of the principles of Colon Classification and its application to advantage to the vast stores of books on Indian civilization, philosophy and culture, especially of the South.

K. KASTHURI RANGACHAR.

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Plant Breeding Technique in Recent Years. By R. H. Richharia. (The Bangalore Press, Bangalore City), 1939. Pp. 73. Price Rs. 2-8.

The publication of this book has removed the long-felt want of amateur plant breeders and persons interested in the science of plant breeding, who have neither the necessary background for understanding the subject nor the proper opportunities to learn the modern technique. It will also be of great use to students of Agriculture and Botany.

The author has divided the book into fourteen chapters describing the different aspects of plant breeding and vividly putting forth the importance of cytological investigations in understanding the problems of plant breeding and genetics, especially by the non-Mendelian methods. Chapters on polyploidy, haploidy, decapitation and effect of temperatures, chemicals and radiations are particularly intersting.

Numerous diagrams and illustrations make the reading of the book more interesting. The get-up of the book and printing are excellent.

R. J. K.

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## From J. J. to G. P.

Theory and Practice of Electron Diffraction. By G. P. Thomson and W. Cochrane. (Macmillan & Co., Ltd., London), 1939. Pp. xii + 334. Price 18*sh*.

SIR J. J. THOMSON, while describing the discovery of the electron writes in his book *Recollections and Reflections*: "At first there were very few who believed in the existence of these bodies smaller than atoms. I was even told long afterwards by a distinguished physicist who had been present at my lecture at the Royal Institution that he thought I had been 'pulling their legs'." Professor G. P. Thomson when he first published in 1927, photographs obtained by sending a beam of homogeneous cathode rays through a very thin film of collodion, could also have been accused of leg pulling. The average physicist then was either unaware of de Broglie's theory or he did not suspect that there would be such a strong coupling between the probability waves and atoms, which would permit them to form diffraction patterns of appreciable intensity. The fundamentals on which this significant achievement has been based are now recounted in this book.

The first chapter deals with the fundamental properties of wave motion and de Broglie's wavemechanics. The theory has been written from the point of view of an experimental physicist, and the physical significance of various mathematical operations has been cleverly pointed out. Thus about the Huygens' construction the authors write that it implies nothing not already given by geometrical optics. They define group velocity as the velocity with which a peculiarity associated with the group, such as a maximum of amplitude will advance.

De Broglie started from the idea that Einstein's equation $E = h\nu$ represents a fundamental relation between energy and frequency. By the theory of relativity a particle of resting mass $m_0$ has associated with it energy $m_0 c^2$, and should therefore have an inherent frequency $\nu_0 = m_0 c^2/h$. De Broglie regarded this as the frequency of a pulsation in the space surrounding the particle. The wave velocity is $V = c^2/u$ and the corresponding wave-length is $\lambda = h/mu$. De Broglie's idea that the waves act as a guide for the particles and determine their motion necessitates that the ordinary Newtonian mechanics, or rather their relativistic generalisation should be replaced by laws which involve the conception of waves. When experiments are carried out to verify de Broglie's law, it would appear that the theory holds up to as high as a million volts, to better than 5 per cent. This result is important because the theory given by de Broglie is incomplete as it takes no account of the spin of the electron; but the terms involving spin should be expected to become important for speeds near the velocity of light. Thus the equation

$$\nabla^2\psi + \frac{8\pi^2 m_0}{h^2}(E - F)\psi = 0$$

is incomplete and it is therefore interesting that it still gives the right value for the wave-length.

The readers are next treated to an account of Ewald's reciprocal lattice, and

how the pattern obtained on a distant screen will be the projection of the points of the reciprocal lattice lying on Ewald's sphere. It is only in exceptional cases that a point will lie actually on the sphere, but the rigorous conditions are relaxed in various ways. The wave-length of the electrons will not be exactly fixed, the real crystals have imperfections, and these imperfections assume enormous importance as the angles of diffraction are very small. This enables the authors to explain such phenomena as the Kikuchi patterns, the so-called forbidden spectra and the subsidiary diffraction maxima observed by Finch and Wilman.

The intensity of the diffracted beams depends not on the atom form factor only but also on the structure factor. The most important point that appears is the very large values of the scattering of electronic waves as compared with X-rays.

There are three chapters which will be of great use to experimental physicists interested in electron diffraction. The effect of the refractive index of the specimen is described and it is pointed out that such an effect should be considered only in the case of reflection experiments from reasonably smooth surfaces. The formation of Kikuchi lines, their changes of intensity and the envelopes of Kikuchi lines have received their due share. The effect of temperature and the size of the crystals on the dimensions of the lattice has been pointed out. But the description of the principal types of diffraction patterns observed and the way they should be interpreted is so important that a beginner would be well advised to master it before he starts taking electron diffraction pictures. It is interesting to note that the minimum thickness to give a detectable pattern with 30,000 volts electrons is of the order of 10–12Å; and it is this property which makes the electrons indispensable for surface investigations. The authors point out that part of the electron diffraction technique is ordinary vacuum practice. They also describe the various types of electron diffraction cameras which have been evolved, how the specimens should be prepared, and photographic patterns measured.

