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Articles

Darwinian Fundamentalism STEPHEN JAY GOULD

June 12, 1997

1.

With copious evidence ranging from Plato's haughtiness to Beethoven's tirades, we may conclude that the most brilliant people of history tend to be a prickly lot. But Charles Darwin must have been the most genial of geniuses. He was kind to a fault, even to the undeserving, and he never uttered a harsh word--or hardly ever, as his countryman Captain Corcoran once said. Darwin's disciple, George Romanes, expressed surprise at the only sharply critical Darwinian statement he had ever encountered: "In the whole range of Darwin's writings there cannot be found a passage so strongly worded as this: it presents the only note of bitterness in all the thousands of pages which he has published." Darwin directed this passage that Romanes found so striking against people who would simplify and caricature his theory as claiming that natural selection, and only natural selection, caused all evolutionary changes. He wrote in the last (1872) edition of *The Origin of Species*:

As my conclusions have lately been much misrepresented, and it has been stated that I attribute the modification of species exclusively to natural selection, I may be permitted to remark that in the first edition of this work, and subsequently, I placed in a most conspicuous position--namely at the close of the Introduction--the following words: "I am convinced that

natural selection has been the main but not the exclusive means of modification." This has been of no avail. Great is the power of steady misrepresentation.

Darwin clearly loved his distinctive theory of natural selection--the powerful idea that he often identified in letters as his dear "child." But, like any good parent, he understood limits and imposed discipline. He knew that the complex and comprehensive phenomena of evolution could not be fully rendered by any single cause, even one so ubiquitous and powerful as his own brainchild.

In this light, especially given history's tendency to recycle great issues, I am amused by an irony that has recently ensnared evolutionary theory. A movement of strict constructionism, a self-styled form of Darwinian fundamentalism, has risen to some prominence in a variety of fields, from the English biological heartland of John Maynard Smith to the uncompromising ideology (albeit in graceful prose) of his compatriot Richard Dawkins, to the equally narrow and more ponderous writing of the American philosopher Daniel Dennett (who entitled his latest book *Darwin's Dangerous Idea*).¹ Moreover, a larger group of strict constructionists are now engaged in an almost mordantly self-conscious effort to "revolutionize" the study of human behavior along a Darwinian straight and narrow under the name of "evolutionary psychology."

Some of these ideas have filtered into the general press, but the uniting theme of Darwinian fundamentalism has not been adequately stressed or identified. Professionals, on the other hand, are well aware of the connections. My colleague Niles Eldredge, for example, speaks of this coordinated movement as Ultra-Darwinism in his recent book, *Reinventing Darwin*.² Amid the variety of their subject matter, the ultra-Darwinists share a conviction that natural selection regulates everything of any importance in evolution, and that adaptation emerges as a universal result and ultimate test of selection's ubiquity.

The irony of this situation is twofold. First, as illustrated by the quotation above, Darwin himself strongly opposed the ultras of his own day. (In one

sense, this nicety of history should not be relevant to modern concerns; maybe Darwin was overcautious, and modern ultras therefore out-Darwin Darwin for good reason. But since the modern ultras push their line with an almost theological fervor, and since the views of founding fathers do matter in religion, though supposedly not in science, Darwin's own fierce opposition does become a factor in judgment.) Second, the invigoration of modern evolutionary biology with exciting nonselectionist and nonadaptationist data from the three central

¹ *Darwin's Dangerous Idea: Evolution and the Meanings of Life* (Simon and Schuster, 1995). (back)

² *Reinventing Darwin: The Great Debate at the High Table of Evolutionary Theory* (John Wiley, 1995). (back)

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disciplines of population genetics, developmental biology, and paleontology (see examples below) makes our pre-millennial decade an especially unpropitious time for Darwinian fundamentalism--and seems only to reconfirm Darwin's own eminently sensible pluralism.

Charles Darwin often remarked that his revolutionary work had two distinct aims: first, to demonstrate the fact of evolution (the genealogical connection of all organisms and a history of life regulated by "descent with modification"); second, to advance the theory of natural selection as the most important mechanism of evolution. Darwin triumphed in his first aim (American creationism of the Christian far right notwithstanding). Virtually all thinking people accept the factuality of evolution, and no conclusion in science enjoys better documentation. Darwin also succeeded substantially in his second aim. Natural selection, an immensely powerful idea with radical philosophical implications, is surely a major cause of evolution, as validated in theory and demonstrated by countless experiments. But is natural selection as ubiquitous and effectively exclusive as the ultras propose?

