

THE CELL
IN DEVELOPMENT AND INHERITANCE

Columbia University Biological Series.

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AND

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THE CELL

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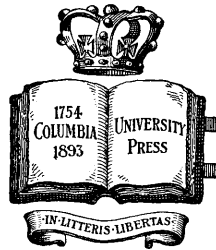
DEVELOPMENT AND INHERITANCE

BY
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SECOND EDITION
REVISED AND ENLARGED

“Natura nusquam magis est tota quam in minimis”

PLINY



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To my friend

THEODOR BOVERI

PREFACE

THIS volume is the outcome of a course of lectures, delivered at Columbia University in the winter of 1892-93, in which I endeavoured to give to an audience of general university students some account of recent advances in cellular biology, and more especially to trace the steps by which the problems of evolution have been reduced to problems of the cell. It was my first intention to publish these lectures in a simple and general form, in the hope of showing to wider circles how the varied and apparently heterogeneous cell-researches of the past twenty years have grown together in a coherent group, at the heart of which are a few elementary phenomena, and how these phenomena, easily intelligible even to those having no special knowledge of the subject, are related to the problems of development. Such a treatment was facilitated by the appearance, in 1893, of Oscar Hertwig's invaluable book on the cell, which brought together, in a form well designed for the use of special students, many of the more important results of modern cell-research. I am glad to acknowledge my debt to Hertwig's book; but it is proper to state that the present volume was fully sketched in its main outlines at the time the *Zelle und Gewebe* appeared. Its completion was, however, long delayed by investigations which I undertook in order to re-examine the history of the centrosomes in the fertilization of the egg,—a subject which had been thrown into such confusion by Fol's extraordinary account of the "Quadrille of Centres" in echinoderms that it seemed for a time impossible to form any definite conception of the cell in its relation to inheritance. By a fortunate coincidence the same task was independently undertaken, nearly at the same time, by several other investigators. The concordant results of these researches led to a decisive overthrow of Fol's conclusions, and the way was thus cleared for a return to the earlier and juster views founded by Hertwig, Strasburger, and Van Beneden, and so lucidly and forcibly developed by Boveri.

The rapid advance of discovery in the mean time has made it seem desirable to amplify the original plan of the work, in order to render it useful to students as well as to more general readers; and to this end it has been found necessary to go over a considerable

part of the ground already so well covered by Hertwig.¹ This book does not, however, in any manner aim to be a treatise on general histology, or to give an exhaustive account of the cell. It has rather been my endeavour to consider, within moderate limits, those features of the cell that seem more important and suggestive to the student of development, and in some measure to trace the steps by which our present knowledge has been acquired. A work thus limited necessarily shows many gaps; and some of these, especially on the botanical side, are, I fear, but too obvious. On its historical side, too, the subject could be traced only in its main outlines, and to many investigators of whose results I have made use it has been impossible to do full justice.

To the purely speculative side of the subject I do not desire to add more than is necessary to define some of the problems still to be solved; for I am mindful of Blumenbach's remark that while Drelin-court rejected two hundred and sixty-two "groundless hypotheses" of development, "nothing is more certain than that Drelin-court's own theory formed the two hundred and sixty-third."² I have no wish to add another to this list. And yet, even in a field where standpoints are so rapidly shifting and existing views are still so widely opposed, the conclusions of the individual observer may have a certain value if they point the way to further investigation of the facts. In this spirit I have endeavoured to examine some of the more important existing views, to trace them to their sources, and in some measure to give a critical estimate of their present standing, in the hope of finding suggestion for further research.

Every writer on the cell must find himself under a heavy obligation to the works of Van Beneden, Oscar Hertwig, Flemming, Strasburger, and Boveri; and to the last-named author I have a special sense of gratitude. I am much indebted to my former student, Mr. A. P. Mathews, for calling my attention to the importance of the recent work of physiological chemists in its bearing on the problems of synthetic metabolism. The views developed in Chapter VII. have been considerably influenced by his suggestions, and this subject will be more fully treated by him in a forthcoming work; but I have endeavoured as far as possible to avoid anticipating his own special conclusions. Among many others to whom I am indebted for kindly suggestion and advice, I must particularly mention my ever helpful friend, Professor Henry F. Osborn, and Professors J. E. Humphrey, T. H. Morgan, and F. S. Lee.

In copying so great a number of figures from the papers of other

¹ Henneguy's *Leçons sur la cellule* is received, too late for further notice, as this volume is going through the press.