In a limited number of special problems, a large proportion of the information has been obtained by the application of electron diffraction methods. The problems thus treated are the measurement of inner potential, the study of the growth of crystals, the nature of oxides and the polished layer and the structure of oils, greases and lubricants. There is also a wider field in which the method of electron diffraction can be used. The authors after describing the technique and the theory of electron diffraction by gas molecules point out that the interpretation of electron diffraction patterns from gas molecules is not so straightforward as in the case of crystalline solids. Generally speaking, a trial and error method must be adopted; a molecular model of definite dimensions has to be found such that the calculated distribution of intensity agrees with the experimental results. This is illustrated by applying the method to a benzene molecule, and pointing out that in such a case it is possible to infer that the C – C bond 'resonates' about equally between a single bond and a double bond. Lastly the slow electrons have an advantage over fast electrons in that they are more sensitive to absorbed gas.

The book closes with a discussion of the present limitations of the theory. Thus a full description is given of Bethe's dynamical treatment of the diffraction of electrons. And although the dynamical theory is based on sounder foundations than the kinematical, it has not been able to claim more successes than its rival—the kinematical theory—which has the advantage of simplicity. Darwin's version of the theory of the spinning electron is given and it has been pointed out that the detection of any effect due to magnetic moment or polarisation is not an easy matter. All theoretical physicists except Mott find no appreciable effects due to polarisation, while Mott finds that nuclear scattering ought to produce an appreciable asymmetry of the scattered electron beam if certain conditions are fulfilled. The experimental results, however, definitely prove that Mott's theory is not correct, as applied to the scattering of electrons by thin films of gold.

The treatment of the subject is throughout lucid and *anschaulich*. The book combines the unique qualities of simplicity and authority and as such is likely to prove itself the bible of electron-diffractionists or should we say interfractionists. But could we expect anything else from a book that comes straight from the pen of Prof. G. P. who is the world-authority on the subject of electron diffraction?

K. R. Dixit.

# Spectroscopy and Its Applications

Proceedings of the Sixth Summer Conference on Spectroscopy and Its Applications, 1938. Edited by G. R. Harrison. (Massachusetts Institute of Technology Press; Chapman & Hall, Ltd., London), 1939. Pp. vii + 172 (10" × 7·5"). Price 15*sh.*

APPLIED Spectroscopy is in a period of active growth. Astronomers, biologists, chemists, geologists, metallurgists, physicians, physicists, and industrialists of many kinds find the techniques of spectroscopy of great advantage, and are taking to it at an increasingly rapid rate. Thus H. R. Kreider of the American Medical Association Laboratory (p. 53) says: "We have practically omitted the chemical qualitative analysis except as a test: .... exact qualitative analysis of from 10 to 15 materials may be made in an hour, and a permanent record of the analysis obtained. This permanency of records is extremely important in the event of law suits, which play a rather important role in the work". Further, notwithstanding certain limitations, spectral analysis has already displaced gravimetric analysis in many instances of routine or control work, opened new fields in science and industry, and gives promise of going still further. It is interesting to recall in this connection that much of this confidence and spread in practical applications is largely due to our theoretical understanding of the principles of spectral emission, based on the work of Bohr and a host of other physicists. One has got only to add to these techniques those of the molecular spectra of the Raman type, which are now equally accessible in an analytical laboratory, to realise the future possibilities.

Under the ægis of the Massachusetts Institute of Technology, annual Summer Conferences have been held on spectroscopy and its applications, commencing from 1932. The volume under review contains, though in an abbreviated form, the 31 papers presented during the Sixth Conference held in July 1938. The subjects covered comprise a very wide range, from descriptions of specific applications as in the investigations of vitamins, enzymes, rare earths in plants, minerals, criminal investigations, etc, to discussions of the methods of exciting spectra, *e.g.*, 'characteristics of spectroscopic light sources' (p. 54), their recording, *e.g.*, use of grating spectroscopes (pp. 71, 80) and their evaluation, *e.g.*, 'a high speed method of absorption spectrophotometry' (p. 91). This last paper describes an apparatus, developed at the M.I.T., which permits density measurements to be made at the rate of 10 or more per second, using a combination of concave grating monochromator, amplification of photo-electric currents with an electron multiplier, and recording with a cathode-ray oscillograph and motion-picture film. There is also the desirable leaven of papers of theoretical interest, *e.g.*, 'photo-chemistry of visual spectrum' (p. 134), and 'the photographic latent image from the standpoint of the modern theory of solids' (p. 157).

Though the papers are presented in an abbreviated form, they are clearly illustrated and include references to original papers. The get-up of the volume leaves nothing to be desired.

M. A. G. RAU.

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# Evolution of the Human Brain

THE size of the Primate brain ranges from about 3 gms. in Tarsius to as much as 2,000 gms. in Man. Its basal structural pattern, however, remains the same throughout the Order and in Old World Primates the interrelation of surface to weight of the cerebral hemisphere and of its parts is more or less constant. The difference in brain-size between an Old World monkey (*e.g.*, a rhesus monkey) and a gorilla is far greater relatively than the difference in size between the gorilla and Man. Yet few, if any, significant and measurable difference exist between the intelligence of the monkey and gorilla, whereas an enormous gap exists between the intelligence of Man and that of any other Primate. The anatomical evolution of the brain thus hardly parallels the evolution of intelligent behaviour. Experimental study has also indicated that there is relatively little difference in the level of learning ability between an ape and an animal as far removed as a goldfish. Significant advances in the evolution of human intelligence would seem therefore to be related to the development of speech and to the elaboration of a symbolic process.—(S. ZUCKERMAN—British Association for the Advancement of Science, Dundee, 1939—*Journal*, p. 118.)