

the relation of the mathematical symbol, in its mathematical context, to measurable quantities, and this is possible in quantum theory as in any other part of physics. The remoteness of the relation has nothing to do with the matter, and may in any case disappear overnight when someone thinks of a new analogy.

Milne's claim that his theory obeys the operational principle raises objections of somewhat different character. In so far as an operation can be described which, if carried out, would yield numbers for the symbols he employs, those symbols may be said to be operationally defined. The trouble is that, for practical reasons, we can get no further than a description of the operations; actually to perform them we should require infinite time, an infinite army of slaves or disciples whom we could transport where we wished, and apparatus of infinite delicacy, to say nothing of the absence of any unsuspected difficulties throughout the great distances and durations involved. This would be of little consequence if it prevented only the final verification of a theory made probable by other observations, but in Milne's theory it is the very first requirement. Until these impossible demands are satisfied, physics cannot begin. Any agreement with observation that the theory might claim must therefore be obtained by departing from the operational definitions. Many, like Prof. Born, will "not wish to discourage anybody who feels in himself the vocation to embark on so adventurous a journey", but they will themselves prefer to see what can be done with measurements that can not only be conceived but actually made.

Like others, Prof. Born has not succeeded in understanding the essential parts of Eddington's theory connecting the constants of quantum theory with those of cosmology. That is not to say that there is nothing of great value in the theory. His final comment is perhaps the wisest that has yet been made on this subject: "I am far from attacking Eddington's theories or from doubting his results. If they should turn out to be right I shall rejoice. But I shall not attribute this (possible) success to Eddington's philosophy, as a doctrine which could be followed by others, but to his personal genius and intuition."

HERBERT DINGLE.

## POLLEN ANALYSIS

### An Introduction to Pollen Analysis

By Dr. G. Erdtman. (A New Series of Plant Science Books, Vol. 12.) Pp. xvi+240. (Waltham, Mass.: Chronica Botanica Co.; London: Wm. Dawson and Sons, Ltd., 1943.) 5 dollars.

**P**OLLEN analysis is the term applied to the quantitative analysis of material containing pollen, by microscopic recognition of the species and genera of plants from which the pollen came. The pollen membranes have qualities of shape, size, surface, and structure which permit these identifications, and their preservation is often excellent.

It was G. Erdtman, a Swede, who in the nineteen-twenties, by a series of papers written in English, introduced British and American scientific men to the principles and technique of pollen analysis, a new method of geological inquiry which had recently been developed in Scandinavia, particularly by the energy and insight of L. von Post. The succeeding years

have seen a very great extension of the applications of pollen analysis. Not only has it been used in countries in all parts of the world to elucidate their forest history, and thence the drift of former climatic conditions, but also it has been shown to afford the means of solving an unexpectedly wide range of problems. Thus, by the analysis of ice in the various layers of the great alpine Aletsch glacier, Vareschi has been able to recognize the regular seasonal alternation of preserved pollen, and on this basis has made important deductions about the character of glacier structure and movement. In the Swiss Alps, in the eastern United States, and recently in South Wales, analyses of the pollen content of the air at different seasons have proved valuable in studies of hay-fever.

It has long been recognized that dating of prehistoric objects and structures found in lake- or bog-deposits is often possible by reference to the geochronological scale afforded by the regular drift of forest history. Similarly, the course of relative movement of land- and sea-level may be effectively dated, and eustatic effects distinguished from isostatic. More recently, it has become apparent that not only is the former distribution of natural plant communities reflected by pollen analyses, so that the conditions of salt-marsh, lake, fen, forest and bog may be accurately recognized in buried layers, but also, as Iverson has shown (see *Nature*, April 29, p. 511), the influence of prehistoric man in modifying natural communities may be detected, together with the origin of the new anthropogenous vegetation he has created.

Hitherto no text-book of pollen analysis has been available, and we warmly welcome, therefore, the appearance of the "Introduction to Pollen Analysis" by Dr. Erdtman. He has himself in the last twenty years contributed important results to the field of pollen analysis. He has developed a technique of preparation by chlorination and acid-hydrolysis which very greatly simplifies counting of grains in materials poor in pollen: he has sharpened the technique of critical recognition of species by their pollen morphology, and he has contributed much to the knowledge of long-distance flight of pollen. In this book these matters are given adequate treatment, together with such related topics as the analysis of pollen in honey as a basis for determination of the country and season of its origin, and the geological use of spore-counts in coal seams.

The greater part of the book is nevertheless devoted to description of the morphology of a wide selection of pollen grains and spores, and of these very numerous drawings are given—very usefully all upon the same scale. The types included are largely north-west European, but a sprinkling of North American and other species is also included. The atlas of twenty-eight plates thus provided is certain to be of the greatest value to all who study pollen analysis.

There is still much to be written of the results of application of pollen analysis to recent geology, and we may perhaps feel that this field has been a little neglected by Dr. Erdtman; but it has been his purpose to direct study to the widest scope possible, and in this he has certainly succeeded. Both he and *Chronica Botanica* are to be congratulated on the easy and natural English of the book: many others deserve credit for having enabled production of the book to be carried through during a world war, with the author still in Sweden and his publishers in the United States.

H. GODWIN.