A Text-Book of
EXPERIMENTAL CYTOLOGY

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by

J. GRAY, M.A., F.R.S.

Fellow of King's College, Cambridge, and
Lecturer in Experimental Zoology,
University of Cambridge

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PREFACE

The present book represents the substance of a series of lectures delivered in Cambridge for some years past. It is intended to be an introduction to that aspect of biology which is commonly associated with the experimental method. The so-called 'experimental' outlook is really a misnomer, for there is no peculiar virtue in experiment as such. The crucial point is whether or not we feel that an analytical study of living processes is more useful, for the time being, than the inductive morphology of the past century.

Until recently the central theme in zoological thought has been Evolution and whatever be the mechanism whereby one species has given rise to others we may be quite sure that the processes involved are essentially of a dynamic nature; the potentialities of the organism and the nature of its environment have operated together to produce new and varied forms of life. Any real insight into the causes of Evolution involves a knowledge of function, and any conception of the organism as a dynamic unit is incomplete without a knowledge of its evolutionary history. It is just as illogical to restrict the study of animal life to morphological observations as it is to study an aeroplane as though it were a static and inert machine. Precise knowledge of the reactions between an organism and its environment is, however, very rare in those cases where the sequence of evolutionary forms is best known, and students of Evolution must either be content with relatively vague and indefinite speculation or must set to work to analyse environmental responses for themselves. Unfortunately, few students of zoology have had that training in the physical sciences which alone can make them realise the full significance of the analytical method. It is important to remember that those whose interests lie primarily in embryology or morphology undoubtedly find that a purely biological conception of the organism carries them much farther and much more securely than any physico-chemical conception can possibly hope to do. On the other hand, any attempt to analyse the relationship of the organism to its external environment without an accurate and precise knowledge of physico-chemical laws is doomed to failure. No branch of biological knowledge can be complete until the facts of form and of function

have been subjected to quantitative treatment and the concepts of Evolution will continue to remain vague and indefinite until we have established units of measurement which will enable us to orientate the facts one to another on a quantitative basis, or until we can decide how far we may accept, as fundamental, those units which have proved to be satisfactory in the inanimate world. It is commonly stated that a study of function must inevitably rest on a knowledge of form. In a restricted sense this is true, but it is a travesty of general truth unless we realise that the instruments of morphological enquiry are more subtle and more significant than the microscope and scalpel. With our present lack of knowledge it is not easy to weld into one generalised hypothesis any considerable mass of morphological and analytical data, and it is safer to put before the student the alternative points of view and leave him to frame his own philosophy after following, as far as he can, each rather bewildering trail. Within the compass of cytology the advantages of the dual viewpoint are obvious, and for this reason the present work was planned as a convenient means of introducing to students some conception of the complexity of ideas which arise from a study of the simplest of morphological units.

Cytology may rightly claim to be the frontier state in the biological commonwealth, for within its borders biologists and chemists find common ground. The chemist is interested in the activities of living matter and the biologist is impressed by the orderly analysis to which the chemist can submit his facts. A biologist who attempts to give a generalised conception of the living cell inevitably invites active criticism, for the attempt to co-ordinate the relevant facts is fast becoming a task beyond the competence of any one individual. Sir William Hardy has recently described the ideal biological college: 'It should have three floors—a ground floor for molecular physics, a first floor for biophysics, and a top floor for cell mechanics'. The present book represents an honest, if pathetic, attempt to creep downstairs. It represents the impressions which the author, as a biologist, has gained by contact with such physical facts as appear to him to bear on the structure of living matter, and which can be imparted to others like himself, whose knowledge of inanimate matter is limited.

In following the analytical outlook in cytology it is often not easy to assess the relative value of related data. Almost unconsciously we adopt from time to time views which are dangerously near to

incompatibility. The need for a covering hypothesis, however frail, is often acute and we tend to frame such hypotheses in terms which are elastic or obscure; this usually ends by adopting a terminology with which we, ourselves, are least familiar. As biologists we tend to put ingenuous trust in the possibilities of the colloidal state—that Alsatia (to borrow again from Sir William Hardy) 'wherein difficult states of matter find refuge from a too exacting enquiry'. So with the chemist, we note from time to time the bones of ignorance draped in the tinsel of hypothetical biology. One may note, not without some element of humour, that those who have done most to resolve biological phenomena into physical terms are the most prone to lay their tribute before the elements of purpose and design, whereas Genetics has produced the vocal advocate of co-ordinated chemistry. Speculation is an essential element in all scientific enquiry, but it is well to define and not conceal the difficulties if we are to reap the full benefit of co-operative effort. It is important to realise that no single activity of the living cell has yet been analysed in physical terms, and although the debt of biology to the physical sciences is fast mounting up, we have not yet emerged from the depths of a very profound ignorance. It is also well to remember that biological units may, for some time to come, prove more valuable in cytology than those of physics—for the cell has already provided us with units (the chromosomes and the genes) which enable us to express the facts of heredity in numerical form as surely as the properties of matter can be expressed in units of molecules or of atoms.

In the following pages the outlook is frankly analytical; at the same time an attempt is made to impress upon the student the fundamental complexity of living matter. Without stirring too vigorously the embers of a sterile controversy, it is well to ask how far it is unreasonable to look upon the cell as an aggregate of matter which is unique in the material world, and over which laws of a specific type hold sway. If once this question has been faced, it is safe to find an inspiration in the thought that a purely mechanistic conception of living matter has led to a more orderly conception of biological data than that provided by any other hypothesis. Whatever be our natural outlook we can at least find common satisfaction in the belief that the established facts will remain long after our most cherished theories have passed away. Whatever viewpoint enables us to establish new facts, that viewpoint is the one we should

cherish; if it stimulates others to frame hypotheses more fruitful than our own we may rest content.

The reader is reminded that this book represents the materials of a course of lectures and for this reason much has been included which has already been incorporated into the works of more competent authors. To these authors the writer has endeavoured to acknowledge his indebtedness. In particular there should be mentioned the works of E. B. Wilson, T. H. Morgan, F. R. Lillie and E. V. Cowdry. Most of the material has been collected together, in the form of notes, from year to year and it is only too probable that I have failed to make due acknowledgment of all original and secondary sources. For many of the diagrams I have to thank both authors and publishers; in particular, I have to acknowledge the generosity of the Rockefeller Institute, New York, for permission to reproduce several figures from their publications.

J. GRAY

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