

## EVOLUTION

## The Overwhelming Evidence

Massimo Pigliucci

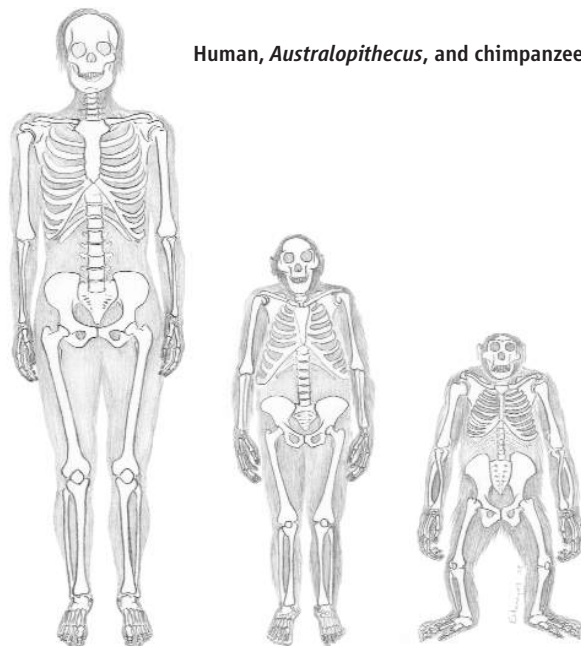
It had to be done, and Jerry Coyne is unquestionably one of the most qualified people for the job. I am referring to a clear, engaging, accessible explanation of the evidence for evolution, an aspect of the so-called evolution-creation “controversy” that is too often neglected. There are, of course, plenty of books criticizing creationism and its cousin intelligent design (1–2) as well as works aiming to explain the creationist phenomenon within the broader context of American anti-intellectualism (3). We can also easily find plenty of superb books for the public about various aspects of evolutionary biology [e.g., (4–6)] even beyond the classical essays by Stephen Gould and Richard Dawkins. And yet, it is hard to get one’s hands on a good non-college-level presentation of why evolution is, as they say, both a theory and a fact. Coyne’s *Why Evolution Is True* begins to fill this obvious lacuna, even though—just like in other branches of science—additional popular writing by scientists and well-informed journalists on evolution will be welcome for many years to come.

The first eight chapters span pretty much everything one may want to know about evolution but, apparently, so few dare to explain. Coyne (an evolutionary geneticist at the University of Chicago) first introduces readers to a basic definition of evolution.

With an expert hand, he then leads them through discussions of the paleontological evidence, developmental biology and vestigial organs (and molecules), biogeography, natural selection (“the engine of evolution”), sexual selection, species concepts, and speciation processes. The latter two entries should actually be read in the singular, because Coyne subscribes to one species concept (based on reproductive isolation) and one chief mode of

speciation, allopatry. He and I disagree on this and on other aspects of current evolutionary theory, but this is not the place to entertain technical arguments at the cutting edge of the field. Still, readers of Coyne’s book will get a fairly conservative version of evolutionary theory, with occasional hints about the many heated discussions that characterize any live science and that eventually fuel its progress toward a better understanding of the natural world.

Perhaps the best part of the book is the one that addresses the real issue: human evolution. It has been noted many times that if evolution-

Human, *Australopithecus*, and chimpanzee.

ary biologists limited themselves to the non-human world, very few people would pound their fists on the pulpits of fundamentalist churches to decry “the evil doctrine.” But when science strikes at our own cherished self-image, then the trouble begins. Just ask Copernicus and Galileo. Coyne is clear and convincing here, at least for those sufficiently open-minded to read the book seriously. He makes a good use of narrative and images, and one of the latter truly is worth a thousand or more words: Early on in the chapter on human evolution, Coyne simply puts side by side the complete skeletons of a modern human, an *Australopithecus afarensis*, and a chim-

## Why Evolution Is True

by Jerry A. Coyne

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panzee. The message is not, obviously, that *A. afarensis* is a “missing link” between us and the chimps, because the latter two species are contemporary and modern whereas *A. afarensis* is ancient. But it takes a particularly obtuse mind to look at the figure and reject the notions that *A. afarensis* is a member of the human lineage and that we and chimps have evolved from a common ancestor. Then again, there is no dearth of obtuse minds when it comes to creationism.

The problem with the creation-evolution issue, however, is that it is not about the evidence. The clash is not a scientific debate, it is a social controversy. Coyne understands this, and he begins his last chapter by recounting the story of a public lecture he gave about evolution and intelligent design. Afterward he was approached by someone in the audience who frankly stated: “I found your evidence for evolution very convincing—but I still don’t believe it.” What is a scientist to do? Coyne admits that the issue goes far beyond science, into philosophy and questions of meaning and morality. Which is why philosophers have been very helpful in this arena during the past several years. It is a matter of explaining to the public not just the power but the limits of science. Coyne is critical, for instance, of much evolutionary psychology and the facile just-so stories that have abounded of late to “explain” all sorts of human behaviors, from rape to depression. I’m with him on this. The point is not that aspects of human behavior did not evolve by natural selection, but rather that the usually high standards of behavioral genetics are simply not met by most, though not all, the evolutionary psychology literature.

Still, creationists have had a problem with evolution ever since Darwin and will continue to challenge its teaching in public schools out of the same paranoia about moral decay that gripped Victorian discussions of *The Origin of Species*. What we need is a cultural change, which notoriously takes a long time and is not just a matter of presenting the evidence for the rational position and walking away while patting oneself on the back for a job well done. Nonetheless, we must present the evidence, and Jerry Coyne’s book does an excellent job of it.