The radicalism of natural selection lies in its power to dethrone some of the deepest and most traditional comforts of Western thought, particularly the notion that nature's benevolence, order, and good design, with humans at a sensible summit of power and excellence, proves the existence of an omnipotent and benevolent creator who loves us most of all (the old-style theological version), or at least that nature has meaningful directions, and that humans fit into a sensible and predictable pattern regulating the totality (the modern and more secular version).

To these beliefs Darwinian natural selection presents the most contrary position imaginable. Only one causal force produces evolutionary change in Darwin's world: the unconscious struggle among individual organisms to promote their own personal reproductive success--nothing else, and nothing higher (no force, for example, works explicitly for the good of species or the harmony of ecosystems). Richard Dawkins would narrow the focus of explanation even one step further--to genes struggling for reproductive success within passive bodies (organisms) under the control of genes--a hyper-Darwinian idea that I regard as a logically flawed and basically foolish caricature of Darwin's genuinely radical intent.

The very phenomena that traditional views cite as proof of benevolence and intentional order--the good design of organisms and the harmony of ecosystems--arise by Darwin's process of natural selection only as side consequences of a singular causal principle of apparently opposite meaning: organisms struggling for themselves alone. (Good design becomes one pathway to reproductive success, while the harmony of ecosystems records a competitive balance among victors.) Darwin's system should be viewed as morally liberating, not cosmically depressing. The answers to moral questions cannot be found in nature's factuality in any case, so why not take the "cold bath" of recognizing nature as nonmoral, and not constructed to match our hopes? After all, life existed on earth for 3.5 billion years before we arrived; why should life's causal ways match our prescriptions for human meaning or decency?

We now reach the technical and practical point that sets the ultra-Darwinian research agenda. Natural selection can be observed directly, but only in the unusual circumstances of controlled experiments in laboratories (on organisms with very short generations such as fruit flies) or within simplified and closely monitored systems in nature. Since evolution, in any substantial sense, takes so much time (more than the entire potential history of human observing!), we cannot, except in special circumstances, watch the process in action, and must therefore try to infer causes from results--the

standard procedure in any historical science, by the way, and not a special impediment facing evolutionists.

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The generally accepted result of natural selection is adaptation--the shaping of an organism's form, function, and behavior to achieve the Darwinian *summum bonum* of enhanced reproductive success. We must therefore study natural selection primarily from its results--that is, by concentrating on the putative adaptations of organisms. If we can interpret all relevant attributes of organisms as adaptations for reproductive success, then we may infer that natural selection has been the cause of evolutionary change. This strategy of research--the so-called adaptationist program--is the heart of Darwinian biology, and the fervent, singular credo of the ultras.

Since the ultras are fundamentalists at heart, and since fundamentalists generally try to stigmatize their opponents by depicting them as apostates from the one true way, may I state for the record that I (along with all other Darwinian pluralists) do not deny either the existence and central importance of adaptation, or the production of adaptation by natural selection. Yes, eyes are for seeing and feet are for moving. And, yes again, I know of no scientific mechanism other than natural selection with the proven power to build structures of such eminently workable design.

But does all the rest of evolution--all the phenomena of organic diversity, embryological architecture, and genetic structure, for example--flow by simple extrapolation from selection's power to create the good design of organisms? Does the force that makes a functional eye also explain why the world houses more than five hundred thousand species of beetles and fewer than fifty species of priapulid worms? Or why most nucleotides--the linked groups of molecules that build DNA and RNA--in multicellular creatures do not code for any enzyme or protein involved in the construction of an organism? Or why ruling

dinosaurs died and subordinate mammals survived to flourish and, along one oddly contingent pathway, to evolve a creature capable of building cities and understanding natural selection?

