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the number of people able to recognize and deal with these problems is on the decrease. In the United Kingdom, the situation for future generations of entomologist and pest managers is dire; there is only one entomology degree in the country and that is at Masters level. Traditional plant pathology is virtually extinct [5], and pest management in depth is taught only at Masters level at fewer than a handful of universities [1]. Other European countries have similar problems: medical and veterinary entomologists in France number 100, with half of those over the age of 50 [6]. As fewer and fewer graduates with experience of insects and fungi are produced, the number of teachers at all levels from primary to tertiary with this essential skill suite will also decline, with a corresponding loss in knowledge for the succeeding generation.

Unless something is done soon to remedy the situation, it will be too late and the only animals that the general public will be able to recognize will be polar bears and tigers [5]. By contrast, the number of students being trained at Masters and PhD levels in mammal and bird ecology is out of all proportion to the needs of the world both ecologically and economically. Unless this institutional vertebratism is dealt with proactively and, if neces-

ary, by positive discrimination [1], the world can look forward to torrid times indeed. If the UK government is indeed serious about food security, it is high time that the BBSRC in particular, which has agriculture within its remit, concentrates on supporting agronomy, in particular crop protection, and, most importantly, moves from the bench and the cell out into the field.

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Letters

Evolution *is* intelligent design

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David Sloan Wilson and E.O. Wilson [1] have argued persuasively that natural selection is multilevel and can work on whole groups of organisms or even 'systems.' Even most multicellular 'organisms' are, in fact, collections of organisms in a coordinated system. For example, it has been estimated that as much as 90% of the cells in the human body are genetically 'non-human' (mostly bacteria*). Evolution is not just random mutations, it is both the generation of alternatives and natural selection to select the best-suited (i.e. most reproductively successful) designs for ever-changing environments.

That the evolutionary process can 'design' organisms and systems has also been demonstrated with computer simulations. Modern designers of computer code sometimes use 'evolutionary algorithms' that mimic the fundamental evolutionary processes to help 'design' new programs that meet specific goals. These algorithms can often find close to optimal solutions that a conscious design process would miss.

It is also clear that cultural change is an evolutionary process [2]. A culture can be viewed as an interdependent set of world views, institutions and technologies that form

a socioecological 'regime' embedded in an ecological context [3]. The evolution of cultures follows rules analogous to those governing the evolution of organisms, but with different units of selection (cultural variants versus genetic variants) and a different method of transmission to the next generation (learning versus genes). It is also clear that humans and their cultures coevolve, with selection occurring at multiple levels.

Thus, evolution is a process that works on multilevel systems to, in a sense, design those systems in a way that functions well and survives. One definition of intelligence is the ability to learn. Therefore, evolution is in a very real sense intelligent: it can learn from experience and improve. It does not do this consciously or, at least, what consciousness there is, is distributed throughout the system, but nevertheless it does produce designs that are the product of an intelligent and adaptive learning process.

Therefore, evolution is an intelligent (as opposed to a 'dumb') design process. Not only does it incorporate random mechanisms (such as genetic mutation) and not-so-random mechanisms (such as sexual reproduction and the conscious creation of new cultural variants) to generate alternatives but it also incorporates selection processes that narrow down those alternatives in a manner analogous to the way that a conscious designer would do. Darwin's original examples of how selection operates used plant and animal breeding programs that

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* American Society for Microbiology (2008) Humans have ten times more bacteria than human cells: how do microbial communities affect human health? *ScienceDaily* 5 June. Retrieved 17 April 2009 (<http://www.sciencedaily.com/releases/2008/06/080603085914.htm>).

involved human goal setting and selection. 'Stupid' alternatives do not improve the reproduction of the system and die out. But natural selection does not require an all-seeing and all-knowing intelligence to do its work. The intelligence is the multilevel evolutionary system itself.

Thus, in a very real sense, if school boards were to require the teaching of 'intelligent design,' they would, in fact, just be calling for the teaching of standard evolution.

