"NATURE", February 27, 1943

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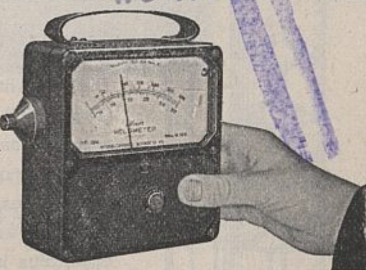

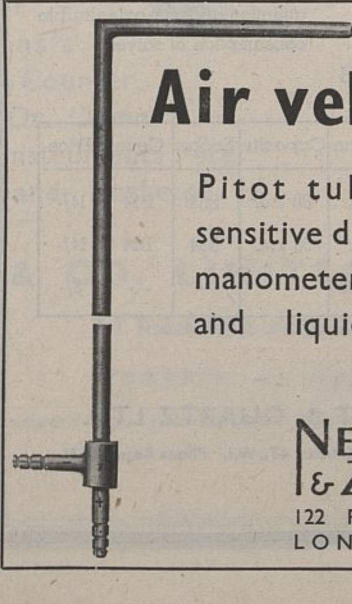

NATURE

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CENTENARY OF THE HOUSE OF MACMILLAN

THE House of Macmillan, as a publishing firm, is a hundred years old. Daniel and Alexander Macmillan founded the firm in 1843, and their first two books, A. R. Craig's "The Philosophy of Training" and W. H. Miller's "The Three Questions: What am I? Whence came I? Whither do I Go?" were published during that year.

Birth and Growing Pains

Daniel and Alexander were both sons of Scottish peasants. Daniel was born in the island of Arran on September 13, 1813; but the family migrated to Irvine, on the opposite coast, when Daniel was three years old. Daniel eventually went to Glasgow where he made several faithful friends, such as Dr. George Wilson, the technologist and author of the "Five Gateways of Knowledge", and Mr. J. MacLehose, who eventually became Glasgow's leading bookseller and publisher, and whose firm to-day is the Glasgow University Press, with whom the House of Macmillan still enjoys happy collaboration. Indeed, Daniel was very fortunate in his friends, and the fruits of such friendships are still being garnered by the present-day firm and the public it serves so well.

In 1833, Daniel came to London. He joined the firm of Simpkin Marshall, but was not content there. He spent some time considering going to Cambridge after failing to obtain a post with the publishing firm of Longman. It is just as well at this stage to examine the character of one of the two most important founders of this great firm. Before leaving London, Daniel decided to see the sights; his letters to various relatives and friends bring out the character of the man. For example, in a letter to his brother William, written on September 30, 1833, he says:

"The top of St. Paul's. What a sight. To see all London, even its highest spires, under one's feet, to think of the many thousand souls that are busy in that mighty mass of brick; the number of sailors who are now busy among yon forestry of masts; the numbers who are dying; the numbers who are just entering upon life. To think of those who are enduring pain, and those who are enjoying pleasure; of the villains and the saints; the active and the indolent: the virtuous and the vicious: the pious and the profane: the prodigiously rich and the miserably poor: the noble and the mean, who inhabit or infest that marvellous and mighty place, improving or injuring its morals, saving or destroying its souls. It is awful beyond description. I can hardly bear it."

Daniel Macmillan was a man who admitted to and performed a mission in life, a man who recognized a debt to society—a very practical sociologist. And like all such individuals, he was impetuous beyond belief. His impetuosity remained with him to the day of his death on June 27, 1857, when, as Thomas Hughes, author of "Tom Brown's School Days", wrote of him: "In a few hours the impetuous spirit was at rest". Here we had a man who, in his impetuosity, was striving to give something to the world, and who, therefore, like his brother Alexander, did not miss his greatest chances in life by wasting time calculating what he himself was to get out of it. Those who, under the cloak of service to humanity, are really seeking self-aggrandizement (and such exist even in the scientific world) might with profit study the lives of such people as the founders of the House of Macmillan.

Cambridge Days

At Cambridge, Daniel Macmillan joined Mr. Johnson, a bookseller, but three years afterwards, in 1837, he left again, having made many friends, some of them rising men in the University. Later, he came to London and entered Messrs. Seeley of Fleet Street, where he was joined by his brother Alexander in 1839. Alexander was five years younger than Daniel, and was a village schoolmaster near Paisley when he left Scotland for London.

After working very hard against considerable poverty, the two brothers, in February 1843, were able to claim independence and they opened a shop in Aldersgate Street, London, with little or no capital to back them up. However, on the advice of Archdeacon Hare, whose reputation at Cambridge was then at its height, the Macmillan brothers transferred their business to Cambridge towards the end of 1843, and there, until Hare's death on January 23, 1855, both brothers, especially Daniel, came under the influence of the Archdeacon.

Daniel married Francis Orridge, daughter of a Cambridge pharmaceutical chemist, on September 4, 1850. Their first boy, Frederick (afterwards Sir Frederick), was born in 1851, and the second, Maurice, in 1853.

The Cambridge book-selling business of the Macmillans flourished in spite of Daniel's ill-health and the firm's lack of sound financial backing. The success was probably due initially to the peculiar experience and whole sympathies of Daniel, and to the enthusiastic support of Archdeacon Hare. Both brothers established good relations with the University undergraduates. As one of their earliest customers wrote :

"When the Macmillans first established their shop in the heart of the University, on a well-chosen site opposite the gates of the Senate House, the undergraduates felt that with men hardly older than ourselves there was opened to us a new sphere of interest. They were the first booksellers whom I, for my own part, had ever known to take an enthusiastic interest in their business and to have a literary insight below the binding of their books."

Thus the Macmillans gained and developed the confidence of the university men—undergraduates and authorities alike. Writing to Thomas Hughes of Daniel Macmillan, the then Headmaster of Uppingham said :

"He stands out in my memory perhaps the most distinct personality of my early manhood—the embodiment of gentle, thoughtful power, which attracted one exceedingly, and lives with me still."

Among the regular visitors to the Macmillans' shop were the 'Olympian Thompson', W. G. Clerk, the mathematicians Todhunter and Barnard Smith, and the three great Cambridge scholars, Westcott, Lightfoot and Hort. Alexander was also a close friend of Clerk Maxwell.

Congratulations and encouragement were now pouring in on the young brothers, so that within the first year at Cambridge, the possibilities of a publishing business of their own crept into Daniel's mind, though the smallness of the capital of the bookseller's shop kept the brothers in constant anxiety. However, after bringing in a succession of partners, capital increased, and in 1845, Daniel was at last convinced that the chance of growth for the business lay in the direction of publishing more than bookselling. The advantages which their position at Cambridge, a great literary centre, gave them had become more and more apparent. Here was a mine, hitherto almost unworked, for the best book-producing power, especially of educational books.

Thus Daniel and Alexander Macmillan, although they had to date published only a few works, turned seriously to publishing, and from the very first established and maintained contact with the best writers and editors, especially among the Cambridge men. The close liaison which they developed between themselves and their authors may be illustrated by the following quotation from a letter written by Daniel Macmillan to Charles Kingsley, commenting on the latter's sketch of his projected "Westward Ho !"

"We are greatly taken with all you tell us about the plan and character of your novel. Of course you will not adopt that pseudo-antique manner in which *Esmond*, *Mary Powell*, &c., &c., are written. That style is now getting a bore. The free march of your own style will be much more Elizabethan in manner and tone than any you can assume. We feel sure it will be a right brave and noble book, and do good to England."

A further comment he wrote on Kingsley's proposed "Wonders of the Sea Shore" is so amusing as to deserve quotation here :

"We don't think it will pay to give copies to the country papers. The rascals sell and lend books, and do more harm than good."

During the first period of publishing, lasting for several decades, most of the Macmillan books were, in keeping with the then public and academic taste, on theological or moral philosophical themes.

Daniel Macmillan died at the very early age of forty-six on June 27, 1857, leaving three sons and one daughter. Two of his sons, Frederick and Maurice, eventually became directors of the firm. It was therefore left to his older brother, Alexander, to develop much of the educational side of the Macmillan business and to sow the seed which eventually grew and ripened into the products which academic and other reading men know so well to-day. Alexander's devotion to F. D. Maurice, the leading Cambridge divine, Archdeacon Hare, Hort, Charles Kingsley, and his affection for Matthew Arnold, John Morley, T. H. Huxley and W. K. Clifford were great assets in helping him to keep in touch with all branches of scholarship in those days.

He, too, like his brother, though deeply religious, was far from being intolerant. This is well illustrated in a letter he wrote to Tennyson, in which, referring to Darwin's "Origin of Species", which had just been published, he said :

"I wish someone could bring out the other side. *But surely the scientific men ought on no account to be hindered from saying what they find are facts*" [italics ours].

The discussions on Darwin's recent publication at one of the Macmillan famous Thursday Evenings held at the Covent Garden premises must have been full of inspiration and have given much food for thought, for such worthies as Huxley, Kingsley, Maurice, Hughes and Masson contributed to them.

Alexander died on January 26, 1896. His son, George, eventually became another director of the firm.

Return to London

In 1858, a London branch of the firm had been opened in Henrietta Street, Covent Garden. Then, the remarkable expansion of the business had made it imperative to move the headquarters to London in 1863, and the firm remained in Covent Garden until 1897, when it built its own fine premises in St. Martin's Street, which it still occupies.

Tracing the period from that date to the present day, it is interesting to note that family continuity in the direction of the business has been maintained to a considerable degree. Sir Frederick Macmillan and Mr. Maurice Macmillan, sons of Daniel, and Mr. George Macmillan, son of Alexander, actively directed the firm until their deaths in close succession to each other in 1936. Since then, Mr. Daniel and the Right Hon. Harold Macmillan, sons of Maurice, and Mr. William Macmillan, son of George, have been chairman, vice-chairman and director respectively.

To-day the influence of the House of Macmillan has extended itself to all parts of the world where books are published or eventually find their way. The Macmillan Company of New York, originally founded by the British firm in 1869, has developed into one of the most important publishing houses in the United States. Although now under independent management, it works in close co-operation with the British company. The Macmillan Company of Canada was established in Toronto in 1906, and now occupies a leading position in the Canadian publishing world. The parent British firm has connexions all over the world, publishes books in many different languages, and has three offices in India and one in Australia.

The modern reader of general literature associates the name of Macmillan with such distinguished authors as Rudyard Kipling, Lewis Carroll, Thomas Hardy, W. B. Yeats, Hugh Walpole, Rebecca West, James Stephens, Pearl Buck, James Hilton, Osbert Sitwell, Mazo de la Roche, to name only a few of the best-known figures in their list. Among the well-known periodicals it publishes are the *Economic Journal*, the *Round Table*, the *Nursing Times* and NATURE.

The firm's activities, however, cover the whole range of literature, history, philosophy, economics and sociology, as well as scientific and technical treatises and all classes of educational books from those suitable for nursery schools to well-known university texts.

Readers of NATURE will be especially interested in the Macmillan scientific and educational publications —those solid, dependable works, the most successful of which go through edition after edition, and, unlike most fiction which is of an ephemeral nature, remain on the catalogue for decades. These scientific, educational and other works of scholarship have proved to be the backbone of the firm, and a brief review of the development of Macmillans along these lines may give some insight into the *raison d'être* of the present firm as one of the leading British publishers of educational books and periodicals.

"NATURE"

The idea of a weekly journal of science began in 1868 with discussions between Sir Norman Lockyer, the astronomer and spectroscopist, and his friends, among whom were Alexander Macmillan. Lockyer was assured of the support of T. H. Huxley, Tyndall and practically all the other leading workers in science of the time. Alexander Macmillan enlisted the support of Sir Joseph Hooker and other of his scientific friends ; but much of the initial success was due to Alexander Macmillan himself, of whom Sir Norman Lockyer once wrote :

"It was in consequence of his sympathy and enthusiastic assistance that the journal started. He was unwavering in his support of the belief that British science would be advanced by a periodical devoted to its interest. . . . It was the hope that a more favourable condition for the advancement of science might be thereby secured that led Mr. Alexander Macmillan to enter warmly into the establishment of *Nature* in 1869."

In this connexion we might quote part of a letter written by Alexander Macmillan to Sir William Thomson (afterwards Lord Kelvin) :

"Lockyer is going to start a weekly Journal of Science, which we are to publish. It is meant to be popular in part, but also sound, and part devoted specifically to scientific men and their intercourse with each other. Huxley, Balfour Stewart, Wilkinson, Tyndall, Roscoe and almost everyone who is about London have given him their names, and he very greatly wishes yours, as among those who promise support. May I tell him you consent ?"

The launching of NATURE is chronicled in a letter to the Glasgow bookseller, MacLehose, written on November 3, 1869:

"*Nature* is to be published on Thursday in London at 2.30. . . . Lockyer was peremptory that our publication day should indicate the point to which our information is brought up. The fallacy of a Saturday publication with a Thursday actual information he does not think right. . . . We start with 18 pp. of advertisements. . . . I think it will look nice."

In the complete context of this letter it is worth noting that Sir Norman Lockyer had an absolutely free hand in reviewing books published by the firm of Macmillan itself, and never hesitated to criticize them adversely if he thought they deserved it. This absolute and complete freedom of policy has been extended to the editors of NATURE from that day to this.

In 1919, Sir Richard Gregory succeeded Sir Norman Lockyer in the editorial chair of NATURE. During his long period of editorship the journal made considerable progress, and its influence in the world of science has gradually become stronger and more secure. To-day it is the leading journal of science. In 1938, Sir Richard Gregory was succeeded jointly by Mr. A. J. V. Gale and Mr. L. J. F. Brimble. The extent to which NATURE has now grown, not only in scientific but also sociological influence, must be left to the opinion of its readers.

One thing, however, we think that readers of NATURE should know is the great debt which they owe to the publishers. NATURE was initially launched and is still being published almost solely for the advancement of science, in spite of the fact that it is privately owned by a business firm. The present editors feel impelled to put on record their gratitude to the present directors of the House of Macmillan for the entirely free hand given them in guiding the policy of NATURE and in deciding what shall and what shall not be published. To-day, as much as ever, if NATURE feels that in the interests of science and culture, any book, whether published by Macmillans or not, should receive adverse criticism, then it gets it. If NATURE desires to follow a certain policy where science is concerned, whether it be against or in support of other authorities, even the Government, then her policy is pursued relentlessly, yet, we hope, with tolerance. The directors never interfere with policy. Rather do they encourage the journal in all manner of ways, some of which have not received the recognition in the past that they deserved. In fact, it is quite possible that had the former directors not been prepared in the interest of scientific development to publish NATURE for several decades at a financial loss, NATURE, as we now know it, might not be in existence.

To-day, financial problems do not exist, and the considerable help given during the present very difficult times (especially of paper shortage and other exigencies of war) by the directors and their staffs certainly relieve the present editors of a considerable amount of care, and thus contribute in no small way towards the advancement of science in general and the success of NATURE in particular.

Educational Books

Text-books and works of scholarship which have emanated from the House of Macmillan have been legion. There has never been anything shoddy or cheap about those publications, for the directors invariably choose their authors with scrupulous care, and having once chosen them give them every possible help towards the best production that can be obtained from a first-class author working in complete harmony with a first-class publisher. In fact, though it is obvious that some works of scholarship, especially the very advanced, can never prove to be paying propositions, that has not deterred the directors from publishing, provided they are assured that in publishing they are contributing towards the advancement of science and culture.

The first directors of the House of Macmillan established a tradition of *esprit de corps* among everyone connected with any book—author, publisher, editor, printer, and all staff concerned—a tradition which is kept very much alive to-day. Contact with authors was always of the closest, and contact and intercourse between different authors was often stimulated through the agency of the directors. This is well illustrated by the list of guests who attended a dinner at the Savoy Hotel on November 22, 1894, to celebrate the twenty-fifth anniversary of the establishment of NATURE.

Mr. F. Macmillan	Sir A. Geikie
Mr. G. Macmillan	Prof. Alfred Newton
Mr. M. Macmillan	Rt. Hon. T. H. Huxley
Mr. G. L. Craik	Sir H. E. Roscoe
Mr. J. Norman Lockyer	Sir John Evans
Sir George Stokes	Mr. F. Galton
Dr. D. MacAlister	Mr. A. E. Shipley
Prof. Silvanus Thompson	Prof. Marshall Ward
Prof. H. E. Armstrong	Mr. F. C. Penrose
Dr. J. H. Gladstone	Sir W. H. Flower
Prof. T. G. Bonney	Dr. Michael Foster
Mr. C. B. Clarke	Prof. T. E. Thorpe
Dr. D. Ferrier	Mr. J. N. Langley
Prof. R. Meldola	Prof. G. B. Howes
Prof. W. Ramsay	Mr. W. H. Preece
Mr. Hughes Lockyer	Capt. Wharton
Mr. W. Crookes	Prof. Roberts-Austen
Dr. E. Klein	Prof. Ray Lankester
Dr. M. Bruce	Dr. Lauder Brunton
Dr. W. Hood	Mr. W. T. Thiselton Dyer
Sir J. Crichton Browne	Prof. Burdon Sanderson
Dr. E. B. Tylor	Prof. A. W. Rücker
Dr. P. L. Sclater	Dr. Thorne Thorne
Prof. A. G. Greenhill	Mr. D. E. Jones
Prof. H. H. Turner	Prof. C. Allbutt

Present-day readers will note the high percentage of names which have now passed with honour into the annals of scientific research, education and scholarship.

It is not necessary to give an exhaustive list of names of men of science whose text-books, treatises and theses have reached the scientific world through the House of Macmillan; but a few of those whose names appeared in the catalogues of the first forty-odd years of Macmillans make interesting reading. Grouped under their various subjects, the following are examples:

Mathematics and Astronomy. Wilson, Todhunter, B. Smith, Christie, C. L. Dodgson (Lewis Carroll), Airy, Challis, Penrose, Lockyer, Routh.

Physics. Clerk Maxwell, Balfour Stewart, Rayleigh, J. H. Gladstone, Stokes, Oliver Lodge, Tait, Sylvanus Thompson.

Chemistry. Roscoe, Würtz, Watts, Thorpe.

Statistics. F. Galton.

Geography. S. W. Baker.

Economics. Alfred Marshall, J. N. Keynes, J. E. Cairnes, H. Fawcett.