I do not deny that natural selection has helped us to explain phenomena at scales very distant from individual organisms, from the behavior of an ant colony to the survival of a redwood forest. But selection cannot suffice as a full explanation for many aspects of evolution; for other types and styles of causes become relevant, or even prevalent, in domains both far above and far below the traditional Darwinian locus of the organism. These other causes are not, as the ultras often claim, the product of thinly veiled attempts to smuggle purpose back into biology. These additional principles are as directionless, nonteleological, and materialistic as natural selection itself--but they operate differently from Darwin's central mechanism. In other words, I agree with Darwin that natural selection is "not the exclusive means of modification."

What an odd time to be a fundamentalist about adaptation and natural selection--when each major subdiscipline of evolutionary biology has been discovering other mechanisms as adjuncts to selection's centrality. Population genetics has worked out in theory, and validated in practice, an elegant, mathematical account of the large role that neutral, and therefore nonadaptive, changes play in the evolution of nucleotides, or individual units of DNA programs. Eyes may be adaptations, but most substitutions of one nucleotide for another within populations may not be adaptive.

In the most stunning evolutionary discoveries of our decade, developmental biologists have documented an astonishing "conservation," or close similarity, of basic pathways of development among phyla that have been evolving independently for at least 500 million years, and that seem so different in basic anatomy (insects and vertebrates, for example). The famous homeotic genes of fruit flies--responsible for odd mutations that disturb the order of parts along the main body axis, placing legs, for example, where antennae or mouth parts should be--are also present (and

repeated four times on four separate chromosomes)
in vertebrates, where they function in effectively
the same way.

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The major developmental pathway for eyes is conserved and mediated by the same gene in squids, flies, and vertebrates, though the end products differ substantially (our single-lens eye vs. the multiple facets of insects). The same genes regulate the formation of top and bottom surfaces in insects and vertebrates, though with inverted order--as our back, with the spinal cord running above the gut, is anatomically equivalent to an insect's belly, where the main nerve cords run along the bottom surface, with the gut above.

One could argue, I suppose, that these instances of conservation only record adaptation, unchanged through all of life's vicissitudes because their optimality can't be improved. But most biologists feel that such stability acts primarily as a constraint upon the range and potentiality of adaptation, for if organisms of such different function and ecology must build bodies along the same basic pathways, then limitation of possibilities rather than adaptive honing to perfection becomes a dominant theme in evolution. At a minimum, in explaining evolutionary pathways through time, the constraints imposed by history rise to equal prominence with the immediate advantages of adaptation.

My own field of paleontology has strongly challenged the Darwinian premise that life's major transformations can be explained by adding up, through the immensity of geological time, the successive tiny changes produced generation after generation by natural selection. The extended stability of most species, and the branching off of new species in geological moments (however slow by the irrelevant scale of a human life)--the pattern known as punctuated equilibrium--requires that long-term evolutionary trends be explained as the distinctive success of some species versus others, and not as a gradual accumulation of adaptations generated by organisms within a continuously

evolving population. A trend may be set by high rates of branching in certain species within a larger group. But individual organisms do not branch; only populations do--and the causes of a population's branching can rarely be reduced to the adaptive improvement of its individuals.

The study of mass extinction has also disturbed the ultra-Darwinian consensus. We now know, at least for the terminal Cretaceous event some 65 million years ago that wiped out dinosaurs along with about 50 percent of marine invertebrate species, that some episodes of mass extinction are both truly catastrophic and set off by extraterrestrial impact. The death of some groups (like dinosaurs) in mass extinctions and the survival of others (like mammals), while surely not random, probably bears little relationship to the evolved, adaptive reasons for success of lineages in normal Darwinian times dominated by competition. Perhaps mammals survived (and humans ultimately evolved) because small creatures are more resistant to catastrophic extinction. And perhaps Cretaceous mammals were small primarily because they could not compete successfully in the larger size ranges of dominant dinosaurs. Immediate adaptation may bear no relationship to success over immensely long periods of geological change.

Why then should Darwinian fundamentalism be expressing itself so stridently when most evolutionary biologists have become more pluralistic in the light of these new discoveries and theories? I am no psychologist, but I suppose that the devotees of any superficially attractive cult must dig in when a general threat arises. "That old time religion; it's good enough for me." There is something immensely beguiling about strict adaptationism--the dream of an underpinning simplicity for an enormously complex and various world. If evolution were powered by a single force producing one kind of result, and if life's long and messy history could therefore be explained by extending small and orderly increments of adaptation through the immensity of geological time, then an explanatory simplicity might descend upon evolution's overt richness. Evolution then might become "algorithmic," a surefire logical procedure, as in Daniel Dennett's reverie. But what

is wrong with messy richness, so long as we can
construct an equally rich texture

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of satisfying explanation?

