


Fig. 1.

THRESHOLD FIELDS OF FINE LEAD WIRES AT 4·21° K.

increased with decreasing diameter of the wire as can be seen from Fig. 1. In the smallest wire (5·6 μ) the threshold field exceeded the normal value by 4·08 per cent. Hysteresis phenomena were observed at the return to the supraconductive state.

This result shows that the depth to which a magnetic field penetrates a supraconductor at the surface cannot be neglected as soon as the size of the supraconductor becomes of the order of 5×10^{-4} cm., thus indicating a depth of penetration of the order of 10^{-5} to 10^{-6} cm. In connexion with the calculations of H. London[4], this would mean that the number of supraconduction electrons is of the order of Avogadro's number. However, more experiments, especially on the free energy of supraconductors, have to be carried out before definite conclusions concerning this last point can be drawn.

R. B. PONTIUS.

Clarendon Laboratory,
Oxford.
May 11.

[1] Mendelssohn, *Proc. Roy. Soc.*, A, **152**, 34 (1935).

[2] Mendelssohn and Moore, *Phil. Mag.* (7), **21**, 532 (1936). Mendelssohn, Moore and Pontius, "Reports of the Seventh International Congress of Refrigeration", **1**, 431, 1937.

[3] Misener, *Canad. J. Research*, **14**, 25 (1936). Misener, Grayson Smith and Wilhelm, *Trans. Roy. Soc. Canada* (3), **29**, 13 (1935).

[4] London, H., *Proc. Roy. Soc.*, A, **152**, 650 (1935).

Sedimentation Equilibrium in the Simplest Air-driven Tops

IT has been highly desirable to develop a simple device everywhere available for accurately measuring sedimentation equilibrium of particles of all sizes from the smallest molecules in solution to the largest colloids or filter-passing organisms. We have used one method of limited scope throughout the past year for measuring the molecular weight of sucrose within 5 per cent in a one-piece hollow air-driven rotor[1].

We have more recently perfected for universal use a rotor consisting of two pieces of steel and a rubber sac in which is laid a pile of 100 ordinary annular washers of coin silver containing 10 per cent copper, and each 0·003 in. thick. The washers are alternately wide and narrow, the outside diameter being the same in all cases. They are held pressed together so that the liquid between the wide washers is immobilized in annular layers, 0·003 in. thick and several millimetres deep. Sedimentation equilibrium is set up in this immobilized liquid in any desired centrifugal field up to a few hundred times gravity.

However, the immobilized liquid is inaccessible. The simple device for studying it is to have a thin layer of excess liquid completely mobile and convecting, lining the cylindrical space within the pile of washers. This liquid is necessarily identical in composition with the most dilute portion of the sedimented liquid. Knowing the speed, the composition of the liquid originally put into the rotor, and the dimensions of the latter and of the washers therein, it is only necessary after the rotor is stopped to withdraw a sample of the supernatant mobile liquid for analysis in order to determine the molecular weight of any molecules or particles of uniform size. Sucrose has given a molecular weight 331 and 339 instead of the theoretical 342. Full details are being published elsewhere.

Another variant in design permits sampling of the liquid in contact with the outside radius of the immobilized liquid as well, to test whether the molecules of particles are all of one size.

JAMES W. MCBAIN.
CLAUDIO ALVAREZ-TOSTADO.

Department of Chemistry,
Stanford University,
California.

[1] See McBain, NATURE, **135**, 831 (1935); and McBain and Stuewer, *Kolloid-Z.*, **74**, 10 (1936); a specimen of the latest model was deposited with Prof. Dr. Wolfgang Ostwald, Kolloidchemische Gesellschaft, Leipzig, in July 1936.

Automatic Plotting of Electron Trajectories

AN apparatus developed independently in this laboratory plots trajectories of charged particles in potential fields entirely automatically. A similar scheme has recently been reported by Gabor[1], but the apparatus described below has certain differences and perhaps advantages.

The basic principle of both systems is the same; namely, the plotting of a trajectory by adjusting the radius of curvature at each point of the path to the value $2V/E_n$, where V is proportional to the total kinetic energy of the particle and E_n to the force acting normal to the path.

In the apparatus here, both these quantities are measured by an electrode unit consisting of two

platinum wires 0·005 in. in diameter and spaced about 0·005 in. apart, the leads from which are connected to the primary of a specially designed

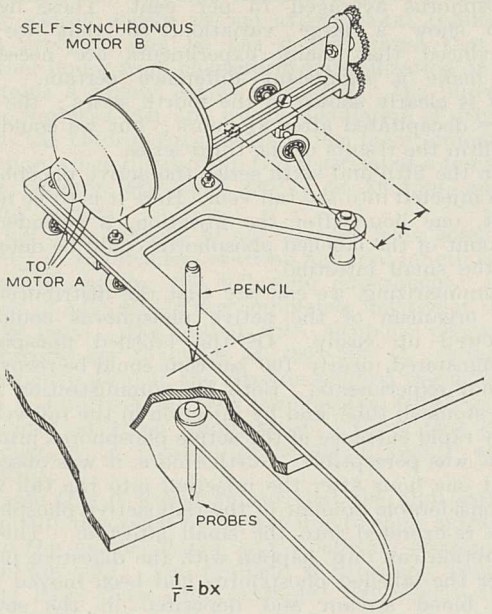


Fig. 1.

shielded transformer. The centre tap from the primary goes to the input of an amplifier used for measuring V, while the secondary is connected to an amplifier which measures E_n. The probe is mounted on a carriage, shown in Fig. 1, which rolls on a piece of plate glass placed directly over the electrolytic tank. A rigid connexion between probe and carriage is formed by a U-shaped bar, one end of which is attached to the carriage, the probes being mounted at the other end, under the glass plate. The pencil is placed directly over the probes. This permits the probe and carriage to move over the entire area of the tank without being obstructed by the glass plate. The paper on which the path is to be recorded is laid on the glass. Moving parts are thus reduced to a minimum, the probes, while rigidly attached to the carriage, are always aligned so as to measure the gradient perpendicular to the trajectory, and the mechanical and frictional difficulties associated with pantographs and parallel links are avoided.

V and E_n are measured by null methods on Kohlrausch slide-wire potentiometers. An electric motor controlled by an amplifier is coupled to each potentiometer and adjusts it automatically to the null position. The accuracy of this automatic setting is approximately 3 parts in 10,000, which is higher than the overall accuracy of the system at its present stage of development. The quotient E_n/kV is obtained on a third automatically driven potentiometer using the circuits shown in Fig. 2. The displacement of the drumhead of the third potentiometer is translated directly to the movable axle of the carriage by means of a pair of self-synchronous motors, one coupled directly to the motor (No. 3) which drives the potentiometer, and the other mounted on the carriage, coupled to a lead screw which varies the displacement X. A method of accounting for initial velocity is indicated in the diagram.

The carriage itself is driven slowly (about 1 mm. per second) along the trajectory by a small electric motor. The process of plotting a trajectory is thus continuous and completely automatic.

The accuracy of the machine is at present limited by the measurement of E_n, which is in error by ± 1–2 per cent. A typical example of the present overall performance is the following : A uniform field was produced by applying 5 volts at 420 cycles between plane parallel electrodes 100 cm. apart in the electrolyte (water). A trajectory was traced starting at $V/V_0 = 0{\cdot}085$ (V_0 = total voltage across the tank), at such an angle that the predicted curve was $y = 1{\cdot}93x + 0{\cdot}138x^2$. The path actually drawn could be accurately represented by $y = 1{\cdot}91x + 0{\cdot}132x^2$ (x varied from 0 cm. to 13 cm.). A retraced path produced by moving the carriage back again deviated by 1·5 mm. from the original at the starting point. As the development is still in progress, these figures must not be regarded as final.

The significance of the constant k is of interest. $k = 1$ signifies that $Ve = \frac{1}{2}mv^2$, and $E_n e = mv^2/r$ in accordance with classical dynamics. If $k = 1$ the transverse acceleration is different from the classical value. Two cases of practical interest in which this is true are, respectively, motion in a transverse magnetic field, and motion at relativistic speeds. By properly adjusting the value of k during the description of a trajectory, either or both these conditions can be taken into account.

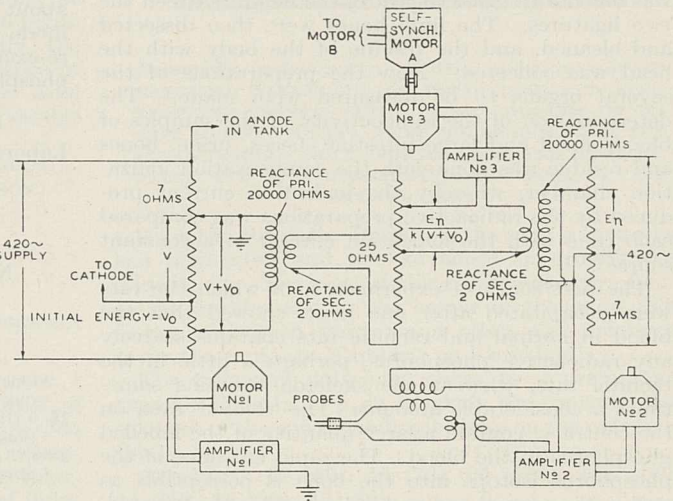


Fig. 2.

DAVID B. LANGMUIR.

RCA Manufacturing Co., Inc.,
Radiotron Division,
Research and Development Laboratory,
Harrison, New Jersey.
April 3.

[1] Gabor, D., NATURE, 139, 373 (Feb. 27, 1937).

Phosphorus Metabolism in Normal, Rachitic and 'Treated' Rats

In a letter to NATURE[1], Chievitz and Hevesy made a provisional communication on the use of radioactive indicators in the study of phosphorus metabolism in rats. In a recent paper to the Royal Society of Copenhagen[2], a detailed account of these investigations was given. Since 1936, we have been making experiments on phosphorus metabolism in normal, rachitic and 'treated' rats, utilizing also a radioactive phosphorus isotope as an indicator[3]. Although the detailed figures will be published shortly in the *Proceedings of the Royal Academy* at Amsterdam, we think a brief review into our experiments may be of general interest.

In six series with about sixty rats, we tried to investigate the absorption, retention and deposition in bone of normal, rachitic and 'treated' animals. The 'treated' rats are those rachitic rats, which received a dose of halibut oil a few hours before the oral administration of the radioactive isotope.

In our experiments the 'labelled' phosphorus was administered as sodium phosphate in an aqueous solution of *p*H 6–7. For that purpose, in four series, a fixed quantity of the radioactive solution was inserted by an exactly calibrated pipette into the stomach of the rat through a small stomach tube. In the fifth and sixth series the radioactive solution was injected in the tail vein.

A certain time after the administration of the active sodium phosphate—in our experiments after 1, 2, 8 and 8½ hours—the rats were decapitated and then quickly sectioned. The œsophagus was ligatured near the pro-stomach, whereas the ileum was doubly ligatured close to the cæcum. Then the œsophagus was cut orally to the ligature, the ileum between the two ligatures. The limb bones were then dissected and cleaned, and the residue of the body with the head was collected. Now the preparations of the several organs to be measured were made. The determination of the radioactivity of the samples of blood, small and large intestine, fæces, urine, bones and residue was done with the compensation ionization chamber, whereby the ionization current produced by the radioactive preparations was compared each time with the ionization current of a constant source[4].