Logic. W. S. Jevons, J. Venn.

Geology. Sedgwick, Geikie, Sabine, J. W. Dawson, Boyd Dawkins.

Biology. A. Newton, D. Oliver, T. H. Huxley, A. Russel Wallace, J. D. Hooker, Ray Lankester, H. C. Bastian, Wyville Thomson, T. J. Parker, Williamson, Gilbert White, Pasteur, Lubbock, Bower.

Medicine and Surgery. G. M. Humphry, Acland, J. R. Reynolds, W. H. Flower, Maudsley, Fox, G. Rolleston.

Education. Matthew Arnold, Dean Farrar, Thring, Sonnenschein, Meiklejohn.

Science Primers. These were some of the first attempts to bring authoritative science text-books within the reach of the schools. They began in 1872 with Roscoe's "Chemistry", and this was followed by Michael Foster's "Physiology", Geikie's "Geology" and "Physical Geography", Hooker's "Botany", T. H. Huxley's "Introductory", Jevons' "Logic" and "Political Economy", Norman Lockyer's "Astronomy" and Balfour Stewart's "Physics".

George Wilson, author of the "Five Gateways of Knowledge" and of several technological books, also figured in the earlier catalogues.

Such men of science, with the essential help of the House of Macmillan, did much towards building the tradition upon which a large number of British educational publications of to-day rest. But progress since those days has been rapid yet sure, so that among the several thousand titles in the present-day Macmillan catalogue can be found many names of first importance in the educational and scientific world.

It is doubtful whether most readers of books realize to what extent those books depend on their publishers as well as their authors. This applies more to educational texts, with graphs, tables, maps, diagrams, and so forth, than to any other type of book; and the same may be said of periodicals.

Among the present directors of Macmillans are two grandsons of the original Daniel Macmillan—Mr. Daniel Macmillan and the Right Hon. Harold Macmillan. At present, Mr. Harold's position as His Majesty's Minister in North Africa is, as one can well imagine, demanding all his attention. Mr. Daniel Macmillan is therefore shouldering a tremendous responsibility ; but well and truly is he doing it and thus carrying on the tradition established by his forebears—a staunch friend of NATURE, a keen judge of a good book, and an ardent worker for the advancement of education. In fact, those of us who have the pleasure of knowing him see much of what was clearly manifest in his grandfather. Impetuous to a degree, impatient of trivial matters, and, therefore, what usually goes with such characteristics, indefatigable in his efforts to do a grand job of work. While the House of Macmillan is able to carry on under the direction of men like the present Mr. Daniel Macmillan, NATURE and Macmillan educational policy have nothing to fear. His is a glorious heritage, and we and the whole world of science must offer him our heartiest congratulations on this anniversary.

MASS OBSERVATION OF THE PEOPLE

The Pub and the People

A Worktown Study. Mass Observation. Pp. 350. (London : Victor Gollancz, Ltd., 1942.) 16*s*. net.

MASS Observation is an organization which has been evolved to make objective studies of the way of life of the peoples of Great Britain. The sponsor of the movement, Mr. Tom Harrisson, was formerly a professional anthropologist, who, whilst working on the island of Malekula in the New Hebrides Group, came to the conclusion that the people in the wilds of Great Britain were as much in need of scientific observation as the cannibals of Malekula. On his return to Great Britain he teamed up with a newspaper reporter, Mr. Charles Madge, who was thinking along similar lines. Thus Mass Observation was born. In August 1939 it consisted of a team of whole-time paid investigators and a nation-wide group of voluntary observers providing information about themselves and their neighbours. This by way of introduction to the organization that produced this book.

For the three years prior to the outbreak of war, this group concentrated on an unnamed industrial town in the north of England, which, short of naming it, Mass Observation takes great pains to suggest must be Bolton. Four major points were considered : the role of the public house in the life of the town, politics and the non-voter, the part played by religion and the annual holiday at Blackpool. This volume deals with only the first of these issues, publication of the other three volumes being suspended for the war period.

"The Pub and the People" is neither a scientific report nor a readable collection of essays. Rather is it a collection of verbose—very verbose—superfluities, interspersed with a number of statistics, which, important though they may be, do little but substantiate empirical deductions which one would inevitably make during a period of regular pub-going. If a scientific report had been intended, this volume would not have been greater than one sixth of its present size. If the writers had envisaged a book that would appeal to any intelligent reader, the contained information should have been more carefully collated and edited.

The following are some of the more interesting facts that emerge from this orgy of words. In "Worktown", the ratio of pubs to people has decreased considerably since the Act of 1839 empowered magistrates to refuse to grant the renewal or issue of beer licences. In the pre-1939 period the pub played a smaller part in the life of the town than it ever did. (It is unfortunate that a short appendix could not have been included indicating the effects of the War on the nation's drinking habits.) As a cultural institution, the pub is a declining force. "Pools, radio, press, motor-culture, dance-halls too (to a surprising extent), cinema, do not create a social group of people sharing consciously the same experience. . . . They are slowly changing the whole aspect of England and no one seems to be noticing it." The latter part of this statement is typical of some of the sensational embellishments which clutter up this book ; this is bound up with complete disregard for objective truth. A frontal attack is made upon "the irresponsibility and ignorance of scientists", without indications of their deficiencies. Other interesting conclusions suggest that the regular pub-goer "puts away" fifteen to twenty pints of beer a week ; the more people in the pub, the more quickly do individuals drink their beer ; drunkenness is not necessarily dependent upon the drinking facilities available ; the usual assumption that the time a pub is open directly affects drunkenness is shown to be unrelated to demonstrable fact. Above all, the main text, which occurs as often as one would expect in a bad sermon, is that the true function of the pub is that of a safety valve, a means of allowing partial release from tensions accumulated in the stress of living. With which, no doubt, we all agree.

T. H. HAWKINS.

MARVELS OF THE VERTEBRATE EYE

The Vertebrate Eye and its Adaptive Radiation
By Gordon Lynn Walls. (Bulletin No. 19.) Pp. xiv+785. (Bloomfield Hills, Mich.: Cranbrook Institute of Science, 1942.) 6.50 dollars.

LIMITATION of vision to a narrow range of wave-lengths of radiation is manifestly related to the absorption of radiant energy by protein and water. The importance of light as a directive agent is associated with a wide range of light detectors in invertebrates. As the pineal eye is relatively unimportant in vertebrates, these devices are crystallized in the two lateral eyes. These lateral eyes show a wonderful variety in structure and versatility in action. The whole subject of the vertebrate eye is discussed by Dr. Walls in his excellent book, which is a mine of information about the eyes of all sorts of vertebrates.

One of the outstanding problems is the difference between vision in air and vision in water. In the former, the difference in refractive index between cornea and air enables the cornea to exert a great effect on focusing the rays of light. In the latter, practically the whole of the focusing of light must be done by the lens. Therefore there is a general difference in the lenses of aquatic and aerial animals, those of the former being spherical and those of the latter flattened from before backwards. The case of Anableps is most interesting. These animals have two pupils. When swimming on the surface with their eyes half submerged they can see objects both above and below the surface. Through the upper pupil by the cornea and less curved sides of a pyriform lens objects above the surface can be focused on one part of the retina, while through the lower pupil and more curved ends of the pyriform lens objects below the surface are focused on another part of the retina.

When the animal is amphibious there are three possibilities. Its eye can be adapted for vision in water, its eye can be adapted for vision in air, or it may have a wide range of accommodation so that it can see fairly well in both water and air. The accommodation can be brought about in several different ways. The lens may be moved backwards and forwards, the curvature of the cornea can be altered, the lens can be compressed round its equatorial plane, the anterior surface of the lens may be made more curved by constriction of the lens by the iris, and finally the lens may become more curved due to the elasticity of its capsule on slackening the suspensory ligament by the ciliary muscles.

Adaptation to different intensities of light may be brought about by a wide diversity of processes. Diurnal, nocturnal and twilight vision are comparatively simple to accomplish. Vision in bright light is associated with the presence of cones in the retina. For dim light, rods sometimes supplemented by visual purple are used. When an animal is active in both bright and dim lights, a duplex retina with both rods and cones is present. Other devices are used to help in the process of adaptation. In some cases extreme variations in pupillary aperture are used. In other cases movements of the retinal pigment combined with movements of rods and cones occur, so that cones are exposed and rods shielded in bright light while rods are exposed in dim light. The linkage of the sensory receptor cells to ganglion cells is such that cones are best for good acuity. The action of the fovea in improving acuity is explained. Maculæ, sometimes two for each eye, are present in some species. The tapetum is recognized as a means of reinforcing the effect of weak light, thus making vision better for nocturnal animals. The pecten is said to be a means for bringing increased nutrition to the inner layers of the retina in species in which the blood supply to the ganglion cell layer is inadequate. The uniformity in number of cell layers in the retina is noteworthy. Sensory receptor cells, bipolar cells and ganglion cells are found in all retinæ. Is this uniformity due to some common physiological need, or does it indicate the stage of development of the cerebral cortex when the optic vesicles were first formed ? The author considers that the original sensory receptor cells were cones, and that the rods were derived from cones. Cones are present in some diurnal animals although their phylogenetic predecessors have rods only. Dr. Walls suggests that these cones have developed from rods. Is it not possible that the power to develop either rods or cones is present in the early stage of the sense cells of any vertebrate ? Visual purple has developed apparently independently in isolated species. Is it possible that there is some common feature present in many retinæ, although visual purple is produced in appreciable quantity in only some of them ?

All these points and many others are adequately discussed in this volume : it is one which has been needed for some time. Where so much is excellent it may seem unnecessary to criticize details. The author considers that small multiple apertures in the closed irides of geckoes may enable them to obtain a greater depth of focus. The multiple images so produced would not be superimposed except by the action of the cornea and lens. If the openings were arranged in a circle or if the pupil were reduced to an annular opening as in Plecostonus, then spherical aberration would be reduced to a minimum. On p. 75 the author states : "No one photosensitive substance could be entirely responsible for colour vision". This statement is misleading, because colour photography is possible with a single photochemical substance. The discussion on the function of coloured oil globules in eliminating scattered light is good, but surely the presence of colour filters in front of certain cones must cause a differential stimulation, and it is difficult to imagine that this differentiation would have no effect on the animal's colour discrimination. In the domestic hen the coloured globules are such as would give rise to a colour vision similar to that of man. Is it possible that trichromatism is a necessary result of some biological factor, or is it due to some physical property of light ?

The author calls his book a text-book. It should certainly be read by all biologists, including medical men, interested in visual problems. H. E. ROAF.

THE EXTREME PROPERTIES OF MATTER*

By SIR CHARLES DARWIN, K.B.E., F.R.S.

WE know a great deal about many of the fundamental properties of matter, and our knowledge enables us to assign limitations on its qualities; so that whereas improvements in materials are possible, we can assign limits beyond which it is fairly certain that these improvements cannot go. It is proposed here to examine some of the principal limitations of this kind. It is only possible to deal with a few of the chief ones, and the list will include the mechanical properties of solids, liquids and gases and some of their electric and magnetic properties.

Strength of Materials

We know a good deal by now about the forces which act between atoms. There are several rather different types of force which occur in various types of solids, and the type which concerns us here is the metallic one, since in considering the strength of materials we obviously turn first to the metals. The basic structure of a metal is a crystal, usually of one of the simplest and most symmetrical classes. In this crystal the atoms have each one or more electrons set free, and these wander about freely as a sort of cloud. This cloud of negative electricity acts as a sort of cement holding together the positively charged atoms. In addition, these atoms exert forces on one another, partly of the repulsive electric type that would be expected, but also others of a kind the principle of which is to be mastered only by going rather deeply into quantum theory. The behaviour of these forces can be imitated by thinking of atoms as exerting attractions or repulsions on one another, but these forces need no longer conform rigorously to the pure electric type. The only character of them that I need at the moment is that they are not to vary violently with the distance; that is to say, if in equilibrium one of the forces between two adjacent atoms is so and so, then if they are displaced to a distance not greater, say, than 20 per cent, this force will not have altered by more than, say, a factor of 2.

Let us now examine what we should expect for the strength of a crystal based on this model. Consider, as the most characteristic thing in a solid, its shearing

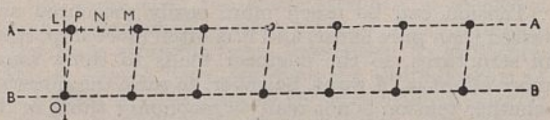

Fig. 1.

strength. Fig. 1 shows two rows of atoms, each of which is intended to represent a whole sheet of atoms standing out at right angles to the paper. The sheets are held together by their mutual atomic forces together with those coming from the atoms in the sheets above A and below B which are not shown. In the unstressed condition the atoms of A and B are supposed to be exactly opposite one another, but this is unessential to the argument; the first atom of A would therefore be at the point L. Now impose a small shear by displacing the whole sheet A and all above it a little to the right. A force will at once

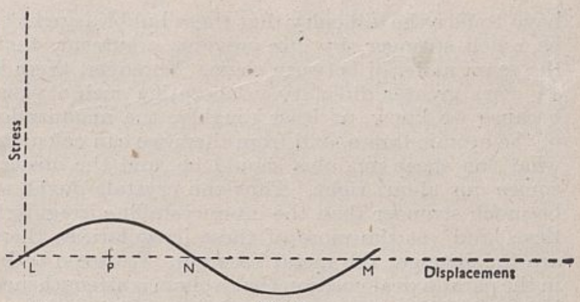

Fig. 2.

come into play resisting this displacement, and we can tell what this force is by our knowledge of the shear modulus.

We can conveniently represent what happens by making a diagram (Fig. 2) in which the stress is plotted against the displacement of the sheet of atoms A, and the shear modulus gives the direction of the tangent at L. As to what happens farther on we cannot be sure, but we do know that if the A sheet is bodily transplanted one atom's length along to M, the force will vanish again, and around this point the curve will repeat itself. Moreover, half-way between there must be another point of equilibrium, and this must be unstable, because it lies between two points of stable equilibrium. This will be represented by the point N and a tangent sloping the other way. We do not know how to complete this curve, but we can make very useful conjectures about it. From all reasonable assumptions about the atomic forces being continuously variable with the distance between the atoms, we may say that the curve should have a reasonably smooth form. The simplest one to take is a sine curve, so we will adopt that. We know the slope at L, and the position of N, and from these it is elementary to calculate the height to which the curve rises at the point P one quarter way along from O to M. This will give the maximum stress that the metal can stand without yielding. An elementary calculation shows that this stress is $G/2\pi$, where G denotes the shear modulus. For a good steel the value of G is about 6,000 tons per square inch, and this suggests a shear strength of about 1,000 tons per square inch, in contrast to 10 tons per square inch, which is roughly the actual value.

The argument I have given suggests that a crystal of a metal ought to be very much stronger than it is; roughly it ought to be possible, without breaking, to shear a cube until it formed a parallelogram with angles given by the slope of OP in Fig. 1, that is to say, more than 10° off the right angle. This is completely contrary to the facts, for when a single large crystal is made of a pure metal it is found to be as soft as putty. This difficulty has been much considered, and I may refer to work of G. I. Taylor, who attributed the hardness that working gives the metal to 'centres of dislocation', that is, to imperfections in the ordering of the crystal, an effect which is practically universal in crystals. It would be out of place to go into his theory, but it confirms the point that to get a strong piece of metal one must have small crystals in it, not large ones.

If one examined the experimental facts without recourse to theory, one would conclude that it is the irregular junctions between crystals that make its strength, and that the metal is a sort of foam of these irregularities containing in its bubbles the putty-like crystals. But this is not a possible view, since we

* From the James Forrest Lecture of the Institution of Civil Engineers, delivered on January 12.

have to face the difficulty that those bubbles ought to be much stronger, by our previous argument, than the foam material between them. Moreover, there is an even greater difficulty in accepting such a view, because we know, at least roughly, the magnitudes of the atomic forces, and from them we can calculate what the shear modulus should be, and the answer comes out about right. Thus the crystals ought to be much stronger than the intercrystalline irregularities ; and yet the more of these irregularities there are the stronger the metal becomes. We seem to be in the paradoxical position that a chain is strengthened by multiplying the number of its weakest links.

Some recent ideas of Bragg and others have done much to clear up the situation. In the model I took of the sheared crystal, I imagined the atoms on each sheet rigidly held together in relatively fixed positions. In fact, however, they are not fixed, since temperature dictates that atoms can never be at rest. Each atom is oscillating all the time in an irregular manner about its average position, and this makes possible a re-adjustment among the atoms without calling into play the strong stresses which would arise if the whole sheet had to be displaced like a rigid body. Consider the matter in more detail. A piece of metal is now to be regarded as composed of a large number of small crystals, all differently oriented and held together by a cement of irregularly placed atoms. When one of the blocks of crystal several layers thick is sheared a little, the displacements of the atoms (more strictly, now, of the average positions of the atoms) will call into play reactive forces which provide the shearing stress. But if the shear is made larger a new possibility occurs, which is that a slip should occur between the two rows. On account of the heat motions of the atoms this may now occur without calling into play the violent reactions that our previous argument suggested ; and to decide whether it will occur or not we adopt the obvious criterion of energy, that is to say, if the strain energy of the slipped crystal is less than that of the unslipped, then slipping will occur. This is illustrated in Fig. 3, where the form *B* will have much less energy than *A*.

The result of this argument is to explain why large metal crystals are so much softer than small, for a shear of one half the atomic distance, measured across the whole width of the crystal, suffices to produce slip, and for a thick crystal this is only a very small shearing strain. There is much else in Bragg's work beyond this which I shall not mention, but we can see how it satisfies the two important conditions, first that it is the crystals themselves that dictate the value of the elastic modulus, and secondly that it is the reduction in size of the crystals that explains the strength of the metal.

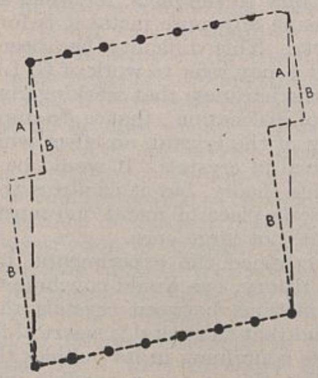

Fig. 3.