2.

Daniel Dennett's 1995 book, *Darwin's Dangerous Idea*, presents itself as the ultras' philosophical manifesto of pure adaptationism. Dennett explains the strict adaptationist view well enough, but he defends a miserly and blinkered picture of evolution in assuming that all important phenomena can be explained thereby. His limited and superficial book reads like a caricature of a caricature--for if Richard Dawkins has trivialized Darwin's richness by adhering to the strictest form of adaptationist argument in a maximally reductionist mode, then Dennett, as Dawkins's publicist, manages to convert an already vitiated and improbable account into an even more simplistic and uncompromising doctrine. If history, as often noted, replays grandeurs as farces, and if T.H. Huxley truly acted as "Darwin's bulldog," then it is hard to resist thinking of Dennett, in this book, as "Dawkins's lapdog."

Dennett bases his argument on three images or metaphors, all sharing the common error of assuming that conventional natural selection, working in the adaptationist mode, can account for all evolution by extension--so that the entire history of life becomes one grand solution to problems in design. "Biology is engineering," Dennett tells us again and again. In a devastating review, published in the leading professional journal *Evolution*, and titled "Dennett's Dangerous Idea," H. Allen Orr notes:

His review of attempts by biologists to circumscribe the role of natural selection borders on a zealous defense

of panselectionism. It is also absurdly unfair.... Dennett fundamentally misunderstands biologists' worries about adaptationism. Evolutionists are essentially unanimous that--where there is "intelligent Design"--it is caused by natural selection.... Our problem is that, in many adaptive stories, the protagonist does not show dead-obvious signs of Design.

In his first metaphor, Dennett describes Darwin's dangerous idea of natural selection as a "universal acid"--to honor both its ubiquity and its power to corrode traditional Western beliefs. Speaking of adaptation, natural selection's main consequence, Dennett writes: "It plays a crucial role in the analysis of every biological event at every scale from the creation of the first self-replicating macromolecule on up." I certainly accept the acidic designation--for the power and influence of the idea of natural selection does lie in its radical philosophical content--but few biologists would defend the blithe claim for ubiquity. If Dennett chooses to restrict his personal interest to the engineering side of biology--the part that natural selection does construct--then he is welcome to do so. But he may not impose this limitation upon others, who know that the record of life contains many more evolutionary things than are dreamt of in Dennett's philosophy.

Natural selection does not explain why many evolutionary transitions from one nucleotide to another are neutral, and therefore nonadaptive. Natural selection does not explain why a meteor crashed into the earth 65 million years ago, setting in motion the extinction of half the world's species. As Orr points out, Dennett's disabling parochialism lies most clearly exposed in his failure to discuss the neutral theory of molecular evolution, or even to mention the name of its founder, the great Japanese geneticist Motoo Kimura--for few evolutionary biologists would deny that this theory ranks among the most interesting and powerful adjuncts to evolutionary explanation since Darwin's formulation of natural selection. You don't have to like the idea, but how can you possibly leave it out?

In a second metaphor, Dennett continually invokes

an image of cranes and skyhooks. In his reductionist account of evolution, cranes build the good design of organisms upward from nature's physicochemical substrate. Cranes are good. Natural selection is evolution's basic crane; all other cranes (sexual reproduction, for example) act as mere auxiliaries to boost the speed or power of natural selection in constructing

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organisms of good design. Skyhooks, on the other hand, are spurious forms of special pleading that reach down from the numinous heavens and try to build organic complexity with *ad hoc* fallacies and speculations unlinked to other proven causes. Skyhooks, of course, are bad. Everything that isn't natural selection, or an aid to the operation of natural selection, is a skyhook.

