

## **The Greatest Show on Earth: The Evidence for Evolution.**

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Source: BioScience, 59(10) : 905-907

Published By: American Institute of Biological Sciences

URL: <https://doi.org/10.1525/bio.2009.59.10.13>

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of *Species* is extremely helpful in providing a balanced view of Darwin's position. He misses no opportunity to show that Darwin did not simply dismiss isolation outright, as is sometimes maintained; rather, his view changed over time, settling into a position that downplayed isolation in comparison with the production of new species in large continental areas.

If Costa is careful not to make Darwin into a 20th-century neo-Darwinian, there is one context that he does not acknowledge. Costa has an understandable opposition to modern anti-Darwinian agendas, especially those challenging the teaching of evolution in the schools. But Darwin on more than one occasion sounds more like an advocate than a critic of "intelligent design" (ID). Perhaps because Costa, like so many scientists, lumps ID together with creationism, he does not make the connection. But many ID advocates—though not all, to be sure—are content with Darwin's view when he suggested that his encounters with nature, including evolution by natural selection, led him to conclude that a higher intelligence had been involved. Perhaps the general expropriation of ID by fundamentalists has convinced Costa that all ID theorists share a political agenda that Darwin would not have condoned.

I appreciated in particular how Costa brought other Darwin works to bear on passages in *On the Origin of Species*. This was especially true with regard to *On Natural Selection*, the big species book that Darwin was working on when the arrival of Alfred Russel Wallace's famous letter spurred him to compose the "abstract" that became the book. Costa shows us the difference between the two works. In *On the Origin of Species*, for example, Darwin briefly illustrates the variability of birds' nesting habits, while in *On Natural Selection*, Costa informs us, Darwin gives 10 manuscript pages of examples. But Costa also draws on many other materials that shed light on passages, from published works before and after 1859 to Darwin's well-known notebooks to his voluminous correspondence.

I have but one complaint. The great usefulness of the volume clearly rests with Costa's annotations, which clarify, inform, and update, as well as explain Darwin's work in the context of the modern view. But, alas, there is no index to this valuable material. The only index in the book is the one Ernst Mayr composed when he edited the first edition of *On the Origin of Species* (Harvard University Press, 1964). This consists of Darwin's original index plus entries by Mayr that refer to modern evolutionary ideas. To his credit, Costa has italicized the entries that Mayr added to Darwin's, something not done in the 1964 edition. But it would have been so easy to add a separate index to the contents of his annotations, and that would have made the book much, much more useful. Costa did include a bibliography of works he consulted, and he also provided a section of biographical notes for individuals that Darwin mentioned. That there is no index to his own contributions, however, is a glaring deficiency.

As a historian, I might have expanded Costa's bibliography a little, and I have minor qualms with one or two of his claims, but in the main, Costa's efforts have yielded an enormously rewarding document. Darwin has sometimes been portrayed as a plodding scientist, a good observer whose second-rate status is masked by the pregnancy of the grand idea he stumbled upon. Costa's work is a wonderful refutation of this portrait. No one who follows Costa through *The Annotated Origin* can possibly doubt Darwin's exceptional stature. There is no better tribute he could have made for this celebration of Darwin's 200th birthday and the 150th anniversary of the publication of his masterpiece.

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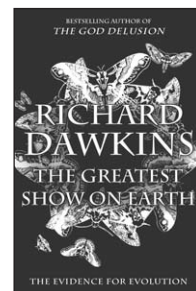
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## WHY DARWIN WAS RIGHT AND CREATIONISTS ARE WRONG

**The Greatest Show on Earth: The Evidence for Evolution.** Richard Dawkins. Free Press, 2009. 480 pp., illus. \$30.00 (ISBN 9781416594789 cloth).

Over the past three decades, biologists and then scientists more generally have become increasingly aware of the threat that creationism, in its many guises, poses not only to science but also to rationalism and evidence-based decision-making. The intention of "intelligent design" advocates, as revealed in the "wedge" document ([www.antievolution.org/features/wedge.pdf](http://www.antievolution.org/features/wedge.pdf)), was to replace evolution in science curricula and to recast the sciences generally in a theological framework (Forrest and Gross 2003). The conflict between evolutionary science and creationism is the front line in the defense of science.