The question then arises whether we can use this theory to reduce the extreme limitation we have derived for the strength of the metal. Evidently the smaller the crystals the stronger the metal should be, but to what limit may we go ? For example, if we could think of crystals only two layers thick we should be back at the earlier argument, but such a supposition would signify that nearly all the metal was composed of the irregular arrangements between crystals. An irregular arrangement of atoms of this kind is very like a liquid or a glass, and is very intractable to mathematical treatment, so that it is difficult to say what would happen from the atomic point of view. We may, however, be fairly sure that there would be some tendency to recrystallization, a sort of self-annealing, which would give rise to crystals up to a certain size, because we know that the process of annealing does tend to build up large crystals, and this tells us that the crystalline form has less energy than the glass form.

In this general connexion I would direct attention to the remarkable observations made some years ago by A. A. Griffiths, who found that a thin fibre of glass when newly made had a greatly enhanced strength. The value obtained was quite near that which would be indicated from the shear modulus as in Fig. 2, and this is most interesting as a confirmation of my general argument. With the lapse of time the fibre lost its excessive strength, presumably on account of re-crystallization. Until we can know how far a similar recrystallization can be permanently prevented in a metal we cannot further reduce the extreme value we have arrived at for its strength.

As a general conclusion for the extreme limit of strength we may ever hope to attain, I therefore conclude that it is certain we cannot get beyond $1/2\pi$ of the shear modulus, and that it is most unlikely we can get beyond, say, one tenth of this—which would correspond to having crystals about ten atoms thick and to the rather unwarranted assumption that the irregular junctions would not provide a closer limitation. Since I cannot suggest any exact values for these further effects, I am going to play for safety, and take as the ultimate strength the value $G/2\pi$. This is about one hundred times as strong as existing materials.

Elasticity and Strength

Tension can be much more easily measured and tested than pure shear, and it is often more important in structures, so the engineer tends to think much more about it. I want, however, to raise the question whether tension is not really a secondary thing in the theory of the strength of materials.

The elasticity of an isotropic material has two properties which can be defined in a variety of ways : for example, by giving Young's modulus and the shear modulus, by giving one of them and Poisson's ratio, or by giving one of these three and the bulk modulus, that is, the reaction to hydrostatic stress. From any two of these the rest can be derived, and the only question is which are the best two to take ? In other words, which are naturally the most primitive ? A rather strong case can be made for taking the bulk modulus and the shear modulus as the two most primitive, since they correspond to the simplest types of strain which can be imposed on a solid body. In effect, this choice is made because it is easier to think of the stress as being called into play by an assigned strain, than to do what is done in a testing-machine, which is to apply a given stress and see what the strain is. If, then, we are to start with strain as given, there can be no question that a linear tension is a rather complicated thing, involving as it does both a distortion and a change of volume.

This point of view derives from the classical theory of elasticity, and it is a very tentative matter to apply it to the question of ultimate strength. In the first place, some materials break in tension and others in shear, as is easily seen from the shape of the fractured surface. The strongest materials always break in shear, and it seems likely that this is the fundamental manner. I should conjecture that breaking in tension is really a secondary business. If a bar under test contains non-uniformities there will result stress concentrations, and it is the shearing at these concentrations that causes the break. This is only a conjecture, but it leads to the plausible consequence that there is one cause, and not two causes, governing the strength of materials.

Now I have pointed out that the classical theory of elasticity suggests that the bulk modulus is a more primitive thing than is Young's modulus, and this suggests that we should consider what is the 'bulk strength' of materials, that is to say, the manner in which they yield under hydrostatic pressure or tensions. We can immediately answer half this question, for there is no doubt that the metal when hydrostatically compressed resists that compression strongly and shows no tendency to break under it. As to its behaviour under a hydrostatic tension we can scarcely give an answer at all, since it is impossible to apply such a system of forces to a solid. I know of only one experiment where something of the kind has been done. Joffe took a sphere of rock-salt crystal (which is cubic and not far from isotropic) and immersed it in liquid air until it was all of one temperature. He then plunged it in hot oil so that the outer parts expanded, and these parts applied a hydrostatic tension to the inside, which was still cold. The tension showed no tendency to produce cracks.

This one experiment is obviously a rather complex business, but it confirms a tentative conclusion that I wish to draw. The characters of solid matter may be divided into two types, namely, those sensitive to details of structure and those insensitive. All the elastic moduli are fairly insensitive, in that, for example, Young's modulus and the shear modulus are roughly the same for hard and for mild steels; but we know that the shear strength is sensitive. I want to suggest that what evidence there is points to the bulk strength being insensitive to structure. If this is correct, then we have the simplification of theory that we can impute the structure-sensitivity of tensile strength to the shear strength. The advantage of this point of view is that we have only *one* quantity to consider which needs close examination, while the second elastic character plays little part in the consideration of strength.

Liquids

The two main characters of a liquid are its compressibility and its viscosity. As to compressibility, there is little to be said. At one end we pass over into degrees of resistance to compression comparable with, but not so strong as, those of solids. At the other end we come up against the *critical phenomena* where liquid passes continuously into vapour, so that again there is no extreme property. Viscosity is more interesting. At one end we have highly viscous materials, such as treacle, then pitch, and then glasses which shade into plastic materials and become indistinguishable from solids. I may also refer to those highly peculiar substances which appear quite stiff but gradually become liquid on stirring, and the converse ones which are liquid, but become stiffer and stiffer as they are stirred; but the theory of these is rather obscure and I must not attempt to discuss them.

At the other end, that of small viscosity, there is much more interest in a particular substance which was discovered only a few years ago. This is liquid helium II. Helium is the substance with the lowest boiling-point of any, about 4° absolute. Liquefaction was achieved in 1908. The next thing to do was to solidify it, but for long no success was achieved, until finally in 1925 it was found that high pressure was essential, and that solid helium could exist only at a pressure of more than 20 atmospheres. But a much more remarkable thing was also found. At ordinary pressures the liquid suddenly changes its character at about 2°. Above this temperature liquid helium I is a fairly ordinary fluid, with a density of about 0·1, and with viscosity and specific heat about the same as those of other liquids. At 2° there is still no change in density or specific heat, but the viscosity drops to a very small value indeed and the heat-conductivity becomes enormous—a hundred times better than that of copper. That, at least, was how the matter appeared at first; but there was a good deal of discrepancy between the measures of various workers, and it was suspected that the viscosity was so low because in every measure turbulence had occurred, while measures of viscosity depend on using such fine tubes that turbulence is eliminated.

Later work has suggested that the matter is not so straightforward, and, in fact, that the character of the substance is not to be explained in terms of the ordinary language used for liquids; but the business is by no means clear yet. We may say, however, that a solid body could move extremely freely in helium II, and that it is practically impossible to keep bodies at different temperatures in its presence: and it has another remarkable characteristic in that the liquid can creep over any surface in apparent defiance of the laws of hydrostatics, so that if a tea-cup were filled with it, in a short time the liquid would appear in the saucer, and then on the table, and finally the level of the liquid would be the same all over whatever space was available.

Gases

When we come to gases there is little to be said, as the gas laws are very precise and admit of little variation. There are variations of equation of state near the condensation-point, but in the truly gaseous condition the only variety is in the density and the specific heat. The most interesting quantity is the ratio of the specific heats, which governs the law of adiabatic expansion and the speed of sound; this is 5 : 3 for monatomic gases, 7 : 5 for diatomic, and still lower for more complicated molecules. We can say at once that 5 : 3 is the highest ratio that could ever be possible. With regard to density, we can say quite definitely that the limit of lightness is attained by hydrogen.

But if I may extend the meaning of the word 'gas' there are much more interesting things to be said. There does exist matter which is much lighter than hydrogen. This is the electron, which has a mass

1/1840 of that of a hydrogen atom. Electron gas can have only a transient existence, because the enormous repulsive electric forces blow it to pieces at once; but we can take advantage of this transient existence in a more limited way. This is especially in connexion with *relays*, which turn a weak cause into a strong effect. In a quick-acting relay, inertia is obviously of the chief importance in making a given force produce the quickest effect. The force on a body, which in the most delicate systems is almost always electric, depends on the electric charge, while the motion depends on the mass, so that e/m is a measure of the capability of a system to act as a relay. The e/m of the electron is 1840 times as large as that of the next best system, the hydrogen atom, and proportionately again better than that of heavier substances. It is this enormous factor that is responsible for the high qualities for amplification of the thermionic valve amplifier.

We know of no reason or evidence that there is anything in the nature of a 'sub-electron', so that we have arrived now at the ultimate limitation in relaying action by the use of the properties of a transiently existing electron gas. It is true that there is something less heavy than electrons, and this is light itself, which carries energy but has no *rest-mass* at all. I have to word this carefully, because in a wider sense anything with energy has mass. But something besides light must always occur in a relay, because at some stage the light has to be acted on or to act on matter with ordinary inertia. The efficiency of a relay is that of its heaviest part, and so we cannot hope by any means to improve on the electronic valve.

Although a free electronic gas can only exist transiently in a tube, there is an extended sense in which it is of much commoner occurrence; this is in the interior of a metal. Here there is a framework of positively charged atoms to neutralize the electron charges, so that the gas can now be permanent. Such a gas has certain properties which are entirely different from those of an ordinary one, a fact which was first recognized with the discovery of the new quantum theory fifteen years ago. The molecules of an ordinary gas are moving about with various and frequently changing velocities, and the frequency of occurrence of these velocities is governed by Maxwell's law of distribution, giving the average numbers at any instant with each velocity in the form of the well-known 'cocked-hat' error law, the size of the curve depending on the absolute temperature.

The electron gas has its velocities distributed quite differently. This is because of the exclusion principle, one of the basic principles of the quantum theory. I must not go into technicalities, but the rule is that two electrons must never be doing the same thing. Thus, if one electron is at rest in the metal no other can be at rest: in an ordinary gas there is no reason why many molecules should not be at rest simultaneously. There are a great many electrons in the metal, and they comply with all the conditions of low energy and many of the higher, so that a lot of them are forced to have quite a high energy. Instead of the Maxwellian figure we get, at ordinary temperatures, a curve with a very sharp fall to zero. The speed at this break corresponds to what in the other curve would be given at a temperature of about 10,000°. To misstate it in picturesque language, the exclusion principle squeezes the electrons out of their rightful temperature; if the metal could be raised to 10,000° without melting, then for the first time the electron gas would behave something like an ordinary gas. I wish I could enlarge further on this, but it is hard to do so without going more deeply into technicalities. Moreover, my main purpose in mentioning it at all has been because I shall want to return to it in the next subject for discussion.

Density

We have already considered what is the lightest substance. It is natural next to ask what is the heaviest. Forty years ago there would have been the immediate answer, metallic osmium which has specific gravity 22, and the only saving clause would have been that there might be other unknown elements which would prove heavier. We now know that there are no unknown elements and yet we must answer the question quite differently. This is on account of certain very unexpected astronomical discoveries of about fifteen years ago. Certain stars were discovered which gave out light at a white heat and yet were very faint; they were therefore called white dwarfs. The white heat implied a high temperature, and with this temperature they had no business to be faint; their faintness could only be explained by small size, and this implied a very high density. For example, the companion of Sirius is about the weight of the sun but about the diameter of Uranus, and therefore its mean density must be about 50,000. At this density a cubic inch of the material would weigh about a ton.

The general theory of these dwarfs is understood, though no one knows yet fully why they occur, and what happens to them ultimately. Their structure is an extreme case of the electron gas in a metal. In the interior of a star the temperature is so enormous —millions of degrees—that the atoms lose most of their electrons, and this large number of electrons becomes subject to the exclusion principle. According to this principle there is a simple relation between pressure and density which is independent of temperature; it is the same relation as that which applies for the adiabatic expansion of a monatomic gas. So long as the temperature is not too high (and by high temperature I now mean something like a hundred million degrees) this relation holds and implies that under sufficiently high pressures there is no limit to the density. As in most things of this kind, the result must not be pushed too far, because we have omitted certain secondary matters which ultimately become important. But there is good reason to believe that in the deep interior of white dwarfs there are densities of something like two tons to the cubic inch—specific gravity a hundred thousand —which are maintained by pressures of the order of a million million atmospheres. It seems reasonable to hope that this is a final limitation on the density of matter.

Electrical Properties of Matter

What is the best insulator we can hope for? Here the answer is fairly definite; we already have it in the form of good transparent crystals such as quartz. The theory of insulators, as formulated nowadays, is curiously like that of conductors. The individual electrons in both are free to move about in the crystal, but the exclusion principle leads to an important difference. In the case of metals there is, so to speak, room for an electron to behave in a different way from what it is doing—not all the seats are occupied—so that it can wander about carrying its electricity with it. In an insulator there is a full house, so that when one electron shifts its place another is forced at once to take that place, and there can be no transport of electricity, and so no conduction.

There are two ways in which insulators fail. First, the surface often becomes covered with some foreign material, often merely water, which causes a leak over it. The second failure is much more interesting. One way of escaping from the rigour of the exclusion principle is to provide an electron with a good deal of energy, because then it can be 'doing something different' from the others. If a crystal, say of rock salt, is illuminated with ultra-violet light, some of its electrons absorb the light and acquire a high energy which sets them free to wander through the crystal. In this way a conductivity not unlike that of electrolysis arises. To get a perfect insulator this must be avoided, and it can best be done by keeping the crystal in the dark and, since there is always radiation due to temperature, to make it very cold will also help.

At the other end of the scale, what is the best electrical conductor ? Here also we can make a rather definite answer. The conductivity of alloys is worse than that of their constituent elements, both theoretically and in practical experience, so that we need only examine the table of the elements to see which is best. If we reckon by weight this is sodium, but others are nearly as good. But a far more important question is the temperature. The conductivity improves with cold, and tends to very high values at the absolute zero. It is not certain whether it might not become infinite, but as a general rule there seems to be a small residual resistance.

The interest of this is very much diminished by the extraordinary phenomenon of superconductivity. Certain of the elements—not by any means the best conductors at room temperature—and also some alloys and compounds, as the temperature drops, suddenly become perfect conductors ; lead does so at 4° K., so that if a current is started in a lead ring below this temperature it just goes on for ever—always provided the stock of cooling liquid lasts. This is a fascinating subject of study, not by any means cleared up yet, which possesses many of the characters of the older physics of Faraday rather than of modern atomic physics. There are, however, pronounced limitations in its practical utility because superconductivity is sensitive to magnetic fields, and fails when the field is strong, so that if too great a current is carried by a superconducting wire, that current's own field destroys the superconductivity.

Magnetism

The question of magnetism is also interesting because such great technical advances have been made in it lately. I can only touch on some parts of the subject, in particular on permeability and saturation values. Of these, the permeability at low fields is important for many purposes. The value for mumetal is about 60,000, and we may ask whether this could be increased.

According to present ideas, iron and nickel have the property of being spontaneously magnetized in small domains, and all that the external field does at first is to turn the direction of spontaneous magnetization into another direction of easy magnetization. There does not seem any particular limitation on this process, so that we can see no reason why quite a small field should not give practical saturation. Thus we know no reason why there should not be a better mumetal in the sense that the permeability for weak fields might be much larger ; but correspondingly the exciting field would have to be reduced, or saturation would ensue.

The question of magnetic saturation may be answered much more definitely, since there exists a fairly complete atomic theory. We can say that it is certain that nothing can show magnetic saturation much greater than that of iron, and it is extremely unlikely that anything will be found perceptibly better than iron. In this matter of saturation we are not concerned with the ease or difficulty with which the magnetization can be set up. In iron it is spontaneous, whereas in some substances it calls for such strong external fields that nothing like the maximum has ever been attained. There is a natural unit of magnetization, the Bohr magneton, but theory indicates that there is no reason why an atom should possess an exact whole number of magnetons. Thus iron has 2·2, cobalt 1·7, and nickel 0·6. The largest number known is in the rare earth europium, some salts of which have 10. This is in exact accord with theory, and as the theory has been applied to the whole table of elements, we can confidently say that it is no use expecting anything better. This magnetization is in the salt, where the europium atoms are fairly far separated from one another, so that the total magnetization is not very large. The europium atom is three times as heavy as the iron atom, so that even if the full magnetization could be produced in the metal, the resulting value would only be half as much again as it is for iron. That is why I said that there was very little expectation of getting anything better than iron.

Summary

I have ranged over a wide field of properties of matter, and had better summarize them in conclusion. I am going to do so in a fanciful manner by taking a structure built out of all the extreme materials I have imagined and seeing what it is like.

I propose to rebuild the ship *Queen Elizabeth*. My metal is one hundred times as strong as that used in the present ship. I do not propose to go into complicated questions of design ; for example, the tension members can be immediately lightened one hundred times, but the thrust members will have to be much enlarged tubes in order to remain stable. I see no reason why I should not build the ship with one-hundredth of the weight of material. As the ironwork weighs something like 30,000 tons in the present ship, my ship will weigh only 300 tons. Therefore, to get the displacement, I shall have to ballast it with nearly 30,000 tons before I begin to put in the cargo. I immediately think of using material from a 'white dwarf' star for this, and my ballast will then occupy about 17 cubic feet. However, I now notice that there will be technical difficulties in this way of doing things, since I should have to keep it at a pressure of one billion atmospheres and at a temperature of one hundred million degrees, so I give up this idea and fall back on ballast made of metallic osmium, of which I shall require as much as 50,000 cubic feet, say a block in the form of a cube of 12 yards side. It is time now to attend to the machinery. Presumably I shall think of putting in an atomic engine, but the trouble is that whatever the engine itself may be like, so far as I can see it will have ultimately to raise steam for a turbine, so that my engine-room will still have to be quite large. For the auxiliary machinery I will certainly take advantage of superconductivity, so that the wiring of the ship will be cooled by liquid helium; it must be made of tin or lead wire, since copper is not a superconductor. The magnets in the dynamos will scarcely be different from those already in use.

This suggests a further flight of fancy. My ship on its journeys still has to contend with the resistance of the water. Would it not be more economical to alter the composition of the sea into something less resistant? If it is liquid helium II, I can economize in many ways. I shall need no special cooling for the superconducting electric wires. I can leave out nine tenths of the ballast, since the density of the sea is now reduced to one tenth. It is possible that I can give up having an engine altogether by giving the ship a good shove at the start of the journey and receiving it on buffers at the end; I know too little about the real viscosity to judge of this.

