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EARLY EMBRYOLOGY  
*of*  
THE CHICK

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BRADLEY M. PATTEN

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*Fourth Edition*

# EARLY EMBRYOLOGY of the CHICK

*by*

BRADLEY M. PATTEN

Professor of Anatomy, University of Michigan Medical School

With One Hundred Two Illustrations  
Containing Three Hundred  
Forty-three Figures

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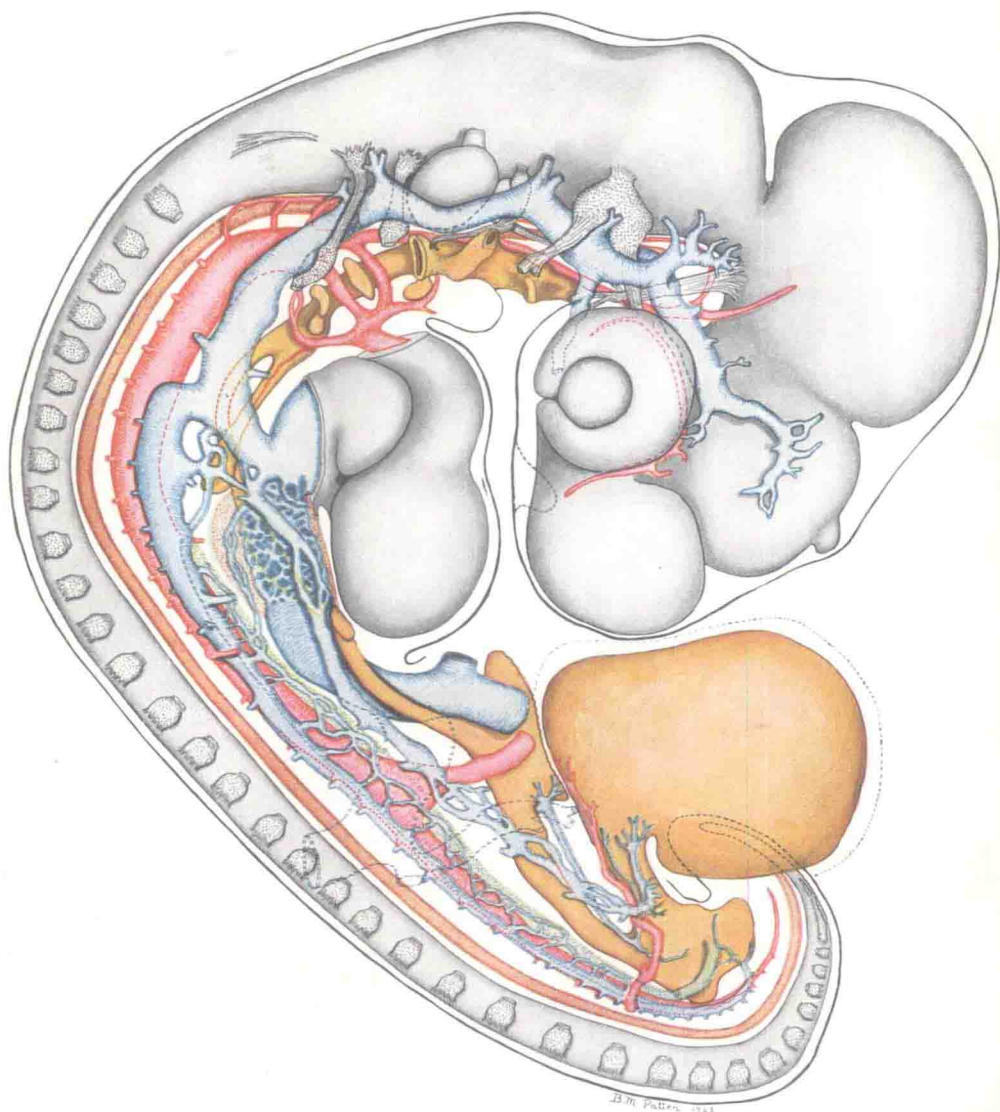
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EARLY EMBRYOLOGY  
of the  
CHICK



CHICK EMBRYO OF FOUR DAYS.

