

COLUMBIA UNIVERSITY BIOLOGICAL SERIES. IV.

THE CELL

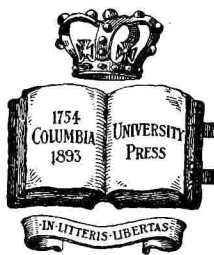
IN

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.

TABLE OF CONTENTS

INTRODUCTION

	PAGE
LIST OF FIGURES	xvii
Historical Sketch of the Cell-theory; its Relation to the Evolution-theory. Earlier Views of Inheritance and Development. Discovery of the Germ-cells. Cell-division, Cleavage, and Development. Modern Theories of Inheritance. Lamarck, Darwin, and Weismann	I
Literature	14

CHAPTER I

GENERAL SKETCH OF THE CELL

A. General Morphology of the Cell	19
B. Structural Basis of Protoplasm	23
C. The Nucleus	30
1. General Structure	31
2. Finer Structure of the Nucleus	37
3. Chemistry of the Nucleus	41
D. The Cytoplasm	41
E. The Centrosome	50
F. Other Cell-organs	52
G. The Cell-membrane	53
H. Polarity of the Cell	55
I. The Cell in Relation to the Multicellular Body	58
Literature, I.	61

CHAPTER II

CELL-DIVISION

A. Outline of Indirect Division or Mitosis	65
B. Origin of the Mitotic Figure	72
C. Details of Mitosis	77
1. Varieties of the Mitotic Figure	78
(a) The Achromatic Figure	78
(b) The Chromatic Figure	86
2. Bivalent and Plurivalent Chromosomes	87
3. Mitosis in the Unicellular Plants and Animals	88
4. Pathological Mitoses	97

	PAGE
D. The Mechanism of Mitosis	100
1. Function of the Amphiaster	100
(a) Theory of Fibrillar Contractility	100
(b) Other Facts and Theories	106
2. Division of the Chromosomes	112
E. Direct or Amitotic Division	114
1. General Sketch	114
2. Centrosome and Attraction-sphere in Amitosis	115
3. Biological Significance of Amitosis	116
F. Summary and Conclusion	119
Literature, II.	121

CHAPTER III

THE GERM-CELLS

A. The Ovum	124
1. The Nucleus	125
2. The Cytoplasm	130
3. The Egg-envelopes	132
B. The Spermatozoön	134
1. The Flagellate Spermatozoön	135
2. Other Forms of Spermatozoa	142
3. Paternal Germ-cells of Plants	142
C. Origin of the Germ-cells	144
D. Growth and Differentiation of the Germ-cells	150
1. The Ovum	150
(a) Growth and Nutrition	150
(b) Differentiation of the Cytoplasm. Deposit of Deutoplasm	152
(c) Yolk-nucleus	155
2. Origin of the Spermatozoön	160
3. Formation of the Spermatozooids in Plants	172
E. Staining-reactions of the Germ-nuclei	175
Literature, III.	177

CHAPTER IV

FERTILIZATION OF THE OVUM

A. General Sketch	180
1. The Germ-nuclei in Fertilization	181
2. The Achromatic Structures in Fertilization	185
B. Union of the Germ-cells	196
1. Immediate Results of Union	200
2. Paths of the Germ-nuclei	202
3. Union of the Germ-nuclei. The Chromosomes	204
C. The Centrosome in Fertilization	208
D. Fertilization in Plants	215
E. Conjugation in Unicellular Forms	222
F. Summary and Conclusion	229
Literature, IV.	231

CHAPTER V

REDUCTION OF THE CHROMOSOMES, OÖGENESIS AND SPERMATOGENESIS

	PAGE
A. General Outline	234
1. Reduction in the Female. The Polar Bodies	236
2. Reduction in the Male. Spermatogenesis	241
3. Weismann's Interpretation of Maturation	243
B. Origin of the Tetrads	246
1. General Sketch	246
2. Detailed Evidence	248
C. Reduction without Tetrad-formation	258
D. Some Peculiarities of Reduction in the Insects	271
E. The Early History of the Germ-nuclei	272
F. Reduction in Unicellular Forms	277
G. Maturation of Parthenogenetic Eggs	280
Appendix	
1. Accessory Cells of the Testis	284
2. Amitosis in the Early Sex-cells	285
H. Summary and Conclusion	285
Literature, V.	287