But the end of all my plans is tragedy. On account of another of its properties the liquid helium II will irresistibly creep up the sides of the ship, over the bulwarks, across the deck, and down the companion ways, until it settles in the hold, in the effort to come to the same level inside as out. Deeper and deeper will grow the water in the hold, and deeper and deeper the ship will settle, until at last my imaginary ship will founder in the depths of the imaginary ocean.

RESEARCH IN THE NETHERLANDS INDIES*

By Dr. P. HONIG

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RESEARCH in the Netherlands Indies which tried to improve existing or developing processes was, and is, principally concerned with agriculture in all its aspects. Research in the field of mining had to do with the geological surveys of mechanical engineering as well as metallurgical and civil engineering.

Most of the progress in the Indies has been culled from experience gained in Europe; new scientific aid from Japan, other countries and even from the United States has been of limited significance, except, perhaps, in military matters.

It is not the purpose of this article to discuss medical research, although in the past fifteen years the relation between nutrition, hygiene and the health of the population has been intensified.

Research, as it has been organized in the Netherlands Indies, has to do, primarily, with agriculture and technology. Agriculture includes agrogeology, diseases (phytopathology and entomology) and the methods of planting, selection of varieties, application of fertilizers; the study of technology is directed towards improving the methods of manufacture of agricultural products.

The beginning of research work in the Netherlands Indies is seen as far back as the origin of the Botanical Gardens in Buitenzorg some sixty years ago. Without doing injustice to its former directors Teismann and Blume, or to individual explorers such as Rumphius and Junghuhn, the real beginning of systematic research began about 1880. Before that time, however, there was a separate survey of the natural wealth of the Netherlands Indies, with the idea of having a detailed summary on minerals, fauna and flora, the geological formations, and the character of natural conditions regarding temperature and weather.

The principle of using science and scientific men to improve existing agricultural industries was first developed in Europe, and it is certain that Germany played a leading part during 1870–1890 in this matter. Treub, of the same era, was ideal as director of the Botanical Gardens. He worked on the plan of introducing science for practical application, although it was his original contention that most of the scientific research, for application to special plantation crops, must be affiliated with Buitenzorg. He believed this necessary in order to centralize in one way or another the scientific work; he thought it to be advantageous to move scientific workers about. The idea of centralization was not used, however, by the new "Proef-stations", as the first research centres were called.

The first research centres were organized as private institutions. There were stations for sugar, tobacco, coffee, indigo and for forestry in general. Later, there followed similar centres for tea, rubber, cinchona, palm oil. Then came the Government Agricultural Institute for the study of native crops: rice, copra, cassava, soja, maize and similar produce. The research organizations previous to 1900 employed, in general, phytopathologists; but later agriculturists and biologists, specializing in genetics and physiology, were introduced. In 1930, for example, the total number of workers on the staffs of the Netherlands Indies Governmental and private institutes was 190. These included those working in the fields of agriculture, agricultural industries and technology. All of them were graduates and experts.

At the start, the selection of the research workers was on a broad international base, and most of the European countries sent men of science to work in the Netherlands Indies. This international cooperation was of great benefit to the country. Further, there were the universities in Holland where it was possible to give a limited number of students thorough training. The Netherlands Indies also had the good fortune to have men of science who could read three major foreign languages.

The total number of experts who worked in the Netherlands Indies from 1880 until 1935 was about 850. About 250 of these men had been connected with the Experimental Station for the sugar industry. More than one quarter were foreign residents, while the average time these men were connected with research in the tropics was seven to eight years.

The total number of chemists, agriculturists and biologists engaged in the Netherlands Indies was much greater, however, than the above-mentioned figures. In 1939, there were 250 chemists, of whom 50 were doing research; the others dealt with education, manufacturing processes, consulting agencies and the like. Of the agriculturists, research workers numbered 45 out of 700 in 1939. There were 90 biologists with 25 research workers. The geologists numbered 70, of whom seven were engaged in research. The number of pharmacists was 200, eight of whom were research workers.

Until 1939, the number of Indonesians and Chinese working in science was very small, and the indigenous part of the population provided only five research

* Substance of an address given at the September meeting of the Society of Netherlands Scientists in the U.S.A. at Cornell University.

workers. Their contribution to scientific literature was likewise very small.

Following the publication of works on science in the tropics, much controversy arose on 'the creation of new wealth'. It was considered for some time, in effect, that the result of scientific study was the property exclusively of those who were paying the bills. Furthermore, they were secret. On the other hand, it was advocated that for scientific progress it was absolutely necessary that publications should be sent to colleagues working in the same fields in other countries, and that free co-operation be a requirement.

Discussion on these points of view began during 1930–32, years of the severest depression. Companies existing at that time thought that a number of foreign competitors had profited specially by the studies in the Netherlands Indies; that the methods developed in the Indies were only copied when free access had been given to all those who were interested in the results of the research work.

Unfortunately, this discussion had as defender a professor. The rights of the vested interests were defended by a lawyer, who evidently put forth the cause of the financing companies to limit and even to forbid foreign co-operation among the scientific workers. In 1933, the final decision for most of the experimental stations was to drop the open-door policy and to try to keep as secret as possible future results from the laboratories. The steps so taken were undoubtedly bad. Only the worst type of 'man of science'—the unreliable and selfish type—saw in this policy of secrecy an opportunity to exploit his own position and his own acumen. In the small, closed communities of manufacturing companies, generally speaking, objective criticism was lacking; and prominence was given those who talked a great deal but said little. The best scientific workers were more or less ignored.

During this unhappy period, the Council for Natural Sciences in the Netherlands Indies made an attempt at a certain amount of co-operation as a counter-measure and, if possible, for the entire Netherlands Kingdom. It did this by an organized exchange of experience between the stations and professors of natural science in Holland, who were acquainted with the problems of the tropics. To this date, however, the matter remains unsettled.

Most of the studies on the Netherlands Indies are published by the stations themselves, usually in the Dutch language, but, where there are large foreign interests, as in the rubber industry, in English as well. The number of technical periodicals distributed throughout the whole world before the War was: engineering, 1; medical, 3; geological, 1; pharmaceutical, 2; chemical and technological, 1; sugar, 2; general agriculture, 3; tea, 1; rubber, 2; cinchona, 1.

In 1914, periodicals in the Netherlands Indies totalled seventeen. About nine tenths of all the studies in the Netherlands Indies were published in these journals, while one tenth was found in other countries. Before the War, the material was contained in Dutch publications; at present it is found in American and British periodicals.

Studying research on the Netherlands Indies reveals excellent co-operation with other countries. The share of work done by foreign men of science, among whom may be mentioned Germans, Swedes, Swiss and Russians, is important. The relations between nationalities and scholars of different universities have been of benefit to all. In the past years, selection of scientific workers has become limited and the trend was preferably national. An additional limiting factor was that well-known professors, or high officials, in the Netherlands were used as liaison officers for the selection of young graduates to be sent to the Dutch Colonies.

There appears to have been an unfortunate narrowing of the field from which men are selected in the Netherlands Indies. After the War, it is to be hoped that all men of science interested in the Netherlands Indies, and living and working in other countries, will stimulate their students to go to the Indies for work and study, because working in the tropics can prove an excellent occupation. The number of research workers in the Netherlands Indies, which has been given above, is very small. The United States has at present 70,000 experts working on natural science. In the Netherlands Indies there is a maximum of 300, partly because some of the findings, especially in connexion with the oil and tin industries, are made in other countries where facilities are better than in the Indies.

The United States at the present time is spending 300 million dollars a year on research. In the Netherlands, three years ago, expenditure amounted to 3 million guilders, which meant that of the exports about one half per cent of export money was used for research. It is generally believed that money used for data on the Netherlands Indies yields profitable returns. In some cases, such funds have had to be increased; but, because of the conditions of prices and quantities of produce to be exported, it is very difficult to stabilize the amount.

It may be expected, however, that the money will be increased eventually. Previous to 1930, more than 80 per cent of the research work was done by private organizations. The trend now is that much more will be done by Government or by private institutes under Government control. It is also to be expected that after the War the Netherlands Indies will ask for more research workers and that they will be asked to come from widely divergent places. The Netherlands Indies are dependent on foreign sources, not only for the scientific workers themselves but also for equipment and literature. Only laboratory buildings and assistants are available in the Indies.

Many countries are even now considering how this research can be directed, including the Indies, where the Government had founded the Council for Natural Sciences for the Netherlands Indies. This may be compared with the Koninklijke Academie voor Wetenschappen, which studied and promoted scientific work in the Netherlands Indies. One of the difficulties for a practical organization is that a number of the directors of experimental stations there must be trained to the right responsibility. Their attitude must still be made more active regarding the proper locale for scientific work, and there still is misunderstanding on the part of a financial board. The director of an experimental station must be convinced that he is the one responsible for the work turned out. He must not be passive about defending the rights of the scientific workers and in finding a proper solution for publication policy as well as in stimulating co-operation. In most experimental stations the scientific locale and general set-up do not rise above the scientific and social outlook of their directors.

Considering the specialized science already established, it may be asked: What of the men themselves to be selected for the future? A start was made with chemists, and later biologists and agriculturists arrived, followed by the biochemist.

So, the first step to take after the War is to seek men who are suitable. The specialized research worker is not so important, for too much value has been attached to the title rather than to the man, his experience and qualifications. A 'clan' formation in the scientific world may develop with biologists sticking together and agriculturists training themselves in mutual admiration. It must be realized that the physicist, as well as the engineer, the biochemist and the technologist are also useful.

In the Netherlands Indies there has always been considerable discussion about pure and applied research. Naturally, there is not a single experimental station which is not interested in fundamental research work, without regard to specific applications of the facts to be discovered. The danger of an experimental station is not that it is doing too much on pure science, but that a research institute has also to act as a consultant.

In certain conditions, this can result in lack of time for real research. The research worker should not be spoken of as an impractical, unsocial, professorial type, with the "zeal and satisfaction of the crusader", in devoting his whole life to science. Perhaps in the past there have been certain of this extraordinary type of man; but those who have been in the Netherlands Indies were no strangers in the economic world, and their outlook upon life was just the same as that of common men with common sense. Most of them, however, had great zeal, with an honest idea of scientific truth and with intelligence above the standard.

The Council for Natural Sciences, which has been studying the scientific future for the past two years, will play a leading part in choosing intelligent and zealous men of science, because it is convinced that governmental encouragement and support of research is a necessity; that the best form for this encouragement is to provide sufficient assistance to existing associations; and that all research should not be handled by a centralized governmental service. Decentralization of research, with boards interested in the problems to be studied, is the future development to be desired. Further, the funds for research must be increased.

It should also be possible in the future to criticize frankly research in certain industries. The Netherlands cinchona industry, for example, which had been a profitable one, was only using pharmacists and keeping secret everything which they were doing. According to the general feeling of a great number of men of science, however, insufficient research on the details of bark composition, quinine chemistry and manufacture of substitutes was being done; the industry felt that it was in a safe corner with its secrecy and profits; but a world with more freedom is the goal, and such secrecy is unpalatable.

An important factor for the future of the Netherlands Indies is that it has decided to create a complete university, with courses in all the natural sciences, to be maintained on the same level as the Dutch universities. Such a university would be an important centre of research in the future. The problems of society *vis-à-vis* science in the Netherlands Indies are not confined to this country. They are general world problems. We must do away with the secrecy impressed upon men of science by their employers. Open discussion is the best for the enlightenment of business executives, and it must be made possible for every man to discuss his work and aims. The post-war scientific world in the Indies must have workers in a free world who feel they belong to a group which has forgotten all limitations set by frontiers, races and laws—because science is one of the expressions of the higher unity of mankind and the world.

ORIGIN OF MALIGNANT TUMOUR CELLS

By DR. P. C. KOLLER
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IN the light of recent knowledge of chromosome chemistry and gene action and its bearing on the interpretation of the mitotic cycle in the cell, a cytological analysis was carried out on 565 human tumours (carcinoma of the skin, œsophagus, colon, rectum, larynx, lung, cervix, uterus and breast)[1]. It was expected that by analysing the characteristics of chromosome and nucleolus behaviour, abnormalities specific to the internal organization of tumour cells might be detected. The present article contains a brief summary of the data obtained[2].

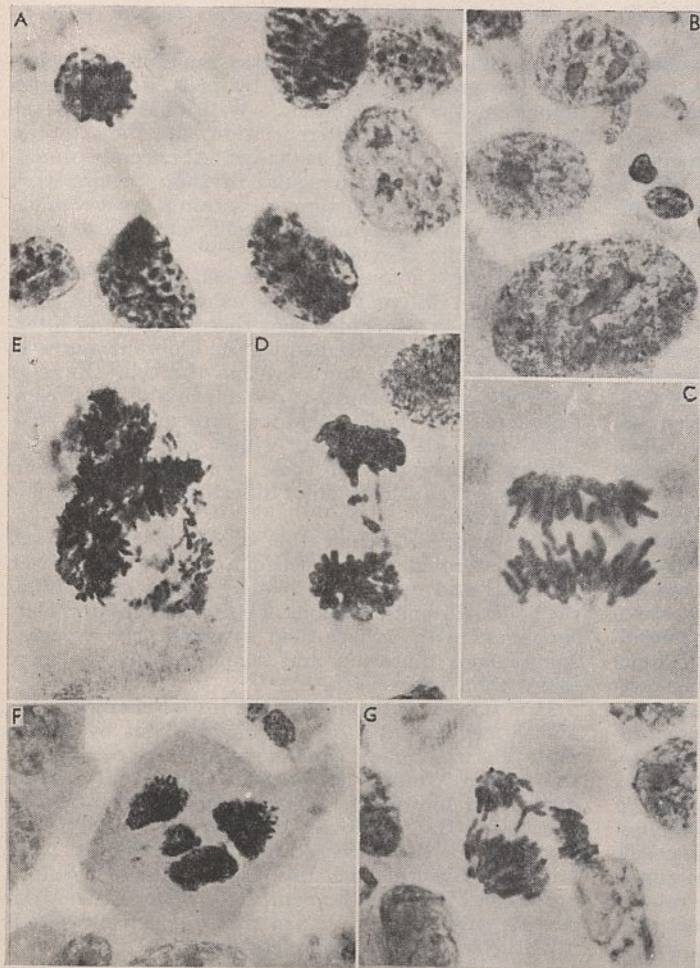
Nucleolus

Pianase[3] had already reported that the nucleolus, a permanent structure in the resting nucleus of cells, is larger in tumours than in normally functioning tissue. His observations have been corroborated since by many investigators[4]. During the last few years cytogenetical research has accumulated experimental proofs that the nucleolus is produced by the so-called 'nucleolar organizers', which are a group of genes located in particular regions of the chromosomes[5]. Nucleoli are formed at the completion of mitosis and their size may increase during the resting stage. They disappear at the beginning of the prophase of the succeeding division. Although there are great differences in the histological structure of tumours of different tissues, the behaviour of the nucleolus is always the same.

It was observed that (*a*) nucleoli in cells of the same tumour differ in their chemical contents; (*b*) they are of varying size; and (*c*) nucleoli in cells of different tumours of the same kind may differ in both, that is, in size and chemical content.

Nucleoli giving Feulgen's positive reaction are known to contain desoxyribose nucleic acid; they usually appear as small, deeply stained granules (*A* in accompanying photograph). Such nucleoli represent heterochromatic regions in the chromosome, which retain the nucleic acid charge during the resting stage. In nucleoli which give a Feulgen's negative reaction, on the other hand, desoxyribose nucleic acid is absent, and, as ultra-violet absorption indicates, there is a large amount of protein of the histone type and the ribose form of nucleic acid. These nucleoli are large (*B*), and they show great variation in size, which is due to the different amount of histone-protein and ribose nucleic acid present.

It is seen that tumours are not homogeneous from a cytological point of view, but are composed of cells with Feulgen's positive and negative nucleoli.



A, Tumour cells from cervix, showing the small Feulgen's positive nucleoli (× 800). *B*, Tumour cells from cervix with large Feulgen's negative nucleoli. One cell is polyploid (× 800). *C*, Anaphase in squamous cell carcinoma of the skin showing the non-disjunction of a chromosome (× 800). *D*, Telophase in basal-cell carcinoma showing chromosome bridge and lagging of chromosomes (× 800). *E*, Highly polyploid cell in carcinoma of the cervix (× *c*. 670). *F*, Multinucleate giant cell in carcinoma of the cervix (× *c*. 670). *G*, Tri-polar spindle in carcinoma of the cervix (× 800).

The analysis has shown that the proportion of these cells varies (*a*) in different regions of the same tumour at the same time, (*b*) in the same tumour at different times, and (*c*) in tumours of different kinds. The proportion of cells with Feulgen's negative nucleoli increases at the expense of the other cells with the development and growth of the tumour.

Mitosis

Tumour cells exhibit a great variation in respect of the details of division. Tumours were found in which most of the dividing cells undergo the process of mitosis normally; on the other hand, tumours were encountered in which a great proportion of dividing cells have shown many abnormalities. These are expressed in chromosome structure and behaviour and in the lack of co-ordination between spindle mechanism and chromosome movements. A close relationship was found to exist between the frequency of abnormalities and the type of nucleolus. While tumours in which the proportion of cells with Feulgen's negative nucleoli is very small exhibit few abnormalities during mitosis, tumours in which the proportion of these cells is high contain a great number of polyploid and giant cells, and most of the dividing cells exhibit various chromosome and spindle abnormalities. Some of the most common abnormalities observed in tumour cells are summarized as follows:

(1) *Stickiness of chromosomes*. At anaphase and telophase of mitosis in tumour cells the daughter chromosomes remain associated. 'False chromosome bridges' are formed, which prevent the separation of the telophase chromosome groups and may lead, by the failure of division of the cytoplasm, to the formation of binucleate cells. This stickiness of the daughter chromosomes caused the configuration, described by Farmer, Moore and Walker[6] as a "bivalent" because it is very similar to that found during the first meiotic division. On account of this similarity they erroneously believed that carcinogenesis is a process similar to gametogenesis abnormally occurring in somatic tissues.

(2) *Non-disjunction of chromosomes*. Daughter chromosomes often fail to segregate to the opposite poles (*C*, *D*), consequently the two nuclei formed will be unbalanced in respect of the chromosomes content. This abnormality is due either (*a*) to chromosome stickiness or (*b*) to rapid division.

