

The facts of evolution: fighting the Endarkenment

Those of us who practice experimental science are living in the best of times and the worst of times, and I'm not talking about *A Tale of Two Cities*, but a tale of two cultures. The prospects for each day in science have never been more splendid, while our larger culture seems caught in a slough of despond. In the last half century, we've landed on the moon, sampled Mars, and deciphered the human genome. Our new technology permits us to clone genes on chips and dial China from the Palm® in our hand. The biological revolution has cracked new diseases as they arose (Lyme, HIV, SARS) and blunted the hurt of the old (cancer, cardiovascular disease, inflammation). We've doubled the longevity of fruit flies and roundworms in the lab and increased human life span in the developed world by a decade and a half.

Meanwhile, much of society at large is beating a hasty retreat to the dark ages: the wars of religion are back, superstition threatens our schools and Bible-thumpers preach that Darwin got it wrong. Our heritage of reason, formed in the Enlightenment, is becoming eclipsed by what a cynic might call the Endarkenment. It's no trivial matter when the editor of *Science*, Donald Kennedy, asks us whether it's "Twilight for the Enlightenment (1)"? Last year, for example, Gallup reported that 45% percent of Americans believe that God created human beings like us ~10,000 years ago. Indeed, less than a third of Americans believe that Darwin's theory is supported by scientific evidence, and just as many believe that evolution is just one of several, equally valid theories. A third of Americans believe that the Judeo-Christian Bible is the word of God to be taken literally, word for word (2).

For over a century in the lands of the West, the forces of faith and fact have largely observed an uneasy truce. Natural scientists were expected to steer clear of moral or religious matters, the clergy (save in the American South) were not expected to contradict the findings of Galileo or Darwin. But in our dangerous decade, the battle lines have formed again and this time they've been drawn around the globe. The trend—from Mississippi to Kabul to Jakarta and Jerusalem—is a return to revealed orthodoxy. Galileo may have been pardoned by his church, common descent accepted by a

saintly pope, but the ancient tide of animist belief is rising again. We could have seen it coming. Fresh from the heady insights of the biological revolution, Jacques Monod warned us in his magisterial *Chance and Necessity* (1971) that

Modern societies accepted the treasures and the power offered them by science. But they have not accepted—they have scarcely even heard—its profounder message: . . . a complete break with the animist tradition, the definitive abandonment of the 'old covenant,' the necessity of forging a new one. Armed with all the powers, enjoying all the riches they owe to science, our societies are still trying to live by and to teach systems of values already blasted at the root by science itself (3).

Nowadays, in thrall to constituencies of unreason, zealots of all stripes are chipping away at evolutionary science. In our own country, "creationism" and "intelligent design" are now considered suitable topics for instruction in science, as if these notions were as testable as the perfect gas laws of Boyle ($pV=nRT$) or the Hardy-Weinberg equation ($p^2+2pq+q^2=1$) of population genetics. In the new spirit of Endarkenment, we ought not to be surprised that the Bishop of Vienna warned us against Jacques Monod:

Scientific theories that try to explain away the appearance of design as the result of "chance and necessity" are not scientific at all, but, as John Paul put it, an abdication of human intelligence (4).

Since the "abdication of human intelligence" might be defined as stupidity, it's clear to me that the truce has been shattered. Sad to say, it's possible that modern science may be at the stage of the arts in quattrocento Florence, when poets and painters broke the mold of monkish severity in outbursts of wanton beauty. Savonarola responded by first scorning their intelligence and then burning their work. Schonhorn and the censors are gathering in the piazza.

So, for prelates and presidents, let's spell out the *facts* of evolution ever since Darwin: the facts of common descent and natural selection. Most scientists agree that evolution is no more a "theory" (in the popular sense) than is gravity. Evolution is based on a collection of

facts that—like gravity—challenge Biblical notions of the nature of the universe and our very selves. The National Academy report on “Evolution and Creationism” reminds us that “In science, theories do not turn into facts through the accumulation of evidence. Rather, theories are the end points of science” (5).

The “theory” of evolution is based on six sets of facts that contradict any number of scriptures, and these facts alone should dictate what is taught as science in our schools:

1. The earth is ~4 billion years old (6).
2. 5.7 million years ago we descended from an ancestor we share with chimpanzees (7).
3. *Homo erectus* (our immediate ancestor) is anywhere from 1.8 to 0.3 million years old and people more or less like us (*homo sapiens sapiens*) arose in Africa 100,000 years ago (8). The fossil evidence for these observations has been validated by newer techniques of molecular biology, capped by the human genome project (5).
4. Natural selection of random mutants (in portions of the genome that may or not be “hot spots”) accounts for the emergence of new strains of viruses (influenza, HIV), microbes, and tumors. Natural selection and survival of the fittest has been demonstrated for the resistance to antibiotics of bacteria, to herbicides of plants, and to chemotherapy of tumor cells (5).
5. Natural selection is the basis of immunity (9).
6. Natural selection and survival of the fittest has been observed in humans as well. Ever since Rochelle Hirschhorn first described reversion to normal (both in DNA and clinical health) of a child with inherited adenosine deaminase deficiency (10), reversion to normal via somatic mosaicism has been shown in several disorders in which the revertant cells have a selective advantage (11).

These facts of life science, directed by the physics and chemistry of DNA, turn out to obey laws as universal as those of Boyle’s perfect gas. Just as $pV = nRT$ describes the behavior of gases in a rocket to the moon or an RPG in Fallujah; the ratios of G:C and A:T are equal in the DNA of fly and earthworm, mouse and microbe, prelate and president. The clock that sets the time to copy DNA was figured out in quahogs; the truth of molecular evolution is that we are such stuff as clams are made of (12).

It would be reassuring for many of us were the lessons of Darwinian evolution simply a collection of tall stories

we could take or leave at will—a tale of comfort or terror, of promise or warning, but tales after all of the mind, texts without bite. Marianne Moore described the world of poetry as composed of imaginary gardens with real toads in them. Well, I’m afraid that the facts of evolution are those of *real* gardens with real toads in them. They are not the baubles of one race, one gender, one class, or one Reich. They have been worked out by the buzzing of eager minds despite complaints by the pious, the zealous and the herbally inspired. Yes, of course, evolutionary theory may be only one explanation for life on our planet, but it’s the only theory that has held up against disproof. And however much we think we know of evolution today, it must be a minute fraction of what remains to be discovered tomorrow. Finally, I’d argue that the facts of evolution impose a kind of necessity on the chance of our imagination, they cut short many a tall tale. Experimental science is our defense—perhaps our best defense—against humbug and the Endarkenment. **[FJ]**

Gerald Weissmann
Editor-in-Chief
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