The first series of experiments, in which the rats were decapitated after one hour, showed that the blood in normal and rachitic rats contains scarcely any radioactive phosphorus, perhaps a little in the rachitic rats, whereas the skeleton contains sometimes a considerable amount. The 'treated' rats, on the contrary, contain a large quantity of the labelled phosphorus in the blood. The rapid entrance of the phosphorus isotope into the bone is perceptible as well in the normal and rachitic rats as in the 'treated' rats[3].

In the second series the rats were decapitated two hours after the administration of the active sodium phosphate. The radioactivity of the residue was also determined, and it was found that we could recover fully the whole of the quantity of the radioactive isotope administered. So our technique is reliable. But significant differences between the three groups of rats could not be found. The variation in the figures is too large to permit reliable conclusions.

Therefore in the third series the rats were decapitated after 8 hours, and here we think we can see small differences in the distribution of the labelled phosphorus in the body of the three groups. The deposition in normal rats averaged 55 per cent, whereas in rachitic rats the deposition of the active phosphorus averaged 75 per cent. These figures also show a large variation, so that we are convinced that many experiments are necessary to make a significant difference certain. This fact is clearly shown in the fourth series; the rats were decapitated after 8½ hours; but we could not confirm the results of the third series.

In the fifth and sixth series the active phosphorus was injected into the tail vein. Here it is to be noted that, one hour after the injection, a considerable amount of the labelled phosphorus could be detected in the small intestine.

Summarizing, we can say that the distribution in the organism of the active phosphorus could be followed up easily. Of the labelled phosphorus administered, nearly 100 per cent could be recovered in our experiments. Both by administration with the stomach tube, and by injection in the tail vein, a very rapid entrance of the active phosphorus into the bone was perceptible. Furthermore, it was observed that one hour after the injection into the tail vein, a considerable amount of the radioactive phosphorus was re-excreted into the small intestine. This re-excretion can only happen with the digestive juices, after the labelled phosphorus had been moved with the blood stream and deposited in the several organs. So far as the gross absorption is concerned, that is the difference between the quantity of phosphorus administered and the quantity present in the stomach and small intestine after a certain period, we could not see any difference in the period between 1 and 8 hours after the administration in the normal, rachitic and 'treated' rats. The same can be said about the re-excretion into the gut. A characteristic mode of action of vitamin D on the absorption or re-excretion into the gut from the administered phosphorus could not be demonstrated.

M. J. L. DOLS.
B. C. P. JANSEN.
Laboratory of Physiological Chemistry,
University,
Amsterdam;
G. J. SIZOO.
J. DE VRIES.
Natuurkundig Laboratorium,
Vrije Universiteit,
Amsterdam.
April 28.

[1] Chievitz, O., and Hevesy, G., NATURE, **136**, 754 (1935).
[2] Chievitz, O., and Hevesy, G., *Kgl. Danske Vid. Selsk., Biol. Medd.*, **13**, 9 (1937).
[3] Dols, M. J. L., VI Weltgeflügelkongress, Berlin-Leipzig, *Kongressber.*, **3**, 198 (1936).
[4] Sizoo, G. J., and Koene, C. P., *Physica*, **3**, 1053 (1936).

Œstrogenic Activity of *p*-Hydroxy Propenyl Benzene (Anol)

FOLLOWING the publication of our letter in NATURE of April 10, p. 627, concerning the high œstrogenic activity of anol, we have received information from some workers who have confirmed our observations, and from some others who have been unable to demonstrate activity with doses very much greater than those described by ourselves.

A re-investigation of the problem has indicated to us that some batches of apparently pure anol, melting

point 93°, are highly active, whilst others are relatively inactive. Prof. W. Schoeller, of the Haupt Laboratorium, Schering Kahlbaum A.G., Berlin, has very kindly shown us his experimental results on this problem, and he has demonstrated that the mother liquor from chloroform crystallization of anol contains a highly active substance. We ourselves have repeated this, and by the distillation of material from the chloroform mother liquor have obtained a fraction which distils from this material at a temperature between 160° and 230° C. at 20 mm. and is highly active.

That this activity is not derived from some impurity in the inactive starting material (anethole), is demonstrated by the following experiment. Two grams of anol, which was completely inactive in doses of 10 mgm., was heated with alcoholic potassium hydroxide for 15 hours at 180°–200° C. After removing the alcohol, the alkaline solution was acidified and a brownish oil was precipitated which partly solidified at room temperature. From this crude product, it is possible to isolate a highly active fraction.

From this it would appear that the high activity originally described by us was due to some substance from the mother liquor and separating occasionally with the anol. The problem is extremely complex since large doses—for example, 100 mgm.—of all preparations of anol are active. This in itself is not surprising, since we have demonstrated that *p*-propyl phenol is active in doses of 100 mgm. It would appear, therefore, that there must be present in the mother liquor a substance of such a high degree of activity that its presence in some batches of anol is not sufficient to lower their melting point. The activity therefore of some batches of anol must be two-fold : first, an activity in the region of 100 mgm. per rat dose due to anol itself ; and secondly, the very high degree of activity due to the presence of the unknown substance from the mother liquor. Anol polymerizes with the greatest of ease, and it is possible that the active substance is a polymer.

E. C. DODDS.
W. LAWSON.

Courtauld Institute of Biochemistry,
Middlesex Hospital, W.1.

Production of Local Depressions in the Development of *Drosophila* Pupæ

IN a previous paper[1], which is now in the press, I have shown that the respiration of the pupæ of *Drosophila melanogaster* is depressed by carbon monoxide, and that the effect is, to a certain extent, reversible by light. (This latter fact may be interpreted as a dissociation, under the influence of light, of the chemical compound, which carbon monoxide forms with the iron-containing respiratory enzyme.) These findings make it possible to apply Runnström's device[2], which he used to obtain local inhibition of the cleavage process in *Ciona* eggs. The apparatus, constructed by Prof. J. Runnström, consists of a microscope with a strong condenser, through which a narrow beam of intense light can be focused on the stage of the microscope. If a living object is put under the microscope in a carbon monoxide atmosphere (for example, in a Carrel dish, filled with the suitable gas mixture), and part of it is illuminated with the beam, while the rest is kept shielded from light, its respiration should be more intense in the regions illuminated, than in the regions in the dark. Thus the apparatus is to a certain extent the reverse of the so-called ultra-violet point radiation, by which local defects can be produced with a narrow beam of ultra-violet light.

Following the suggestion of Prof. Runnström, the method was applied to developing *Drosophila melanogaster*. (The experiments were started in the Department of Experimental Zoology, University of Stockholm, and continued in this laboratory, where they are still going on.) After several unsuccessful attempts, it was found that early stage pupæ (less than 40 hours from pupation, when reared at constant temperature, 25° C.), in a suitable gas mixture (10 per cent oxygen and 90 per cent carbon monoxide), can be affected locally in their development by this method. Almost all external characters of superficial nature seem to be affected. If, for example, the treatment is applied laterally in such a way that one side of the pupa is illuminated and the other kept in the dark, the legs are found in some cases (if the treatment has begun early enough) shorter on the

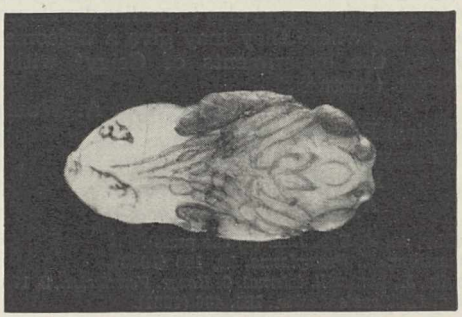


Fig. 1

Drosophila melanogaster. PUPA, SHORTLY BEFORE HATCHING, TAKEN OUT OF PUPAL CASE AND SEEN FROM THE VENTRAL SIDE. IT WAS TREATED ON ITS LEFT SIDE FOR 8 DAYS, FROM THE BEGINNING OF THE PUPAL PERIOD. NOTE SHORTER LEGS, AND BRISTLES, PALER EYE AND UNDERDEVELOPED WING ON THE TREATED SIDE.

side kept in the dark. Similarly the wing is somewhat less pigmented and less advanced in growth (less folded), etc. The most striking differences are found in the bristles and in the colour of the eyes. The former are much shorter and often also deformed, as in the mutants 'stubble', or 'stubbloid'.

The following data may serve as a preliminary example (lengths in μ, in brackets the controls, that is length of the corresponding bristles on the untreated side) :

Orbitals : 60 (80), 45 (70), 60 (105), 105 (140), 45 (70), 25 (90), 45 (60).

Verticals : 105 (115), 30 (140), 125 (175), 80 (125).

Supra-alars : 80 (140), 35 (60), 115 (170), 35 (115), 70 (105), 45 (90).

Post-alars : 70 (105), 105 (140), 70 (105), 185 (285), 55 (80), 115 (130).

Dorso-centrals : 140 (200), 90 (140), 200 (250), 125 (140), 115 (160).

Scutellars : 160 (205), 140 (185), 275 (300), 230 (265).

The eye colour is always definitely paler on the side kept in the dark, and in this respect, again, the difference is especially striking when the treatment is begun soon after pupation (Fig. 1). Control experiments have shown that this result is not due to lack

of light, because the same treatment applied in a normal atmosphere does not produce any differences in eye colour. Thus the effect must be due to the differential depression of cellular respiration in the tissues of the two respective eyes. In this connexion it is of great interest to note that the pigment of the *Drosophila* eye has been shown to act as a reversible redox-system, being colourless when reduced, and fully coloured when shaken with oxygen (cf. Schultz[3]).

The importance of the method for embryological experimentation seems to be that deficiencies are produced by a well analysed physiological treatment, instead of by the more crude method of killing or extirpating certain parts.

Lately the method has been modified. Instead of using one single beam, the whole dish, filled with carbon monoxide, was illuminated, and several pupæ were put in at once, but the pupal cases were first varnished at various places with a quick drying, thick black varnish, as used in blinding experiments on insects.

It is proposed to extend the studies to the histology of the treated pupæ, and also to earlier developmental stages (eggs), where they may give a welcome completion of the experiments of Geigy[4] with local ultra-violet treatment.

ALEXANDER A. WOLSKY.
Biological Research Institute,
Tihany, Lake Balaton,
Hungary.
April 21.

[1] Wolsky, A., *J. Exp. Biol.* (in the press).
[2] Runnström, J., *Protoplasma*, **10**, 106 (1930).
[3] Schultz, J., *Verhandl. internat. 6. Kongr. Vererbwiss.*, **2**, 178 (1932).
[4] Geigy, R., *Roux's Archiv.*, **125**, 406 (1931).

Genes for Dwarfing in Rice

THE typical dwarf varieties of rice vary in height from 10 cm. to 75 cm. They are characterized by shortened internodes, short and broad leaves and small compact panicles. Crosses of dwarf with normal varieties have generally shown that they are mono-recessive (Parnell[1], Akemine[2], Nagai[3] and Yamaguti[4]). Sugimoto[5], however, reports a dominant dwarf. Except for Akemine's work[2], there have been no attempts to determine the number of genes for dwarfing in rice. He crossed two dwarfs, differing in height, and obtained tall F_1 plants. In F_2 the segregation was 9 tall; 3 first type of dwarf; 3 second type of dwarf; 1 third type of dwarf; the last phenotype being the result of segregation.