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## On the Metazoan Tree

Wallace Arthur

Unlike many books, *Perspectives in Animal Phylogeny and Evolution* has a remarkably accurate title. Alessandro Minelli (an evolutionary biologist at the University of Padova, Italy) presents perspectives rather than “facts,” because our view of the structure of the animal kingdom is still changing, and he discusses both that structure (phylogeny) and the mechanisms of evolution through which it has come about.

The book deals separately with evolutionary pattern and process, in that order. The very different flavors of the two sets of chapters suggest a parallel between the organization of the book and the organization of animals that Minelli calls “the double animal.” That refers

to the quasi-independence of parts derived from ectoderm or mesoderm and from endoderm (e.g., the many cases where the ectodermal or mesodermal structures are segmented while endodermal structures, such as the gut, are not).

Two commendably brief and effective introductory chapters indicate how Minelli sees the relation between evolutionary pattern and process. One theme that emerges here is that the reasons for the evolutionary origin of a structure can rarely be found in the functions of its more elaborate, much later form. For example, feathers did not begin to evolve because of selection for the ability to fly. To put it another way (one that would have appealed to Stephen Jay Gould), exaptation is everywhere.

Minelli makes it clear that he sees phylogeny as a backdrop against which evolu-

tionary processes can be better understood. This “pattern before process” argument is familiar to us from cladistics. But Minelli subsequently goes much further than many cladists into evolutionary processes, and I confess that I find this side of things (both in the book and in general) the more interesting.

That's not to say that there is nothing of interest in the phylogenetic chapters. At their outset, Minelli reminds us that there is little evidence in the fossil record for animal life before about 550 million years ago (Ma) and nothing at all before the base of the Vendian period (about 650 Ma). This reminder

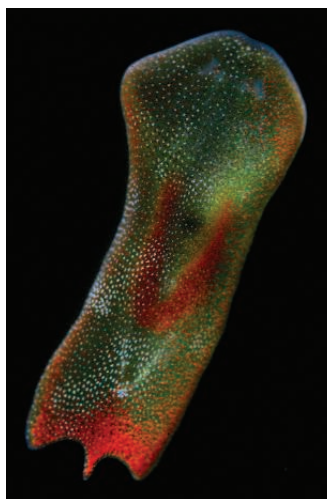
is timely, as it is becoming less and less likely that the 1990s molecular clock estimates of billion-year-old divergences between major animal groups (such as protostomes and deuterostomes) are correct.

With regard to the branching pattern of basal metazoans, Minelli discusses various possibilities, including the recent, unexpected placement of comb jellies (Ctenophora)—rather than the sponges (or some of them)—as the sister group to all other animals. I am skeptical of this suggestion, and, as Minelli emphasizes, the jury is still out on it. Nonetheless, the surprising frequency with

which such new possibilities appear in the literature reminds us of how important a cautious, perspectives approach is.

As Minelli pushes on toward what we might want to call (although he doesn't) more advanced animals, the book is readable enough to keep right on going. However, I suspect that most readers will instead use these chapters, especially “A gallery of the major bilaterian clades,” for reference. In any event, these chapters lay the foundation for what follows, the three chapters on processes.

These offer lots of interesting ideas, all eloquently explained. I don't accept all of them, but I don't imagine that Minelli would expect me to. There are also instances where I agree with his main point but not with his underlying reason. For example, he states that “we still have no satisfactory and comprehensive theory of development,” a situation he largely attributes to “the near-universal adultocentric attitude adopted until now.” I accept the second statement—many biologists



On the basal Bilateria branch? The acoel *Convolutriloba longifissura*.

regard developmental stages as functioning simply “to produce an adult” rather than as organisms having (especially in the case of larvae) their own lives. But I believe the main reason we lack a comprehensive theory of development is that we don't understand the quantitative dynamics of gene-protein interactions; we are still largely restricted to a more qualitative view in which interactions are described in a binary way, as activations or inhibitions.

Similarly, I like very much Minelli's concept of paramorphism, perhaps best explained in relation to limbs. As he points out, with very few exceptions segmented animals have segmented limbs and unsegmented animals have unsegmented limbs. That suggests the limbs are “axis paramorphs”: the genetic machinery used to make the trunk has been reused to produce them. Minelli sees paramorphism as an alternative to gene cooption, whereas I would see it as a version of that. In any event, it is an important concept.

Minelli ends with five “guidelines for future investigations into animal evolution.” One is to abandon the adultocentric view and recognize that “the fundamental unit of evolution is represented by the life cycle as an integrated whole,” with each stage subject to mutationally introduced and selectively driven changes. This position has already been accepted by many, and it can be seen as a way to unite evo-devo and population genetics.

The book's one-to-five ratio of references to text suggests a wide-ranging scholarship presented in a style of writing sometimes described as “spare”—the opposite of verbose. And indeed that is exactly what Minelli offers. Whether or not one agrees with his various perspectives on phylogeny and evolutionary mechanisms, the book is easily recognized for what it is: a magnificent tour of metazoan relationships, characterized by a cautious, nondogmatic approach to both pattern and process. Minelli knows how much we don't yet know for sure, and he suggests interesting and potentially productive ways forward. This concise account easily can and should be read by all serious students of animal phylogeny and evolution.

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