Drawn from a wax-plate reconstruction—original  $\times 51$ , reproduced  $\times 23$ .  
For key to structures represented, see Figures 84 and 91.

FRONTISPIECE

## Preface

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The fact that chick embryos are so generally used as laboratory material for courses in vertebrate embryology warrants the treatment of their development in a book designed primarily for the beginning student. To one commencing the study of embryology the very abundance of the information available is likely to be confusing and discouraging. He has difficulty in culling the essentials and fitting them together in their proper relationships and tends to become lost in a maze of detail. This book has been written in an effort to set forth for him in brief and simple form the basic mechanisms of embryology. It does not purport to be a reference work. Details and controverted points have been avoided for the sake of clarity in outlining fundamental processes.

The story of development as illustrated by the chick has been taken as the scheme of presentation. This departure from the conventional comparative method of approach does not imply any undervaluation of the comparative point of view. On the contrary, I am convinced that it is the goal to be sought by anyone who would consider himself trained in embryology; and, wherever it seemed possible without breaking the thread of the story of development, processes have been interpreted from this broader outlook. But for the beginner attempting to follow the development of several forms simultaneously seems to me irrational. A student new to the subject is merely confused when confronted at the outset by a mass of comparative data. What a beginner needs is not a vast array of facts to be memorized, but the thread of a coherent story to hold together the new facts he acquires. The story of the development of a single form, told without digression, has an inherent quality of sustained interest which is of inestimable value in creating an understanding of embryological processes. Building on such a foundation, each new excursion into the broader field of comparative embryology becomes more stimulating because its findings are progressively more significant.

It has seemed inexpedient, likewise, to confront beginners with an extensive discussion of experimental embryology, fascinating as is this approach to the study of development. The proper interpretation

of embryological experiments depends on first acquiring a basic knowledge of the normal course of development such as this book aims to present. Moreover, the techniques employed, and the laboratory equipment necessary, make experimental work much more suitable for advanced courses with small numbers of students than it is for introductory courses. I have, therefore, limited myself in this field to including a few examples of experiments which seemed especially helpful in interpreting the underlying mechanisms of normal development.

Because of my conviction that so-called elementary texts too frequently overreach their avowed scope, the ground covered by this book has been rigidly restricted. The account of development has been carried only through the first four days of incubation, the later developmental processes being dismissed with mere statements as to the adult structures that are derived from the various organs of the embryo. The reasons for thus devoting the major part of the book to the early phases of development would seem quite obvious. In this period the body of the embryo is laid down and the organ systems are well established. To one at all familiar with the adult structure of vertebrates it is relatively easy to understand the later changes in the position and proportions of organs if he has seen how they are first formed. Furthermore, courses in elementary embryology rarely continue work on the chick beyond the early stages of its development, and more extensive courses, in which a knowledge of mammalian embryology is the objective, ordinarily pass from the study of three- or four-day chicks to work on mammalian embryos. Although the text has been kept brief, illustrations have been freely used in the belief that they convey ideas more readily than can be done in writing. Much time and care has been used in an effort to make each figure convey its message with clearness and accuracy.

The increased size of the pages in the present edition as compared with earlier editions has permitted making the new illustrations of a generous size, and made possible the enlarging of a number of the original figures which had suffered by too great reduction. Many of the older illustrations in which the labeling was too small have been relabeled in larger type. These changes should materially improve the usability of the book as a whole. In revising the text advantage was taken of the great volume of important work that has appeared in recent years on the mechanism of gastrulation and this section was entirely rewritten. In so doing considerable material was added on

amphibian gastrulation. This, however, has been handled as an aid to understanding the corresponding processes in the chick rather than an excursion into amphibian development and the book remains as it was originally planned, a simply presented story of the early embryology of the chick.