Through the courtesy of rice workers in India, Japan, Australia and the United States of America, I obtained a number of dwarf varieties. These were crossed in various combinations with the view of determining the number of genes causing dwarfness. The studies have revealed that five genes are responsible in causing short stature. The various varieties are grouped below according to the existence of genes:

Gene.	Varieties.
d_1	Japan-I
d_2	Japan-II, Ratanghose, Kr-226, T-433, Mohmyaw, "Louisiana" and "California"
d_3	Kolamba-dwarf[6]
d_4	Y-2139
d_5	Bunketu-to

It will be seen that the gene d_2 occurs very extensively. The reactions of the various gene combinations are very varied.

The full results will be reported elsewhere.

B. S. KADAM.
Karjat, Bombay Presidency,
April 17.

[1] Parnell *et al.*, *Mem. Dept. Agr. India, Bot. Ser.*, **11**, 185–208 (1922).
[2] Akemine, *Rept. Jap. Assoc. Adv. Sci.*, **1**, 308–314 (1925).
[3] Nagai, *Jap. J. Bot.*, **3**, 55–66 (1926).
[4] Yamaguti, *Ber. Ohara Inst.*, **5**, 1–56 (1931).
[5] Sugimoto, *Jap. J. Genetics*, **2**, 71–75 (1923).
[6] Kadam, NATURE, **129**, 616–617 (1932).

Growth of *Lemna minor*.

IN view of the recent work on the growth and metabolism of *Lemna minor*[1], the following observations are of interest.

The multiplication of fronds in a colony of *Lemna* under favourable conditions has been regarded as exponential. While this conveniently expresses the growth of a *colony*, it does not express the rate of appearance of the daughter fronds from the individual 'mother'.

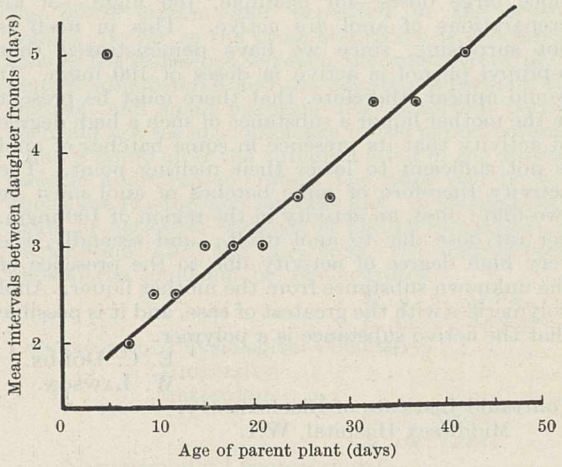


Fig. 1.

Under standard controlled conditions (full nutrient medium, illumination of 400 foot candles, temperature 25° C.) a frond produces 10–12 daughter fronds in succession. These appear alternately on two sides of the mother frond. The whole process takes 40–42 days; at the end of this time the mother frond dies. The mean interval between the appearance of successive daughter fronds is not constant.

The relation between rate of production of fronds and the age of the mother frond is illustrated by the accompanying graph (Fig. 1), on which the mean intervals between daughters are entered. Apart from the five-day period before the appearance of the first daughter frond, the observations lie on a straight line. The rate of frond production is therefore a hyperbolic function of time, and for the particular environment described above may be expressed by the equation:

$$r = \frac{1}{0{\cdot}089t - 1{\cdot}26}$$

where r is the rate, and t is time in days.

There is remarkable uniformity in the number of daughter fronds produced, the life of the mother frond, and the history of frond production described above. The effect of changes in the environment on the process is under investigation in this laboratory, and a fuller communication will be published in due course.

ERIC J. WINTER.

Department of Botany,
The University,
Bristol.
May 7.

[1] Ashby *et al.*, *Ann. Bot.*, **42** (1928); **43** (1929); **49** (1935); White *et al.*, *ibid.*, **50** (1936); n.s. **1** (1937).

Neutrino Theory of Light

RECENTLY some doubts have been expressed about the neutrino theory of light, and Fock[1] has claimed to have found some general rigorous arguments against the possibility of such a hypothesis, especially in its existing form. We believe that Fock's arguments are not valid, though it seems that Jordan's original work[2] on the derivation of the photon amplitudes $b(k)$ from neutrino amplitudes, $a(k)$,$c(k)$ is somewhat ambiguous, as it contains in fact an indefinite expression of the type $\infty - \infty$; later, Jordan proved the convergence of the result but in a somewhat artificial way.

We wish to remark that all these difficulties can be avoided at once by using the following expansion for the neutrino wave functions satisfying the one-dimensional Dirac equation:

$$\psi(x,t) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} \left[A_\varrho(k) \exp(- ic|k|t + ikx) + C^*_\varrho(k) \exp(ic|k|t - ikx) \right] dx$$

where $A\varrho(k)$ and $C\varrho(k)$ are readily found to relate to *neutrino* and *antineutrino* respectively[3]. These Fourier coefficients are expressed through independent amplitudes $a(k)$, $c(k)$ obeying the Fermi commutation rules $a^*(k')a(k) + a(k)a^*(k') = \delta(k' - k)$, etc.

For the photon wave, we take the analogous expansion from the well-known paper of Dirac[4] with the coefficients $b(k)$ satisfying the Bose commutation rules:

$$b(k')b^*(k) - b^*(k)b(k') = \frac{ch}{2|k|} \delta(k' - k).$$

Now, we can easily proceed to the construction of the Bose amplitudes $b(k)$ from the Fermi amplitudes $a(k)$,$c(k)$. For this, we consider the absorption of a photon as due either to the absorption of a neutrino and antineutrino of frequencies $(k - l)$ and (l), respectively, or as due to the absorption of a neutrino (antineutrino) of frequency $(k + l)$ and to the simultaneous emission of the same particle of frequency (l) (Jordan's neutrino Raman effect without change of direction). In this way we find:

$$b(k) = \frac{1}{k} \sqrt{\frac{ch}{2}} \left[\int_0^{\infty k_1} a^*(l)a(l+k)\, dl - \int_0^{\infty k_1} c^*(l)c(l+k)\, dl - \int_0^{k} a(l)c(k-l)\, dl \right].$$

($k = k/|k|$ defines the sign of the upper limit) where usually one takes all states above a certain one as unoccupied[5].

With b (k) constructed analogously, one immediately verifies the required Bose commutation rules for $b(k)$,$b^*(k)$ and thus proves the validity of the neutrino theory in a quite straightforward way. Apparently, Fock obtained his result by using, for the wave function, insufficiently general Fourier expansion.

A. SOKOLOW.

Siberian Physical-Technical Institute,
Tomsk.
March 26.

[1] Fock, V., NATURE, **138**, 1011 (1936). *Phys. Z. Sovjetunion*, **11**, 1 (1937).

[2] Jordan, *Z. Phys.*, **93**, 464 (1935). Iwanenko, D., and Sokolow, A., *Phys. Z. Sovjetunion*, **9**, 692 (1936). The purely statistical-thermodynamical developments of the last article are quite independent of any considerations about the connexion of Bose and Fermi amplitudes.

[3] Iwanenko, D., and Sokolow, A., *Phys. Z. Sovjetunion*, in the press, where the application of such expansions to the Dirac theory is discussed.

[4] Dirac, P. A. M., *Proc. Roy. Soc.*, A, **136**, 453 (1932).

[5] Born, M., and Nath, N., *Proc. Ind. Acad. Sci.*, **3**, 318 (1936).

A Lead Extrusion Phenomenon

DR. DUNSHEATH has referred[1] to the presence, in polished and etched sections of lead cable sheathing, of radial lines which pass through the crystals. It was held as one possible explanation that segregation of dissolved oxide might be responsible.

The presence of similar, but more pronounced, lines has frequently been observed in etched sections cut through lap welds in lead sheet. The appearance of such lines is shown in the photomicrograph (Fig. 1), and

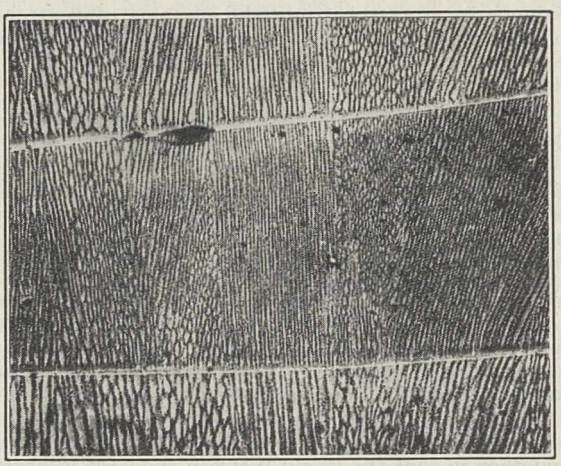


Fig. 1.
× 40 DIAMETERS.

it is deduced from their position and direction that they coincide with the surfaces of successive layers of cast metal with which the weld was built up. As each layer solidifies, a surface skin of oxide is formed; this skin forms the base of the next layer and it is suggested that some oxide is taken into solution during the application of the welding flame each time fresh metal is added. The heat applied is so local and solidification so rapid that any oxide taken into solution would only diffuse to a minor extent.

The coring effect shown in the photomicrograph is due to the small amounts of impurities present in the particular lead illustrated.

BRINLEY JONES.
Goodlass Wall and Lead Industries, Ltd.,
Research Laboratories,
Perivale, Middlesex.
May 11.

[1] NATURE, **139**, 755 (May 1, 1937).

Calcium Iodate as a Temporary Preservative

FOR the past two years we have been using a 0·1 per cent solution of calcium iodate as a temporary preserving agent for class material. The iodate is dissolved in distilled water and warmed to ensure thorough solution.

We find it particularly valuable for material to be preserved in a fresh and pliable condition from one practical class to the next. With the exception of Arthropods, it will keep any comparatively small object fresh and odourless for two to three weeks, and we have kept specimens of *Heterosepiola*, *Rana* and *Bufo* for six months. At the end of that period, the flesh of all specimens was soft and pliable, though slightly brown, and in *Rana* and *Bufo* the blood was still red in the arteries. Results with dogfish have not proved successful for a period longer than ten days.

H. F. STEEDMAN.

Department of Zoology,
University,
Bristol, 8.

Points from Foregoing Letters

BY subjecting to harmonic analysis the hourly records of the intensity of cosmic rays observed over a period of two years by means of 'counters' inclined at various angles to the horizon, Drs. J. Barnóthy and M. Forró find that there is a straight line relation between the maximum of the first harmonic wave (sidereal time) and the total thickness of the absorbing material through which the cosmic rays have passed. They consider this effect to be related to the galactic rotation.

From considerations of energy interchanges between an atomic nucleus and the universal 'background', Dr. F. L. Arnot concludes that the continuous beta-ray spectrum (the emission of electrons of varying energy by radioactive substances) can be explained without assuming the existence of undetectable neutrinos.

A graph showing the dependence of the threshold value of supra-conductivity (field strength at which resistance appears) in thin lead wire at 4·2° K. is given by B. Pontius. A change in threshold value was first noticed at 14·2μ diam., and the effect reached a value of 4 per cent in excess of normal at 5·6μ diam., indicating a depth of penetration of 10^{-5}–10^{-6} cm. for the magnetic field.

Prof. J. W. McBain and C. Alvarez-Tostado give a brief description of a simple 'rotor' for ultra-centrifuging solutions of pure substances such as sugar in order to determine their molecular weight. It consists essentially of a pile of very thin (0·003 inch) silver washers, alternately wide and narrow, pressed together so that the liquid between the wide washers is imprisoned in anular layers. This enables the central core of liquid to be withdrawn and analysed after centrifugation.

