

I Scientists and Their Hecklers

I.1 DARWIN PRESENTS HIS THEORY

Charles Darwin presented his theory of evolution in his book *On the Origin of Species*, published in 1859. In so doing, he transformed biology from a scientific backwater to a fully professional science. Prior to Darwin, biology was little more than the art of catching an animal, killing it, cutting it open, and then writing detailed descriptions of what you saw. Alternatively, some biologists concerned themselves with classifying organisms according to whatever arbitrary characteristics had their attention that week. Valuable work, no doubt, but hardly a science. *Real* science involved abstract theorizing, mathematical modeling, and predictive power to several places past the decimal point. Or so went the stereotype, at any rate.

That all changed with Darwin. By marshaling evidence from classification, biogeography, embryology, and comparative anatomy, he established, to the satisfaction of most scientists, that organisms shared a far greater degree of relatedness than had previously been appreciated. He also provided a possible mechanism to explain how populations of organisms gradually became better adapted to their environments – the process of natural selection. He anticipated, and provided cogent replies to, numerous theoretical objections to his ideas. Biology now had a bona fide theory from which to work, one which could be tested against data and which suggested fruitful directions for further research.

The ensuing 162 years (keeping in mind that I am writing this in early 2021) led to one success after another for evolution. Realizing that a thorough understanding of heredity was necessary for assessing the theory, scientists undertook a program of research that

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eventually led to the modern science of genetics. In the 1920s and 1930s, mathematical models were developed to help understand gene flow and other evolutionary processes, thereby showing that natural selection was not just possible but also plausible as a mechanism for large-scale evolution. In the 1940s, developments in paleontology, genetics, physiology, zoology, and botany were united into the so-called modern synthesis, showing that the data from every branch of the life sciences seemed to converge on evolution, with natural selection as its primary mechanism. Subsequent developments in molecular biology, and technological developments that made possible new research directions in genetics, provided lines of evidence for evolution undreamed of by Darwin or his immediate successors. The more that was learned about biology, the more evolution came to seem obvious.

Evolutionary thinking soon led to progress in other branches of science. Ecologists realized that evolution was essential to understanding the temporal and spatial distribution of species. Medical researchers came to use evolutionary thinking to understand the process of antibiotic resistance in bacteria, to investigate the origins of genetic disorders, and to devise effective treatments against a host of ailments. Computer scientists used genetic algorithms to solve problems in engineering, meaning they explored large spaces of possibilities by mimicking the process of evolution by natural selection.

Today, evolutionary theory retains pride of place in biological thinking. Modern evolutionary biology includes a large role for Darwin's main ideas, in the sense that the common descent of all modern organisms is considered to be beyond dispute and natural selection is still considered to be an especially important mechanism of evolution. But the subject has also been enriched by many ideas that go well beyond anything Darwin considered. Research into evolution seems to generate novel ideas faster than they can be assessed and assimilated. The field is marked by ferment over details coupled with confidence in the fundamentals.

However, there are today, and always have been, others who are unimpressed by this long track record of success. For as long as biologists have been studying the processes of biological evolution, there have been critics heckling them from the sidelines. The critics claim that evolution is only weakly supported by the available evidence, to the extent that it is supported at all. They claim that evolution has represented a tragic wrong turn in the history of ideas, and that it must be replaced, or at least heavily supplemented, with the idea that an intelligent designer is in some way manipulating the process. In their more florid moments, they claim that evolution is a flatly ridiculous theory, that nothing more than common sense and a high school education is sufficient to see this, and that scientists are blind to this reality because of morbid anti-religious bias.

They make many arguments in support of this view. Some of those arguments rely heavily on mathematics. This book explains why those mathematical arguments are wrong.

I.2 WHO ARE THE HECKLERS?

In the United States in the twenty-first century, there are two main schools of anti-evolutionist thought: Young-Earth Creationism (YEC) and Intelligent Design (ID). You can certainly identify other schools and draw subtle distinctions among their various religious commitments, but the fact remains that YEC and ID all but monopolize the discourse.

