BOOK REVIEWS

MARC W. KIRSCHNER & JOHN C. GERHARDT. *The Plausibility of Life: Resolving Darwin's dilemma*. New Haven (CT): Yale University Press (2005). 336 pp. Cloth-bound: $30.00. ISBN: 9780300108651. Also available in paperback: $18.00. ISBN: 9780300119770.

There is little as engaging and impressive as the variety of living things that have inhabited the earth and the way life has changed since it first emerged on our planet. This is the part of the story of evolution that we see recorded in textbooks, museum exhibits, and popular accounts of the history of life. Organic change is a fundamental theme in what we teach about evolution. But there is another, equally impressive aspect of evolution: the continuity that connects all organisms to an array of common ancestors. Because common ancestry is essential to understanding evolution, any view of evolution that focused only on novelty and ignored conserved traits would fail to account for the emergence of new species from ancestral ones.

In *The Plausibility of Life*, Kirschner and Gerhardt introduce a number of conserved "core cellular processes" shared by all living things. They argue that an important key to understanding life's history (and evolution) is understanding the biological continuity among living things. These core processes represent successful innovations pioneered by ancestral organisms that are inherited by evolutionary descendants. For example, all living things on earth use the same process of transcription based on the same nucleotide bases.

What is perhaps more dramatic is the authors' conclusion that the evolutionary success of these processes lies in their ability to produce quite variable outcomes under different environmental conditions – essentially a refutation of the "irreducible complexity" argument of "Intelligent Design" proponents. Based on extensive review of the research literature, Kirschner and Gerhardt show how a single molecule with a highly specified function can perform different functions under different environmental conditions. In other words, the molecular imperative for the cell is flexibility, *not* specificity. The appar-

ent specificity that we observe is so reliably produced, they argue, because the genome is selected for adaptability. How else could organisms so full of complex biochemical and developmental pathways have so few genes?

Kirschner and Gerhardt show us how contemporary biological research has solved problems regarding the evolution of unique, complex traits from a common pool of features that organisms have put to work in different ways. This highlights the two essential features of evolutionary biology: change *and* continuity. Two of the key concepts they use to illustrate their thesis are weak linkage and exploratory behaviour.

For example, we know that there are many steps between the DNA sequence for a particular protein and the function that the protein performs. The authors document several cases in which a protein produces a particular effect only under specific conditions. The "linkages" between the form and function are "weak" or "easily forged and broken" so different outcomes are possible without requiring any significant change in the DNA (p 110-111). So, even two organisms with essentially the same DNA sequences can form different linkages to produce new pathways and products.

Exploratory behaviour is the basis for the appearance of complex organization from simple actions. In the case of the development of blood vessels and nerves, the authors show how these structures emerge in response to signals generated by the target tissues so that they grow in the "right" directions and connect to the "right" cells. In the case of the pattern of blood vessels that we all can see in the skin of our arms and hands highly variable patterns occur even within the same individual.

These two examples capture only a bit of the flavour of this book which presents contemporary research to nonspecialists. Although they are frank about what is known and what is still to be learned, Kirschner and Gerhardt present a strong case for how conserved core processes account for the evolution of complex, highly specific functions, and yet also support change in structure-function complexes under differing conditions. The conserved core process may be geared to producing specific components, but their assembly, final configuration, and biological effects are anything but fore-ordained.

The implications of the authors' thesis for how we teach evolution – and what we teach about it – are potentially revolutionary. What makes patterns of biological similarities and differences among organisms' *phylogenies* and not just their *classification* is their connection to common ancestors. The evidence for these connections lies in the conserved core processes that Kirschner and Gerhardt explore in this important book. The lesson in *The Plausibility of Life* for all of us who teach evolution is that we shortchange our students when we focus *only* on the changes in living things over the last 3500 million years. The complete – and more interesting and compelling

– story of evolution involves as much an exploration of what living things have in common as it does what makes them different. *The Plausibility of Life* is an important resource for educators in developing a curriculum built on the twin themes of evolution: continuity and change.

ANDREW J. PETTO
University of Wisconsin–Milwaukee