An apparatus is described by D. B. Langmuir which draws the trajectories of charged particles in potential fields continuously and entirely automatically. Methods of accounting for initial velocity, transverse magnetic fields, and relativistic change of mass are described, and data illustrating the precision are presented.

The influence of vitamin D on phosphorus metabolism in normal and rachitic rats has been the object of a series of experiments made by Dr. M. J. L. Dols and Prof. B. C. P. Jansen in collaboration with Prof. G. J. Sizoo and J. de Vries. A radioactive phosphorus isotope was used as an indicator. In all the experiments a very rapid entrance of the labelled phosphorus into the bones was perceptible. One hour after the injection of the active phosphorus into the tail vein, a considerable amount was re-excreted into the small intestine.

Further experiments on the œstrogenic action of *p*-hydroxypropenyl benzene (anol) indicate, according to Prof. E. C. Dodds and W. Lawson, that while the pure compound has in itself a certain activity when given in large doses, the very high activity shown by certain specimens in small amounts is due to an unknown substance, probably a polymer of anol.

A. A. Wolsky finds that by means of partial illumination in a carbon monoxide atmosphere, local depressions in the development of *Drosophila* pupæ can be induced in the regions which are not illuminated. It is believed that the respiration of the pupæ is depressed by carbon monoxide, but illumination diminishes the effect, possibly because the chemical compound, formed between carbon monoxide and the iron-containing respiratory enzyme, dissociates under the influence of light.

By crossing a number of varieties of dwarf rice plants from India, Japan, Australia and the United States of America, B. S. Kadam has been able to determine that five genes are responsible in causing short stature.

E. J. Winter points out that although growth in a colony of a duckweed, *Lemna minor*, is exponential, yet when the individual frond is considered this is not the case. The rate of production of daughter fronds from a parent frond is shown to be a hyperbolic function.

A. Sokolow submits equations to overcome the difficulties raised by Fock in connexion with the new neutrino theory of light.

Brinley Jones submits a photomicrograph to support his view that the lines observed in etched sections cut through lap welds in sheet lead are due to a surface skin of oxide on each layer of metal used in building up the weld.

Research Items

Archæological Exploration in Peru: Cañete Valley

In a third report on the results of an archæological expedition to Peru for the Field Museum, Chicago, in 1925 and 1926, Prof. A. L. Kroeber describes (*Anthropology, Memoirs, Field Museum, Chicago*, **2**, 4) excavations at Cerro Azul and Cerro del Oro, in the valley of Cañete, a large valley, as Peruvian coastal valleys go, but containing no town of much importance. The Cañete River, which has a large catchment area, maintains a considerable flow in all seasons, and the valley contains a number of well-known groups of ruins. Of the two sites under investigation, Cerro Azul is an imposing cluster of pyramidal ruins set immediately at the back of the modern port of Cerro Azul. Only one culture is represented here, belonging to the Late period, more or less synchronous with the Inca dominion, though no doubt partly antedating it. It is very similar to the Late Chincha culture, previously described by the author and other investigators. The Cerro del Oro is a nearly free-standing hill about four kilometres inland. It is connected by a low saddle with hills beyond, but otherwise is surrounded by ditches and cultivated lands. San Luis, a kilometre to the south-east, may represent an ancient settlement of which the inhabitants used the hill for their cemetery. It contains no remains of a non-funerary character. Many thousands of burials represent two cultures. One is the Late Cañete culture; the other, here provisionally called Middle Cañete, is shown to be earlier by its stylistic affiliations and by an established stratification. The Middle Cañete culture is characterized by skulls deformed fronto-occipitally, structures of small cubical hand-made adobe, a scarcity of metal, and by pottery and textiles, which show some Nasca influence, but no direct Tiahuanaco influence. The Nasca elements in the pottery are of Late Nasca type. On the other hand, there are occasional elements which suggest later Peruvian styles of the coast, Late Ica especially. While it has distinctive stylistic elements, the Cañete Middle is post-Early and pre-Late chronologically; but the absence of Tiahuanaco elements makes chronological correlations with other Middle period cultures uncertain.

Horned Ruminants of North America

The deer, antelopes and other horned ruminants now existing in North America are few in number and give no hint of the vastness of the fauna inhabiting the continent in Tertiary and Quaternary times, of which they are the veriest remnant. This is brought out with great effect in the monograph on the horned ruminants of North America by Childs Frick (*Bull. Amer. Mus. Nat. Hist.*, **69**, 669, 103 text figures; 1937), a worthy companion to the similar volume previously published on Siwalik fossil deer and antelopes. The evidence upon which the account is based consists of more than 7,000 fossil skulls or parts of skulls, horns and limb bones. Most of the still-existing forms have been identified in the superficial deposits of the Ice Age, but so far only the prong-horn and deer groups have been found in the much older deposits of Late and Middle Tertiary. Even in glacial deposits, however, the modern types are associated with distinctive species which must have become extinct long before the advent of white races to America. It is difficult to account precisely for the impoverishment which has taken place since the great assemblage of the Tertiary fauna, but changes in topography and climate, accompanied by the shifting of faunas and the ravages of predators of both the animal and the plant world have played a great part. To these in latter days the destructiveness of man has been added, and the preservation of the remnant of a once magnificent and diversified fauna now lies in his hands.

Biological Races in Fruit-Flies

In the *Canadian Journal of Research*, **15**, Sec. D, March 1937, Mr. A. D. Pickett gives an account of an investigation of the biological and morphological relations of certain species of flies belonging to the genus *Rhagoletis* of the family Trypetidæ. The author concludes from his observations that the practice of separating species on the basis of very slight morphological characters, which may all be the result of influences exercised by the particular plant host in which any such species has developed, is open to criticism and of doubtful soundness. The forms of the genus in question, which develop in apple, hawthorn and blueberry, were studied extensively with the view of ascertaining their relations to their hosts. The conclusion is reached that one species, namely, *Rhagoletis pomonella*, is involved, and that the female insects show a decided preference for laying their eggs in the plant host in which they themselves have developed during the larval instars.

Anatomy of the Carpel

Dr. Mabel S. Fraser has recently published a very thorough study of the vascular supply to the carpels in the follicle-bearing Ranunculaceæ (*Trans. Roy. Soc. Edin.*, **59**, Pt. 1, 1936–7). This study brings into prominence the variations in the vascular supply not only in the different genera but also within the individuals of the species, and shows that caution is necessary in attaching wide evolutionary significance to isolated facts of anatomy. She adduces evidence of a carpellary trace of five vascular strands in many genera, as *Caltha* and *Trollius*, two strands running between midrib and marginal strands, and concludes that the primitive carpel may have been a palmately veined structure with a five-trace supply. The secondary vascular supply in the carpel wall varies widely within the species, but in the majority of genera it arises as a branch system from the marginal veins. In *Trollius* and *Caltha* there is variation in the vascular supply to the style which, in one gynæcium, may be provided by midrib or marginal bundles or both. On the whole, the author's position brings her near to the interpretation of the carpel advanced by Prof. A. J. Eames, but the paper is valuable for its wealth of anatomical data and the conservative and cautious treatment they receive. The author concludes that our knowledge of the putatively primitive angiosperm only suffices to show "the tremendous gap in our knowledge of the probable primitive Angiosperm from which our present-day carpel arose".

Cytology and Genetics of Cotton

A FURTHER study of the chromosomes and their pairing in various hybrids of *Gossypium* has been made by Dr. A. Skovsted (*J. Gen.*, **34**, No. 1). He concludes that the results confirm the division of the genus into three groups: (1) the cultivated New World cottons and certain wild species from America and the Pacific Islands, with $2n=52$ chromosomes; (2) wild species from America and the Pacific Islands having $2n=26$; (3) species from Africa, Asia and Australia, all having $2n=26$. In hybrids between members within each group the chromosome pairing in meiosis is almost normal. In hybrids between groups (2) and (3) the conjugation was incomplete and variable, while hybrids between members of (1) and (2) generally showed 13 bivalents and 13 univalents. From these and other results the inference is drawn that the genus *Gossypium* is monophyletic, with an early separation between the American and the Old World diploids. The New World tetraploids are believed to have originated from a hybrid between Asiatic and American diploid species. From the secondary pairing in American wild species, it is suggested that 13 is a secondary polyploid number from 6, five chromosomes being duplicated and one triplicated. In the same journal, Dr. S. C. Harland has investigated the inheritance of red petal spot in a series of *Gossypium* hybrids. By successively backcrossing plants of *G. purpurascens* heterozygous for spot with a spotless *G. hirsutum*, the spot was progressively weakened in the segregates and the tendency of the spot gene to show somatic and gametic mutation was greatly increased. From these and similar results it is concluded that the species of cotton may possess a complex of modifiers, the general effect of which is to preserve the stability of the genes and prevent them mutating at an excessive rate.

Distribution of Deep-Focus Earthquakes

MR. S. YAMAGUTI has made an interesting study of the distribution of 241 deep-focus earthquakes recorded in the "International Seismological Summary" for the years 1919–30 (*Bull. Earthq. Res. Inst.*, **15**, 170; 1937). The epicentres are plotted on a map of the world, and four lines are drawn in various regions surrounding those in which the focal depths are greater than 700, 500, 300 and 100 km. The regions of very deep foci are near Japan, in the middle of South America, the southern part of the Philippines, and the ocean east of Australia. On the Mediterranean coast, deep-focus earthquakes do not exist, while in North America they are rare. By projecting the foci of those in South America on a vertical plane containing the equator, the points obtained tend to lie on a zone through the middle of the continent and inclined towards the Pacific with a slope of one in five from the horizontal.

Troublesome Radio Echoes

IT is well known that radio signals passing between two points on the earth follow great circle paths, the radio energy being confined only by the earth and the ionosphere. There are two directions that a radio signal can take in passing from London to New York. One path extends westerly in the great circle plane and the reverse path extends easterly. As the latter has much the longer distance to travel, it arrives later, and may interfere with the former, causing an 'echo'. Short-wave transmission over long distances depends largely on the reflection of the waves between the earth and the ionized layer high overhead. In a paper by A. C. Peterson on "Around-the-World Radio Echoes" published in the *Bell Laboratories Record* of March, an account of the difficulties that radio engineers have to overcome is given. The altitude of the reflecting layer varies from 60 miles to 150 miles in height. The reflecting behaviour of this layer depends both on the frequency of the waves and on the exposure of the layer to light from the sun. When the layer is in darkness, frequencies greater than 10,000 kilocycles are generally not reflected and so transmission is poor. When the layer is illuminated, these waves are reflected and long-distance communication becomes possible. Observations show that the average intensity of the echoes varies in about the same way as the percentage illumination at different seasons of the year. Owing to the long round-the-world path, the echoes are considerably attenuated, and so a double or a treble echo is difficult to observe. Oscillograph records are given which show the echo plainly. The echo signal is rarely found to have a serious effect on the intelligibility of fixed carrier radio-telephone circuits.

Finite Elastic Deformations

IN the classical theory of infinitesimal deformations a fundamental principle (Hooke's law in its most general form) is equivalent to the statement that, in a virtual displacement of the strained elastic medium, the virtual work of all the forces, both surface and body, acting on the medium, may be obtained by integrating over the medium the scalar product of the stress tensor by the variation of the strain tensor. F. D. Murnaghan (*Amer. J. Math.*, 59, 235; 1937) shows that this principle is merely an approximation, valid in the infinitesimal theory, but not valid in the finite theory, in which the variation of the strain tensor must be replaced by the space derivative of the virtual displacement vector. Fortunately the exact equations for an isotropic solid are sufficiently simple to yield numerical results, which the author compares with the experimental data obtained by P. W. Bridgman, showing a remarkably close agreement. A treatment of the Young's modulus experiment gives a qualitative explanation of the yield point phenomenon, which cannot be explained by the classical theory.