CHAPTER VI

SOME PROBLEMS OF CELL-ORGANIZATION

A. The Nature of Cell-organs	291
B. Structural Basis of the Cell	293
C. Morphological Composition of the Nucleus	294
1. The Chromatin	294
(a) Hypothesis of the Individuality of the Chromosomes	294
(b) Composition of the Chromosomes	301
D. Chromatin, Linin, and Cytoplasm	302
E. The Centrosome	304
F. The Archoplasmic Structures	316
1. Hypothesis of Fibrillar Persistence	316
2. The Archoplasm Hypothesis	318
3. The Attraction-sphere	323
G. Summary and Conclusion	327
Literature, VI.	328

CHAPTER VII

SOME ASPECTS OF CELL-CHEMISTRY AND CELL-PHYSIOLOGY

A. Chemical Relations of Nucleus and Cytoplasm	330
1. The Proteids and their Allies	331
2. The Nuclein Series	332
3. Staining-reactions of the Nuclein Series	334

	PAGE
B. Physiological Relations of Nucleus and Cytoplasm	341
1. Experiments on Unicellular Organisms	342
2. Position and Movements of the Nucleus	346
3. The Nucleus in Mitosis	351
4. The Nucleus in Fertilization	352
5. The Nucleus in Maturation	353
C. The Centrosome	354
D. Summary and Conclusion	358
Literature, VII.	359

CHAPTER VIII

CELL-DIVISION AND DEVELOPMENT

A. Geometrical Relations of Cleavage-forms	362
B. Promorphological Relations of Cleavage	378
1. Promorphology of the Ovum	378
(a) Polarity and the Egg-axis	378
(b) Axial Relations of the Primary Cleavage-planes	379
(c) Other Promorphological Characters of the Ovum	382
2. Meaning of the Promorphology of the Ovum	384
C. Cell-division and Growth	388
Literature, VIII.	394

CHAPTER IX

THEORIES OF INHERITANCE AND DEVELOPMENT

A. The Theory of Germinal Localization	397
B. The Idioplasm Theory	401
C. Union of the Two Theories	403
D. The Roux-Weismann Theory of Development	404
E. Critique of the Roux-Weismann Theory	407
F. On the Nature and Causes of Differentiation	413
G. The Nucleus in Later Development	425
H. The External Conditions of Development	428
I. Development, Inheritance, and Metabolism	430
J. Preformation and Epigenesis. The Unknown Factor in Development	431
Literature, IX.	434
GLOSSARY	437
GENERAL LITERATURE-LIST	449
INDEX OF AUTHORS	471
INDEX OF SUBJECTS	477

LIST OF FIGURES

INTRODUCTION

	PAGE
1. Epidermis of larval salamander	3
2. Section of growing root-tip of the onion	4
3. <i>Amœba Proteus</i>	5
4. Cleavage of the ovum in <i>Toxopneustes</i>	11
5. Diagram of inheritance	13

CHAPTER I

6. Diagram of a cell	18
7. Spermatogonia of salamander	20
8. Group of cells, showing cytoplasm, nucleus, and centrosomes	21
9. Living cells of salamander larva, showing fibrillar structure	24
10. Alveolar or foam-structure of protoplasm, according to Bütschli	26
11. Structure of protoplasm in the echinoderm egg	27
12. Aster-formation in alveolar protoplasm	28
13. Nuclei from the crypts of Lieberkühn	32
14. Special forms of nuclei	35
15. Scattered nucleus in <i>Trachelocerca</i>	37
16. Scattered nucleus in Bacteria and Flagellata	39
17. Ciliated cells	43
18. Cells of amphibian pancreas	44
19. Nephridial cell of <i>Clepsine</i>	45
20. Nerve-cell of frog	47
21. Diagram of dividing cell	49
22. Diagrams of cell-polarity	56
23. Centrosomes in epithelium and in blood-corpuscles	57

CHAPTER II

24. Remak's scheme of cell-division	64
25. Diagram of the prophases of mitosis	66
26. Diagram of later phases of mitosis	69
27. Prophases in salamander-cells	73
28. Metaphase and anaphases in salamander-cells	75
29. Telophases in salamander-cells	76
30. Mid-body and cell-plate in cells of <i>Limax</i>	79
31. Middle phases of mitosis in <i>Ascaris</i> -eggs	80
32. Mitosis in <i>Stypocaulon</i>	81