BRADLEY M. PATTEN

*Ann Arbor, Michigan*  
*September 1950*



## Acknowledgments

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It is a pleasant duty to acknowledge the assistance I received in the preparation of the material for the first edition from Mrs. Mary V. Bayes, then embryological technician in the Department of Histology and Embryology, at the School of Medicine of Western Reserve University. In the initial shaping of the book I was most deeply indebted to my father, William Patten, late Professor of Biology and of Evolution at Dartmouth College, for his many helpful suggestions and especially for his criticism of the illustrations. In preparing the new illustrations for the present edition I was fortunate in having the unusually skillful assistance of Miss Cecelia Banwell. The critical reading of the revised text by my colleague, Dr. Alexander Barry, has been most helpful. For much painstaking work in the preparation of the manuscript I am deeply indebted to my wife, and for assistance with the bibliography and most efficient proofreading to my secretary, Mrs. Dorothy Hargis.

In all phases of the initial publication of this book and its revisions The Blakiston Company has been most generously coöperative. The unusually faithful reproduction of the original drawings, especially the new colored illustrations, has been due to the expert supervision of Mr. Willard T. Shoener; and for shepherding this fourth edition through the vicissitudes of publication I am particularly indebted to Mrs. Eunice Stevens, of Blakiston's editorial staff.

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## Introduction

*Embryology; the chick as laboratory material; plan and scope of this book; methods of study.*

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**Embryology.** Every one of the higher animals starts life as a single cell—the fertilized ovum. This fertilized ovum, as its technical name zygote implies, has a dual origin. It is formed by the fusion of a germ cell from the male parent with one from the female parent. The union of two such sex-cells to form a zygote constitutes the process of fertilization and initiates the life of a new individual. Embryology is the study of the growth and differentiation undergone by an organism in the course of its development from a single fertilized egg-cell into a highly complex and independent living being like its parents.

As a study embryology offers more than the mere acquisition of an encyclopedic array of facts. It gives one an understanding of some of the ways of life. We are all egoists, to a certain extent at least, and anything that touches the matter of our own whence and whither is of absorbing interest. The processes by which a fish, or an alligator, or a chick grows from a single fertilized egg-cell to its fully elaborated adult structure are fundamentally the same as those involved in our own development (Fig. 1). And these growth processes hold for us something definite and tangible in answer to that ever recurring question, “Whence do we come, and how?”

Embryology is also an important source of evidence as to the path followed by Evolution. It tells us in one short, uninterrupted story how each individual grows into an adult. We can see this process going on under our very eyes. And we know that the story of individual development sketches for us in outline the evolutionary changes of our forbears. For the law of biogenesis or recapitulation is that *every living thing in its individual development, passes through a series of constructive stages like those in the evolutionary development of the race to which it belongs.* “This means that there is but one main way to upbuild a given kind of organism, and that every individual must do it in essentially the