Is τ Tauri a Double Star?

MR. BERTRAND M. PEEK has published a short paper (*J. Brit. Astro. Assoc.*, 47, 6, April 1937), with the title, "Occultation of τ Tauri". On January 22 he observed that the star was occulted with a succession of flickers, the process lasting about 0·4 second. On referring to his notes of February 1929, he found that he recorded the star as going out in two stages. He suggests that it is a double star, the separation not being less than $0{\cdot}2''$. It is worth noticing that Mr. G. F. Kellaway at Yeovil saw a similar phenomenon with this star on January 22, a fainter star continuing to be visible at least 0·5 sec. after the observed time of disappearance. Mr. Peek points out that the star will not be occulted in Great Britain before 1947, but a series of occultations will occur in the southern hemisphere until the end of the present year, and observers are asked to pay particular attention to the manner of disappearance.

Rockefeller and Philanthropy

By Willard Connely,

Director of the American University Union in London

THE life of John D. Rockefeller, who died on May 23, was a history of system, not only in the American business of oil, but also in the American business of philanthropy. Whilst Rockefeller was learning how to accumulate money, he was concurrently learning methods by which he should in time give it away. The nearer he approached monopoly, the easier it was for him to retreat to charity. It is because of Rockefeller's skill in the ways of corporations, in planning, shaping and extending them, that the vast 'benevolent trusts' which he created, trusts operated by business men as able as the executives of Standard Oil a generation ago, have become a model of American philanthropic enterprises to-day. That model has stood for 'efficiency in giving'.

These trusts admittedly share leadership in kind with the great Carnegie funds, which originated at almost the same time near the turn of the century. But Rockefeller early set an example to his eminent associates—Harkness, Archbold, Flagler, Folger—in giving money to the public cause. When still other capitalists devised similar charities, capitalists who in the era which Rockefeller dominated had like himself learnt from business the principle of consolidation, there ensued that rise of American philanthropy which has left few corners of the world untouched.

Shortly after the Rockefeller family moved west (1853) from New York State to Cleveland, Ohio, their son, aged about sixteen years, left school, to become a clerk at 4 dollars a week (16*s*.). Even then he began his lifelong practice of giving. He used to give dimes (5*d*.) to poor children worth helping. Of every such item Rockefeller kept a record; his meticulous juvenile notebook, which he called 'Ledger A', shows even the deposit of a penny at church. Establishing a commission firm of his own at nineteen years of age, he soon admitted partners, who multiplied his profits. There was in Cleveland an infant industry, the refining of petroleum. Rockefeller saw that if he could get a start in this business, he could make use of the competing transport facilities which Cleveland offered by both rail and water to distribute the oil widely at low cost. By the time he was twenty-eight he had formed the company of Rockefeller, Andrews and Flagler, and had bought a large oil refinery. Three years later, though his personal fortune was only £10,000, Rockefeller brought into being the Standard Oil Company, capitalized at £200,000. In another five years he had made his first million pounds. He was thirty-six years old. The rest of the story—the Oil Trust, its dissolution in 1892, its renewed prosperity as a New Jersey corporation, its second dissolution in 1911—is the story as well of the growth of Rockefeller's millions to the point at which he believed he could engage in effective and continuous philanthropies.

In planning his gifts, Rockefeller relied for many years on the advice of the late Frederick Gates, his intimate friend. One result of their collaboration was to place the disposal of capital as well as interest entirely in the hands of self-perpetuating trustees. In this respect the Rockefeller charities differed from other great American foundations. If the trustees decided to liquidate a trust, they could give all the capital away and discontinue the fund. This was recently done in the case of the International Education Board. The policy of Rockefeller in allowing absolute discretion to his trustees has been followed by his son, who although one of the trustees, casts only one vote.

Founding his first great benefaction in 1901, ten years before he retired from the presidency of Standard Oil, Rockefeller, while still in the business of accumulating, was able to apply his experience to the business of giving. This first trust was the Institute for Medical Research. He gave it a hospital in New York, and laboratories in New York and in Princeton (New Jersey). Such names as Flexner, Carrel and Noguchi are sufficient to remind one of the quality of work carried out, which has included the discovery of the anti-serum for cerebro-spinal meningitis, and the development of a serum for yellow fever, now in wide use in the tropics, especially by aviators. Huge sums have, of course, been expended as well on the study of cancer, infantile paralysis, and other diseases the mysteries of which are not yet fully solved.

The second trust, created by Rockefeller a few years later, was the General Education Board, designed to assist American universities. Rockefeller from the start had been anxious to help the Negro, particularly in medical education, and the Board contributed heavily to the medical schools of Negro universities in the South: Howard University, in Washington; Maharry Medical College of Fisk University, Tennessee; and Dillard Medical School in New Orleans. But on a wider scale, one of the signal appropriations of this Board was £2,000,000 for medical schools in general, to ensure a high quality of clinical instruction; schools which specially benefitted from this fund were those of Harvard, Yale and Columbia in the east, Johns Hopkins and Vanderbilt in the south, and Chicago and Iowa in the west. Having given medicine this great lift up, the Board turned to the basic sciences, physics, chemistry, biology, and in like manner established them on a sounder footing of research and teaching in important American university centres. Yet perhaps no grant of the General Education Board has been more welcome than the distribution of another £2,000,000, just after the Great War, to endow and increase salaries in all departments of higher education. The scheme was to match dollar for dollar, though in some cases the scale was one dollar to two, and in still others one to three. Graduates rushed to the call. Under this scheme, 170 American colleges large and small received grants, which needless to say have gone far to transform the quality of their staff.

In 1909 the third trust, the Rockefeller Foundation, came into being, a £20,000,000 corporation, with the world as its field of effort—"for the well-being of mankind". The Foundation has co-operated with

Governments of many countries to combat, for example, hookworm, malaria and yellow fever; and at the same time to institute centres of public health, to promote nursing education, and to develop medical schools. An instance of significant medical benefaction has been the support in large part of the Peking Union Medical College in China; again, the London School of Hygiene and Tropical Medicine was built and equipped by a gift of half a million sterling. The recent larger gifts of the Foundation in England have been mainly for other than medical purposes, such as funds for the University of London site in Bloomsbury, the grant to the London School of Economics, the grant to Cambridge to include the new library, and about three fifths of the sum needed for the Bodleian extension at Oxford, the foundation stone of which will be laid on June 25 by Queen Mary. The total of these benefactions amounts to £1,872,000.

In 1929, the trustees of the Foundation, again acting with the free hand which the policy of Rockefeller accorded them, absorbed a fourth trust set up some years earlier by the founder, the Laura Spelman Rockefeller Memorial, named after his wife and dedicated to the aid of the social sciences and to the welfare of children. The work of the whole now comprehends not only the international health division of the Foundation and the social sciences division of the Memorial, but also divisions for medical sciences, natural sciences and the humanities.

A characteristic of the Rockefeller philanthropies is that their practice comes from time to time under systematic review and revision by the trustees. This is done in order to meet the altering social needs of given countries. Vigilant attention to system, at home in the General Education Board and in the Institute for Medical Research, abroad in the Foundation whose work now encompasses the world, is the heritage of the business genius of John D. Rockefeller.

Regularities and Irregularities in the Ionosphere

PROF. E. V. APPLETON, in the Bakerian Lecture before the Royal Society, delivered on June 10, surveyed the information derived from radio sounding of the ionized regions of the upper atmosphere and compared the results with those derived from a theory of simple layer formation by solar ionizing radiation, travelling rectilinearly and attenuated according to a mass-absorption law. Such a formation is called a 'simple region'. The comparisons are concerned chiefly with the variation of maximum electron content N_m with solar radiation angle of incidence χ, with the total conductivity for direct currents such as determines the quiet-day magnetic variations and with the high-frequency absorption of radio waves traversing such a region, the two latter quantities being, to some extent, related.

For the lower Region E, where the daytime recombination is sufficiently rapid to maintain the electron concentration close to the equilibrium value, recombination substantially balancing ionization, the value of N_m is found to vary, experimentally and theoretically, as $(\cos\chi)^{1/2}$. The high-frequency absorption for radio transmission, on the other hand, varies theoretically as $(\cos\chi)^{3/2}$. Here fair agreement is found with the experimental seasonal noon variation when the sun is high, as in summer, but the winter values show disagreement, the absorption being then greater than simple theory predicts. For the case of the diurnal variation of absorption during a summer day, Best and Ratcliffe, working at Cambridge, have found good agreement with the theoretical relation.

No evidence is found suggesting the existence of permanent highly reflecting regions in the lower or middle atmosphere.

From the high-frequency absorption and other data, the transverse direct-current electron conductivity of a simple region is estimated and found to be less than that calculated by Schuster and Chapman from the magnitude of the magnetic variations, even after allowing for the revised estimates of upper-atmospheric motions recently made by Pekeris. This difficulty is met by the assumption of the existence of quantities of positive and negative ions in the lower part of the ionosphere, undetectable by radio methods, but which contribute to the conductivity for steady electromotive forces. From this assumption follows an explanation of the high effective electron recombination coefficient in the lower region, where the value is high because of the large number of positive ions. There is a marked difference between the day and night values of the effective electron recombination coefficients in Region E.

The identification of the lower regions of the ionosphere with the levels at which flow the currents affecting terrestrial magnetism is supported by evidence from systematic measurements of the value of $N_{max.}$, for Regions E, F_1 and F_2, which show that the ionization in Regions E and F_1 varies by about 50 per cent over the sunspot cycle, as does the magnetic variation. The variation of Region F_2 ionization, on the other hand, exhibits no parallelism with the magnetic changes, either in respect of seasonal or sunspot cycle trends, indicating that the magnetic currents do not flow at high levels.

The two types of ionospheric abnormalities, the one associated with bright solar eruptions and the other with terrestrial magnetic storms, were compared and discussed.

An estimate of the actual heights reached by radio waves at the level of reflection leads, in turn, to an estimate of the proportional variation of air density with height for the ionized component. From the fact that Region F is found to be some four or five times as thick as Region E, it follows that the local 'scale-height', H, in Region F is correspondingly greater than in Region E. The atmosphere therefore extends to much greater heights than are estimated from the simple exponential decrease of pressure with height found in the lower atmosphere. Such an extension of the ionizable gases to great heights indicates either that the temperature at 300 km. is higher than at lower levels, or else that it is there composed largely of a light gas such as helium. Difficulties in the way of the acceptance of the latter alternative are discussed.

Television Exhibition at the Science Museum

THE choice of the Science Museum, South Kensington, as a venue for the Television Exhibition which was opened there on June 10 is a singularly appropriate one, for not only does it enable an outline of the technical development of television to be well illustrated, but also it will enable the general public to observe and appreciate the value of television as a new form of home entertainment in a manner which is impossible at any commercial demonstration. The Exhibition is to remain open for about three months.