If you think that I am being simplistic or unfair to Dennett in this characterization, read his book and see if you can detect anything more substantial in this metaphor. I could only find a rhetorical stick for beating pluralists into line. Can't Dennett see that a third (and correct) option exists to his oddly dichotomous Hobson's choice: either accept the idea of one basic crane with auxiliaries, or believe in skyhooks. May I suggest that the platform of evolutionary explanation houses an assortment of basic cranes, all helping to build the edifice of life's history in its full grandeur (not only the architecture of well-engineered organisms). Natural selection may be the biggest crane with the largest set of auxiliaries, but Kimura's theory of neutralism is also a crane; so is punctuated equilibrium; so is the channelling of evolutionary change by developmental constraints. "In my father's house are many mansions"--and you need a lot of cranes to build something so splendid and variegated.

For his third metaphor--though he would demur and falsely label the claim as a fundamental statement about causes--Dennett describes evolution as an "algorithmic process." Algorithms are abstract rules of calculation, and fully general in making no reference to particular content. In Dennett's words: "An algorithm is a certain sort of formal process that can be counted on--logically--to yield a certain sort of result whenever it is 'run' or

instantiated." If evolution truly works by an algorithm, then all else in Dennett's simplistic system follows: we need only one kind of crane to supply the universal acid.

I am perfectly happy to allow--indeed I do not see how anyone could deny--that natural selection, operating by its bare-bones mechanics, is algorithmic: variation proposes and selection disposes. So if natural selection builds all of evolution, without the interposition of auxiliary processes or intermediary complexities, then I suppose that evolution is algorithmic too. But--and here we encounter Dennett's disabling error once again--evolution includes so much more than natural selection that it cannot be algorithmic in Dennett's simple calculational sense.

Yet Dennett yearns to subsume all the phenomenology of nature under the limited aegis of adaptation as an algorithmic result of natural selection. He writes: "Here, then, is Darwin's dangerous idea: the algorithmic level *is* the level that best accounts for the speed of the antelope, the wing of the eagle, the shape of the orchid, the diversity of species, and all the other occasions for wonder in the world of nature" (Dennett's italics). I will grant the antelope's run, the eagle's wing, and much of the orchid's shape--for these are adaptations, produced by natural selection, and therefore legitimately in the algorithmic domain. But can Dennett really believe his own imperialistic extensions? Is the diversity of species no more than a calculational consequence of natural selection? Can anyone really believe, beyond the hype of rhetoric, that "*all* the other occasions for wonder in the world of nature" flow from adaptation?

Perhaps Dennett only gets excited when he can observe adaptive design, the legitimate algorithmic domain; but such an attitude surely represents a blinkered view of nature's potential interest. I regard the neutral substitution of nucleotides as an "occasion for wonder in the world of nature." And I marvel at the probability that the impact of a meteor wiped out dinosaurs and gave mammals a chance. If this contingent event had not occurred, and imparted a distinctive pattern to the evolution of life, we would not be here to wonder about anything at all!

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"Straight is the gate, and narrow is the way." Fundamentalists of all stripes live by this venerable motto, and must therefore wield their unsleeping swords in constant mental fight against contrary opinions of apostates and opponents (who usually make up a sizable majority--for, as Jesus also noted, "Wide is the gate, and broad is the way, that leadeth to destruction"). The favored fate for the nonelect varies, according to the temperament and power of true believers, from the kindness of simple pity to the refiner's fire of extirpation. But the basic ideological weapon of fundamentalism rarely departs much from the tried and true techniques of anathematization.

Unfortunately, at least for the ideals of intellectual discourse, anathematization rarely follows the dictates of logic or evidence, and nearly always scores distressingly high in heat/light ratio. Anathema also requires an anathemee--and I seem to have been elected. (Whatever my professional contributions to proper Darwinian pluralism, I stand convicted, I suggest, primarily for my efforts to bring the full scope of technical debate, with all its complexities and messiness, but without loss of substance, to general readers.)

Personal attack generally deserves silence by way of response. But as two old troupers (Noam Chomsky and Salvador Luria) once advised me in my only comparable earlier incident, an exception must be made in one and only one circumstance: when denigrators float a demonstrably false charge that, if unanswered, may acquire a "life of its own." A false fact can be refuted, a false argument exposed; but how can one respond to a purely *ad hominem* attack? This harder, and altogether more discouraging, task may best be

achieved by exposing internal inconsistency and unfairness of rhetoric.