YEC holds that Earth was created no more than 10,000 years ago. (Relative to the more standard scientific estimate of roughly four and a half billion years, this constitutes a young Earth.) YEC also claims that modern species were created in essentially their present form. Moreover, it claims that species can be grouped together into distinct “kinds,” and that while small amounts of evolutionary change within a kind are possible, more significant change between kinds is not. The basic facts of geology and paleontology, they go on to argue, are best explained by reference to a global deluge a few 1,000 years ago. Critically, they claim that while these ideas are certainly

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consonant with what is presented in the early chapters of the biblical book of Genesis, they are nonetheless also supported by our best current understanding of the scientific data.

ID is far more modest. It claims only that natural selection is insufficient to explain certain aspects of modern organisms and that therefore modern evolutionary theory is fundamentally flawed. Proponents of ID also claim they can prove that even in principle no naturalistic mechanism can fully explain the interlocking complexity of modern organisms and that a satisfactory explanation can only be found by appealing to some sort of action on the part of an unspecified intelligent designer. They take no stand on the age of Earth, though most of ID's leading representatives accept that Earth is older than the biblical chronologies suggest. They also have nothing much to say about the identity, abilities, and motivations of the designer, nor do they tell us what the designer actually did. There is really little more to their scientific theorizing than the assertion that an intelligent designer of unspecified motives and abilities did something at some point in natural history.

There are cultural differences between the two groups. Proponents of YEC generally endorse the anti-evolution arguments presented by proponents of ID, but they also find that ID does little to promote religious evangelism. They argue that vague references to an unspecified designer do nothing to win souls for Christ and that this is a serious shortcoming of ID. While they are adamant that their views can be defended entirely on scientific grounds, they also make no secret of their religious motivations.

On the other side, proponents of ID are mostly contemptuous of YEC. They find that YEC literature is generally of such low quality that it brings disrepute to the whole project of anti-evolutionism. The leading proponents of ID are better credentialed than their counterparts in YEC, and they express themselves with far more scientific sophistication than most proponents of YEC can muster.

These differences are real and important. Nonetheless, the proper analogy for the relationship of YEC to ID is that of different

dialects of the same language. Both are religiously motivated attacks on evolution, and both camps see the evolution/creation dispute as one front in a larger culture war. While ID proponents are more skillful at deploying scientific jargon, the arguments presented by the two camps are essentially the same.

This leads us to the most important similarity of them all: scientists are all but unanimous in finding both ID and YEC arguments to be entirely fallacious. In most cases, scientists do not even find the arguments interesting or thought provoking. They just find them to be wrong for crass and obvious reasons.

While ID and YEC both have considerable cultural cachet, we will be spending far more time discussing the arguments of the former than the latter. Our interest in this book is solely in the merits of their mathematical arguments as applied to evolution, so we will not give any further consideration to the cultural milieu in which these arguments are presented. The arguments stand or fall on their own merits, independent of any unsavory motivations underlying them.

That acknowledged, it is pointless to deny that certain overly-conservative interpretations of religion are at the foundation of modern anti-evolutionism. And since we are going to conclude that the anti-evolutionist's mathematical arguments are very poor, it is reasonable to keep their unscientific motivations in mind as we consider them.

I.3 BAD MATH CAN BE RHETORICALLY EFFECTIVE

My introduction to anti-evolutionism came a little over 20 years ago when I was a graduate student studying mathematics at Dartmouth College. While I was there, the student newspaper published an opinion piece by a creationist student. In part because I was looking for a distraction from my thesis research, which was not going well at that time, I used it as an opportunity to learn more about the evolution/creation dispute.

Initially, I did not have a strong opinion on this issue one way or the other. I have never been especially religious, and I certainly

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was not inclined to treat the book of Genesis as a literal, historical account. However, I was open to the possibility that biologists, precisely because they were so often attacked by religious demagogues, had overreacted by exaggerating the strength of their case.