While it is probable that the only way of appreciating fully the entertainment value of the new service is by the installation of a receiver in one's own home, yet an endeavour has been made at the Science Museum to enable the general public to observe the broadcast programmes for considerable periods by the installation of eight receivers, one from each of the principal manufacturers. These receivers will be in operation daily from 3 p.m. until 4 p.m., receiving the B.B.C. programme, and they will also be operated at intervals throughout the day by means of a film transmitter which has been specially installed in the Exhibition by Messrs. A. C. Cossor, Ltd., for this purpose.

In the technical section of the Exhibition there is a considerable number of exhibits to illustrate the past and present trends of development. The early work of J. L. Baird is illustrated by several exhibits, and there is a working demonstration of the 30-line television which was broadcast from 1932 until 1935. An important part of this section of the Exhibition is devoted to the development of cathode ray tubes. The old Crookes and Braun tubes are shown in operation, and all the important stages of development of the modern television tube are illustrated by appropriate exhibits.

From the scientific point of view, there can be little doubt that the chief interest is centred around a series of exhibits which have been provided by the Scophony Company, relating to their system of large-screen television. As is indicated in the handbook which has been produced in connexion with the Exhibition, one of the major difficulties of large-screen television is that of controlling a sufficient intensity of light and of projecting it on to the screen. The familiar Kerr cell is practically useless for large-screen television since the optical difficulties and low efficiency are insuperable, even if the cell could be made to operate at the very high frequencies required.

The Scophony system makes use of a patented 'supersonic light control cell' in which the principle of diffraction is employed to control the light intensity. The cell consists of two pieces of glass, between which is a transparent liquid; the beam of light is passed through this liquid. A small plate of piezo-electric quartz is mounted at the base or side of the cell and connected with a source of high-frequency oscillations. The mechanical oscillations thus induced in the quartz crystal produce stress waves in the liquid, which travel through the liquid in a direction transverse to the beam of light with a velocity equal to that of sound in the liquid. The waves in the liquid cause the production of diffraction spectra, the intensity of which is proportional to the intensity of the quartz oscillations. By stopping out the normal ray through the cell and by modulating the quartz oscillations by the incoming television signals, the light in the spectra may be employed to form the television image on the screen.

Used in this simple manner, the supersonic light control would possess no great advantage over the Kerr cell. Its great superiority lies in the fact that, with scanning and optical systems of appropriate design, the velocity of the transverse waves of the cell enables between 400 and 500 elements of the picture to be simultaneously active. With a cell of the Kerr type, only a single elemental area can be active at any instant.

The optical system employed makes use of crossed cylindrical lenses for focusing the light beam, thus making possible the use of very small rotating scanners. The focusing and scanning systems associated with the supersonic light control are radically different in design from any previously used for mechanical systems of television. Space must forbid a description here, but the special features are all illustrated by suitable exhibits.

The Scophony Company's exhibits conclude with two demonstrations of large-screen television, one of which employs a screen measuring 5 feet by 4 feet. The programmes are being transmitted by radio from the Company's laboratories at Campden Hill on a standard of 240 lines, 25 pictures per second.

Another exhibit relating to large-screen television is one provided by the Baird Company of an experimental 'projection cathode ray receiver'. This exhibit comprises a conventional receiver, but instead of reproducing the picture on the fluorescent screen of a large-diameter cathode ray tube, an extremely bright image is reproduced on the screen of quite a small tube. A few inches in front of this tube is fitted a wide-aperture lens which projects an enlarged image on to a ground glass screen placed two feet in front, thus providing an image measuring 18 inches by 12 inches. This type of receiver is only experimental at present, and it is understood that one of the chief difficulties is the short life of the screen of the high-intensity cathode ray tube.

Although the Exhibition gives some indication of a trend towards larger screens, one is forced to wonder if a genuine demand for larger screens exists. Obviously, the larger the screen, the larger is the overall bulk of the apparatus, and, to some extent, the larger is the initial cost and upkeep. If, as seems likely, the future development of television proceeds on the lines of home entertainment, the size and cost of a receiver are of vital importance, and while a small increase in the size of the screen as provided on the present commercial receivers would be an improvement, there is a wide belief amongst owners of receivers that the present size of screen is adequate for home entertainment purposes.

There is, however, a potential field of application for television in the provision of entertainment for large audiences in public halls and cinemas, especially when the broadcasting of important current events becomes a daily feature of the television programmes. For such applications, receivers having the largest possible screens will be required.

The Fuel Research Station

ANNUAL VISITATION

THE Fuel Research Station at Greenwich, the headquarters of the fuel research organization of the Department of Scientific and Industrial Research, was inspected by nearly four hundred representatives of science and industry on June 1. The visitors were received by Sir Harold Hartley, chairman of the Fuel Research Board, and the director of fuel research, Dr. F. S. Sinnatt.

The work of the fuel research organization is divided into a number of programmes which are given a different degree of priority from year to year; individual programmes may be curtailed, concluded or extended according to national and industrial requirements.

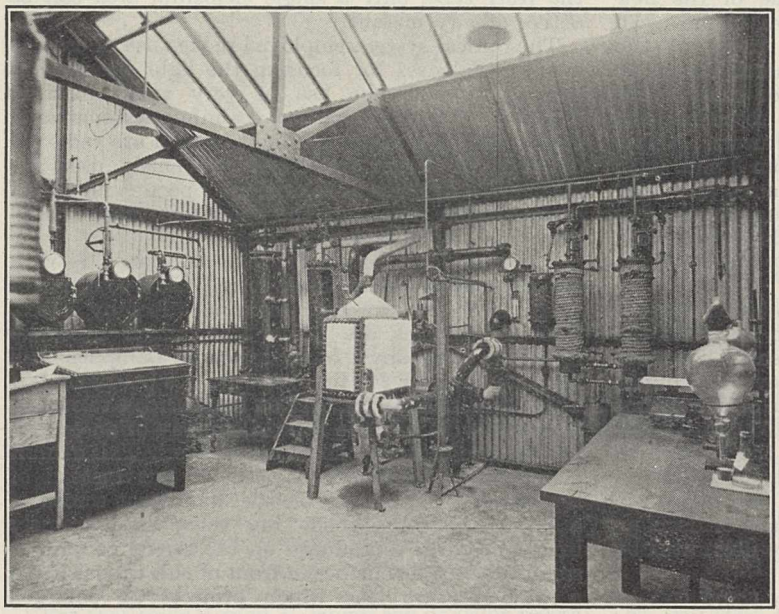


Fig. 1.

EXPERIMENTAL PLANT FOR THE SYNTHESIS OF HYDROCARBONS FROM MIXTURES OF HYDROGEN AND CARBON MONOXIDE. *Crown copyright reserved.*

The National Coal Survey is one of the major programmes. It is necessarily carried out at central points in the chief coalfields, where nine fully equipped laboratories have been established. In these laboratories the properties of the coals of the districts are examined, but equipment is available at the Fuel Research Station for extending the scale of the investigations, so that the results may be applied in industrial practice. Detailed knowledge of the coal seams is becoming increasingly valuable as the methods of utilizing coal grow more precise. New processes such as hydrogenation call for coals with special characteristics, and the study of these is incorporated in the scheme of work at Greenwich.

This scheme comprises laboratory and large-scale investigations of the following problems:

(1) Screening, washing and sizing of coal.

(2) The combustion of coal (*a*) in a marine boiler and (*b*) in the pulverized form, and the elimination of dust and sulphur from the flue gases.

(3) The hydrogenation of coal and tar.

(4) The carbonization of coal.

(5) The complete conversion of coal into gas.

(6) The synthesis of hydrocarbons from mixtures of carbon monoxide and hydrogen.

(7) The burning of coal in the open domestic grate.

(8) The use of pulverized coal in the internal combustion engine.

A brief description of the nature of these problems and of the recent advances made is given below.

(1) Work on the purification and cleaning of coal has lately been concerned with the elimination of dust. Coal treated, according to its type, with 3–20 lb. of oil per ton is quite freed from dust, and possesses certain characteristics which may be of commercial significance. The effect of the presence of very fine material, largely fusain and clay, upon the efficiency of coal washing has also been studied and a process for eliminating this fine material has been developed. Advances have been made in the development of the so-called 'desliming process'.

The importance of the size of coal is being recognized to an increasing extent in industry, and, in collaboration with a number of collieries in several of the coalfields, an exhaustive study is being made of the problems associated with the production of sized materials. This work is being reinforced by more fundamental study at the Station and at the Imperial College of Science, South Kensington.

(2) Since the system, devised at the Station, of burning coal in the pulverized form is already in commercial operation in a number of works, investigation of this problem is now less urgent. Attention has been devoted to the burning of coals containing a low percentage of volatile matter, in order that methods of using this valuable material should be available. The effects upon combustion of blending low-volatile coals with different proportions of high-volatile coal are being explored. The whole problem of the elimination of fine grit and sulphur from flue gases is being investigated, largely with the view to devising a process which can be applied to relatively small units.

(3) The work on the hydrogenation of tar and of coal has aimed at increasing the range of products that can be obtained, and, during the year, methods have been worked out for the conversion of tar and coal into aviation spirit. It has been found possible to produce a volume of aviation spirit equal to the tar treated. Some 140 gallons have been obtained from a ton of coal. The work on the treatment of

high-temperature tar has been partially successful, in that catalysts have now been found by which the tar from vertical retorts can be hydrogenated to produce motor spirit.

(4) The blending of non-caking coals with caking coals is being studied in gas-making plant of the intermittent chamber type.

(5) A process has been worked out by which non-caking coals can be completely gasified in a water-gas plant. If this process can be introduced into commerce, then it will be possible to replace the coke generally used for this purpose and thus conserve the caking coals of the country.

(6) In the search for new products an investigation is in an advanced stage upon the conversion of carbon monoxide and hydrogen into hydrocarbons. This has been worked out in the laboratory, and now a plant is in operation yielding about 10 litres of primary product a day. Lubricating oil has been made from certain fractions of this hydrocarbon product. Fig. 1 shows the actual converter in the centre, and the plant for the removal of organic sulphur from the gases behind it on the left; the condenser is immediately on the right of the converter, and the activated carbon scrubbers on the wall to the right.

(7) Considerable interest is attached to the results which have been obtained upon the burning of coal in the open domestic grate, the investigation of which is financed by funds provided by the Coal Utilisation Council.

(8) As a preliminary study of the combustion of coal in an engine, the effect of coal ash upon engine components is being measured.

University Events

CAMBRIDGE.—Prof. H. R. Dean, master of Trinity Hall and professor of pathology in the University, has been elected vice-chancellor for the academical year 1937–38, beginning in October. He will succeed Mr. G. H. A. Wilson, master of Clare College, whose customary two years of office will then expire. Prof. Dean was educated at Sherborne and New College, Oxford. He went to Cambridge as professor of pathology in 1922, and since then has been a fellow of Trinity Hall, being elected Master in 1929.

Candidates for the Michael Foster studentship in physiology are requested to send their applications, with a statement of the course of research they propose to undertake, to Sir Joseph Barcroft, Physiological Laboratory, by July 7. The student receives the annual value of the fund (about £100), and may be re-elected for a second year.

LONDON.—In recognition of the pre-eminent services rendered, first, by Sir William Beveridge in connexion with the purchase of the Bloomsbury Site and, later, by Lord Macmillan in the raising of the funds necessary to carry out the first part of the building scheme, it has been decided to name two of the halls now completed in the new buildings the "Macmillan Hall" and the "William Beveridge Hall".

OXFORD.—E. S. Duthie has been appointed University demonstrator in pathology for four years from October 1.