(3) *Displacement of chromosomes*. One or more chromosomes may lie off the equatorial plate during metaphase. Such chromosomes are usually unoriented in relation to the centrosome and spindle.

(4) *Clumping*. The chromosomes during metaphase fail to form a well-defined equatorial plate. Clumping often interferes with chromosome segregation and may result in the degeneration of the chromosome elements.

(5) *Binucleate cells*. These are the result of the failure of cell division to take place after nuclear division.

(6) *Polyploid cells*. In these cells the 48, that is, the diploid chromosome number, is multiplied; the cells are larger than diploid cells. They are due to the failure of spindle formation.

(7) *Multinucleate cells*. These are the result of 'polymitosis' or repeated nuclear division, without cell division (*F*).

(8) *Giant cells* with highly polyploid chromosome number (*E*); these are due to rapid division. Such cells very often degenerate.

(9) *Spindle abnormalities*: (*a*) delay in spindle formation, (*b*) incomplete and (*c*) multipolar spindle (*G*). The result of such spindle abnormalities is incomplete or irregular chromosome segregation, and the formation of unbalanced or polyploid nuclei.

Discussion

The analysis of this aberrant chromosome and spindle behaviour has shown that they are chiefly due (1) to stickiness; and (2) to increased rate of division. It was concluded as a result of the analysis that not only the characteristic abnormalities such as polyploid, multinucleate, and giant cells, multipolar spindles, stickiness, displacement of chromosomes at metaphase in tumour cells, but also the increased rate of division itself can all be attributed to a quantitative change in the nucleic acid synthesis. The argument is here presented, and it is based on data obtained by Astbury[7], Caspersson[8], and Darlington[9].

The chromosomes are known to be long polypeptide chains on which are fixed, at regular intervals, active groups, identified genetically as the genes. The genes, besides being the physical basis of heredity, regulate the division of the nucleus, by attaching to themselves the nucleotides of desoxyribose nucleic acid, which polymerizes in columns (thymonucleic acid) parallel with the polypeptide chains. The polymerization of thymonucleic acid is responsible for (1) the coiling, (2) the reduplication or reproduction of chromosomes, and (3) making them visible. Thymonucleic acid is obtained from desoxyribose, which is provided by the reduction of ribose nucleic acid. The latter is produced in the cytoplasm under the influence of histone.

During the resting stage, the nucleus contains a relatively small amount of thymonucleic acid, because at the end of mitosis most of the nucleic acid charge of the chromosomes is given up. There are chromosome regions (blocks of genes or even whole chromosomes) the function of which is the production of ribose nucleic acid through the formation of histone, which is normally collected and stored during the resting stage in the nucleolus. These chromosome or chromosome regions are designated as heterochromatic, to distinguish them from the euchromatic regions. It is known that the whole or part of the sex chromosomes in animals, the so-called 'inert', and '*B*' chromosomes in various organisms are heterochromatic. For a normal functioning of the cell a specific heterochromatin-euchromatin balance is required. Since the amount of nucleic acid and the rate of its production determine the frequency of division, the excess amount of nucleic acid present in the tumour[10] must be considered as the fundamental cause of increased division-rate and malignancy. Thus the quantitative change in the nucleic acid metabolism, indicated by chromosome behaviour, may be one of the most important differences which distinguish tumour cells from normal cells.

The incorrect balance between heterochromatin and euchromatin, that is, an increase in the nucleic acid supply, may be very slight, and result only in a shortening of the resting stage between two divisions. In this case, which may be considered as the first stage in the development of the tumour, the 'malignant' cell cannot be identified morphologically. The excess nucleic acid over the normal supply, however, besides reducing the resting period, will sooner or later have repercussions in chromosome behaviour. One of the most frequent failures in the mechanism of the division under such conditions is irregular segregation of chromosomes at anaphase, which secondarily leads to a further unbalance and increase in the nucleic acid supply within the cell. This will be manifested now by (1) abnormal chromosome behaviour and (2) by a change in the size and contents of the nucleolus. As a result of the excess amount of nucleic acid produced, the chromosomes become sticky because they are coated with fluid non-polymerized nucleic acid. Several other abnormalities such as those described above will also be exhibited by the chromosomes, and nuclear division will become so rapid that it will not always be followed by cell division. This may be considered as representing the second stage in tumour development.

The cells with a slight extra amount of nucleic acid are gradually replaced by cells with a much higher nucleic acid content. With this change the development and differentiation of the tumour arrives at the third and last stage. Abnormal chromosome behaviour and irregular division become very frequent. The tumour tissues contain a great number of large, giant polynucleate cells, and show widespread cellular degeneration.

These three stages of tumour-cell types have been identified in different tumours, as well as in the same tumour. It is concluded that these stages and intergradations are conditioned by the different increases in the nucleic acid supply within the cell. In most tumours the various cell-types showing differences in the amount of nucleic acid are present side by side. Data were also obtained which suggest that the various proportions of these types in the tumour may be used as a criterion of differentiation and degree of malignancy.

The question is how this excess of nucleic acid supply is brought about within a normal cell ? From genetical and cytological evidence it is known that the heterochromatic regions of chromosomes primarily concerned with nucleic acid synthesis can undergo spontaneous mutation and structural change more easily than other parts[11,12,13].

It is not improbable that the initial change in the nucleic acid metabolism is brought about by a gene mutation which may be assumed to have occurred in the region controlling nucleic acid supply either directly or indirectly. Thus a somatic mutation, as postulated by Lockhart-Mummery[14], would be responsible for the increased nucleic acid supply. The ultimate cause of such mutational change within a normal cell is not yet known. The cytological analysis reveals only the fact that in the tumour cell there is a disturbed nucleic acid metabolism.

Summary

Cytological analysis of tumour cells shows that all chromosome abnormalities and the increased rate of division itself can be explained by assuming that there is a quantitative change in the nucleic acid synthesis due to alteration in the heterochromatic region of the chromosomes[15].

[1] The cytological analysis was made possible by the financial support of the British Empire Cancer Campaign, and by the generous help of the Holt Radium Institute, Manchester.

[2] A more detailed description will be given elsewhere.

[3] Pianase, G., *Ziegl. Beitr. path. Anat.* (Suppl. 1), 1–193 (1896).

[4] Ludford, R. T., *Proc. Roy. Soc.*, B, **102**, 463 (1928).

[5] Kaufmann, B. P., *Z. Zellforsch.*, **28**, 1 (1938).

[6] Farmer, T. B., Moore, T. E. S., and Walker, C. E., *Proc. Roy. Soc.*, B, **77**, 336 (1906).

[7] Astbury, W. T., Proc. 7th Int. Genet. Cong., 49 (1939).

[8] Caspersson, T., *Naturwiss.*, **29**, 33 (1941).

[9] Darlington, C. D., NATURE, **149**, 66 (1942).

[10] Caspersson, T., Nystrom, Cl., and Santesson, L., *Naturwiss.*, **29**, 29 (1941).

[11] Darlington, C. D., and La Cour, L., *J. Genet.*, **40**, 185 (1940).

[12] Darlington, C. D., and Thomas, P. T., *Proc. Roy. Soc.*, B, **130**, 127 (1941).

[13] Muller, H. J., *Cold Spring Harbor Symp.*, **9**, 151 (1941).

[14] Lockhart-Mummery, T. P., Proc. 7th Int. Genet. Congr., 196 (1939).

[15] Dr. T. Caspersson, using cytochemical methods, arrived at the same conclusion. His data indicate that "the heterochromatic section of the nucleus must play a very specific role in carcinogenesis" (personal communication).

NEWS and VIEWS

Dr. J. C. Willis, F.R.S.

DR. J. C. WILLIS, the well-known botanist, celebrated his seventy-fifth birthday on February 20. When Dr. Willis was appointed director of the Royal Botanic Gardens, Ceylon, in 1896, he not only developed the gardens to a high state of efficiency but he also began a very fruitful study of the flora of the island, coming for the first time in contact with a most interesting tropical flora. He began with the investigation of the Podostemaceæ, a group of highly modified type of flowering plants which grow on the waterworn rocks of rapidly flowing tropical streams in various parts of the world. When at Cambridge as personal assistant to Sir Francis Darwin, he had accepted with enthusiasm Darwin's doctrine of natural selection, but faced with the fact of numerous species of the same family living under practically similar conditions of life he began to question the Darwinian theory of evolution. Thus the views which he has put forward in his later stimulating books had their origin in his intensive study of the Podostemaceæ.

Dr. Willis's studies of the endemic plants of Ceylon, and later those of New Zealand, confirmed him in his conclusion, formulated in his earlier publications, that the older a species is the greater is its geographical distribution, and vice versa. This view was put forward at some length with numerous examples verified by himself in "Age and Area", published in 1922. As this book met with some criticism, Dr. Willis published in the following year a reply to criticism. Further studies on endemism and geographical distribution have occupied Dr. Willis's time and energy since then and two accounts of his work and his conclusions were given to the Linnean Society in 1936 and 1938 respectively. Advancing age has not diminished his output of important contributions to botanical science, and 1940 saw the publication of "The Course of Evolution by Differentiation or Divergent Mutation rather than by Selection", a book showing the vigour of his mind and summing up with a wealth of mature and critical judgment the arguments in favour of his conclusion. Marooned in Switzerland during the present War, he is still hard at work and last April (1942) he published an article in the *Proceedings of the Royal Society* indicating the kaleidoscopic manner in which the mutations referred to in his "Evolution of Plants" takes place. This publication may be taken as an instalment toward a projected volume on geographical distribution, the publication of which has been retarded by the difficulties caused by the War.

Post-War Commercial Air Transport

THE recent discussion in Parliament upon the necessity for making provision for the development of civil aviation in the immediate post-war period has aroused much interest in many different circles, political, commercial and technical. Mr. F. C. R. Jaques, of North Eastern Airways, Ltd., 31–32 Haymarket, S.W.1, has prepared a memorandum in which he endeavours to apply his experience in commercial air transport to the post-war problem. He suggests that much technical progress in design has been made, necessarily secret at present, that has improved performance, reduced the labour needed for construction, and simplified maintenance. This should be reflected in a general lowering of costs of air transport, the principal bugbear of the earlier air-line operator. If schemes, both for commercial air transport and private flying, are launched with sufficient vision and energy they will help in the problem of re-establishing the skilled personnel of the R.A.F. in civil life.

The memorandum postulates that international freedom of the air is a necessary preliminary for the fullest development of civil flying, and suggests that sufficient balance can be maintained if each country controls its nationals, guaranteeing their bona fides, technical skill, and the airworthiness of their machines. These standards will obviously need to be aligned, at least approximately, by some international agreement. As such did exist before the War there should be no difficulty in resurrecting them. His suggestions include the removal of civil aviation from the Air Ministry, introducing a sense of competition in the air transport world by allowing other selected companies to operate, the development of internal routes possibly by smaller companies as feeders to the big transcontinental lines, and the immediate appointment of a powerful committee to examine such questions.

René-Just Haüy (1743–1822)

ON February 28 occurs the bicentenary of René-Just Haüy, recognized everywhere as the founder of the science of crystallography. Born in the small town of St. Just, in the Department of Oise, he was the son of a weaver, but in spite of his poor circumstances gained admission to the College of Navarre, in Paris, and at the age of twenty began to teach there. Led to the study of minerals through an accident with a crystal of calcareous spar, he discovered the law of crystallization, and became widely known thereby. In 1783, at the age of forty, he was elected to the Academy of Sciences, and in the following year he published his "Essay in the Structure of Crystals", the first of his various books. He was deprived of his posts at the Revolution, and for a short time imprisoned; but after the fall of Robespierre, he took his place among his scientific peers, being given a chair in the short-lived Normal School, and a seat in the Institute. He was also made keeper of the mineralogical collections at the School of Mines and secretary to the Commission of Weights and Measures. In 1802 he became professor of mineralogy in the Natural History Museum, where his lectures attracted large audiences. His numerous memoirs are to be found in the periodicals of the time. He continued to lecture to an advanced age, and died in Paris on June 3, 1822. His collections and his statue are in the galleries at the Museum, and on November 8, 1903, a monument to him and his brother, Valentin Haüy (1745–1822), a pioneer in work for the blind, was unveiled at St. Just, when a discourse was pronounced by Lacroix. The *American Mineralogist* (No. 6, 3, 1919) contains a series of articles on aspects of Haüy's life and works and includes a number of portraits.

British Mammals in War-time

THE increase of many species of British birds due to war-time changes in the countryside has already been noted in NATURE. Evidence is now accumulating to show that many British mammals are likewise increasing, and one of the most welcome is the pine-marten, which had reached a dangerously low population in many districts. Reports were recently made of its presence in North Wales at Bettws-y-Coed (*Field*, Jan. 1943), and in Scotland in the Forestry Commission and deer forest areas of the Highlands and in a cairn in the Grampians (H. M. Batten, *Scotsman*, Jan. 30, 1943). In Lakeland it has recently been reported from Ennerdale. The polecat is also increasing in the wilder parts of Great Britain. Foxes have increased at an alarming rate in most parts, even where there were no organized hunts as in Lancashire, while in Lakeland, where the Eskdale Hunt killed a record total of sixty foxes in January, there is considerable controversy over organized fox hunts.

The Scottish mountain hare, which inhabits only a few parts of the Pennines at Penistone above Sheffield, has wandered from the Cheviots, where it is plentiful, to inhabit some of the moors on the extreme northern fringe of Cumberland above Gilsland and Bewcastle. The increase of stoats, weasels and badgers is of considerable agricultural value, because rabbits form such a large part of the food of stoats and badgers, and weasels feed mainly on field mice. The increase of foxes is responsible as much as is trapping for the reduction of rabbits, which form the chief food of foxes, but their depredations upon poultry have necessitated a campaign against them.

A Laboratory in Physical Geography

A development in geographical research and teaching is the subject of an article in the *Geographical Journal* of November–December by Prof. F. Debenham, in which he describes the laboratory for physical geography which he has planned and equipped at Cambridge, even though the exigencies of the times have necessitated its temporary dismantlement. The object of the laboratory is to study field processes, usually in miniature, under conditions of close observation and control with the view of ascertaining their mechanism, stages and effect. An amazing array of apparatus has been crowded into one room barely 50 ft. long by 19 ft. broad. In the wave trough, waves are generated by various methods and ingenious devices allow the measurement of period, height, length, etc. Here also beach building with sand and shingle can be studied. The wave tank, on a smaller scale, provides, among other aims, for the study of land forms produced by long-shore drift. An even more ambitious piece of apparatus is the tidal tank in which the difficulties of producing tidal currents seem to have been overcome, and good results are expected. The stream flume or delta tank seems to work well in the study of alluvial deposition, and the stream curve apparatus is to be used for the investigation of water movement in the bed of a stream. Other problems, too, are to be studied, and the whole laboratory is a promising step in the introduction of quantitative methods in the problems of physical geography.

Public Library of South Australia

The first report of the Public Library of South Australia, which was formed under the Libraries and Institutes Act, 1939, creating a Libraries Department under a Libraries Board of South Australia, with a Principal Librarian as administrative head, covers the half-year ending June 1940, and stresses the need for the permanent allocation of sufficient land for the natural growth of such an essential service. The various properties of the Public Library, the Museum and the Art Gallery have now been reallocated, but despite adaptations the accommodation for library work, particularly for staff and for the country lending service, is entirely inadequate. War conditions have not affected adversely the use made of the Library, as is shown by an increase in readers of more than 7,000 during the year, and the Library staff has been taxed to its utmost to provide information regarding all sorts of conditions arising from the War. Financial provision for books is still inadequate and the Board has recommended the establishment of a research department for handling requests for scientific, technical and economic information. For this a more extensive range of periodicals is urgently required. The country lending service has also been called upon for books beyond the limit of its capacity, and its work has grown so rapidly that early extension of accommodation is necessary to provide adequate working space. The Archives Department has reached the limit of its shelving accommodation and offers of many important series of documents, arising from the present extensive pulping of old records, cannot be accepted because of lack of accommodation.

Joints in Submarine Cables

R. Miller and C. T. Rose contribute an article on this subject in the Engineering Supplement of *Siemens Magazine* (Oct.–Nov., 1942). In submarine cables particular care has always to be exercised in dealing with the joints, and every endeavour is made to limit their number by manufacturing individual cable lengths as long as possible, consistent with the methods of transport, storage accommodation, etc., available, and the scheme of laying to be adopted. With submarine cable-laying under normal conditions, it is unlikely that more than one sea joint will be necessary, the cable being laid in two parts, one section from each shore termination. This necessitates cutting the cable at a convenient position, buoying the end, and picking up again after the other section has been laid. The joint is then made on the ship and on completion is cast overboard, after due precautions have been taken. The article refers to both communication cables and power cables, the latter for voltages, for example, up to 33 kV. In the section on communication cables the authors discuss gutta-percha joints, splicing the sheathing wires, rubber joints, rubber to gutta-percha joints, and paper joints. The section on power cables is confined to those of the impregnated paper-insulated and lead-covered types and describes the making of subaqueous joints, super-tension joints and the handling of the shore ends of the cable. The article is illustrated and several photographs are included showing different stages in the operations of laying submarine cables.

Conference of X-Ray Analysis

The analysis of substances and the examination of their behaviour by X-ray diffraction methods has become of considerable importance in the war effort. The Institute of Physics is therefore arranging a second conference on the subject to take place in Cambridge during April 9–10. The provisional programme includes a lecture on "Future Developments in X-Ray Crystallography" by Prof. J. D. Bernal, and discussions on "Quantitative Treatment of

Powder Photographs", "The Fine Structure of X-Ray Diffraction" and "Line Broadening". A report is to be presented to the Conference on the progress made in the preparation of an index to X-ray diffraction photographs, for which the Institute has undertaken to be jointly responsible with the American Society for Testing Materials and the American Society for X-Ray and Electron Diffraction. Further particulars of the Conference and of the Index can be obtained from the Secretary of the Institute of Physics (temporary address: at the University, Reading).