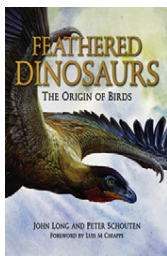
Book Review

A colorful mesozoic menagerie

Feathered Dinosaurs: The Origin of Birds by John Long, illustrated by Peter Schouten. Oxford University, Press. 2009. £20.00 hbk (280 pages) ISBN 978 0 19 537266 3.

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The past decade has witnessed the greatest fossil gold rush of modern times, producing an amazing picture of the Cretaceous, especially from the Jehol Biota of north-eastern China. The discovery of presumed 'feathered dinosaurs' and other fossils has amplified the number of new species, more than tripling those described during the past two centuries. New tantalizing material has resulted in unprecedented understanding of the early avian radiation, but has also provided a bonanza for paleontological speculation and controversy.

Fossil discoveries call for artistic interpretation, the most spectacular effort being the beautifully executed and designed *Feathered Dinosaurs* by paleontologist John Long and illustrator Peter Schouten, who together provide an astonishing view of the new Mesozoic aviary, and an array of Cretaceous theropods: 'dinosaurs like *Velociraptor* are the ancestors of the modern birds we know today.' Artist Schouten provides a daring venture into the Cretaceous, with stunning portrayals of these animals, at times fanciful and flamboyant, pushing artistic license to its limits, but then that's the nature of fossils. Yet, at least in body profiles, the art provides a stunning account of the fauna of this little known geological time span.

Although Long and Schouten promote the orthodoxy of 'feathered dinosaurs', compelling evidence for any proto-feathers in these fossils has always been lacking, and new evidence shows that the filamentous fibers on the small 'feathered dinosaur' *Sinosauropteryx* represented a complex mesh work of supportive skin collagen fibers [1,2]; and the body outline on the specimens encloses the fibers. Furthermore, new evidence suggests that feathered micro-raptors and other groups of plumed maniraptorans are derivatives of the early avian radiation that produced an aviary at all stages of flight and flightlessness [1].

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The small theropod *Compsognathus*, 'compys' of *Jurassic Park*, is depicted with a covering of down-like proto-feathers, and modeled after the roadrunner; it is given an expanded throat sac 'critical for temperature regulation' and a pattern of small spots and bars for camouflage. Yet, there is no evidence for any type of feathers in the 'compys' (and, in fact, evidence to the contrary [3]) or for endothermy; unfortunately, no references are provided in the text to papers marshalling evidence contrary to the dogma of feathered dinosaurs, part of an alarming trend in paleontology towards censorship by lack of citation.

During the 1860 s, Thomas Huxley envisioned a dinosaurian origin of birds via the flightless ratites: 'The road from Reptiles to Birds is by way of Dinosauria to the Ratitae [ostrich and allies]. The bird 'phylum' was struthious, and wings grew out of rudimentary forelimbs.' [4]; and his compatriot Darwin viewed the ratites to have reduced their wings in Larmarckian fashion, from disuse. It was the much-maligned Richard Owen who, in 1875, set the record straight, correctly implicating a pedomorphic origin (i.e. whereby the adults retained traits previously seen only in the juveniles) of ratite flightlessness, 'dispensing justice to Huxley and Darwin alike' [5], and in one sentence outlines the nature of the current debate on avian origins. His statement should also provide a cautionary note for advocates of today's bird origin orthodoxy, which, among myriad problems, calls for all the sophisticated avian aerodynamic flight architecture to have evolved as exaptations, in earth-bound theropod dinosaurs: '...science will accept the view of the Dodo as a degenerate Dove rather than as an advanced Dinothere.'

Later, in 1956, Gavin de Beer showed that all flightless birds were derived from volant ancestors, and, following Owen, demonstrated that the evolutionary mechanism was pedomorphosis; that is, the ratites were big chicks. History sometimes repeats itself, in this case in the form of secondarily flightless oviraptorosaurids that adorned the