Prof. P. Jacobsthal, formerly of the University of Marburg, has been appointed University reader in Celtic archæology for three years from October 1.

Science News a Century Ago

Snow Harris at the United Service Museum

ACCORDING to the *Nautical Magazine* of 1837, on June 12 and 19 lectures were given by Snow Harris at the United Service Museum on atmospheric electricity and the means of defending buildings and ships from its effects. In his second lecture, Harris "described thunder-clouds as insulated and highly charged surfaces, extending sometimes over an area of 40,000 or 50,000 acres, opposed to the surface of the earth as a conductor, with the air as an intervening insulating medium. The electricity accumulated in the clouds, in order to regain a more equal distribution, passes over the lines where the resistance is weakest, or breaks through the intervening air, discharging itself upon the nearest conductor. The lecturer's plan for conducting lightning from ships was illustrated by the model of a frigate floating in a trough of water, with gunpowder at the royal masthead, and with a boat astern filled with gunpowder. A metallic ball, charged with lightning, was made to traverse a wire, by which the gunpowder exploded and also that in the boat, but the lightning was conducted into the water without damage to the vessel. A mast without the conductor, in a similar experiment, was shivered to pieces."

On Lightning Conductors for Ships

FIVE days after Snow Harris gave his lecture at the United Service Museum, Martyn Roberts on June 24, 1837, read a paper to the Electrical Society of London entitled "On Lightning Conductors, particularly as applied to Vessels". Roberts had been led to inquire into the causes of the many accidents to ships through lightning and to suggest improvements. "The conductor most in use", he said, "is a chain, each link of which becomes by the action of the saline moisture in the atmosphere highly oxidated . . . and therefore when the vessel is struck by lightning, every joint in this conductor becomes a point at which an explosion may take place."

Roberts's suggestion was that a metallic rope of fine annealed copper wires should be led from a copper point at the masthead, down the mast and then to a back stay, from which it was to be taken outside the ship and there fastened to the copper sheathing. Harris's conductor consisted of a double copper tape led down the mast and connected to copper bolts passing through the ship's bottom timbers. This plan was favourably reported on in 1839 and was soon widely adopted.

Lyell's Forecast of Submarine Telegraphy

WRITING on June 21, 1837, from Copenhagen to his sister Caroline, Lyell referred to Wheatstone's telegraph. "By-the-bye," he wrote, "have you heard of this wonderful invention? It has made a large figure in my waking dreams ever since I first heard of it at Babbages' and I shall be disappointed if it fail to work a mighty change in the 'march of intellect', at least of civilisation." After describing how Wheatstone had experimented with four miles of silk-covered wire in the crypts of King's College, London, and how with four wires and four needles sixty distinct signs could be sent, he went on, "It has been found that by employing small ropes steeped in india-rubber gum, you may isolate the wires much cheaper than by silk and then each wire shall only

cost between £3 and £5 per mile, or for the four wires under £20. Now they had been obliged on the Birmingham and Liverpool railroad to use a very much more expensive telegraph, to give notice of trains coming to tunnels or places where they cross, by means of long iron tubes through which a blast of air is sent which blows a whistle at the end. So when this new rope with the four copper wires is substituted, we shall have not only railway news but all others sent out with the speed of lightning, ciphers being used for private confab. A few days after I left, a tarred rope was to be continued from the end of the four miles of wire, and thrown into the Thames and then carried to the shot tower on the other side, and the rapidity of conveying intelligence through about five miles was to be tried. So perhaps a rope in the sea may carry news from Dublin to Holyhead. . . ."

Captain Graah's Expedition to Greenland

IN the *Athenæum* of June 24, 1837, is a review of the "Narrative of an Expedition to the East Coast of Greenland by Captain W. A. Graah, of the Danish Royal Navy". Captain Graah had proceeded to Greenland at the command of the King of Denmark. He arrived off the coast in May 1828, spent ten months examining the coast towards Cape Farewell and in 1829–30 proceeded to explore the eastern side of Greenland in boats. "The expedition of Captain Graah", said the *Athenæum*, "appears to set at rest for ever the question which it was designed to elucidate. That able officer explored the east coast of Greenland as far north as the latitude of Iceland; he sojourned on it a year and a half; and yet he discovered no vestiges whatever of ancient Icelandic civilization. He found there no iron, no bell metal, no stones with inscriptions or other relics, such as are found on the western coast; and he was assured by the natives, who are well acquainted with the interior of their firths, that they never saw nor heard of ruins in their country."

Autopsy on William IV

THE *London Medical Gazette* of June 24, 1837, contains the following account of the post-mortem examination on William IV, who died on June 20, aged seventy-one years. "On opening the body the heart was perceived to be enlarged and flabby, with a few shreds of soft lymph gluing the surfaces of the pericardium together. The right side was comparatively healthy, but the left side showed very extensive disease of both sets of valves; those of the aorta were ossified, presenting an obstruction to the passage of blood into that vessel, which was rough on its internal surface, but without dilatation. The mitral valves were also ossified, and suffered the blood to regurgitate. The tendency to bony degeneration extended to the respiratory organs, the larynx, trachea, and even the bronchi, being ossified. The left lung was greatly gorged, and the pleuræ on this side firmly united by thick adhesions of ancient date. In the right cavity of the chest were some 12 or 14 ounces of serous fluid, probably poured out during the few days immediately preceding dissolution. The liver was enlarged and granulated; there was also slight granular disease of one kidney. To the medical reader it will be obvious that the deficiency in the general circulation and the overloaded state of the lungs are clearly explained by the dilatation without hypertrophy of the left ventricle, the obstruction of the aortic and patulous condition of the mitral valves."

Societies and Academies

Dublin

Royal Dublin Society, April 20.

D. A. WEBB: Spectrographic analysis of marine invertebrates, with special reference to the chemical composition of their environment. Quantitative data for the occurrence of 25 elements in a variety of forms are presented, and considered in relation to the concentration in which the same elements are found in sea water. Li, B, Sr, Al and Ag can frequently be detected in organisms, but not in concentrations significantly higher than in the environment. Si, Cu, Fe, Co, Ni, V, Cr, Zn, Cd, Sn and F, can be accumulated by some species from food or water in which they are scanty or undetectable. Pb, Ba and Mn, are intermediate. Previous work on the subject is discussed, with more than a hundred references.

J. CARROLL: Potato eelworm investigations. Recent research on the potato root eelworm, *H. schachtii*, has demonstrated conclusively that the eelworm can by itself give rise to 'potato sickness' in its most severe form. It has also been established that healthy crops of potatoes can be produced on eelworm-infected soil whenever the plants make a fair amount of growth before normal hatching of eelworm eggs in the soil commences. Experiments are designed to test the usefulness of trap-cropping with potatoes for the purpose of reducing the eelworm population of the soil.

C. S. RONAYNE: A curious lightning photograph. An exposure of about two minutes with an aperture $f/6{\cdot}3$ at about 11.30 p.m. B.S.T. in the month of July recorded two flashes. One was completely solarized, and appeared on the print as a thin black line, with the exception of the lower end which was white. Another neighbouring flash was not reversed and appeared white and of appreciable width. This flash showed a thin black edge and black branches. It would seem that the effect must be due to double reversal of the photographic image.

Paris

Academy of Sciences, May 3 (*C.R.*, 204, 1285–1374).

RICHARD FOSSE and ROGER DE LARAMBERGUE: The synthesis of cyanamide by the oxidation of glucose and ammonia. Cyanamide is produced by the oxidation of glucose in ammonia solution by potassium permanganate.

CHARLES ACHARD, AUGUSTIN BOUTARIC and MME. MADELEINE ROY: The optical activity of sera and their proteins separated by the acetone method in the cold. The rotations produced by sera or by the proteins separated from the sera are practically identical. From this it is concluded that the extraction by the acetone method causes no change in the proteins.

GEORGES CLAUDE: The search for aeroplanes lost at sea. Suggests the use of dyes in special containers giving a coloured area visible for about six hours.

SERGE BERNSTEIN: Quadrature formulæ with non-negative coefficients and equidistant abscissæ.

JEAN BAPTISTE SENDERENS: Researches on benzoyl chloride. Aromatic ketones.

LAUGE KOCH: The question of the Caledonian chain in northern Greenland.

PAUL VINCENSINI : A property of convex bodies of space of n dimensions.

SZOLEM MANDELBROJT : The regularization of functions.

RADU BADESCO : The cyanide method in the extraction of gold. A mathematical discussion of some problems arising in the cyanide extraction of gold ores.

RAYMOND TREMBLOT : The spectroscopic triple star 113 Hercules.

LÉON AGOSTINI : The flow of air with velocities higher than sound through holes of very small diameter. Experiments were made with holes 0·03–0·5 mm. diameter, and over this range the empirical relation of Emden was found to be verified.

LOUIS SACKMANN : The study of the flow of air in the immediate neighbourhood of a wall. Application to the study of the characteristics of aeroplane wings.

ANDRÉ LABARTHE and ALEXANDRE PONOMAREFF : The internal injection of petrol in an internal combustion motor.

D. G. DERVICHIAN and MAURICE JOLY : The viscosity of monomolecular surface layers.

PIERRE JACQUET : The value of the microscopic method for the study of electrolytic deposits. It is claimed that by using the method described the whole surface of the cathode can be explored, and this cannot be realized by the electron diffraction method.

ALEXANDRE DUFOUR and FERNAND PRUNIER : The observation of Sagnac's phenomenon with a source of light not forming part of the rotating system.

BORIS VODAR : The absorption spectrum of nitrous oxide in the liquid state.

H. OLLIVIER : Contrast between the laws of thermal variation of the magnetic rotatory power in the case of the nitrates of manganese and gadolinium on one hand and the nitrates of cerium, neodymium, praseodymium on the other.

MLLE. CATHERINE CHAMIÉ : Rapid identification by the γ-radiation of actinium, radiothorium and mesothorium.

JEAN PERREU : The heats of saturation and of hydration of sodium sulphate.

JEAN COURNOT and MLLE. LOUISE HALM : The methods of testing by corrosion of magnesium and non-protected ultra-light alloys. A description of two methods, one based on loss of weight, the other on gas evolved, which have been proved to give satisfactory comparative results.

MLLE. JEANNE FORET : The action of soda in solution on hydrated tetracalcium aluminate.

EDOUARD RENCKER and PIERRE VALLET : The thermal decomposition of ammoniacal copper sulphates. The compound $CuSO_4$, $5NH_3$ when decomposed by heat gives as intermediate products $CuSO_4,2NH_3$, $CuSO_4.NH_3$, and finally the anhydrous $CuSO_4$. The hydrated compound $CuSO_4.4NH_3.H_2O$ gives the same intermediate products.

EMILE CARRIÈRE and HENRI GUITER : The precipitation and determination of vanadates. Study of the completeness of precipitation in solutions of varying pH by precipitation with barium chloride, silver nitrate and lead acetate.

CHRISTIAN AALL : The influence of magnesia on the working of a carbide furnace. Experiments explaining the anomalies and inconveniences resulting from the introduction of magnesia into a carbide furnace.

MLLE. FRANCE BLOCH : Contribution to the study of the thioacids. The preparation and properties of the acid $C_6H_5CS.SH$.

RENÉ HEILMANN : Isoamylidene-acetone.

ROGER PAJEAU : Beryllium bromide in some synthetical reactions. Beryllium bromide does not always give the Friedel and Crafts reaction, but can be used in certain cases.