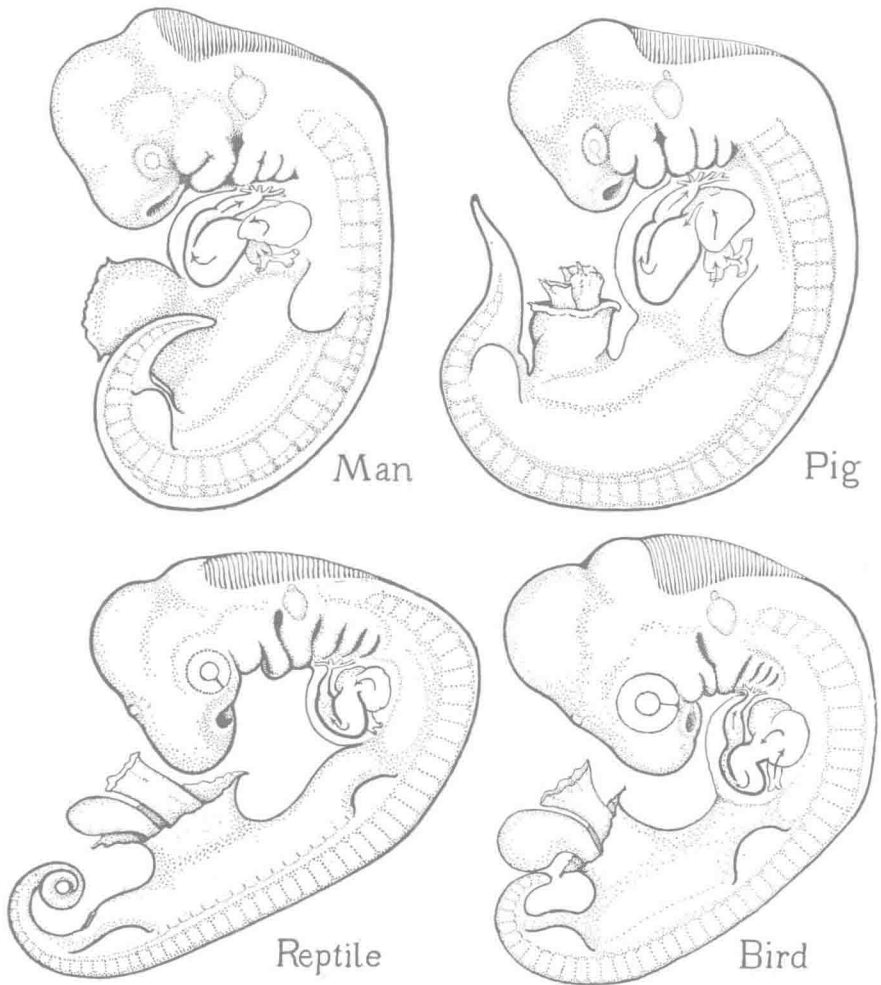


FIG. 1. Embryos of man, pig, reptile, and bird at corresponding developmental stages. The striking resemblance of the embryos to one another is indicative of the fundamental similarity of the processes involved in their development. (From William Patten, "Evolution," Dartmouth College Press.)

same way his ancestors did. But to-day the individual can do this much more quickly and economically than its ancestors, because it does not have to find out by long and costly experimenting just how to do it. Essentially the right ways and means of doing it 'automatically' are provided for it by its antecedents. At every step in the process it is using something which Nature, out of all the efforts of the past, has provided for it. These ways and means constitute the Heritages of individual life, and range all the way from ancestral germinal ma-

terials, stored up foods, and other parental provisions, to the environmental, physical and social provisions in which the growing organism is placed.”<sup>1</sup>

More tangible perhaps than the perspective embryology gives on the life of to-day and on its evolutionary history in the past, is its direct help in the study of anatomy. Not until the student becomes enmeshed in a maze of structural details does he realize his imperative need of a knowledge of how and why adult conditions became as they are. For only this knowledge will lead him beyond blind memorizing to comprehension. And when he delves still deeper into anatomy he begins to encounter puzzling variations from the normal body architecture. Sometimes these are merely minor anomalies which do not materially affect the functional fitness of the individual; sometimes they are extensive malformations which render continued life precarious or even altogether impossible. Our present understanding of such conditions, and what future hope there may be of reducing the frequency with which they occur can come only through embryology.

The only method of attaining a comprehensive understanding of embryological processes is through the study and comparison of development in various animals. Many phases of the development of any specific organism can be interpreted only through a knowledge of corresponding processes in other organisms. The beginning student, however, can most readily and with least risk of confusion acquire his knowledge of embryology through intensive study of one form at a time. Building on the familiarity with fundamental processes of development thus acquired, he may later broaden his horizon by the comparative study of a variety of forms.