² Allen Thomson.

investigators, I must make a virtue of necessity. Many of the facts could not possibly have been illustrated by new figures equal in value to those of special workers in the various branches of cytological research, even had the necessary material and time been available. But, apart from this, modern cytology extends over so much debatable ground that no general work of permanent value can be written that does not aim at an objective historical treatment of the subject; and I believe that to this end the results of investigators should as far as practicable be set forth by means of their original figures. Those for which no acknowledgment is made are original or taken from my own earlier papers.

The arrangement of the literature lists is as follows. A general list of all the works referred to in the text is given at the end of the book (p. 449). These are arranged in alphabetical order, and are referred to in the text by name and date, according to Mark's convenient system. In order, however, to indicate to students the more important references and partially to classify them, a short separate list is given at the end of each chapter. The chapter-lists include only a few selections from the general list, comprising especially works of a general character and those in which reviews of the special literature may be found.

E. B. W.

COLUMBIA UNIVERSITY, NEW YORK,
July, 1896.

PREFACE TO THE SECOND EDITION

SINCE the appearance of the first edition of this work, in 1896, the aspect of some of the most important questions with which it deals has materially changed, most notably in case of those that are focussed in the centrosome and involve the phenomena of cell-division and fertilization. This has necessitated a complete revision of the book, many sections having been entirely rewritten, while minor changes have been made on almost every page.

In its first form, the work was compressed within limits too narrow for a sufficiently critical treatment of many disputed subjects. It has therefore been considerably enlarged, and upwards of fifty new illustrations have been added. The endeavour has, however, still been made to keep the book within moderate limits, even at some cost of comprehensiveness; and the present edition aims no more than did the first to cover the whole vast field of cellular biology. Its limitations are, as before, especially apparent in the field of botanical cytology. Here progress has been so rapid that, apart from the difficulty experienced by a zoölogist in the attempt to maintain a due sense of proportion in reviewing the subject, an adequate treatment would have required a separate volume. I have therefore, for the most part, considered the cytology of plants in an incidental way, endeavouring only to bring the more important phenomena into relation with those more fully considered in the case of animals.

The steady and rapid expansion of the literature of the general subject renders increasingly difficult the historical form of treatment and the citation of specific authority in matters of detail. This plan has nevertheless still been followed as far as possible, despite the increased bulk of the book and the encumbrance of the text with references thus occasioned, in the hope that these disadvantages will be outweighed by increased usefulness of the work. I beg the reader to remember, however, that no approach to a complete history of cytology and experimental embryology could be attempted, save in a work of far greater proportions, and that it has been necessary

to pass by, or dismiss with very brief mention, many works to which space would gladly have been given.

Recent research has yielded many new results of high interest, conspicuous among them the outcome of experiments on cell-division, fertilization, and regeneration; and they have cleared up many special problems. Broadly viewed, however, the recent advance of discovery has not, in the author's opinion, tended to simplify our conceptions of cell-life, but has rather led to an emphasized sense of the diversity and complexity of its problems. "One is sometimes tempted to conclude," was recently remarked by a well-known embryologist, "that every egg is a law unto itself!" The jest, perhaps, embodies more of the truth than its author would seriously have maintained, expressing, as it does, a growing appreciation of the intricacy of cell-phenomena, the difficulty of formulating their general aspects in simple terms, and the inadequacy of some of the working hypotheses that have been our guides. It is in the full recognition of such inadequacy, when it exists, and of the danger of hasty generalization in a subject so rapidly moving as this, that our best hope of progress lies.

My best thanks are again due to many friends for helpful criticism, suggestion, and other aid; and I am indebted to Professor Ulric Dahlgren for the beautiful preparation imperfectly represented by Fig. 59 (from a direct photograph); to F. Emil, E. M. Van Harlingen, and Dr. G. N. Calkins, for aid in the preparation of new illustrations; and to Messrs. Ginn & Co. for the electrotypes of Figs. 11, 12, and 188, from the Wood's Holl Biological Lectures for 1899.

COLUMBIA UNIVERSITY,
December 7, 1899.

POSTSCRIPT. — Of especial importance for some of the discussions in Chapters I, V., and VII. are Fischer's extensive work on protoplasm (see Literature, I.) and Strasburger's new researches on reduction (see Literature, V.), both received while this volume was in press and too late for more than a passing mention in the text.

MARCH, 1900.

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