The response to creationism (and its intelligent-design incarnation) has included several excellent books (e.g., Alters and Alters 2001, Pennock 2001, Pigliucci 2002, Scott 2009) and institutional statements (e.g., NAS 2008). However, most of these deal primarily with how to counter creationists and their arguments. Most books, except for one by Donald Prothero (2007) on the fossil record and my own effort published 26 years ago (Futuyma 1983), provide only bare-bones treatment of the positive evidence for evolution. But in this sesquicentennial anniversary of *On the Origin of Species*, two excellent books

doi:10.1525/bio.2009.59.10.13

fill the gap: Jerry Coyne's *Why Evolution Is True* (2009), and the book many of us have long hoped Richard Dawkins would write, *The Greatest Show on Earth: The Evidence for Evolution*.

Among Dawkins's strengths are his command of evolutionary science and his vivid metaphors, his wicked wit, and his ability to present the reader with a thoroughly enjoyable stage performance rather than a classroom lecture. Few others would write that "tree trunks are standing monuments to futile competition," or relate that what nontranscribed pseudogenes are useful for is "embarrassing creationists." One of his visual aids is a photograph of a phylogeny, together with some of its species, tattooed on the back of an Australian graduate student. *The Greatest Show on Earth* contains almost no allusions to *The God Delusion* (Dawkins 2006) or its thesis. "That's not what I'm about here," Dawkins remarks.

After the opening chapter in which he explains that evolution is both a scientific theory and a fact—both words are suitably defined and analyzed—Dawkins launches into the subject the way Darwin did: with artificial selection, then natural selection. Here and throughout the book, Dawkins shows that he is an undisputed master in exposition of natural selection and adaptation, which serves him well as he goes about showing how only this theory can account for countless facts of biology that would otherwise be inexplicable (unless one attributed caprice, sadism, or other unappealing properties to a designer). In chapters 3 and 4, he moves into macroevolution (the real area of conflict), describing the bases of radioactive dating and the temporal orderliness of the fossil record. Chapter 5, on rapid contemporary evolution (microevolution), is excellent, though it seems somewhat out of place amongst the macroevolutionary chapters. Chapters 6 and 7 are splendid disquisitions on the fossil record generally ("Missing link? What do you mean, 'missing'?" and on the hominin record in particular ("Missing persons? Missing no longer").

In the next chapter, on development, Dawkins shows palpable excitement as

he describes the "auto-origami" of embryos and of proteins. This section is wonderfully done, but it left me unsatisfied: Dawkins doesn't provide concrete examples of, say, the evolution of new protein functions, and despite some patches "so that this chapter on embryos should not end up as a mere digression in a book on evolution," I'm afraid it does indeed end up as just that. He offers no specific examples from the wonderful new world of evolutionary developmental biology ("evo-devo"), and hardly any indication that this frontier in evolutionary research exists.

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In contrast, chapter 9 ("The Ark of the Continents") is a powerful analysis of the evidence for evolution and against creationism that biogeography provides. He quotes Jerry Coyne: "The biogeographic evidence for evolution is now so powerful that I have never seen a creationist book, article, or lecture that has tried to refute it. Creationists simply pretend that the evidence doesn't exist" (Coyne 2009, p. 88). Dawkins continues: "Creationists act as though fossils provide the only evidence for evolution. The fossil evidence is indeed very strong," but "even if not a single fossil had ever been found, the evidence from surviving animals would still overwhelmingly force the conclusion that Darwin was right" (Coyne 2009, p. 283). This is a message that we teachers should all be sending, loud and clear.

The following chapter, on phylogeny and molecular clocks, is not quite as strong. Dawkins's description of how phylogeny can be inferred from DNA sequences would be helped by some

phylogenetic diagrams; the difference between raw similarity and shared derived similarities as evidence is not stressed; and the development of the theory of neutral sequence evolution and rate constancy is not followed with concrete evidence. This is the chapter in which Dawkins describes pseudogenes, but, oddly, he doesn't carry them over into the following chapter ("History Written All Over Us") on imperfections and other signatures of history. This is a wonderful chapter, highlighted by his vivid description of watching a dissection of a giraffe's recurrent laryngeal nerve. This nerve, which in mammals takes a long detour (15 feet in a giraffe!) from the brain to the larynx, is an instance of absurdly poor engineering, a consequence of evolutionary history that every biology teacher should know about. So is the mammalian vas deferens, which Dawkins also describes. Fine as this chapter is, I think it could have been still better if Dawkins had included some examples at the molecular level. Much of what is being found in genomes is interpretable only in light of evolutionary history, and molecular examples, with their cachet of modernity, help to dispel the notion (wrong on multiple counts) that the evidence for evolution is just musty old morphology.