Figuring that I at least knew the basics of evolutionary biology, I started by working my way through a stack of creationist books and articles. What I found was a bewildering array of arguments drawn from numerous branches of science. Creationist authors discussed fossils in one chapter, then genetics in the next, then anatomy, then physics, and on and on. Never having made a serious study of these fields up to that time, I often did not have cogent replies at my fingertips. Still, I was skeptical of the sheer magnitude of their accusations and the extreme simplicity of their arguments. People study for years to become experts in any one of those disciplines, but here was a creationist author with no particular credentials telling me that the professionals in almost every branch of science were just foolish and incompetent. I was expected to believe that the professionals had simply overlooked things that would have been obvious to a bright high school student. That seemed unlikely.

The near-unanimous scientific consensus in support of evolution has held up for well over a century. Now, it is certainly true that entrenched ideas can become so ossified and unquestioned that rival theories find it difficult to get a fair hearing. Just as with every other human enterprise, professional science sometimes confronts its practitioners with social or political pressure to conform to the dominant paradigm. For these reasons, I would never consider the mere fact of consensus to be proof that the theory is correct.

However, I do think a long-standing consensus in support of a theory counts for *something*. To me it suggests that while the theory might be wrong, it is not going to turn out to be crazy. We can always imagine some future discovery that forces us to rethink fundamental ideas, but it is hard to imagine that a well-supported theory will suddenly collapse because a talented amateur notices a conceptual

error at the heart of the entire enterprise. If you possess any skeptical impulses at all, then claims of that sort really ought to trigger them.

This skepticism was justified for me by the abuse of mathematics in creationist discourse. Their arguments frequently used probability theory, and they often carried out specific calculations meant to convince me that evolution had been refuted. (We will discuss arguments of this sort in Section 5.5.) The fine points of paleontology and biology might have been beyond me at that time, but I certainly knew a bad probability argument when I saw one. To be clear, I am not speaking now of subtle errors. I am not saying they raised interesting questions, but had overlooked some difficult, technical point. I am talking instead of errors that betrayed an utter incomprehension of the subject.

I reasoned that if creationists were *that* wrong when discussing topics with which I was very familiar, what confidence could I have that their arguments in other branches of science were any more cogent? As I delved into the responses to creationists provided by scientists and philosophers, and more importantly as I had the chance to discuss these questions in person with the relevant professionals, it became clear that I was right to be very skeptical.

I finished graduate school in 2000 and accepted a postdoctoral position (academic speak for an internship) at Kansas State University. A significant portion of my job involved issues in public education, specifically related to the training of mathematics teachers. At that time, Kansas was the focus of national controversy because a politically conservative state school board had voted to eliminate all mention of evolution in the state's standards for science teachers. This put the evolution/creation issue back on my radar, and when I subsequently learned of a large creationist conference taking place near to my home, I decided to attend.

Over the next 8 years or so, both in Kansas and later when I moved to the western part of Virginia, I attended a great many gatherings related to anti-evolutionism. Some were large conferences

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like the one I attended in Kansas, and others were small, one-day gatherings in local churches. Some of these meetings were devoted to YEC, while others were about ID. Regardless, mathematical arguments were prominent at both. The reactions of the conference goers led me to the conclusion in the title of this section.

For example, at one major creationist conference, I was in the audience for a keynote talk devoted to the branch of mathematics known as “information theory.” There were roughly two thousand people in the audience. The speaker went on for close to an hour about how insights from this field could be used to refute evolution and to support creationism. When the talk ended, the audience erupted into a standing ovation. The host of the conference session said, in awe-struck tones, that this was one of the most powerful apologetic arguments he had ever heard. My reaction was considerably more critical. Apparently, where I had seen an absurd caricature of a major branch of mathematics, the audience had seen mathematical support for their religious convictions. (We will look at arguments of this sort in Chapter 6.)