The Night Sky in March

NEW moon occurs on March 6d. 10h. 34m. U.T., and full moon on March 21d. 22h. 08m. Conjunctions with the moon are as follows: March 3d. 03h., Mars 3° S.; March 4d. 19h., Mercury 2° S.; March 8d. 08h., Venus 3° N.; March 12d. 11h., Saturn 4° N.; March 15d. 18h., Jupiter 4° N.; March 31d. 22h., Mars 2° S. Occultations of stars brighter than magnitude 6 are as follows: March 12d. 16h. 40·2m., α Tauri (*D*); March 12d. 17h. 51·8s., α Tauri (*R*); March 17d. 22h. 43s., o^1 Cancri (*D*); March 17d. 23h. 03m., o^2 Cancri (*D*). The times are given for Greenwich, and *D* and *R* refer to disappearance and reappearance respectively. Mercury is a morning star at the beginning of the month. Venus is a conspicuous evening star and sets about 2h. 40m. after the sun in the middle of the month. Jupiter souths at 19h. 36m. in the middle of the month and is visible for the greater part of the night. Saturn is becoming an evening star and sets about midnight towards the end of the month. Vernal equinox commences on March 21d. 12h.

Comet Whipple will probably still be visible through a small telescope. An ephemeris is given below.

Date 1943		R.A. h.	m.	Dec.	ρ	r
March	1	12	11·2	+ 55·2°	0·532	1·392
	5		19·1	54·8	·552	·407
	9		25·3	54·1	·574	·424
	13		31·2	53·2	·597	·443
	17		35·5	52·3	·620	·464
	21		38·4	51·0	·647	·487
	25		41·2	49·7	·674	·512
	29		43·8	48·3	·703	·539

Announcements

THE War Office announces that in deference to a request from the Lord President of the Council, it has been agreed that Sir Charles Darwin, scientific adviser to the Army Council, shall return to his duties as director of the National Physical Laboratory on March 1. He will be succeeded as scientific adviser by Prof. C. D. Ellis, Wheatstone professor of physics, King's College, London, who has been serving as deputy scientific adviser.

PROF. F. C. LEA, emeritus professor of engineering in the University of Sheffield, has been elected president of the Institution of Mechanical Engineers.

SOUND films of honorary members and Faraday medallists of the Institution of Electrical Engineers are being shown before the Institution as follows: March 4: Sir J. J. Thomson and Lord Rutherford; April 1: Sir Ambrose Fleming and Dr. A. E. Kennelly; April 29: Lord Hirst and Dr. F. B. Jewett. Each meeting will be at 5 p.m.

THE Herbert Jackson Prize for 1942 of the London Midland and Scottish Railway has been awarded to Mr. J. Dearden, of the Metallurgical Section of the Railway's Research Department, for papers entitled "The Inspection of Welded Steel Joints in Relation to their Static Mechanical Strength" and "The Influence of Welding Defects on the Resistance to Fatigue of Welded Steel Joints".

THE third Pan-American Congress of Endocrinology will be held at Buenos Aires during July 1–6, when discussions will be held on the endocrine factors in diabetes, gonadotropism and the suprarenal cortex. Further information can be obtained from the Office of the Congress, Córdoba 2122, Buenos Aires.

THE British Laboratory Ware Association, Ltd., has recently formed a technical committee, the objects of which are as follows: (1) To promote closer co-operation between bodies responsible for the design of standard laboratory instruments and apparatus and the manufacture of same. (2) To assist in rationalization of the design of apparatus and to eliminate overlapping, with the aim of securing economical production. (3) Collaboration to these ends with standardizing authorities, research associations, etc., in the drafting of specifications. It is hoped that research and other associations will avail themselves of the facilities offered in order that improved service and quality may result to users of the apparatus. All communications should be addressed to the secretary of the Technical Committee, British Laboratory Ware Association, Ltd., 73 Basinghall Street, London, E.C.2.

WE have received a copy of the catalogue entitled "Medical Miscellany Lot 'G'", published by Schuman's, 20 East 70th Street, New York, of which the special feature is an extensive section on psychiatry and neurology. Among these mention may be made of the following works: Esquirol's "Mental Diseases in relation to Medicine, Hygiene and Medical Jurisprudence" (first French edition, 1838), Griesinger's "Mental Pathology and Therapeutics" (Sydenham Society, 1867), Charcot's "Diseases of the Nervous System" (New Sydenham Society, 1877–89), Ramon y Cajal's "Structure of the Optic Chiasma" (first German edition, 1899), and Freud's "Three Contributions to the Sexual Theory" (first English edition, 1916). Other interesting works contained in the catalogue are Fracastoro's "Poem on Syphilis" (Latin text and French translation, 1753), the "Genuine Works of Hippocrates" (Sydenham Society, 1849), Hirsch's "Handbook of Geographical and Historical Pathology" (New Sydenham Society, 1883–86), and Hirsch's "Biographisches Lexikon" (second edition, 1929–35).

ERRATUM. In NATURE of February 20, p. 219, paragraphs on "Science and Government" and "Parliamentary and Scientific Committee", reference was made to the "scientific advisers to the Ministry of Supply"; it should have read "scientific advisers to the Minister of Production", as is indicated on the chart on p. 206.

LETTERS TO THE EDITORS

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

A Simple Method of Demonstrating the Circular Polarization of Ionospherically Reflected Radio Waves

SINCE the ionosphere is a doubly refracting medium, due to the influence of the earth's magnetic field, a plane-polarized radio wave incident normally on it is split into two elliptically polarized components of opposite rotational sense. For a certain range of frequencies, in the neighbourhood of the gyro-frequency, only one of these two components is reflected in strength, the other being strongly absorbed. In northern temperate latitudes this reflected component is of left-handed, approximately circular, polarization. In corresponding latitudes in the southern hemisphere the sense of the polarization is reversed.

To demonstrate the circular polarization of ionospherically reflected waves in such cases it is necessary to show that the two components of the magnetic vector along the two axes Ox and Oy in the ground plan are equal and are 90° out of phase. (See Fig. 1, where the direction of propagation of the downcoming waves is supposed to be normally into the paper.) If two equal loop aerials are placed with their axes along these directions, the electromotive forces in these aerials will have the same phase difference as the magnetic vector components ; but to exhibit the value of this quantity on a cathode-ray oscillograph requires both pulse transmissions and elaborate receiving equipment in the form of two high-frequency amplifiers of exactly similar phase and amplitude characteristics.

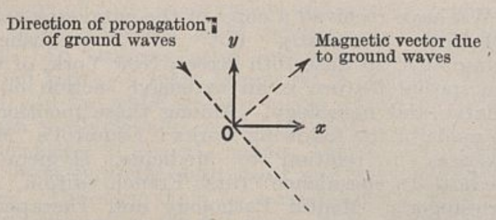


Fig. 1.

It is, however, possible to demonstrate this phase difference in a much simpler manner. Let us suppose that the incoming signal is caused to beat with a locally produced oscillation, the frequency of which is very slightly less than that of the downcoming waves. Low-frequency beats can then be obtained from the signals in the two aerials, and it may be shown that the phase difference of the two beat envelopes is then exactly the same as that of the two high-frequency components under examination in the two aerials.

To produce the required low-frequency beats it is not necessary to provide a separate heterodyne, since the oscillations produced by the ground waves answer the same purpose. During the early morning when the height of ionospheric reflection is being slowly reduced, under the increasing solar influence, the frequency of the reflected waves is slightly higher than that of the ground waves due to Doppler effect. The variations which then take place in the outputs from the two aerials are due to the beats between ground and ionospherically reflected waves, and the phase difference we seek to demonstrate is equal to that between the signal variations in the two systems. If we set the two loops at 45° to the directions of propagation of the ground waves, we ensure that the ground waves have equal influence on both systems, and, if each aerial is provided with a rectifier and recording galvanometer, the relative magnitudes of the fading depths and the phase difference between the fading cycles can be simply demonstrated.

With waves of frequency of 2–3 Mc./s., the early morning fading is usually quite regular and the two records are similar to those shown in Fig. 2. It will be seen that the vector along Ox leads that along Oy by 90° and this, together with the fact that the fading is of equal depth in the two cases, shows that the downcoming wave is of left-handed circular polarization.

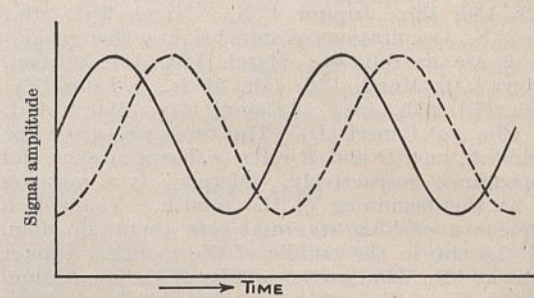


Fig. 2. THE FULL LINE REPRESENTS THE SIGNAL VARIATIONS IN THE LOOP WITH AXIS Ox; THE DOTTED LINE THOSE IN THE LOOP WITH AXIS Oy.

In the case of observations made in the evening (for example, on medium wave broadcasting stations) the ionospheric height of reflection is increasing, and the frequency of the down-coming waves is therefore slightly less than that of the ground wave. The phase difference between the beats as produced with a common heterodyne (that is, the ground wave) is then shown by the examination of the fading curves read in the *negative* direction along the time axis, since the beat notes are then reversed in phase relative to the original signals.

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Feb. 2.

Absolute X-ray Wave-lengths

AN important discrepancy is beginning to make itself felt in X-ray diffraction measurements. At present, lattice spacings of crystals are based on the Siegbahn X-unit[1], which is defined as 1/2814·00 of the 200 spacing of rocksalt ; this definition made the X-unit as near as possible to 10^{-3} A., in the light of the then-known value for Avogadro's number, N_0. Such a standard was necessary because relative measurements of wave-lengths could be made much more accurately than absolute ones.

So long as the same value of N_0 was used both to specify the scale of X-ray wave-lengths and to work out the contents of a unit cell, no important errors could arise. Now, however, the accepted value of

Avogadro's number[2] has been decreased by about 0·6 per cent from the value on which the X-unit was based. The new value is derived from the measurement of the density and unit cell of calcite[3], the wave-length of the X-rays used being determined on an absolute scale by diffraction from a ruled grating. The error is equivalent to the statement that the X-unit differs from 10^{-3} A. by 0·2 per cent. Therefore, if the new value of N_0 be accepted, one cannot use the Siegbahn scale of wave-lengths.

The formula for the number of molecules, n, in a unit cell is

$$n = \frac{N_0 \rho V}{M},$$

where ρ is the density, V is the volume of the cell, and M is the molecular weight. There are two ways of evaluating correctly n, M or ρ from this equation.

(1) The most recent value of N_0, 6·0228 (±0·0011) × 10^{23} mole^{-1}, may be used, and V expressed in A.^{3}, that is, in absolute units. In order to derive the lattice constants the X-ray wave-lengths used must be corrected from the Siegbahn scale; some examples of the necessary changes are shown in the accompanying table.

		X-units	Ångström units
Cu	$K\alpha_1$	1537·395	1·540522
	$K\alpha_2$	1541·232	1·544367
	$K\alpha$ (weighted mean)	1538·7	1·5418
	$K\beta_1$	1389·35	1·39218
Mo	$K\alpha_1$	707·831	0·709271
	$K\alpha_2$	712·105	0·713553
	$K\alpha$ (weighted mean)	709·26	0·71070
	$K\beta_1$	630·978	0·632261

(2) If one wishes to retain the Siegbahn scale, one must use an arbitrary value of N_0, namely, 6·060 × 10^{23} mole^{-1}. In this case the lattice constants are in 1,000 X-units, although it is an invariable practice to call them Ångström units.

An error of the order of 0·6 per cent will occur if the new value of N_0 is used with the Siegbahn wave-lengths; this may be quite considerable if substances of high molecular weight are being studied.

The question arises as to which is the better of the two procedures. There is no doubt that the more logical is the former, in which case all wave-lengths need to be converted to Ångström units by multiplying the X-values by $1{\cdot}00203_4 \times 10^{-3}$, the conversion factor given by Bearden[4]. There are two main objections to this. First, there may be some confusion during the change. Warren[5] has suggested that this confusion would be lessened by using the symbol 'AA' to express 'absolute Ångström units'. Secondly, the conversion factor is still not known so accurately as are the relative wave-lengths, and so another adjustment may have to be made later. The relative wave-lengths are known probably to 0·001 per cent; and though Bearden is of the opinion that the conversion factor is also known to 0·001 per cent, Birge puts the error much higher, namely, 0·006 per cent. It might thus be thought preferable to wait until the conversion factor is known more accurately. It is possible, however, that no great improvement in accuracy can be expected with present techniques, in which case there would be no point in delay on this account.

Our own opinion, and that of the members of this Laboratory with whom we have discussed the matter, is that the new wave-lengths should be adopted; and it is hoped to get a more general opinion at the second X-Ray Conference of the Institute of Physics to be held in Cambridge in April. We should, however, be glad to know the opinions of others who may be interested in the question, and whose results may be affected by it.

H. LIPSON.
D. P. RILEY.

Cavendish Laboratory,
Cambridge.
Feb. 9.

[1] Siegbahn, M., "The Spectroscopy of X-Rays" (London, 1925).
[2] Birge, R. T., "Reports of Progress in Physics", 8, 118 (1941).
[3] DuMond, J. W. M., and Bollman, V. L., *Phys. Rev.*, 50, 524 (1936); 54, 1005 (1938).
[4] Bearden, J. A., *J. App. Phys.*, 12, 395 (1941).
[5] Warren, B. E., *J. App. Phys.*, 12, 375 (1941).

Penillic Acid, an Optically Active Acid from Penicillin

WE have observed that when highly active penicillin preparations are kept in aqueous solution at pH 2 there occurs a rise in the optical rotation which reaches a maximum and there remains constant. After this treatment only part of the material formerly readily extractable by ether can be removed by this solvent and there is left in the colourless aqueous phase a substance which is strongly dextro-rotatory and has a pale bluish fluorescence in ultra-violet light. This substance, which we have named *penillic acid*, can be extracted from the aqueous solution by butyl alcohol, from which it can be separated in crystalline condition. Penillic acid has been obtained in this way from barium penicillin preparation varying in activity from 300 units to 1,200 units per mgm., and as the yield is directly proportional to the biological activity of the penicillin used it seems not unlikely that penillic acid is derived from penicillin itself and not from its concomitants. The best yield so far obtained amounts to 20 per cent of the barium penicillin.

Penillic acid crystallizes from water in brilliant rhombs or in hexagonal plates which decompose at about 175° with evolution of gas but without charring. In aqueous solution (c = 0·2) it has the high specific rotation of + 600° for the mercury green line. The solution of the recrystallized material shows the pale bluish fluorescence referred to above. It is acid to litmus and has some of the properties of an amino-acid. It gives a deep bluish-purple colour with ninhydrin and is precipitated by mercuric chloride and phosphotungstic acid. It forms a sparingly soluble silver salt. It readily decolourizes bromine water without formation of a precipitate. It does not give the blue colour with ferric chloride characteristic of penicillamine[1].

The penicillin used in these experiments was purified by the silica gel – barium carbonate column recently described by Catch, Cook and Heilbron[2] from penicillin kindly supplied by Dr. C. G. Pope, of the Wellcome Physiological Research Laboratories, to whom we make grateful acknowledgment.

The work described above was carried out under the auspices of the Therapeutic Research Corporation of Great Britain, Ltd.

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Wellcome Chemical Research Laboratories,
Beckenham.
Feb. 15.

[1] Abraham, Chain, Baker, Robinson, NATURE, 151, 107 (1943).
[2] Catch, Cook, Heilbron, NATURE, 150, 633 (1942).

Linkage of Physico-Chemical Processes in Biological Systems

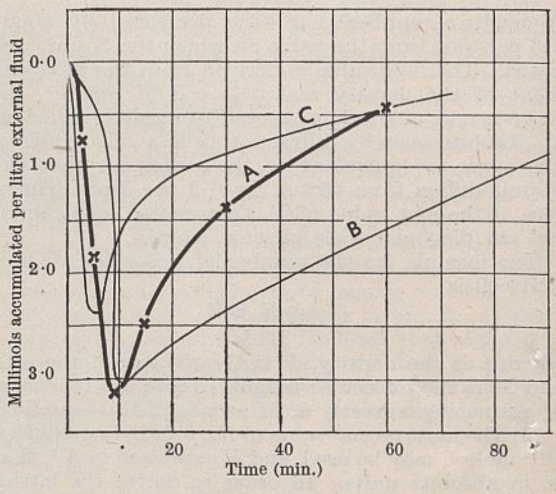
IN a recent communication in NATURE[1], it was pointed out that the shift of equilibrium between extracellular and intracellular potassium during fermentation of sugar either by yeast or bacteria[2,3] was a striking example of the general application of certain principles underlying the accumulation of potassium in cells[4,5,6,7]. If our views as to the nature of such in and out movement during fermentation are correct, it should occur with other cations besides the potassium ion, provided they can diffuse across the cell membrane, or in other words, it should not be *specific* for potassium.

Such another cation is ammonium, and we have recently found that a shift of the ammonium ion occurs in 'ammonia' yeast just as it occurs in 'potassium' yeast.

The 'ammonia' yeast was formed by replacing all the potassium in ordinary baker's yeast in the manner previously described[8], the concentration of the external ammonium being $N/5$ and the process hastened by maintaining at 37° C. The concentration of potassium in such 'ammonia' yeast was much less than 1 mgm. K/100 gm. Yeast so treated was then washed a few times with 0·3 per cent sodium chloride, and left for some hours suspended in this solution, when the external ammonium ion concentration was about 20 mgm./100 ml. To a measured volume of this yeast suspension (1 in 3) was added a small amount of a concentrated solution of glucose and sodium acid phosphate to produce 1·4 per cent glucose in the mixture and $M/140$ phosphate, and to an equal volume of the yeast suspension the same addition was made but without the glucose. The ammonia content of the external solution was examined after varying times, and the values for the mixture containing glucose subtracted from the control figures, giving in one typical example curve A in the accompanying graph, which is compared with the curves of K accumulation, B and C, of Pulver and Verzar[2] with yeast (second experiment in their paper), and of Leibowitz and Kupermintz[3] for bacteria (*E. coli*). Similar curves for 'ammonia' yeast were also obtained in repeat experiments on the same yeast where glucose in saline was added to the mixture from which glucose had disappeared by fermentation, and saline to the control mixture.