In chapter 12 ("Arms Races and Evolutionary Theodicy?"), Dawkins returns to natural selection, especially the consequences of the selection exerted by organisms on each other. Ecosystems, he points out, are clearly not planned economies. If they were, trees would not need to extend above ground level, for they could capture as many photons there as they do in forests. Only natural selection, stemming from competition, can explain tree trunks, which are monuments to futile competition—"futile if we think in terms of a planned economy. But the natural economy is not planned." Similar analyses lead us to understand why predators and prey have counter-adaptations despite costly investment. If we imagined that ecosystems were planned by a moral philosopher instead of an economist, Dawkins suggests, we might expect the designer

to minimize suffering. But no, he says; “the world of nature seems to take no steps at all to reduce the sum total of suffering.” Ichneumon wasp larvae are selected to eat the innards of caterpillars, keeping their host alive until they have completed their own development. “I don’t know whether caterpillars can feel pain,” Dawkins writes, but wasp larvae would not profit from minimizing whatever pain they cause, nor would selection favor caterpillar genes for insensitivity to pain. Natural selection is indifferent to suffering unless it affects survival or reproduction.

This may be an unappealing conclusion, although explanations of evil from theological theodicy are hardly more reassuring. But as Dawkins reminds us in his final chapter, value judgments—whether good, bad, evil, or immoral—do not bear on the factual content of a hypothesis. Much of the opposition to teaching evolution is based on the presumption that it justifies or encourages immorality. But even if that were true (and there is not the slightest shred of evidence that it is), “that would not imply that the theory of evolution was false. It is quite astonishing how many people cannot grasp this simple point of logic.” I learned from Dawkins that this logical fallacy is called the *argumentum ad consequentiam*—the argument that a statement is true or false because I like or dislike the consequences.

Were there to be a second edition, I might suggest that Dawkins add more concrete examples to his conceptual explanations of some topics and address the balance between development and evolution in treating what Darwin, in a letter to Asa Gray, called “by far the strongest single class of facts in favour of change of form.” Dawkins remarks, “I know that not all my readers like my digressions,” and I confess that I am among them, but really, some of the longer digressions do risk the reader’s losing the thread of the argument altogether. But these are minor points. If readers are at all sympathetic to science or are honestly interested to learn why biologists prize evolution as the central fact and organizing principle of the science, they will enjoy reading *The*

*Greatest Show on Earth*, and they will find insights on every page.

Coyne (2009) and Dawkins make many of the same fundamental points and even use some of the same examples, but they differ in style. Readers who want a short, quick, straightforward account of the evidence may find that Coyne (who focuses on evidence for evolution, not refutation of creationism) suits them better; those who prefer their science served with more anecdotes, a chattier style, and explicit revelation of the failures of creationism may opt for Dawkins. Better still, read both, assign both to your class, make them a gift for all your friends and relatives. *Why Evolution Is True* and *The Greatest Show on Earth* are among the most important books on evolutionary science for a broad audience in decades. Both desperately needed to be written and need to be read.

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## THE “IF..., THEN” OF EVOLUTION

**Why Evolution Is True.** Jerry A. Coyne. Penguin (Viking), 2009. 304 pp., illus. \$27.95 (ISBN 9780670020539 cloth).

The evidence for evolution is overwhelming, yet a substantial proportion of Americans (and people of other nationalities) have doubts about the reality of evolution. These doubts tend to come in two related flavors: Darwin’s theory of evolution is, after all, “only a theory”; and creationism (and its close relatives, such as “intelligent design”) represents a plausible scientific alternative to evolution. Despite a long history of legal rejections of these notions, including the *Kitzmiller v. Dover* decision in 2005, this distrust and misunderstanding of evolution remains pervasive. When your seatmate on an airplane or your uncle Ernie at the dinner table asks what you, as a biologist, think this evolution stuff is all about, how should you respond? Tell them what I would: Read Jerry Coyne’s excellent new book, *Why Evolution Is True*.

Coyne, a distinguished evolutionary geneticist at the University of Chicago and a regular contributor to National Public Radio and *The Times Literary Supplement*, begins by defining the modern theory of evolution in terms of six components: evolution, gradualism, speciation, common ancestry, natural selection, and nonselective mechanisms. What distinguishes Coyne’s treatment from many previous books on the topic is a determined focus on prediction and retrodiction: “If evolution is true, then we predict that....” Throughout the book, Coyne uses this simple but powerful device to illustrate how scientists have accumulated the evidence demonstrating how and why evolution happened and continues to happen.

This approach is particularly successful in discussions of the evidence for evolution, gradualism, and common ancestry in the first half of the book. In lucid prose, Coyne leads the reader

doi:10.1525/bio.2009.59.10.14