creationists, appreciate having a chance to examine the assumptions and beliefs about science that provide the foundations of standard accounts of evolution and the antievolutionary rivals, because it helps them reason for themselves what can be appropriately labeled as 'science'.

References

1 Scott, E.C. and Branch, G. (2003) Evolution: what's wrong with 'teaching the controversy'. *Trends Ecol. Evol.* 18, 499–502

2 Damman, C. *et al.* (2002) *Discover Biology*, Sinauer Associates

3 Audesirk, T. *et al.* (2003) *Life on Earth*, Pearson Education

4 Pruitt, N.L. *et al.* (2000) *BioInquiry Learning System 1.0: Making Connections in Biology*, John Wiley and Sons

5 National Research Council, (1996) *National Science Education Standards*, National Academy Press

6 Alters, B.J. and Nelson, C.E. (2002) Teaching evolution in higher education. *Evolution* 56, 1891–1901

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Teaching about scientific dissent from neo-darwinism

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In their recent Opinion article in *TREE* [1], Eugenie Scott and Glenn Branch argue that teaching students that there is a scientific controversy about the 'validity of evolution' is 'scientifically inappropriate and pedagogically irresponsible'. In so doing, Branch and Scott assume that they have critiqued my position on the teaching of evolution. But they fail to define their terms and engage the main arguments for my position, misrepresenting it as a consequence. My position is not that students should be taught that there is a scientific controversy over the validity of evolution per se, but that they should be informed about the scientific controversies that exist about neo-darwinism, the long-dominant theory of evolution.

I recently co-authored a major law review article [2] arguing for this pedagogical proposal and have co-edited a peer-reviewed volume about the subject [3]. The book develops a comprehensive pedagogical, legal and scientific case for exposing students to the scientific controversies that exist about the key claims of neo-darwinism, including the claim that the selection–mutation mechanism can fully account for the appearance of design in biological systems. Scott and Branch mention neither of these works, although my co-editor, the distinguished Darwin-scholar John Angus Campbell, asked Scott to contribute a critical response to the book, which she declined.

Instead of engaging the arguments of these works, Scott and Branch attempt to associate our position with that of holocaust deniers and creation scientists. They also repeatedly use the perjorative term 'anti-evolutionist', thereby confusing the issue [4] and mischaracterizing the motives and rationale of those of us who want to see students informed of the scientific controversies that exist within and about aspects of contemporary darwinism.

Scott and Branch deny the existence of any significant scientific controversies about the 'validity of evolution'. But the credibility of their position depends on definitional equivocation. All reputable scientists agree that 'evolution happened', they insist. Overwhelming evidence reinforces this opinion. And, of course, they are right if they equate 'evolution' with 'change over time' or 'descent with modification' (as they do when pressed).

Yes, life has changed over time. But, of course, neo-darwinism affirms a good deal more than that. In particular, it affirms that: (i) that an undirected processes, principally natural selection acting on random mutations, is sufficient to generate biological complexity; and (ii) all organisms have descended from a common ancestor.

Scott herself acknowledges significant scientific debate about the sufficiency of the neo-darwinian mechanism. Recently, in a public forum at the University of San Francisco, she also acknowledged that many evolutionary biologists now disagree about the truth of universal common descent. Our position, radical though it might seem, is that students should be informed about such dissenting opinion and, furthermore, that they should be told why some scientists doubt aspects of neo-darwinism.

Thus, Scott and Branch misrepresent our position when they suggest that we justify it mainly by an appeal to fairness. Teaching students about scientific controversies is less a matter of fairness (still less, to religious sensibilities as they imply) than it is a matter of full scientific disclosure. Students should know, for example, that many embryologists dispute that different classes of vertebrate embryos strongly resemble each other during their earliest stages of development [5], although many American biology textbooks claim or show the opposite in their presentations of evolution (often using misleading photos or Haeckel's famously inaccurate drawings). Students should also know that many scientists now question whether microevolutionary processes can be extrapolated to account for macroevolutionary innovation and that the lack of such a mechanism leaves unexplained the origin of major groups of animals, such as the Cambrian Metazoa [6].

Scott and Branch acknowledge the existence of disputes about the sufficiency of the neo-darwinism mechanism, but dismiss them as being of little consequence to the status of contemporary evolutionary theory, as if the absence of an agreed mechanism of macroevolutionary change constituted

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a minor theoretical lacuna. Scott and Branch are forced by this logic, however, to defend a less than fully neo-darwinian view of evolution.