This movement of potassium and ammonium ions is in itself to be differentiated from possible specific effects of the ions on yeast activity or that of yeast extracts. For this there is an extensive literature. A short review is given, for example, by Stavely *et al.* in their first paper on zymin[8]. From a recent communication in NATURE[9], Farmer and Jones appear to have obtained some new evidence in this field.

The explanation previously given of the potassium shift during fermentation, which now extends to a similar ammonium shift, would appear quite satisfactory, and relates to those principles which are fundamental to the accumulation of potassium in cells[4-7]. The ion movement would appear to be controlled by the effective product of the free phosphate and potassium (or ammonium) ion concentrations (free phosphate being present mainly as the univalent ion at the pH obtaining within and without the cells). When glucose diffuses into the cells, there is a very rapid formation of glycogen, according to Willstätter and Rohdewald[10]. In the first two minutes, 90–100 per



cent of glucose which has diffused in is present as glycogen. This stage is rapidly followed by a marked increase of phosphate esters formed from the glycogen. In the present explanation it is then supposed that the product of the potassium (or ammonium) and phosphate ion concentrations falls steeply and phosphate ions enter with K (or NH_4), the diffusible cations being held within by the electrostatic attraction of the newly formed non-diffusible ions. When these are broken down again the process is reversed, and K (or NH_4) leaves the cells.

This explanation does not imply that there is a simple equality of concentration products within and without the cell, as would be considered for a Donnan equilibrium of the simplified kind for very dilute solutions, for, apart from the effect of the total ionic concentration, the yeast cell membrane is practically non-distensile and the internal pressures are likely to be very much different from those without, with corresponding alteration of the ion activities ; but it does imply that an equilibrium will occur with a definite ratio of the products of the ion concentrations (probably not far from unity) and that a change in this ratio will influence the movements of the ions in the direction of its restoration.

Further work on this question is in progress, being assisted by a grant to one of us from the Irish Medical Research Council.

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Biochemical Department,
University College,
Dublin.

[1] Conway, E. J., NATURE, **150**, 461 (1942).
[2] Pulver, R., and Verzar, F., *Helvetica chim. Acta.*, **23**, 1087 (1940).
[3] Leibowitz, J., and Kupermintz, N., NATURE, **150**, 233 (1942).
[4] Conway, E. J., and Boyle, P., NATURE, **144**, 709 (1939).
[5] Boyle, P., and Conway, E. J., *J. Physiol.*, **100**, 1 (1941).
[6] Conway, E. J., NATURE, **147**, 574 (1941).
[7] Donnan, F. G., and Conway, E. J., NATURE, **149**, 383 (1942).
[8] Stavely, H. E., Christensen, L. M., and Fulmer, E. I., *J. Biol. Chem.*, **111**, 771 (1935).
[9] Farmer, S. N., and Jones, D. A., NATURE, **150**, 769 (1942).
[10] Willstätter, R., and Rohdewald, M., *Z. physiol. Chem.*, **247**, 269 (1937).

Mechanism of Lysis of Red Blood Cells

STUDY of the etiology of blackwater fever has led us to examine the wider problem of the mechanism of red cell destruction in the body. A summary of the preliminary work and the conclusions reached is given below.

We have observed that certain tissues (lung, liver, kidney, spleen, bone marrow and muscle) will lyse saline suspensions of washed red blood cells. This lysis is observed consistently only if the tissues are themselves first thoroughly washed or rinsed in saline. On the other hand, tissue slices have little or no lytic effect on suspensions of unwashed red cells.

Inhibition of this lysis is produced by: (*a*) The addition of the animal's serum to the mixture of tissue plus red cell suspension. This inhibitory effect of serum is not confined to the animal's own species, but can be produced by the exhibition of sera of other species. The inhibitory effect of heterologous sera is, however, observable only in a definite zone of dilution. This is particularly noticeable in the case of human serum, which in low dilutions has been found to lyse guinea pig red cells even in the absence of washed tissue. (*b*) The addition of sodium cyanide in a dilution of as little as 1 in 20,000,000 and of mercuric chloride in a dilution of 1 in 32,000. (*c*) Heating the tissue to a temperature of 80° C. or above for a period long enough to affect all the tissue used in the experiment.

Species used in these experiments have been man, monkeys (Cercopithecus, Erythrocebus, Colobus) and guinea pig. So far as our experiments have gone, the lytic agent appears to be species specific, while the serum inhibitor is not.

Consistent results have been obtained with guinea pig tissue, using washed guinea pig lung as the lytic agent and a 5 per cent physiological saline suspension of guinea pig red cells, washed three times in physiological saline, with or without the addition of 5 per cent glucose.

In the uninhibited red cell suspension – washed tissue system, lysis is completed in 18–24 hours.

The strictest aseptic technique must be employed throughout these experiments. It is essential that all glassware should be scrupulously clean by chemical standards.

It is difficult to conceive that the lytic agent demonstrated by the above experiments can be other than an enzyme, although as yet we have been unable to perform the crucial respiratory experiments. If our contention is correct, there exists in the animal body an enzyme capable of destroying red cells. The activities of this agent are held in check by an inhibiting substance which is present in both the tissues and the blood serum. The degree of lysis occurring at any time in the animal body may thus depend upon the balance of inhibitor over lytic enzyme activity. Abnormal degrees of lysis such as those met in blackwater fever and other lytic anæmias may therefore be due either to interference with the activity of the inhibitor or to its actual destruction.

Brian Maegraith.
G. M. Findlay.
N. H. Martin.

West African Force.
Dec. 21.

A New Land Nemertean

In January 1938, Yngvar Hagen, zoologist of the Norwegian Scientific Expedition to Tristan da Cunha (1937–38), discovered a new nemertean species on Nightingale Island. The animal was found attached to the underside of boulder stones situated on a beach, though far above the high-water mark. The fauna of the area was quite a terrestrial one, as land snails, mites and spiders were also found there. The worm was later handed to me for a closer examination, and this investigation has now been finished. Publication of the paper must wait until after the War, but I should like nevertheless to place this interesting find on scientific record now.

The animal turned out to be a new species of terrestrial nemertean, belonging to the genus *Geonemertes* Semp., which I have called *Geonemertes nightingaleensis*, n. sp. The length varied from 3 to 29 mm. In colour it is olive-grey, with two broader black-brown dorsal stripes. Four eyes were found. The animal is characteristic in its lack of an accessory lateral nerve and a frontal organ, the cephalic gland, however, being well developed. The animal seems to be more closely related to *G. agricola* and *G. chalicophora* than to the other members of the genus.

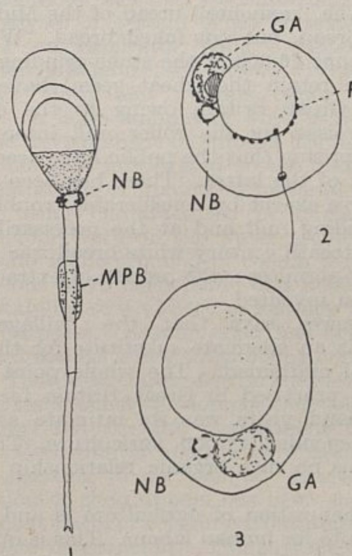
August Brinkmann (jun.).

c/o Gothenburg Museum of Natural History,
Gothenburg.
Jan. 11.

Middle-Piece Beads in the Cavia Spermatozoon

It is well known[1] that the silver nitrate methods of Da Fano, Cajal and Aoyama for the Golgi apparatus impregnate densely a bead just around the neck of the guinea pig sperm (Fig. 1, *NB*). It has been assumed that this bead is identical with the middle-piece bead depicted by Retzius[2] in so many kinds of mammalian spermatozoa.

We have recently been studying the spermatogenesis of the dog, and in trying to clear up some difficult points, we have reviewed the spermatogenesis of the cavy. We have been able to show that there are two beads on the spermatozoa from the epididymis, as shown in Fig. 1. The upper (*NB*) is extremely argentophile, and we have easily followed it back to the early spermatocyte in both the dog and the cavy (Fig. 3), as a vesicle almost invariably lying against the sphere (Golgi apparatus). The lower (*MPB*) is certainly the structure depicted by Retzius (Taf. XLV, Fig. 3, etc.) and so far we have



not found it on ripe spermatozoa within the testicular tubules. In such silver preparations as we have examined, it appears after the spermatozoa have entered the epididymis, and while it is generally found in the middle region of the middle-piece its position may vary. The position of the upper bead (*NB*) never varies, though its size may slightly. The material of the lower bead (*MPB*) assumes a brown colour on impregnation, like the secretion of the epididymis. More than this we cannot say at present.

On the point of the origin of the upper bead (*NB*) by budding from the Golgi apparatus remnant, as was previously believed by observers who have studied this matter, we cannot now support such an account. It is quite true that the bead (*NB*) is closely associated with the Golgi apparatus, before, during, and for a time after, the secretion of the acrosome (Fig. 2), so as to give the appearance of budding, but this view must be abandoned, since what is undoubtedly the same bead can be seen in the newly-formed spermatocyte and spermatid both in dog and cavy. It is interesting to note that the upper bead (*NB*) in the dog is very clearly formed of a vacuole and several separate argentophil elements. A similar structure was described in the human by one of us[3] some years ago, only in this case not so closely associated with the Golgi apparatus. Further work in the human is being undertaken in an endeavour to clear up this point.

J. Brontë Gatenby.
L. Collery.
Zoology Department,
Trinity College,
Dublin.
Jan. 18.

[1] Gatenby, *Proc. Roy. Soc.*, B, **104** (1929).
[2] Retzius, *Biol. Untersuch.*, B, **14**, No. 11–14 (1909).
[3] Gatenby, *Anat. Record*, **48** (1931).

The Countryside As It Was

In his notice of my book, "Field Fellowship", the reviewer makes certain animadversions on my "scientific accuracy". The issue over whole wheat flour is not one between white and brown bread but bread deprived of the wheat germ by the modern roller mills and bread which contains this nutritive essential. The "manchet" bread of the Middle Ages *was* white bread, but not faked bread. When it is considered that 26,000 of the stone-grinding country mills (which retain the wheat germ) have become derelict in Great Britain owing to the enormous powers exercised by the roller mill interest, it is scarcely surprising that the public have accepted the white bread of the latter. There has been virtually no alternative except by considerable trouble to find a stone-grinding mill and at the necessarily higher price. Eighteenth century white bread was of course never wheat-germless ; the process of extraction had not yet been invented.

The reviewer says that the "village garage mechanic" is an adequate substitute for the demise of the rural craftsman. The whole point of rural industry as practised in Great Britain for at least three thousand years was its intimate association with, and dependence upon, agriculture. The garage mechanic has no such organic relationship with the land.

The mechanization of agriculture is and must be as a substitute for human labour. This is quintessential in war-time, but disastrous in peace, because it must necessarily increase unemployment at a time when the problem of employment is the most harassing that modern governments have to face. Also, the small farm can never be mechanized to the same extent as the large, so that the whole tendency of excess mechanization is the formation of "Latifundia", which experience has shown to be extremely deleterious to fertility.

The reason for "the intellectual stagnation" of village life in the past was the effect of the enclosures and the industrial revolution in breaking down the whole structure and pattern of country life. All the best blood was either transported to the Colonies or drawn off to the towns. The restoration, not the urbanization, of country life is surely the remedy.

H. J. Massingham.
Reddings,
Long Crendon, Bucks.

With regard to Mr. Massingham's first comment. The point made in the review was that the public had adopted the whiteness of the bread as their criterion of its desirability long before the roller mill was introduced, so that the roller millers cannot be accused of originating this criterion. They have never had to advertise "Eat Whiter Bread" ; it is Mr. Massingham and the nutritional experts who have tried to persuade the public to "Eat off-white Bread", that is, stone ground or "manchet" bread, which the majority still prefer not to do.

The review did not pass judgment on whether any one village craftsman is an adequate substitute for any other. The point made was that new crafts are in fact springing up in the village. The good garage mechanic has often the same relation with the land as the village blacksmith. Neither are of the land, but it was the smith who enabled much of England to be brought under cultivation two thousand years ago. Was he an adequate substitute for the demise of the flint knappers ?

Mr. Massingham makes three statements about mechanization. First, that it decreases employment. This statement depends entirely on economic policy, for before the War many farmers actually increased the number of men employed when they turned to mechanization, as they could then intensify their agriculture. Secondly, that the small farm can never be mechanized to the same extent as the large. Categorical statements about future developments can rarely be statements of fact, so that Mr. Massingham must allow me to part company with him here, as pointed out in the review itself. Finally, he states that mechanization tends to the formation of "Latifundia", which are extremely deleterious to fertility. It is difficult to argue a point like this, owing to the vagueness of the word "Latifundia" applied to present-day conditions. There is no evidence that mechanization has yet increased the number of large farms, and, for reasons largely irrelevant in Great Britain, the trend of agricultural engineering development is towards small machines that can work irregularly shaped fields. The real flaw in Mr. Massingham's arguments is that he thinks of mechanization as applied to grain ranching only, which was the first but will not be the last set of agricultural operations to be completely mechanized. The marriage of the tractor to the dairy cow is rapidly taking place wherever agriculture is founded on Western European methods.

E. W. Russell.
Rothamsted Experimental Station.

NATIONAL RESEARCH COUNCIL OF CANADA

SCIENTIFIC research in Canada during the past three years has been directed almost wholly to the solution of new and urgent problems arising out of the War. The National Research Council is serving as a central co-ordinating body directing research within its own laboratories and in the universities and industry. The Council has been appointed the official research station of the Navy, Army and Air Force in Canada.

For the Navy

Scientific problems arising in connexion with the work of the Navy are studied jointly by officers from Naval Headquarters and civilian personnel on the Council's staff. The National Research Council maintains civilian scientific groups at several points on both the Atlantic and Pacific coasts who work in the closest co-operation with the Naval stations. A group is also located in Ottawa and contact is maintained with similar research stations in the United States and Great Britain.

Many of the problems presented relate to the supply of materials and the preparation of specifications. Highly technical problems have arisen from anti-submarine warfare and minesweeping operations. Several sections of the Division of Physics and Electrical Engineering are concerned almost exclusively with research and development programmes for the Royal Canadian Navy. In the Electrical Engineering Section a shock and vibration machine based on standard British Admiralty design has been installed. The specifications for building the machine were modified to permit the use of Canadian materials. This machine is used for testing resistance to shock of various electrical equipment, such as switches, rheostats, junction boxes, lighting fixtures used by Navy and merchant ships. From the results obtained specifications for all electrical equipment for the purposes enumerated are being developed as required. Problems investigated in the electrical engineering section have included studies of gear for magnetic minesweeping. A rocking machine to stimulate the rolling of a boat has been constructed, and tests of various instruments have been made on this unit.

In the Division of Chemistry many problems of interest to the Navy have been investigated. Work on paints, rubber, low-alloy high-strength steels and aluminium alloys, and sea-water resistance of various coatings and inhibition of corrosion of various metals by chemicals may be mentioned. In the Division of Mechanical Engineering, likewise, the several laboratories are engaged on numerous problems for the Navy, notably in matters relating to engines and their lubrication, the design and test of boats of various types.

For the Army

For the Army and also for the other Services all kinds of supplies have had to be tested to determine whether they are acceptable according to required military standards. Apparatus has been developed and constructed for work in ballistics on an increasing scale. Measuring equipment for ammunition proof and gun proof has been developed and is in continuous service at proving grounds. Problems on the direction of gun-fire have been attacked with success. Numerous tests have also been made on the armouring properties of various materials and work is in progress on the improvement of anti-aircraft projectiles.

An important war service was rendered in 1939 by promoting the development in Canada of optical glass manufacture for the production of precise optical parts for military equipment. The project is now being carried forward in production by a Government-owned company. Equipment was installed and a staff assembled in the National Research Laboratories for the inspection of gauges used in the production of guns, shells, fuses, bombs and other mechanical items which are now being made in mass production.

Another important activity of the Army which is built on science is chemical warfare. From a small co-operative effort between the National Research Council and the Army, this activity has developed rapidly and is now a highly co-ordinated project operating as a directorate of the Department of National Defence, but under a director-general who is a civilian scientific worker on the staff of the National Research Council. Of the active personnel about one half are civilian men of science and the rest are Service men.

Indicators for war gases and chemicals for other war services have been synthesized and studied. The rubber laboratory has investigated, for production purposes or improvements, products used by almost every branch of the Armed Forces, including surgeons' gloves, ground sheets, gas-mask components, artillery and tank parts, crash and steel helmets. In addition, the laboratory has made numerous acceptance tests on contract deliveries. Recently much attention has been given to rubber conservation problems and to the study of synthetic rubber processes. Commercial production of fuse-powder charcoal was carried on until recently by the National Research Council; manufacturing has now been turned over to a commercial concern. Research on the fundamental problems involved in the operation is being continued by the Council.

Activities in the textile laboratory have been largely in connexion with acceptance test work and specifications. Special problems included an investigation of methods to reduce weathering of canvas duck, a study of thermal transmission of blankets, colour analyses of certain types of textile products and work on respirator pads. Materials tested included felt, silk gauze, silk thread, braid, vulcanized cloth, box cloth and various types of uniform materials. A large amount of work is being carried out on the development of suitable types of anti-gas impermeable-type fabrics and on the maintenance of suitable standards of quality in material of the type which is being manufactured in Canada. Other studies include work on the water-proofing, mildew-proofing and flame-proofing of cotton textiles.

Inspections have been made and advice given as to the suitability of a variety of leathers for different military purposes. Examination has been made of numerous dressings and waterproofing compounds for leathers. Tensile-strength tests on leathers, and wear-resistance tests, chiefly on composition-sole materials, were carried out for the Department of National Defence. Used militia boots were examined for the cause of cracking in the vamps. Research on the deterioration of shoe uppers has been continued.

Component parts of certain anti-aircraft protection devices were constructed. Transparent sheet resins for military purposes have been tested against specifications; vulcanized fibre identification disks and other objects have been examined, and general consideration has been given to the substitution of plastics for metals in a number of articles and parts related to war materials.