FIG.	PAGE
33. Mitosis in <i>Erysiphe</i>	83
34. Mitosis in pollen-mother-cells of lily, according to Guignard	84
36. Mitosis in spore-cells of <i>Equisetum</i>	85
37. Heterotypical mitosis	87
38. Mitosis in Infusoria	89
39. Mitosis in <i>Euglypha</i>	90
40. Mitosis in <i>Euglena</i>	91
41. Mitosis in <i>Acanthocystis</i>	92
42. Mitosis in <i>Noctiluca</i>	93
43. Mitosis in <i>Paramæba</i>	95
44. Mitosis in <i>Actinosphaerium</i>	96
45. Mitosis in <i>Actinosphaerium</i>	97
46. Pathological mitoses in cancer-cells	98
47. Pathological mitosis caused by poisons	99
48. Van Beneden's account of astral systems in <i>Ascaris</i>	100
49. Leucocytes	102
50. Pigment-cells	103
51. Heidenhain's model of mitosis	104
52. Mitosis in the egg of <i>Toxopneustes</i>	107
53. Pathological mitoses in polyspermy	109
54. Nuclei in the spireme-stage	112
55. Early division of chromatin in <i>Ascaris</i>	113
56. Amitotic division	115

CHAPTER III

57. Volvox	123
58. Ovum of <i>Toxopneustes</i>	126
59. Ovum of the cat	127
60. Ovum of <i>Nereis</i>	129
61. Germinal vesicles of <i>Unio</i> and <i>Epeira</i>	130
62. Insect-egg	132
63. Micropyle in <i>Argonauta</i>	133
64. Germ-cells of <i>Volvox</i>	134
65. Diagram of the flagellate spermatozoön	135
66. Spermatozoa of fishes and amphibia	136
67. Spermatozoa of birds and other animals	138
68. Spermatozoa of mammals	140
69. Unusual forms of spermatozoa	141
70. Spermatozoids of <i>Chara</i>	142
71. Spermatozoids of various plants	143
72. Germ-cells of <i>Cladonema</i>	146
73. Primordial germ-cells of <i>Ascaris</i>	147
74. Primordial germ-cells of <i>Cyclops</i>	149
75. Ovarian ova and follicles of <i>Helix</i>	151
76. Egg and nurse-cells in <i>Ophryotrocha</i>	152
77. Ovarian eggs of insects	153
78. Young ovarian eggs of various animals	154
79. Young ovarian eggs of birds and mammals	155
80. Ovarian eggs of spider, earthworm, ascidian, showing yolk-nucleus	157

FIG.	PAGE
81. Ovarian eggs of <i>Limulus</i> and <i>Polyzonium</i>	159
82. Formation of the spermatozoön in <i>Anasa</i>	162
83. Transformation of the spermatids of the salamander	164
84. Formation of the spermatozoön in <i>Salamandra</i> and <i>Amphiuma</i>	166
85. The same in <i>Helix</i> and in elasmobranchs	168
86. The same in mammals	169
87. Formation of spermatozoids in cycads	173
88. Formation of spermatozoids in cryptogams	174

CHAPTER IV

89. Fertilization of <i>Physa</i>	180
90. Fertilization of <i>Ascaris</i>	183
91. Germ-nuclei of Nematodes	184
92. Fertilization of the mouse	185
93. Fertilization of <i>Pterotrachea</i>	186
94. Entrance and rotation of sperm-head in <i>Toxopneustes</i>	187
95. Conjugation of the germ-nuclei in <i>Toxopneustes</i>	189
96. Diagrams of fertilization	190
97. Fertilization of <i>Nereis</i>	191
98. Fertilization of <i>Cyclops</i>	193
99. Fertilization and persistence of centrosomes in <i>Thalassema</i>	195
100. Entrance of spermatozoön into the egg	197
101. Pathological polyspermy	199
102. Polar rings of <i>Clepsine</i>	201
103. Paths of the germ-nuclei in <i>Toxopneustes</i>	203
104. Fertilization of <i>Myzostoma</i>	209
105. Fertilization of <i>Pilularia</i>	216
106. Penetration of the pollen-tube in angiosperms	217
107. Fertilization of the lily	219
108. Fertilization in <i>Zamia</i>	220
109. Diagram of conjugation in Infusoria	223
110. Conjugation of <i>Paramæcium</i>	225
111. Conjugation of <i>Vorticella</i>	226
112. Conjugation of <i>Noctiluca</i>	227
113. Conjugation of <i>Spirogyra</i>	228

CHAPTER V

114. Polar bodies in <i>Toxopneustes</i>	234
115. Genesis of the egg	235
116. Diagram of formation of polar bodies	237
117. Polar bodies in <i>Ascaris</i>	239
118. Genesis of the spermatozoön	240
119. Diagram of reduction in the male	242
120. Spermatogenesis of <i>Ascaris</i>	244
121. Diagrams illustrating tetrad-formation	247
122. Tetrads of <i>Gryllotalpa</i>	249
123. Tetrads and polar bodies in <i>Cyclops</i>	250

