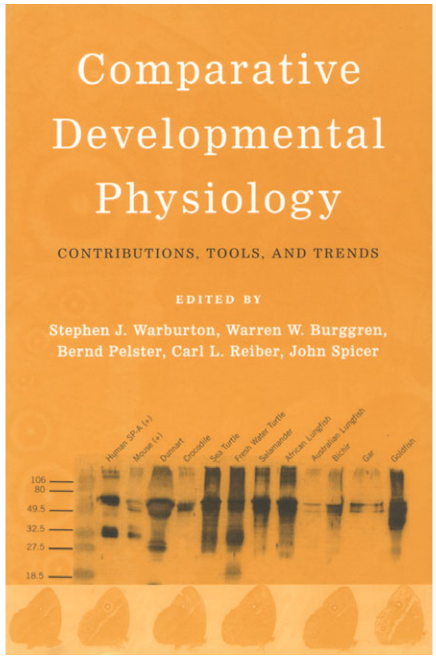
Book Review

AN INTEGRATIVE APPROACH TO ANIMAL LIFE



Comparative Developmental Physiology – Contributions, Tools, and Trends

Edited by S. J. Warburton, W. W. Burggren, B. Pelster, C. L. Reiber and J. Spicer

Oxford University Press, New York
216pp. ISBN 0-19-516860-7
$44.50, £26.99

Comparative Developmental Physiology – Contributions, Tools, and Trends is a collection of thirteen articles selected from topics discussed at the meeting ‘New Directions in Developmental Physiology’, held in Texas in 2002. The chapters cover quite different subjects, in seemingly casual order, ranging from theoretical or almost philosophical essays to modeling and experimental details. As neither the book nor the individual chapters have summaries, I will briefly allude to their content in this review.

What comparative developmental physiology really means is not easy to explain. To some of us, development refers to the early stages of animal life, when organs and tissues get formed, but the precise chronological boundaries are undefined. Some organisms grow throughout their entire life, while in others, metamorphosis closes one phase, just to introduce the early stages of the next one. The term comparative, in the common biological and physiological jargon, is often applied to experiments on exotic non-model organisms, or to studies comparing different species, such as those adopting allometric or phylogenetic approaches. In the broadest sense, comparative developmental physiology impacts on many fields of research, and investigators have the opportunity to take advantage of the diverse technical tools and intellectual approaches that are available.

Three chapters touch on the meaning, potential impact and diversity of approaches in comparative developmental physiology. Martin Feder sees the goal of comparative developmental physiology as an attempt to explain the ontogenetic diversity of the animal kingdom, combining knowledge of the various levels of biological organisation, and using the enormous variety of methods and theories available. In chapter 11 he discusses the suitability of *Drosophila* and other models, and the search for new ones, and the benefits and necessities of inter-disciplinary collaboration. Feder also touches on the beliefs and attitudes of those embracing the ‘naturalistic culture’ (which encourages creativity and originality from observations of non-model organisms), often perceived as the underpinning of the comparative approach. Bernd Pelster and Thorsten Schwerte discuss in chapter 9 the contribution that ecology can make to physiological studies, providing mechanistic interpretations of why environmental changes can have different effects on various animal forms, with implications on the mechanisms of evolution. The authors highlight the responses of fish larvae to temperature and oxygenation, and indicate that adaptive strategies and mechanisms to environmental conditions differ at various developmental stages, and not necessarily in the same direction. In chapter 10, Bradley Keller reflects on the cellular and subcellular mechanisms leading to the development of congenital cardiovascular malformations. Hundreds of genes and transcription factors are involved in the construction of the cardiovascular system, but the physiological counterpart of the genetically controlled scaffold and the translation of altered genotype to phenotype are still unclear. There are still many unanswered questions, including the importance of the maternal–fetal interaction, metabolic control in cardiovascular development, and how environmental conditions determine the normal and abnormal physiological trajectories during development.

Many researchers working in comparative developmental physiology will find a wealth of methods at their fingertips, some of which are discussed in chapters 1–3. In chapter 1, Christopher Daniels and Sandra Orgeig present the case of the surfactant system as a probe for evolutionary processes in respiratory physiology. Surfactant material is found in all vertebrates, preceding the evolution of the lungs, and its protein and lipid compositions are highly conserved. The authors also discuss complementary approaches for developmental studies, for example the use of cell culture, which is amenable to mechanical stimuli, and the study of regeneration of adult tissues after a discrete lesion. Elisabeth Brainerd and Melina Hale review in chapter 2 the potential offered by imaging techniques for studying animals *in vivo*, for example the study of segmented musculature biomechanics and the neural control of movement of the Zebrafish larvae. In chapter 3, Roger Seymour and Craig White stress the importance of modeling in developmental physiology, together with experimental observations. Modeling can anticipate results that may be difficult to predict, or could be overlooked, solely with experimental measurements. For example, models of embryonic respiration can predict oxygen gradients and regional differences within egg masses.