R. TRUHAUT : The action of mercuric oxide in alkaline solution on glycocol.

PIERRE BEDOS and ADRIEN RUYER : The stable dibromide of 1,3.cyclohexadiene.

PIERRE CHATELAIN : Is the double refraction of liquid crystals independent of the action of the walls or of the action of the magnetic field ?

ANDRÉ DEMAY : The connexion between the Dinantian granite, microgranite and rhyolite in the eastern part of the Guéret massif.

M. and MME. FERNAND MOREAU : The toxicity and antagonism of certain anions in cultures of *Saprolegnia*.

MAURICE MARIE JANOT : The phenomena of growth produced in plants following injections of heteroauxin (β-indolacetic acid).

ALBERT BERTHELOT and MLLE. GERMAINE AMOUREUX : Remarks on the utilization of aseptic seedlings for the study of the formation of tumours.

FERNAND WILLAUME and OSIAS BINDER : The absorption spectra by reflection in the ultra-violet of some basic copper salts and other fungicidal and insecticidal products.

JEAN LOUIS PERROT : The activity of the spermatozoids at the level of the hermaphrodite canal of *Helix pomatia*.

MAURICE FONTAINE : The amount of flavine in various organs of the eel.

JEHAN VELLARD : Geographical variations of the poison of *Bothrops atrox*.

HENRI SIMONNET : Contribution to the study of the fate of morphine in the animal organism.

LÉOPOLD NÈGRE, ALBERT BERTHELOT and JEAN BRETEY : The action of the ethyl esters of certain saturated fatty acids on the evolution of experimental tuberculosis in the guinea pig.

Moscow

Academy of Sciences (*C.R.*, 14, No. 4 ; 1937).

A. ALEXANDROV : New inequalities for volumes of convex bodies.

B. GNEDENKO : Unity of a system of orthogonal functions invariant with regard to the derivation.

M. KOURENSKY : A method of integration of equations with partial functions of the first order, linear with reference to the Jacobians, and with several unknown functions.

V. S. IGNATOVSKIJ : The Laplacean transformation (4).

N. S. KOŠLJAKOV : Developments into Fourier-Bessel series.

S. MIKELADZE : (1) The numerical solution of the differential equation :

$$\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} + \frac{d^2u}{dz^2} = \Phi(x, y, z).$$

(2) The numerical integration of the Laplacean and Poisson's equations.

N. J. SELJAKOV : Nature of ordinary ice. The existence of two modifications of ice belonging to different classes of symmetry is proved.

M. KONSTANTINOVA-SCHLESINGER: Percentage of atmospheric ozone at the altitude of 9,620 m. determined by fluorometric procedure.

W. A. PLOTNIKOV: Isotopes.

E. E. BABKIN: Vapour tension of a mixture of phosphoric and nitric acids.

M. A. KLOČKO: Conductivity of electrolytic systems.

I. LOBANOV and A. JUNGERMAN: The age of old rocks at Isahkovski Hill.

T. T. DEMIDENKO and E. F. TIMOFEIEVA: (1) *Azotobacter* as a source of nitrogenous foodstuff for the higher plants. (2) The role of straw as a source of carbohydrates for nodule bacteria.

D KOSTOFF: (1) Interspecific hybrids in *Secale* (Rye). (2) Studies on polyploid plants (17). *Nicotiana multivalvis* ($2n = 48$) × *Nicotiana suaveolens* ($2n = 32$) amphidiploid ($2n = 80$).

M. KLIUČNIKOVA: Physiological characteristics of vernalized and non-vernalized *Perilla*.

N. I. EFIMOVA: Influence of different substances, artificially introduced into leaves of tobacco, on the development of the disease called 'riaboukha'.

A. A. KUZMENKO: Experiments on the illumination of grains by light of different wave-length.

T. T. DEMIDENKO and E. F. TIMOFEIEVA: Influence of nodule bacteria and *Azotobacter* on the yield of leguminous and cereal plants sown together.

M. I. SALTYKOVSKIJ: Causes of intermediate cold resistance in wheat hybrids of the first generation.

Forthcoming Events

Tuesday, June 22

INSTITUTION OF HEATING AND VENTILATING ENGINEERS, at 7.—A. F. Dufton: "The Air we Breathe".

Thursday, June 24

LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE, at 5.30. Oration Day.

Sir William Beveridge: "The Place of the Social Sciences in Human Knowledge".

Saturday, June 26

ROYAL METEOROLOGICAL SOCIETY.—Summer meeting to be held at the Solar Physics Observatory, Cambridge.

ASSOCIATION OF TECHNICAL INSTITUTIONS, June 25–26.—Annual Summer Meeting to be held at Blackpool.

Appointments Vacant

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

LECTURER IN MECHANICAL ENGINEERING in the Hull Municipal Technical College—The Director of Education, Education Offices, Guildhall, Hull (June 21).

HEAD of the Department of Hygiene and Public Health in the Battersea Polytechnic, S.W.11—The Principal (June 26).

LECTURER IN GEOGRAPHY in the Portsmouth Municipal Technical College—The Registrar (June 26).

LECTURER IN CHEMISTRY in the Battersea Polytechnic, London, S.W.11—The Principal (June 26).

LECTURER IN PHYSICS AND METHODS OF TEACHING SCIENCE in the Borough Road College, Isleworth, Middlesex—The Principal (June 26).

ASSISTANT MASTERS TO TEACH ENGINEERING AND SCIENCE AND MATHEMATICS in the Bolton Municipal Technical College—The Director of Education, Education Offices, Nelson Square, Bolton (June 30).

LECTURER IN PRODUCTION ENGINEERING and LECTURER IN ELECTRICAL ENGINEERING in the Central Technical College, Birmingham—The Principal (June 30).

ASSISTANT FOR COMPUTATIONAL WORK, etc., in the Mathematics Department, Imperial College of Science and Technology, South Kensington, S.W.7—The Secretary (June 30).

SENIOR PHYSICIST, CHEMIST AND RESEARCH ASSISTANT IN BIOCHEMISTRY on the staff of the Wool Industries Research Association—The Secretary, Torridon, Headingley, Leeds, 6 (June 30).

LECTURER IN BIOLOGY AND SCHOOL GARDENING in the Swanley Horticultural College for Women, Swanley, Kent—The Principal (July 1).

BIOCHEMIST in the Rowett Research Institute, Aberdeen—The Secretary (July 1).

DEMONSTRATOR in the Physics Department, Guy's Hospital Medical School, London Bridge, S.E.1—The Dean (July 2).

PSYCHOLOGIST (woman: part-time) in the Maudsley Hospital, Denmark Hill, S.E.5—The Medical Superintendent (July 3).

PRINCIPAL AND HEAD MASTER of the Sheerness Technical Institute and Junior Technical School—Mr. V. C. Stupples, 46 High Street, Sheerness (July 3).

Official Publications Received

Great Britain and Ireland

Department of Scientific and Industrial Research. Report of Test by the Director of Fuel Research on the Carbonising Plant of Coal and Allied Industries, Ltd., at Seaham Harbour, County Durham—Test carried out 10th to 17th September 1936. Pp. iv+33. (London: H.M. Stationery Office.) 9*d*. net. [245

Ministry of Health. Costing Returns, Year ending 31st March 1936. Part 2: Poor Law Institutions, Separate Casual Wards. Pp. 27. (London: H.M. Stationery Office.) 1*s*. 3*d*. net. [245

Twenty-five Years of the London Museum: an Album of Photographs illustrating the Range of the Collections. Pp. 142+130 plates. (London: London Museum.) 2*s*. 6*d*. [265

Other Countries

U.S. Department of Commerce: Coast and Geodetic Survey. Special Publication No. 205: Cartography. By Charles H. Deetz. Pp. vi+83+29 plates. (Washington, D.C.: Government Printing Office.) 60 cents. [215

U.S. Department of the Interior: Office of Education. Bulletin, 1936, No. 19: Functional Planning of Elementary School Buildings. By Alice Barrows. Pp. viii+83. (Washington, D.C.: Government Printing Office.) 25 cents. [215

Achema Jahrbuch, Jahrgang 1937: Berichte über Stand und Entwicklung des Chemischen Apparatewesens. Begründet von Dr. Max Buchner. Herausgegeben unter Mitwirkung von Fachgenossen aus Wissenschaft und Technik der Achema. Pp. 296+xlviii+96. (Berlin: Verlag Chemie, G.m.b.H.) [245

U.S. Department of the Interior: Geological Survey. Bulletin 868-D: The Kaiyuh Hills, Alaska. By J. B. Mertie. (Mineral Resources of Alaska, 1934.) Pp. ii+145–178+plate 9. 10 cents. Bulletin 878: Analysis of Rocks and Minerals from the Laboratory of the United States Geological Survey, 1914–36. Tabulated by Roger C. Wells. Pp. x+134. 15 cents. Bulletin 880-A: Mineral Industry of Alaska in 1935. By Philip S. Smith. (Mineral Resources of Alaska, 1935.) Pp. ii+95+plate 1. 20 cents. Professional Paper 186-C: Fossil Plants from the Stanley Shale and Jackfork Sandstone in Southeastern Oklahoma and Western Arkansas. By David White. (Shorter Contributions to General Geology, 1936.) Pp. ii+43–67+plates 10–14. 10 cents. Professional Paper 186-D: Some Organic Constituents of a Recent Sediment from Chincoteague Bay, Virginia. By Roger C. Wells and E. Theodore Erickson. (Shorter Contributions to General Geology, 1936.) Pp. ii+69–79+plate 15. 10 cents. Professional Paper 186-G: Stratigraphic Relations of the Austin, Taylor and Equivalent Formations in Texas. By Lloyd William Stephenson. (Shorter Contributions to General Geology, 1936.) Pp. ii+133–146+plate 44. 10 cents. Professional Paper 186-I: Some Deep Wells near the Atlantic Coast in Virginia and the Carolinas. By W. C. Mansfield. (Shorter Contributions to General Geology, 1936.) Pp. ii+159–161. 5 cents. Water-Supply Paper 786: Surface Water Supply of the United States, 1935. Part 6: Missouri River Basin. Pp. 353. 40 cents. (Washington, D.C.: Government Printing Office.) [245

Koninklijke Vereeniging "Koloniaal Instituut", Amsterdam. Zes en twintigste Jaarverslag, 1936. Pp. 135. (Amsterdam: Koloniaal Instituut.) [245

Proceedings of the U.S. National Museum. Vol. 84, No. 3016: Two New Beetles of the Family Mordellidae from Orchids. By Eugene Ray. Pp. 239–242. (Washington, D.C.: Government Printing Office.) [245

Catalogues, etc.

Catalogue of Books and Journals on Zoology, Biology and Geology. (No. 507.) Pp. 66. (Cambridge: W. Heffer and Sons, Ltd.)

A Collection of Old Medical Books: Bacteriology, Circulation of the Blood, Electrotherapy, Ophthalmology, Pharmacology, etc. (List No. 25.) Pp. 36. (London: E. P. Goldschmidt and Co., Ltd.)

Scientific Instruments. Pp. 100. (Delft: P. J. Kipp and Zonen; London: W. Edwards and Co.)

Vergleichende Anatomie: Histologie, Ontogenie, Anthropologie. (Antiquariatskatalog Nr. 712). Pp. 202. (Leipzig: Gustav Fock, G.m.b.H.)

Cambridge Pressure and Draught Indicators and Recorders. (Folder No. 47a.) Pp. 6. (London: Cambridge Instrument Co., Ltd.)