Another time, at a conference promoting ID, I was in a small breakout session of about twenty people. The speaker presented a probability calculation of the sort to which I referred a few paragraphs ago. The result of the calculation was a very small number, and the speaker breathlessly informed the audience that this showed that evolution required us to believe that something extremely improbable, if not flatly impossible, had occurred. At the end of the talk, an audience member said, with a facial expression that suggested the utmost seriousness, “When scientists are confronted with a number that small,” and here he paused for dramatic effect, “what else can they do but just stare at it helplessly?” Many of the other audience members offered vigorous nods in response. When it was my turn to speak, I suggested that an alternative to staring helplessly was to question the assumptions underlying the calculation, and I pointed to several ways that those assumptions were hopelessly unrealistic. The audience was not amused.

I could provide many further anecdotes of this sort. Mathematics is unique in its ability to bamboozle a lay audience, making it well suited to the cynical machinations of anti-evolutionist speakers and authors. As a mathematician, I take some offense at that. In large measure, that is why I decided to write this book.

I.4 DOES EVOLUTION HAVE A MATH PROBLEM?

Though Darwin was largely successful at persuading scientists of the fact of common descent, he also faced formidable critics. In the later decades of the nineteenth century, it was still possible to be a scientifically informed skeptic of evolution, especially of the idea that natural selection was a plausible mechanism for large-scale change. First-rate scientists like Louis Agassiz and St. George Mivart placed themselves in opposition to Darwin's ideas, and their arguments could hardly be dismissed as the ignorant ravings of religious demagogues. For his part, Darwin offered forceful replies to the critics, and the debate petered out to something of a draw. Darwin presented a strong case for common descent and a decent plausibility argument for natural selection, but there were numerous gaps that could only be filled by further research.

By the early twentieth century, the debate landscape had changed in at least two ways. Scientifically, the case for evolution only became stronger. Paleontologists found numerous transitional fossils that made it easier to accept the possibility of large-scale transmutation in the course of natural history. Advances in the study of heredity showed that the proposed rivals of natural selection were not workable, and mathematical modeling established that selection could be a more powerful force than had been previously understood. These and other research findings were all consistent with the main ideas of evolutionary theory, and this made it harder to be an informed critic.

Meanwhile, evolution had made the jump from an esoteric theory of interest primarily to professional scientists to an idea that pervaded the culture more generally. The theory made its way into

public school curricula, and religious fundamentalists saw this as nothing less than an attack on the souls of their children.

These two shifts – the growing strength of the scientific case for evolution coupled with its increased cultural presence – led to a dramatic decline in the quality of anti-evolutionist discourse. Where once the critics could boast of giants like Agassiz and Mivart, now their most visible advocates were amateur scientists like George McCready Price and politicians like William Jennings Bryan. Cogent scientific arguments against evolution became more difficult to find, but imprecations against godless scientists and creeping materialism were commonplace. This sort of advocacy came to a head in the events of the Scopes “monkey” trial in Tennessee in 1925. Culturally, the legacy of the trial was that anti-evolutionism became all but synonymous with an especially obscurantist form of religion.

As representative of the poor state of their argumentation, let us consider a small book by William A. Williams called, *The Evolution of Man Scientifically Disproved, in 50 Arguments*, the final version of which was published in 1928. Williams was a Presbyterian clergyman, and he placed mathematical arguments front and center in his argumentation. He writes,

Every theory to which mathematics can be applied will be proved or disproved by this acid test. Figures will not lie, and mathematics will not lie even at the demand of liars. Their testimony is as clear as the mind of God. ... The evolution theory, especially as applied to man, likewise is disproved by mathematics. The proof is overwhelming and decisive. Thus God makes the noble science of mathematics bear testimony in favor of the true theories and against the false theories.

(Williams 1928, 3–4)

Williams helpfully numbered and labeled his arguments, so let us see two examples of what he regarded as overwhelming and decisive proofs.

Argument 1 is called “The Population of the World.” The thrust of the argument is that the human population is too small, if we