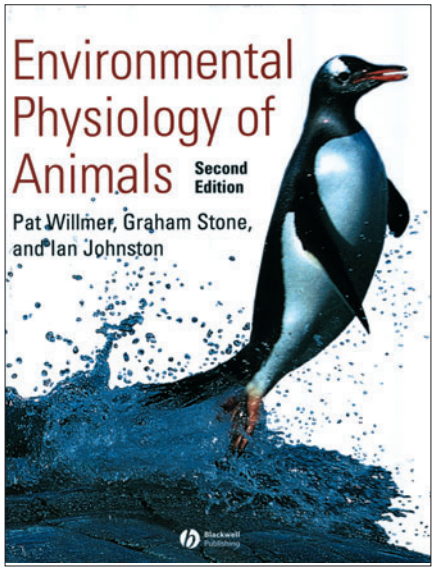
Book Review

IT'S LIFE JIM, BUT NOT AS WE KNOW IT



Environmental Physiology of Animals, 2nd Edition

P. Willmer, G. Stone and I. Johnston

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Many physiologists, most of us now middle aged, cut our scientific 'teeth' on the words of the masters; Scholander, Schmidt-Nielsen, Prosser, Johansen and Bartholomew. These scientists tackled the problems of 'How Animals Work' using strongly mechanistic and adaptational approaches. The student textbooks of the '70s and '80s summarised the mechanistic and adaptational approach clearly and succinctly and instilled in the budding scientist the mantra of the founder of Comparative Physiology, August Krogh, that '*for every problem in biology there is an ideal animal to study it in.*' Whilst re-reading Gordon et al.'s *Animal Physiology* (1982), McFarland et al.'s *Vertebrate Life* (1979) and Schmidt-Nielsen's *How Animals Work* (1972), as part of the process for this current review, it is certainly clear that, not only do these early texts provide quality descriptions of physiological systems in animals, but they also tend to use the same examples. From these classic texts we learnt about the desert oryx as a model for temperature regulation in mammals, the whelk for intertidal life, lung function in lungfish, albatross flight and the crocodile heart, to name a few. In the middle of the 20th century such an approach was certainly exciting, and PhD students the world over hunted for the perfect animal to demonstrate an interesting or novel physiological mechanism.

Unfortunately, in today's scientific world the emphasis is on problem solving and applied solutions to biological issues, not on describing quirky things (some) animals do. Comparative Physiology, once the vanguard of physiological research, has become regarded, to some extent, as interesting but not really *important*. The focus of research has moved firmly away from selecting animals for their relevance to a problem, to deeper and deeper analyses of a very few species, such as the rat, mouse, guinea pig, fruit fly, worm (*C. elegans*) and zebrafish. August Krogh's famous mantra is no longer practiced (or at least appreciated). Whether we like it or not, Comparative Physiology is on the outside looking in.

Over the last 15–20 years, however, Comparative Physiology has quietly reinvented itself as a discipline by developing new approaches to understanding how animals work. Phylogenetic analyses place the physiological mechanisms exhibited by different animals in the context of their relatedness to each other. Allometry proves that body size matters (often more than any other variable tested). Developmental physiology, which demonstrates how physiological systems evolve and using variable environmental conditions in selection experiments, has led to a greater understanding of how animals respond to environmental change (including human activities). The boom in genetic, molecular biology and cell culture techniques has also created opportunities for comparative physiologists to no longer focus on whole animal or system biology, but to get to the heart of cell function. These approaches have demonstrated that developmental plasticity in physiological systems can be selected for, predict how (and on which animals) rapid and violent environmental change may impact, and show that it may be unwise in many cases to relate mouse physiology to human function. Comparative Physiology is making a comeback as Evolutionary and Environmental Physiology and it is time for a student textbook to reflect this shift in emphasis. Willmer et al.'s text goes a long way to providing the new approach for students as they enter the brave new world of evolutionary physiology.

In *Environmental Physiology of Animals*, Willmer, Stone and Johnston present animal physiology in the context of

evolutionary and environmental constraints whilst also providing the background information necessary for the novice physiologist to understand the diversity in system structure and function. The book highlights the variation in systems with examples from both the vertebrates and the invertebrates. There is no doubt that this task is Herculean, but the authors have made excellent progress and met with considerable success. I particularly enjoyed reading the first section, Basic Principles. Here, the book describes in detail the issues at the core of the renaissance in comparative physiology. Evolution, adaptation, phylogeny, genes and proteins as mediators of evolution, adaptation and function, and the crucial importance of scaling in understanding physiological function, are all carefully described and evaluated. This section 'sets up' the direction and philosophy of the book, and is well written and reasonably easy to read.

The second section of the book deals with Central Issues in Comparative Physiology and has some strengths and weaknesses. I was particularly delighted to read about the physical basis of systems. It has always annoyed me that many physiology and medical texts do not give credit to the physical and mathematical basis behind physiology. It appals me to see the Nernst, Fick and Goldman equations missing from physiology texts, and I applaud this book for being so upfront about the physics of physiology. Also, some chapters have overtly taken the environmental and evolutionary focus to understanding a physiological process. The chapter on Temperature and Its Effects makes particularly enjoyable reading, because of the environmental context for the systems involved. However, some other chapters are somewhat more mundane and descriptive. I was particularly disappointed with Respiration and Circulation, which was presented as a 'catalogue of systems', an approach standard in early texts. The newly added section on Excitable Tissues reads well, but the chapter itself is too long, being over double the average length of the other chapters. This long chapter gave the section an unbalanced feel. Some of the text was also rather dense in places and read as though it had been edited rather too severely, presumably to keep the word count down. I also thought it unusual that Developmental (including larval) Physiology and, in particular, the Immune System were not well covered. Given the tenor of the third section (coping with the environment), an understanding of both development and immunity are crucial and these topics seem to need chapters of their own.

The strength of the book is the third section, Coping With Environment. It reads as if this is the heart and soul of the book, and the authors are passionate, even zealous about environmental effects. I particularly enjoyed the inclusion of human-affected environments (referred to rather enigmatically as anthropogenic effects). The parasite section makes a very interesting read.

Once embarking down the road of environmental selection, and human-impacted environmental influences, the book could have concluded with a summary chapter highlighting the issues facing the physiological systems of animals, and the plight that may befall them. The reality of today's world is that few if any environments are not influenced by human activity and many animals live in entirely man-made environments (e.g. cities and cultivated rural environments). Phytoestrogens, fertilisers, global climate change, changes in water availability and quality, the rapid transport and distribution of pathogens around the world, the spread of cities, domesticated animals, humans themselves and a myriad other human-induced environmental forces will shape the fauna of the future. How will these new and rapid environmental forces affect 'How Animals Work'? More than any other comparative physiology text I have read, *Environmental Physiology of Animals* will expose undergraduate students to the excitement and relevance of evolutionary and environmental physiology. The New Comparative Physiology has the approaches necessary to tackle the big issues in biology and it is important that students finish the book (and the course that goes with it) with the sort of zeal to problem solve in physiology that Schmidt-Nielsen and others imbued in generations past.

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References

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