Preservative coatings for use on military vehicles and other equipment for war purposes have been developed. A surprising variety of finishes is required in this field and many of the materials are comparatively new to Canadian industry. The laboratories have co-operated with Government authorities and manufacturers to facilitate the supply of these highly specialized coatings. Gas-detector paints, luminous paints, finishes for rifle barrels, camouflage paints and other special paints have been developed.

Mention should be made of the establishment of an explosives laboratory to carry out testing required under the Explosives Act and to conduct research on explosives and related compounds. This laboratory is under the joint administration of the National Research Council and the Department of Mines and Resources. An Associate Committee on Explosives has been established to co-ordinate and direct all work in this field.

For the Air Force

Establishment of the new aeronautical laboratories just outside Ottawa has provided improved facilities for research on the multitude of problems arising from modern trends in aviation. Closest co-operation is maintained between the Royal Canadian Air Force and the Council's laboratories through the Associate Committee on Aeronautical Research, the chairman of which is the Air Member for Aeronautical Engineering, R.C.A.F. Much of the work in progress relates to problems that have been suggested by Air Force authorities in Canada, the United Kingdom or the United States.

Horizontal and vertical wind tunnels are in use. In the engine laboratory dynamometer rooms are provided for the testing of aircraft engines, while in the gasoline and oil laboratory complete equipment is provided for physical and chemical testing of aviation fuels and lubricants. A structures laboratory provides for the fabrication of prototypes of aircraft and for the test of component parts.

Experimental work required in connexion with scientific problems under investigation in the National Research Laboratories is often carried out co-operatively with the Royal Canadian Air Force Test and Development Establishment, which is really a full-scale experimental flying station.

During the year the Radio Section continued to work on the development of secret radio locator equipment with considerable success. There are already in the hands of the Services numerous different equipments which have been developed in the National Research Laboratories. Some of these have already been used successfully against the enemy.

Medical Research

In the field of medical research an active committee of the Council has made great progress. The original purpose of this committee was to co-ordinate medical research in Canadian institutions and to assist in its development. The activities of this committee are now wholly directed to war problems. The work has grown to such an extent that several new sub-committees have had to be established to deal with questions of shock and blood substitutes, wound infection and surgical problems. Regional committees have been appointed to facilitate the work. Liaison with Great Britain and the United States has enabled Canada to co-operate effectively with them in the promotion of medical investigations arising from war problems. More recently, Australia and New Zealand have been included in the interchange of reports.

In the field of medical research as applied specifically to the Services, three associate committees are in operation dealing respectively with aviation, naval and army medical research problems.

The first of these associate committees, on aviation medical research, was formed early in 1940 and has carried out a most impressive programme of work, especially in the fields of high-altitude flying and protective clothing. The work of the Naval Committee has been directed to the improvement of innumerable factors effecting the efficiency of personnel on boats, and the Army deals with similar problems of Service men who have to operate in tanks and work under the innumerable special Service conditions attendant on modern warfare.

Research activities under these committees have been carried on at most of the universities of Canada and at the National Research Council, the Ontario Research Foundation and the clinical investigation units and other establishments of the Services. The close collaboration existing between the civilian and Service groups of workers and the help and advice so freely offered by industrial concerns have greatly accelerated the solution of a number of important problems.

For War Industries

The Division of Applied Biology has rendered valuable assistance in the fitting of temporary refrigerators on merchant vessels. The successful transport of perishable foodstuffs demands refrigerated shipping space or the conversion of the material to a less perishable form that can be carried in ordinary stowage. This problem is most acute for bacon, which goes forward in large volume. The shortage of refrigerated space has also affected other perishable commodities. Considerable work has been done on the treatment of shell eggs to avoid deterioration during shipment at ordinary temperatures. All export eggs, however, are now shipped in powder form, and the work of this group of investigators is therefore directed towards the development of methods for assessing quality and developing drying processes capable of producing a dried egg material of high quality.

Dehydration of meat, chiefly pork and cured ham, has been studied,and an acceptable quality of product has been obtained. Closely related to food studies on products for shipments overseas is the development of containers in which a substitute for tin plate has been used. Packages based primarily on fibre and wax combinations have been found useful. Dehydrated products require packaging in waterproof materials.

The need for magnesium led to intensive research and resulted in the development of a process well suited to Canadian conditions of production. A plant of ten tons capacity per day, built by the Department of Munitions and Supply to use this process, is in operation, while plants totalling about a hundred tons per day capacity are being built in several centres in the United States.

The shortage of natural rubber, which is so important for military purposes in this age of mechanization, has stimulated research on the possibility of producing rubber from plants that can be grown on the American continent. Synthetic rubbers of various types are being developed and tested, and plants are being established for the production of the more useful types.

SCIENTIFIC PROGRESS SINCE 1840

IN a lecture, "A Century of Progress : Men, Manners, Inventions", given before the Lancastrian Frankland Society on January 15, Dr. E. F. Armstrong drew a stimulating comparison between the conditions of Edward Frankland's early years in Lancaster and to-day. Referring to the encouragement which Frankland received from the Johnsons in Lancaster, who sent him to Playfair in 1845, Dr. Armstrong remarked that the energy to get on in spite of the most adverse and discouraging circumstances was characteristic of the 1840's. A deep interest in Nature and in intellectual matters was also widespread in the north of England during the Victorian period and led to the formation of many local societies, ranging from the mutual improvement societies of the chapels to the mechanics institutes and literary and scientific societies of the small towns and the philosophical societies of the large cities. These societies, which besides spreading knowledge gave inspiration to the younger members, persisted until improved communications, a multitude of technical journals and the spread of technical colleges drove most of them out of existence, although even now technical societies with local sections have a most important function.

Frankland apparently took up science as a career through his parents instilling a spirit of inquiry and the desire to find out things for oneself. Commenting on the fact that the period 1840–70 saw the birth and entry into the sciences of a great many men from very diverse walks of life, whose achievements have laid the foundations on which we are building to-day, Dr. Armstrong directed attention to the early life of austerity and struggle which developed their powers. Among these were James Dewar, Horace and Adrian Brown, Charles Lapworth, Richard Threlfall, Alfred Yarrow, Bates of Amazon fame, C. F. Cross, James Alfred Ewing, and H. B. Baker.

The chief characteristics of the last hundred years, Dr. Armstrong suggested, are the inventions and discoveries which have so markedly affected the material progress of the world that they may well be regarded as the seven modern wonders of the world, superseding the seven architectural wonders of the past. The first of these is pure water supply, in the provision of which Frankland himself played a large part. As a scientific member of the Royal Commission appointed in 1867, he found that the oxidation and destruction of the organic matters present in town drainage took place with extreme slowness, contrary to the previous belief. He found, on the other hand, that slow percolation through porous soil effected this oxidation and destruction with great rapidity. Frankland also improved the old and devised new methods of water analysis, and throughout his life took special interest in the water supply of London, while his son, Percy Frankland, took up the study of the biological aspects of the problem. Continuing this work, Sir A. C. Houston, the pioneer of systematic chlorination treatment on a large scale, was also responsible for the scientific application of bacteriology for improving and safeguarding the purity of water. Dr. Armstrong referred here to his previous suggestion that a tablet commemorating these achievements of Frankland should be placed on the great new dam across Hawes-water.

Second of the modern seven wonders, both in point of time and importance to pure water, must be ranked electricity, which from its gradual development, starting with its use in signalling by Cook and Wheatstone, with no encouragement by the State, has now become a major industry touching almost every home. The third wonder was the spinning of viscose or Rayon from wood, with the consequent revolution in women's dress. Even now we are only at the beginning, the newest of all these fibres being Nylon, a wholly synthetic fibre, built up as it were from carbon, water and air, with properties as good or better than those of silk spun by the silkworm.

The fourth and fifth wonders, the internal combustion engine and hydrocarbon oil, are so interdependent that they may well be considered together. Giving us speedy transport on land, on sea and in the air, they have made the world one community. Speedy travel has had great political repercussions; and no individual, community or nation can withdraw at will to a quiet corner to follow its own inclinations. The development of the internal combustion engine was based on progress in design correlated with progress in metallurgy, while the oil industry was providing raw materials for many diverse chemical operations and was destined to displace coal tar and coal as the world's most important basic raw material for chemical synthesis —probably with further effects on our own post-war economy following on those already involved in the displacement or disappearance of cheap coal.

Next among modern wonders came the radio, which is enabling all to lead a fuller and broader life. Its cultural and scientific significance is not yet fully appreciated, and despite its importance in war the future applications may be astounding. The last wonder, Dr. Armstrong said, was the plastics, of which the man in the street is as yet only dimly conscious, although they are destined to make life easier for us all, to provide objects of utility, and should also make artistic design and beauty available at prices diminishing rather than increasing. Finally, Dr. Armstrong pointed out that the satisfactory solution of the problems of society into which science enters will be based on moral influence, and our effectiveness will depend on the devotion, wisdom and goodwill which we bring to our task.

A SPREAD-SCALE RECORDER

IN an article with this title (*Bell. Lab. Rec.*, 21, No. 3; November 1942) O. D. Engstrom points out that the transmission tolerances of telephone circuits have become more severe, requiring a corresponding improvement in measuring technique and equipment. When a telephone circuit had only a few amplifiers or other circuit units, each could be permitted a larger share of the total permissible distortion, and errors in measurement of 0·25 db. meant very little. With the present transmission systems requiring many more circuit units than the earlier systems, this situation has changed. More accurate and faster operating testing equipment has been required, and a recording transmission-measuring set was developed that covers the voice-frequency spectrum in a few minutes. As originally used, the chart of this recorder could be read to about 0·2 db., but for many present-day measurements this is not adequate, and a new 'spread-scale' recorder has been developed that can be read to 0·02 db.

For a transmission measurement, an adjustable-frequency oscillator is provided with a small synchronous motor that changes the output frequency continuously over the range from 200 to 3,500 cycles for each test. An equalizer and adjustable attenuator in the output of the oscillator maintain the output power constant at the desired level for the test. At the output of the circuit being measured is an I–U amplifier-rectifier that converts the received A.C. into D.C. for operating the recorder. A 500 cycle selective detector is employed to mark the chart at a point corresponding to a test frequency of 500 cycles, and this mark is used in placing the frequency ordinates on the chart. A biasing circuit was added as one of the changes required to produce the spread-scale characteristic.

To secure the added precision needed for a chart that is to be read to 0·02 db., certain other changes were made, including principally an increased voltage stability of the power supplies and an increased stability of the oscillator output and of the detector gain as the frequency varied over the test range. Steps taken to improve the circuit in these respects include the provision of a regulated plate-battery power supply for both the oscillator and the detector, storage battery for filament supply, the selection of quiet tubes, and special regulation for the oscillator output characteristics.

The circuit is calibrated by applying an input of 10 db. below 1 milliwatt to the amplifier-rectifier, and then adjusting the resistance in the circuit of the biasing battery until a mid-scale deflexion is obtained. When making a measurement of the transmission characteristic of a piece of equipment, it is then necessary to adjust the oscillator output so that the output of the equipment under test is 10 db. below 1 milliwatt at roughly the frequency of the mean attenuation. The dial of the oscillator is then set below the edge of the desired band, and the oscillator and recorder are both started. The article describes and illustrates the recorder and its performance characteristics in detail.

FORTHCOMING EVENTS

(Meetings marked with an asterisk are open to the public)

Saturday, February 27

MALACOLOGICAL SOCIETY (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Annual General Meeting and Commemoration of the 50th Anniversary of the Society's Foundation.

LIGHT RAILWAY TRANSPORT LEAGUE (at Fred Tallant Hall, Room J, Drummond Street, London, N.W.1), at 3 p.m.—Dr. Hugh Nicol: "A Scientist Looks at Transport".*

Monday, March 1

FARMERS' CLUB (at the Royal Empire Society, Craven Street, Strand, London, W.C.2), at 2.30 p.m.—Sir William Prince-Smith, Bart.: "An Industrialist's Views on Agriculture and its Future".

Tuesday, March 2

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Geographical Department, The University, Manchester), at 5 p.m.—Prof. J. Kenner, F.R.S.: "Historical Method in Teaching Science".

INSTITUTE OF WELDING (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 6 p.m.—A series of Papers on "Developments in Arc Welding Technique".

Wednesday, March 3

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Dr. J. D. Robertson: "Calcium Metabolism in Health and Disease".

PHYSICAL SOCIETY (COLOUR GROUP) (in the Lecture Theatre of the Science Museum, Exhibition Road, London, S.W.7), at 2.30 p.m.—Third Annual General Meeting. At 3 p.m.—Mr. J. Guild: "The Significance and Limitations of the C.I.E. Standard Observer Tables".

INSTITUTE OF METALS (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 3 p.m.—35th Annual General Meeting. Dr. Harold Moore: "Co-operative Research in the Metal Industries".

INSTITUTION OF MECHANICAL ENGINEERS (JOINT MEETING WITH THE IRON AND STEEL INSTITUTE AND THE INSTITUTE OF METALS) (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. S. W. Smith: "The Life and Work of Sir William Chandler Roberts-Austen".

Thursday, March 4

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—Sound Films of Honorary Members and Faraday Medallists—Sir J. J. Thomson, O.M., F.R.S.; Lord Rutherford, O.M., F.R.S.

Friday, March 5

ROYAL SOCIETY OF ARTS (INDIA AND BURMA SECTION) (at John Adam Street, Adelphi, London, W.C.2), at 1.45 p.m.—Sir Malcolm Darling: "The Indian Village and Democracy".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5 p.m.—Sir John Russell, F.R.S.: "Restarting of Agriculture in Devastated Europe".

Saturday, March 6

GEOLOGISTS' ASSOCIATION (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Annual General Meeting. Prof. H. H. Read, F.R.S.: "Meditations on Granite" (Presidential Address).

Friday, March 5—Sunday, March 7

INSTITUTE OF INDUSTRIAL ADMINISTRATION (at the Waldorf Hotel, Aldwych, London, W.C.2). Conference on "Training for Industrial Management".*

Friday, March 5

4.30 p.m.—Registration of Members.

Saturday, March 6

10 a.m.—Management and the Nation.
11.15 a.m.—Address by His Grace the Lord Archbishop of Canterbury.
12.30 p.m.—Management and Industry.
3 p.m.—External Training for Industry.
5.30 p.m.—Internal Training in Industry.

Sunday, March 7

10 a.m.—Management and the Board Room.
11.30 a.m.—Review of Conference.

APPOINTMENTS VACANT

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

LECTURER-INSTRUCTOR IN ENGINEERING WORKSHOP TECHNOLOGY AND PRACTICE in the Bolton Municipal Technical College—The Director of Education, Education Offices, Nelson Square, Bolton (March 5).

MASTER TO TEACH MATHEMATICS AND SCIENCE at the Bingley Technical School—The Divisional Educational Officer, Education Offices, Bingley, Yorks. (March 7).

LECTURER IN MECHANICAL ENGINEERING in the Oxford Schools of Technology, Art and Commerce—The Chief Education Officer, City Education Office, 77 George Street, Oxford (March 9).

LECTURER OF TEXTILE TESTING in the School of Textiles—The Principal, College of Technology and Commerce, Leicester (March 13).

CHAIR OF CHEMISTRY in the University College of North Wales—The Bursar and Acting Registrar, University College of North Wales, Bangor (April 3).

ASSISTANT FIELD OFFICER (either sex) for Crop Investigations of Mineral Deficiencies—The Secretary, Research Station, East Malling, Kent.

ASSISTANT (woman) FOR THE STRAWBERRY NUCLEAR STOCKS SCHEME—The Secretary, Research Station, East Malling, Kent.

TECHNICAL ASSISTANT (male or female) IN THE DEPARTMENT OF ECONOMICS—The Secretary, South-Eastern Agricultural College, Wye, Kent.

ASSISTANT ENGINEERS for operation and maintenance of hydro-electric Public Supply Company, Nigerian Plateau—The Ministry of Labour and National Service, Central (Technical and Scientific) Register, Section D.553X, Alexandra House, Kingsway, London, W.C.2.

LECTURER IN MECHANICAL ENGINEERING—The Secretary, Woolwich Polytechnic, Woolwich, London, S.E.18.

MURDOCH TRUST

For the BENEFIT of INDIGENT BACHELORS and WIDOWERS of good character, over 55 years of age, who have done "something" in the way of promoting or helping some branch of Science.

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UNIVERSITY OF LONDON

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THE FRIDA MOND STUDENTSHIP for the promotion of Literary Studies of the value of £130 a year, tenable for two years, will be offered in 1943 to men and women who as Internal Students of the University have taken Honours in a Final Examination for an Arts Degree preferably not more than two years before the date of the award. Applications (on a prescribed form) must reach the Academic Registrar, University of London, at 42 Gyles Park, Stanmore, Middlesex (from whom further particulars may be obtained) not later than May 1, 1943.

February, 1943.

WOOLWICH POLYTECHNIC

The Governing Body invite applications for the post of full time Lecturer in Chemistry from Honours Graduates, duties to commence immediately. Burnham London scale.

Particulars of the appointment and forms of application may be obtained from the Secretary on receipt of a stamped addressed envelope.

HUDDERSFIELD TECHNICAL COLLEGE

Principal: Dr. J. W. Whitaker

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

Applications are invited for the position of lecturer in the above department. Candidates should have University Degree qualifications or equivalent, and some years of industrial experience. Salary—Burnham Scale plus bonus. Forms of application may be obtained from the Principal. They should be returned by March 15.

H. KAY,
Director of Education.

Well-known insecticide manufacturers require a qualified entomologist (preferably lady) to supervise biological assay. Previous industrial experience not essential.—Write stating age, experience, etc. Box 3885, R. Frost-Smith & Co., 64 Finsbury Pavement, E.C.2.

Director of research and development, to take complete charge of these departments, required by a London firm of Electrical Engineers manufacturing radio frequency, acoustic and electrical instruments. First class qualifications in Physics or Electrical Engineering essential, coupled with wide industrial experience.—Write, stating full particulars to Box 915, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Entomologist, young graduate, with field and research experience, requires post.—Box 920, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

Research Assistant required with qualifications equivalent to Intermediate B.Sc.—Write fully to Director, Research Association for British Flour-Millers, Old London Road, St. Albans.

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Physicist, B.Sc., 25. Research, development and production experience. Interested in electronics. Seeks active position.—Box 923, T. G. Scott & Son, Ltd., 9 Arundel Street, London, W.C.2.

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