**The Chick as Laboratory Material.** The chick is one of the most satisfactory animals on which student laboratory work in embryology may be based. Chick embryos in a proper state of preservation and of the stages desired can readily be secured and prepared for study. Used as the only laboratory material in a brief course they afford a basis for understanding the early differentiation of the organ systems and the fundamental processes of body formation common to all groups of vertebrates. In more extended courses where several forms are taken up, the chick serves at once as a type for the development characteristic of the large-yolked eggs of birds and reptiles, and as an intermediate form bridging the gap between the simpler processes of development in fishes and amphibia on the one hand and the more

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<sup>1</sup> From William Patten: "Evolution."

complex processes in mammals on the other. In medical school courses where a knowledge of human embryology is the end in view the chick not only makes a good stepping-stone to the understanding of mammalian embryology, but also provides material for the study of early developmental processes not readily demonstrable in mammals.

**Plan and Scope of This Book.** This book on the development of the chick has been written for those who are beginning the study of embryology and has accordingly been kept as brief and uncomplicated as possible. Nevertheless it is assumed that the beginner in embryology will not be without a certain background of zoölogical knowledge and training. He may reasonably be expected to be familiar with the fundamental facts of evolution and heredity, the structure of cells and their methods of division, the nature of the various types of tissues, and the more general phases of the morphology of vertebrates. It, therefore, seems unnecessary to include here any preliminary discussion of these phenomena.

For the reasons set forth in the preface the subject as a whole has not been presented from a comparative standpoint. Nevertheless, where the comparative background for some particular phase of chick development seemed to promise to make it more intelligible I have not hesitated to bring it in. This has been done especially freely in connection with cleavage and gastrulation in the early parts of the book, and in connection with the cardiovascular and excretory systems in the final chapter. It is hoped that these excursions, instead of rendering the student's task more onerous will lighten it by making these phases of development more readily understandable.

It has seemed wise to take essentially the same standpoint with reference to experimental embryology. This rapidly growing and important field is one which can be handled best in an advanced course, building on a background such as this book aims to provide for beginners. Accordingly no attempt has been made to deal with it systematically. But, as with comparative embryology, when the experimental approach seemed to offer particular help in interpreting some phase of development it has been freely drawn upon. References for collateral reading on these and other phases of the subject are given in the bibliography.

**Methods of Study.** Like other sciences embryology demands first of all accurate observation. It differs considerably, however, from such a science as adult anatomy where the objects studied are relatively constant and their component parts are not subject to rapid changes in their inter-relations. During development, structural conditions



within the embryo are constantly changing. Each phase of development presents a new complex of conditions and new problems.

Solution of the problems presented in any given stage of development depends upon a knowledge of the stages which precede it. To comprehend the embryology of an organism one must, therefore, start at the beginning of its development and follow in their natural order the changes which occur. At the outset of his work the student must realize that proper sequence of study is essential and may not be disregarded. A knowledge of structural conditions in earlier stages than that at the moment under consideration, and an appreciation of the trend of the developmental processes by which conditions at one stage become transmuted into different conditions in the next, are direct and necessary factors in acquiring a real comprehension of the subject. Without them the story of embryology becomes incoherent, a mere jumble of confused impressions.

A knowledge of the phenomena of development is ordinarily acquired by studying a series of embryos at various stages of advancement. Each stage should be studied not so much for itself, as for the evidence it affords of the progress of development. In the study of embryology it does not suffice to acquire merely a series of "still pictures" of various structures, however accurate these pictures may be. The study demands a constant application of correlative reasoning and an appreciation of the mechanical factors involved in the relations to each other of various structures within the embryo, and in the relation of the embryo as a whole to its environment. In order really to comprehend the embryological significance of a structure one must know not only its relations within the embryo being studied at the time, but also the manner in which it has been derived and the nature of the changes by which it is progressing toward adult conditions. To get absolutely the whole story it is obvious that one would have to study a series of embryos with infinitely small intervals between them. Nevertheless the fundamental steps in the process may be grasped from a much less extensive series. The fewer the stages studied, however, the more careful must one be to keep in mind the continuity of the processes and to think out the changes by which one stage leads to the next.

The outstanding idea to be kept in mind by the student beginning the study of embryology is that the development of an individual is a process and that this process is continuous. The conditions he sees in embryos of various stages are of importance chiefly because they serve as evidence of events in the process of development at various intervals