FIG.	PAGE
124. Diagrams of tetrad-formation in arthropods	251
125. Germinal vesicles and tetrads	252
126. Maturation in <i>Anasa</i>	254
127. Maturation in <i>Anasa</i>	255
128. Diagrams of reduction	259
129. Maturation in <i>Thalassema</i>	260
130. Maturation in <i>Thalassema</i> and <i>Zirphæa</i>	261
131. Maturation in <i>Salamandra</i>	262
132. The maturation-divisions in angiosperms	264
133. Maturation in <i>Lilium</i>	266
134. Maturation in <i>Lilium</i>	268
135. Diagrams of reduction in the flowering plants	270
136. Ovary of <i>Canthocamptus</i>	273
137. Polar spindles without centrosomes	276
138. Polar bodies in <i>Actinophrys</i>	278
139. Polar bodies in <i>Actinosphaerium</i>	278
140. Conjugation and reduction in <i>Closterium</i>	279
141. First type of parthenogenetic maturation in <i>Artemia</i>	282
142. Second type of parthenogenetic maturation in <i>Artemia</i>	283

CHAPTER VI

143. Abnormalities in the fertilization of <i>Ascaris</i>	295
144. Giant embryo of <i>Ascaris</i>	296
145. Individuality of chromosomes in <i>Ascaris</i>	297
146. Independence of chromosomes in fertilization of <i>Cyclops</i>	298
147. Hybrid fertilization of <i>Ascaris</i>	300
148. Mitosis with intranuclear centrosome in <i>Ascaris</i>	305
149. Abnormal mitoses in <i>Hemerocallis</i>	306
150. Centrosomes in <i>Chatopterus</i> and <i>Cerebratulus</i>	307
151. Artificially produced asters and centrosomes in echinoderms	308
152. Diagram of different types of centrosome and centrosphere	310
153. Polar mitoses in <i>Dialula</i>	312
154. Astral systems in <i>Unio</i>	313
155. Astral systems in <i>Cerebratulus</i> and <i>Thalassema</i>	320
156. Structure of the aster in spermatogonium of salamander	326

CHAPTER VII

157. History of chromosomes in the germinal vesicle of sharks	339
158. Nucleated and enucleated fragments of <i>Stylonychia</i>	342
159. Regeneration in <i>Stentor</i>	343
160. Nucleated and enucleated fragments of <i>Amæba</i>	344
161. Nucleated and enucleated fragments of plant-protoplasm	345
162. Position of nuclei in plant-cells	347
163. Ovary of <i>Forficula</i>	349
164. Normal and dwarf larvæ of sea-urchins	352
165. Supernumerary centrosome in <i>Ascaris</i>	355
166. Cleavage of dispermic egg of <i>Toxopneustes</i>	356
167. Centrosomes and cilia	357

CHAPTER VIII

FIG.		PAGE
168.	Geometrical relations of cleavage-planes in plants	363
169.	Cleavage of <i>Synapta</i>	365
170.	Cleavage of <i>Polygordius</i>	367
171.	Cleavage of <i>Nereis</i>	369
172.	Variations in the third cleavage	370
173.	Meroblastic cleavage in the squid	372
174.	Rudimentary cells in <i>Aricia</i>	373
175.	Teloblasts of the earthworm	374
176.	Contradiction of Hertwig's rule in <i>Ascaris</i>	376
177.	Bilateral cleavage in tunicates	380
178.	Bilateral cleavage in <i>Loligo</i>	381
179.	Eggs of <i>Loligo</i>	382
180.	Eggs and embryos of <i>Corixa</i>	383
181.	Variations in axial relations of <i>Cyclops</i>	385

CHAPTER IX

182.	Half-embryos of the frog	400
183.	Half and whole cleavage in sea-urchins	407
184.	Normal and dwarf gastrulas of <i>Amphioxus</i>	408
185.	Dwarf and double embryos of <i>Amphioxus</i>	409
186.	Cleavage of sea-urchin eggs under pressure	411
187.	Cleavage of <i>Nereis</i> -eggs under pressure	412
188.	Diagrams of cleavage in mollusks and polyclades	414
189.	Partial larvæ of ctenophores	418
190.	Partial cleavage in <i>Ilyanassa</i>	420
191.	Double embryos of frog	421
192.	Cleavage in <i>Crepidula</i>	424
193.	Normal and modified larvæ of sea-urchins	428
194.	Regeneration in coelenterates	429