

# Preface

Living systems achieve each generation the truly amazing feat of reinitiating organismal development from a single cell. A first key step in this process is the establishment of the embryonic body plan, with its species-specific, stereotypic arrangement of differing cell types within layers, tissues, and organs. In this early event, the embryo achieves multicellularity through cell division. At the same time, the resulting cells acquire different gene expression programs that will influence cell fate and behavior, often influenced by biases caused by the localization of maternal factors inherited from the egg. The processes leading to multicellularity and cell fate specification are fully integrated. For example, achieving threshold cell numbers results in zygotic gene activation, and patterns of cell division influence the segregation of patterning determinants and the three-dimensional arrangement on which those determinants act. Conversely, inheritance of maternal cell determinants can affect patterns of cell division and the behavior of cells within the overall cellular framework.

This integrated process mediates the transition between the egg as a structure generated by the previous generation and the embryo with an established set of gene expression programs. Processes during this transition, which can last several cell cycles in mammals and significantly longer in amphibians and fish, are driven largely by products produced by the mother and inherited through the egg. The end point of this transition involves the achievement of gene expression from the embryonic genes themselves and the specification of cell types. This volume addresses this transitory yet key developmental period, involving the transfer of maternal to zygotic control during embryonic development.

Our goal was to compile descriptions of various mechanisms involved in this integrated process, focusing on the vertebrate embryo, from egg activation to the initiation of zygotic gene expression and clearance of maternal factors. To achieve this, we employed a comparative approach, based on principles established largely in the primary vertebrate developmental model systems (fish, amphibians, chicken, and mice) while incorporating information from other vertebrate species where available. While the basic body plan of vertebrates is highly conserved, the strategies used by embryos in various vertebrate species to reach that basic body plan can differ. A comparative approach allows us to highlight the diversity between such

varied strategies, which result from differences in reproductive selective pressures. At the same time, comparisons can also identify mechanisms that are similar in multiple lineages, perhaps even throughout all vertebrates, and which may in turn reflect fundamental cellular and developmental mechanisms conserved through evolutionary time. Both differences and similarities are informative and essential for the modern developmental biologist to understand.

The chapters in this volume address the basic mechanisms as developmental themes and are roughly arranged following the temporal order in which the related processes are implemented during embryogenesis. Chapter [One](#) addresses changes that occur as the egg becomes fertilized, which will prevent polyspermy and initiate cascades of events that initiate embryonic development. Chapter [Two](#) describes mechanisms involved in the initiation of a primary cascade of events: the regulation of maternally inherited transcripts to produce proteins that will drive embryonic development. Chapter [Three](#) discusses mechanisms and regulation of the early embryonic cell cycle as a modified version of the cell cycle in adult cells, caused at least in part to accelerate the process of achieving multicellularity. Chapter [Four](#) describes mechanisms by which the outcome of cell division is spatially regulated, which generates the cellular arrangement of the early embryo onto which other developmental processes are implemented. Chapter [Five](#) focuses on the initial transfer of patterning information from the egg to the embryo, with particular emphasis on the Balbiani body, a cellular structure conserved throughout vertebrates that helps determine polarity in the egg and which facilitates the transfer of positional information from the egg to the embryo. Chapters [Six](#), [Seven](#), and [Eight](#) address further processes of cell fate information transfer to specify, respectively, embryonic axes, cellular layers, and the germ line. Chapter [Nine](#) summarizes our knowledge on mechanisms required for the initiation of expression from the zygotic genome at the end of the maternal control period, in the so-called midblastula transition, as well as changes in the cell cycle associated with this transition. Chapter [Ten](#) addresses mechanisms used by the embryo to further ensure a precise transition from maternal to zygotic control, involving the degradation of maternal factors. This chapter also describes epigenetic changes in the embryonic chromatin, which both facilitate and reinforce acquired gene expression programs. Interconnections between various developmental mechanistic themes are common and are highlighted throughout the book.

We hope this volume will be useful for the reader to obtain a more comprehensive view of early vertebrate embryogenesis, both within a single species with regard to the integration of various developmental processes and across lineage boundaries with regard to the conservation and divergence of mechanisms involved in early embryonic development. While we feel that the chapters in this volume can convey mechanistic details relevant to these processes, we also hope they can convey those broader principles which stand out for their beauty and elegance and sometimes astounding simplicity. We additionally hope that topics presented in this compilation can not only facilitate ongoing research but also inspire and engage new generations of scientifically educated audiences. Concepts conveyed in this volume are key for our basic understanding of the process of embryonic pattern

formation, with implications for our interpretation and possible prevention of developmental abnormalities and the development of reproductive biology therapies and technologies in animals, including humans. Processes occurring in the fertilized egg and early embryo may also be able to help us understand the reprogramming of cells, harnessed to implement the regeneration of embryos, cell types, and organs useful for applications varying from biomedical research to conservation biology.

As an integral element of the life cycle, the events occurring in the very early embryo represent much more than a set of related mechanistic processes. In a broader sense, these events reflect how organisms can generate pattern out of simplicity; how biological processes are reused, reorganized, and innovated; and how life continues through generations even as it adapts to new conditions. As such, the transition from the maternal to zygotic control is a microcosm that encapsulates the essence of life itself: self-generating, malleable, and enduring.

Madison, WI, USA  
Portland, OR, USA  
Charlottesville, VA, USA

Francisco Pelegri  
Michael Danilchik  
Ann Sutherland

Vertebrate Development

Maternal to Zygotic Control

Pelegri, F.; Danilchik, M.; Sutherland, A. (Eds.)

2017, X, 549 p. 81 illus., 71 illus. in color., Hardcover

ISBN: 978-3-319-46093-2