Groups of chapters in the book focus onto specific research areas of comparative developmental physiology. Most biology, zoology and physiology students have heard of the ‘mouse-to-elephant’ metabolic curve, but few of them are likely to be aware of the intricate and lively discussions that have accompanied interpretations of metabolic scaling. Ione Hunt von Herbing, in chapter 6, summarises the main steps of the long debate and theories in the search for a universal primary determinant of animal energetics. The difference in metabolic rate scaling of fish larvae (and newborn mammals) to adults brings an additional twist to the story; understanding the mechanisms of these differences could lead to a better grasp of animal energetics. In chapter 7, Peter Rombough focuses on the questions emerging from the discussion of the partitioning of energy budgets in growing organisms. Growth is a major source of energy expenditure, but little is known about how environmental factors affect energy allocation, and how it is prioritised.

Three chapters touch on the extent to which phenotypic plasticity – where environmental factors shape phenotype – is under genetic control. Experiments on varied animal models highlight the advantages and disadvantages of genetically based adaptability *versus* phenotypic plasticity, and survival implications. Kimberly Hammond and colleagues consider in chapter 5 the hypoxic adaptation of the deer mouse, a species that lives over a wide range of altitudes and responds to the various levels of hypoxia both with genetic and phenotypic adaptation. Phenotypic plasticity occurs only in response to environmental pressure during early development, showing that an understanding of the adult phenotype benefits from consideration of the natural history during development. In ectotherms, the rate of diverse developmental processes is often coordinated across a wide temperature range, a phenomenon referred to as developmental canalization, touched on by Ian Johnston and Robbie Wilson in chapter 8. When the time-sequence of development is broken, changes in temperature are responsible for phenotypic plasticity. In chapter 4, Paul Brakefield presents the interesting story of the butterfly eyespots, where seasonal patterning is temperature dependent. This case study also exemplifies the potentials offered by multidisciplinary analysis and the integration of developmental physiological approaches with evolutionary genetics.

The timing of development of specific physiological traits, and their differences among species, or heterochrony, is another main interest of *Comparative Developmental Physiology*, with implications also on the way that we look at evolutionary processes. On one hand, time-sequence measurements of physiological traits can be technically very difficult, time consuming, and expensive, as discussed by John Spicer in chapter 13. The chronology is blurry when the physiological event picked as stage-mark develops gradually, and the relationships between an organ’s structure and function, morphology and physiology may not correspond to what is assumed. Who would have guessed that the legs of the porcelain crab could function, for a period, as a gas exchange organ? Spicer calls attention to the risks of confusing time-sequence of phenotype expression between species with variation that may occur within a species, or heterokairy. While heterochrony is genetically hard-wired, heterokairy can result from environmental factors that modify the relative development of physiological processes. In chapter 12, Warren Burggren sees heterokairy as a further degree of complexity during development. Interactions between morphological structures and physiological processes contribute to the complexity of an organism during development. Physiological complexity does not follow a linear process, and can also diminish with developmental time, contrary to what may seem at first glance.

The chapters of this book are not review articles, and the reader should not expect to find abundant data or exhaustive reference lists. Rather, the uninhibited ideas and comments provide a taste of the enormously broad scope of comparative developmental physiology and of its potentially vast contributions to both the biological and clinical fields, including the embryonic and fetal origins of adult physiological and pathological conditions. In fact, of all biological disciplines, comparative developmental physiology is the most integrative approach to understanding animal life that I can think of. Seen from this angle, I found all chapters successful, because they raise challenging questions and stimulate our thoughts on a large number of topics. In some cases, the authors provide expert suggestions and informative views on the future directions that would seem appropriate to take. Young investigators will discover in this book abundant material for deep biological, and even philosophical, thoughts, and an invitation to formulate their own ideas and contribute to one of the most exciting fields in Life Sciences.

10.1242/jeb.02685

Jacopo P. Mortola
McGill University
jacopo.mortola@mcgill.ca

Published by The Company of Biologists 2007