References

1 Scott, E.C. and Branch, G. (2003) Evolution: what's wrong with 'teaching the controversy'. *Trends Ecol. Evol.* 18, 499–502
2 DeWolf, D.K. *et al.* (2000) Teaching the origins controversy: science, religion or speech? *Uni. Utah Law Rev.* 39, 39–110
3 Campbell, J.A. and Meyer, S.C. eds (2003) *Darwinism, Design and Public Education*, Michigan State University Press
4 Meyer, S.C. and Keas, M.N. (2003) 'The meanings of evolution'. In *Darwinism, Design and Public Education* (Campbell, J.A. and Meyer, S.C., eds), pp. 135–156, Michigan State University Press
5 Richardson, M.K. *et al.* (1997) There is no highly conserved embryonic state in the vertebrates: Implications for current theories of evolution and development. *Anat. Dev.* 196, 91–106
6 Valentine, J.W. (2003) *On the Origin of Phyla*, University of Chicago Press

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Letters Response

Teaching the controversy: response to Langen and to Meyer

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We thank Langen for his generous and thoughtful comments regarding the teaching of evolution [1]. Judging from his description of his approach, Langen is not 'teaching the controversy' in the sense in which we use the phrase: he is not telling his students that evolution is scientifically controversial. Rather, he is teaching about antievolutionism in the service of clarifying the nature of science (a worthy goal). We have no quarrel with his approach, although we have reservations about applying it at the high school level: doubtless Langen's students are 'not far removed from the high school classroom' [1], but he sees only students who succeeded there; and these, unlike the average high school student, enjoy the advantage of having a trained research biologist for a teacher.

Meyer suggests that we misrepresent his position: he is, he says, recommending only the teaching of scientific controversies about neo-darwinism [2]. However, he presents what we consider to be an idiosyncratic definition of 'neo-darwinism'. According to a standard reference [3], the term 'is typically used for the kind of Darwinism practiced by today's evolutionary biologists…based on the so-called neo-Darwinian synthesis…between the Darwinian theory of natural selection and Mendelian genetics'. Owing to the prominence of selectionist views in the middle of the 20th century, "two views of neo-Darwinism…exist simultaneously: a 'narrow' [selectionist] and a 'broader' interpretation" [3]. As in Meyer's reply, the Discovery Institute's Center for Science and Culture (CSC) has been known to misrepresent scientists who reject neo-darwinism in the narrow sense as rejecting it in the broad sense [4].

The crucial phrase in clause (i) of Meyer's definition of 'neo-darwinism' [2] is 'undirected processes', the alternative to which is, presumably, directed processes. But directed by what? In spite of the CSC's nods in the direction of extraterrestrial aliens and time travellers from the future [5], God is clearly the favored candidate, as reflected in the CSC's original logo, featuring Michelangelo's God from the Sistine Chapel [6]. Is there, as Meyer implies, a scientific controversy about whether 'directed processes' are responsible for 'biological complexity'? We are unaware of such a controversy, and we are confident that readers of *TREE* are too.

In clause (ii) of Meyer's definition, it is perhaps sufficient to observe that he conflates the undebated idea of common ancestry in general with the actual debate about whether it is possible to identify a single universal common ancestor. Woese's work (e.g. [7]), to which Scott was alluding in the forum that Meyer mentions, contributes to the latter debate. There is no reason not to sketch Woese's basic idea in a pre-university biology class. However, it would be scientifically inappropriate and pedagogically irresponsible to pretend that it challenges the common ancestry of primates, tetrapods, or eukaryotes, or that it constitutes evidence for a special creation of the three domains, or that it is anything but a necessary refinement of the idea of common ancestry.

It is worth observing that the CSC serves as the institutional home of 'intelligent design', which the American Association for the Advancement of Science describes as scientifically unwarranted [8]. We recommend Forrest and Gross's *Creationism's Trojan Horse* [9] to anyone seeking a critical discussion of the motivations, agenda and methods of the CSC, of which Meyer is director. Now disclaiming any desire for 'intelligent design' to be taught in public schools, the CSC bases its recommendations on Wells's *Icons of Evolution* [10], which (as a reviewer observed) comprises 'scientific quotations out of context, incomplete summaries of research, and muddled arguments' [11]. Such systematic misrepresentation of the scientific literature characterized the recent criticism by the CSC of the treatment of

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