

Preface

It has become increasingly embarrassing for me to ask students to read the Eighth Edition of this textbook. It's so, well, 2006. Developmental biology has progressed so rapidly in the past four years that my lectures have fundamentally diverged from their reading. My "big" lecture on transcription now focuses on the ability of transcription factors to reprogram cell fates; and my lectures on stem cells and cloning have scrapped the notion of therapeutic cloning altogether, focusing instead on induced pluripotent stem cells. In both instances, we discuss what this means for understanding normal development, as well as what implications these technologies have for the future of medicine. Neither induced pluripotent stem cells nor "transdifferentiation" was established when the last edition of this book was published.

Even my most basic lectures have changed. The lecture on fertilization has to cover the new data on mammalian egg activation. My lectures on sea urchin development—an area of study that has been fundamental to developmental biology for over a century—now include systems theory operations involving double-negative gates and feedforward loops, and my evo-devo talks have led to discussions of mathematical modeling and parasitism. I can't talk about limb development without including the variations seen in dachshunds and bats, and I can't discuss sex determination without using the β -catenin model for mammalian ovary production. None of these areas were covered in earlier editions of my book. So this is really a very new edition. My editor tells me it has close to 700 new references; she only wishes I had deleted at least that many old ones.

Developmental biology is in a state of rapid metamorphosis. And, as in insect and amphibian metamorphosis, some old tissues remain the same, some get substantially remodeled, and some old tissues perish altogether; and all the while, new tissues are forming new structures. I hope that I have gotten these correct, and that the added new material will stand the test of time. I have tried to remodel the retained material into new narratives that are more inclusive of the data, and to appropriately jettison the information that was needed for earlier stages of the book's development but which is no longer needed by undergraduates.

Embryologist John Fallon once wrote me that new data change the story one tells. It is, he said, like putting together a picture puzzle. At first, you think the structure in front of you is a sailboat; but you add another piece, and—no, wait—it's a mountain. Psychologists call these alterations "Gestalt changes," and I think that we are seeing these changes in both our day-to-day interpretations of data and

in the entire field of developmental biology. We are seeing an inversion of relationships within the biological sciences. Genetics is more and more becoming a subset of development. Similarly, the dynamic of evolution is being studied as a question of gene expression as well as gene frequencies. And developmental biology may be on the threshold of changing medicine as much as microbiology did at the turn of the twentieth century.

I began the Preface of the last edition with a quotation from the Grateful Dead, recalling "What a long, strange trip it's been." The epigram for this edition might be Eminem's "Be careful what you wish for." We may achieve biological powers that are "tenfold" what we had hoped to have. And it is axiomatic for this generation that "with great power comes great responsibility."

I hope this Ninth Edition of *Developmental Biology* presents a better way of teaching and learning (and questioning) developmental biology. The introductory section has been streamlined from six chapters to three—one each on developmental anatomy, the mechanisms of gene regulation during differentiation, and cell-cell communication during morphogenesis. Another new feature is the addition of short part-opening "chaplets" that address key concerns in developmental biology. These provide an introduction to the subsequent chapters, placing the forthcoming information into a specific context. Each chapter ends with a guide to web-based resources relevant to that chapter's content, and the Ninth Edition is the first to include an extensive glossary of key terms.

During the writing of this edition, I re-read some of the papers written by the first generation of experimental embryologists, scientists who were experiencing a Gestalt change as important as what we are experiencing today. What impressed me was not necessarily their answers (although some of them were remarkably good even by today's standards); rather, it was their asking the "right" questions. Some of their research did not give us any answers at all. But the results told the next generation of biologists what questions to ask. These embryologists stood in awe of the complexity of the embryo; yet they began to remove, transplant, destroy, and recombine cells in order to find out just how the fertilized egg could give rise to a structured body composed of different cell types. They had faith that these were scientific questions and that science would eventually be able to answer them.

The glory of developmental biology is that we now have interesting answers to many of their questions. But numerous questions that were asked a century ago still lack answers. How does the human brain become organized so that we can think, plan, recall, interpret, hate, and love?

How is the development of plants and insects timed so that the flower opens at the same time when its pollinator has left its cocoon? How does exercise increase muscle mass, and how does our face come to resemble those of our parents more than any one else's? To these questions, we have only very partial answers, but we are on our way.

Developmental biology presents a nascent scientist with a host of fascinating questions that are worth solving. And that's the invitation this book offers. One can enter developmental biology through many portals—genetics, cell biology, embryology, physiology, anatomy—and with many valid motivations. This is a field that needs the help of people with all sorts of competencies and talents. It is an old field that is itself undergoing metamorphic change and emerging as a new field that welcomes newcomers with open arms—full of questions.

Acknowledgments

In addition to the remarkable reviewers listed below, whose candid and thorough criticisms of early chapter drafts made this book so much better, there are some people whose help was absolutely critical. In particular, David McClay and Bill Anderson gave me many suggestions that were outstandingly important in constructing this edition. I also appreciate enormously the cooperation from all those scientists who sent me their photographs, and who even told me about others they had seen. The graphics of this book are truly amazing, and this is due to the community of developmental biologists.

The book's beauty and success is also the result of Andy Sinauer's vision and the hard work of the immensely talented staff he has assembled at Sinauer Associates. David McIntyre's ability to find appropriate photographs from the public and private databases is almost uncanny. Chris

Small and Janice Holabird of Sinauer's production department have put together the artwork, the photographs, and the text into a format that is both informative and pleasing. For a book of this size, this is a heroic undertaking. And, more than any other edition of this book (and she has been with it since its inception), this incarnation has been a collaborative effort with my editor Carol Wigg. The book seems to have become a full-time job for both of us.

I especially wish to thank Dr. Hannah Galantino-Homer of the University of Pennsylvania School of Veterinary Medicine, who took it upon her shoulders to compile a glossary for this book. Numerous people have said that they wanted such a glossary for their students, and putting one together is an extremely difficult task, involving an enormous amount of thought and expertise.

This textbook officially entered the "electronic age" in the mid 90s, and its web segment, www.devbio.com, has grown more important with each subsequent edition. With this edition, the *vade mecum*³ companion that debuted in 2002 is also on the web. Mary Tyler and Ron Kozlowski not only created *vade mecum*³, with its laboratory sections and its introductions to model animals, they have also produced interviews and filmed the techniques of several developmental biologists. You really have to see these films to realize what a valuable resource these are.

I am blessed by teaching some remarkable students who have not been shy about offering constructive criticism. Their suggestions will, I hope, benefit the next round of students.

And finally, this revising process has taken much longer than expected. I apologize to my wife, Anne Raunio, who has had to put up with me through it all, and to my friends, who may have wondered where I've been. I'll be back.

SCOTT F. GILBERT