John Maynard Smith, Emeritus Professor at Sussex and dean of British ultra-Darwinians, reviewed Dennett's book in this publication--thus providing small prospect for critical commentary. Maynard Smith began his supposed analysis of ultraDarwinian criticism with the following gratuitous remark:

Gould occupies a rather curious position, particularly on his side of the Atlantic. Because of the excellence of his essays, he has come to be seen by non-biologists as the preeminent evolutionary theorist. In contrast, the evolutionary biologists with whom I have discussed his work tend to see him as a man whose ideas are so confused as to be hardly worth bothering with, but as one who should not be publicly criticized because he is at least on our side against the creationists.³

It seems futile to reply to an attack so empty of content, and based only on comments by anonymous critics; if they were named, they would, I suspect, turn out to be a very small circle of true believers. And if I may beg the editor's indulgence for one emotional outburst, may I say, at least, that I resent Maynard Smith's pompous offer of grudging acceptance for my utility in fighting creationism. I did not do so to win entry into his circle of genuine professionals (for I think that we both hold honored union cards therein), but rather as a member of the larger scientific community, and as a small contribution to the continual struggle of people who cherish rationality. We will not win this most important of all battles if we descend to the same tactics of backbiting and anathematization that characterize our true opponents.

Instead of responding to Maynard Smith's attack against my integrity and scholarship, citing people unknown and with arguments unmentioned, let me, instead, merely remind him of the blatant

inconsistency between his admirable past and lamentable present. Some sixteen years ago he wrote a highly critical but wonderfully supportive review of my early book of essays, *The Panda's Thumb*, stating: "I hope it will be obvious that my wish to argue with Gould is a compliment, not a criticism."⁴ He then attended my series of Tanner Lectures at Cambridge in 1984 and wrote in a report for *Nature*, and under the remarkable title "Paleontology at the High Table," the kindest

³ *The New York Review*, November 30, 1995. (back)

⁴ *London Review of Books*, September 17-30, 1981. (back)

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and most supportive critical commentary I have ever received. He argued that the work of a small group of American paleobiologists had brought the entire subject back to theoretical centrality within the evolutionary sciences.

The attitude of population geneticists to any palaeontologist rash enough to offer a contribution to evolutionary theory has been to tell him to go away and find another fossil, and not to bother the grownups.

In the last ten years, however, this situation has changed by the work of a group of palaeontologists, of whom Gould has been a leading figure.

He ended the article with a quintessential Oxbridge metaphor: "The Tanner lectures were an entertaining and stimulating occasion. The palaeontologists have too long been missing from the high table. Welcome back."

Maynard Smith then republished both papers (along with two others that cast my work in the central role of a section entitled "Did Darwin Get it Right?") in his 1988 volume of essays, *Did Darwin Get it Right? Essays on Games, Sex and Evolution*. Most remarkably of all, he then reviewed two books on dinosaurs for this journal and devoted more than half his space (much to the distress, I am sure, of the authors of the books supposedly under review) to a trenchant critique of my views on adaptation. He began by writing: "When, as often happens, I find myself dissenting from something written by Stephen Jay Gould, I remind myself that we share a common childhood experience. We were both dinosaur nuts." And he ended with an apology: "I fear that what started out as a review of two books about dinosaurs has

wandered off into a discussion of the functional and adaptationist approaches to anatomy."⁵

So we face the enigma of a man who has written numerous articles, amounting to tens of thousands of words, about my work--always strongly and incisively critical, always richly informed (and always, I might add, enormously appreciated by me). But now Maynard Smith needs to canvass unnamed colleagues to find out that my ideas are "hardly worth bothering with." He really ought to be asking himself why he has been bothering about my work so intensely, and for so many years. Why this dramatic change? Has he been caught up in apocalyptic ultra-Darwinian fervor? I am, in any case, saddened that his once genuinely impressive critical abilities seem to have become submerged within the simplistic dogmatism epitomized by Darwin's Dangerous Idea, a dogmatism that threatens to compromise the true complexity, subtlety (and beauty) of evolutionary theory and the explanation of life's history. I shall examine this Darwinian fundamentalism further in a second, and concluding, article in the next issue.

⁵ *The New York Review*, April 25, 1991. (back)

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