Reports of the National Center for Science Education

Reports of the National Center for Science Education is published by NCSE to promote the understanding of evolutionary sciences, of climate sciences, and of science as a way of knowing.

Vol 32, No 5 (2012)

Spicebush Swallowtail butterfly (*Papilio troilus*). Photograph: David DesRochers, Dalton State College.

ISSN: 2159-9270

Table of Contents

Features

The Butterfly Effect 3
Minda Berbeco

A Thrilling Chase: Nick Lane's *Life Ascending* 6
Jere H Lipps

Sue Hicks (1895 – 1980) 13
Randy Moore

Reviews

Among the Creationists • Jason Rosenhouse 15
Taner Edis

Seeking God in Science • Bradley Monton 18
Matthew H Haber

American Genesis • Jeffrey P Moran 22
Adam Laats

Evolution and Religion in American Education • David E Long 25
Steve Watkins

Darwinism and the Divine • Alister E McGrath 28
Bruce H Weber

Evolution and Creationism • Warren D Allmon 31
Robert "Mac" West

ISSN: 2159-9270

REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

Published bimonthly by the National Center for Science Education

REPORTS.NCSE.COM
ISSN 2159-9270

FEATURE

The Butterfly Effect

Minda Berbeco

In 2010, University of California, Davis professor Arthur Shapiro wrote a startling article for the *News of the Lepidopterists' Society*. He revealed that as a "butterfly guru", he had always "pooh-poohed" the notion that butterflies were disappearing, noting that populations will decline in response to disruptive factors such as development, but some losses were reversible.

"I regarded such losses as regrettable, but inevitable," he wrote in the article, but then went on to confess, "Now I know better. I don't think butterflies are in trouble. I know it" (Shapiro 2010).

When Shapiro started collecting data on butterflies in northern California over 40 years ago, he had no idea how important his surveys would be today.

"I guess I was ahead of my time when setting this thing up back when I did," Shapiro said in a recent interview.

He originally devised a five-year butterfly monitoring study over a transect running over 120 miles from the San Francisco Bay all the way up to the Sierra Mountains in northern California. Butterflies in particular are ideal subjects for studying environmental effects on biological organisms over large regions due to their prevalence, distribution, and size.

As it happened, the data ended up being extremely interesting, and after Shapiro received tenure he decided to keep his data collection going.

"I ended up some thirty years later sitting on a huge mountain of data with no precedent in North America."

This work resulted in a study published in *Proceedings of the National Academy of Sciences* in which he and his colleagues found profound impacts of both climate and land-use change on butterflies in Northern California (Forister and others 2010).

Shapiro and his colleagues expected that all butterfly species would move up in elevation in response to warming temperatures to seek a more suitable climate. They found, though, that habitat loss in the lower elevations reduced the population of ruderal ("weedy" or non-specialist) butterflies, which resulted in fewer of these butterflies being available to move up in elevation. Meanwhile, the nonruderal species (the specialists) living in the undisturbed mid-elevation range were able to move upslope in response to climate, as predicted.

Northern California is not the only place where these shifts in butterfly species are being observed. "We have lots of studies pointing in the same direction," Shapiro said, with stud-

ies from Massachusetts to Britain demonstrating similar species movement in response to climate change (Breed and others 2012; Franco and others 2006).

Shapiro quipped that "if I could come back in 300 years, the butterfly fauna of the central valley might look sort of like the butterfly fauna of San Diego," where the average annual temperature is approximately 4°F warmer.

Though all of this spells calamity for species responding to the combined pressures of habitat destruction and climate change, Shapiro says that it is not all bad news. "We are losing things, and depending on the availability of necessary resources, like host plants, we are gaining things."

Shapiro points to the example of the Gulf Fritillary, a non-native subtropical species whose larvae feed exclusively on passion flowers, an ornamental garden plant. In the past, cold winters have kept this animal from establishing itself in northern California, but recent warm winters have allowed this butterfly to survive and spread across the Sacramento region. "If the warming trend means we are less likely to have extreme freeze conditions, maybe [this butterfly species] will persist longer."

Overall, though, Shapiro reports finding a net loss of species at most of his sites, with such a large population crash at his lowest elevation sites that he has been able to start individual animal counts, instead of just recording species richness.

"Removal of butterflies is extremely sad for people," Shapiro said. "It has aesthetic and perhaps moral resonance."

More importantly, though, this type of research demonstrates how humans are a force of nature, altering both the landscape and climate. Shapiro's study is part of a growing body of research demonstrating human impacts on both climate and biological systems.

"If we are interested in conservation," Shapiro said, "we have to try to understand what the forces are that put species … in peril. By teasing out the factors most likely to account for the trends we observed, we hope to gain insight into the processes that work so we can take action."

Shapiro's research demonstrates that anthropogenic climate change and habitat loss have started to transform our natural world. As more data continue to demonstrate these trends, the arguments for action will become undeniable.

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About the author

Minda Berbeco received her PhD in biology from Tufts University in 2011 specializing in the effects of climate change on terrestrial systems. She joined NCSE in the fall of 2012 as a Programs and Policy Director in NCSE's new global climate change program.

Author's address

Minda Berbeco
NCSE
PO Box 9477
Berkeley CA 94709-0477
berbeco@ncse.com

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Published bimonthly by the National Center for Science Education

REPORTS.NCSE.COM
ISSN 2159-9270

FEATURE

A Thrilling Chase: Nick Lane's *Life Ascending*

Jere H Lipps

Nick Lane's book is terrific, a different presentation of evolution than we have generally had in the past. Lane, a biochemist, has chosen ten "Great Inventions of Evolution" to write about and to convey "some of my own thrill in the chase". And thrilling each chase is. Lane brings his discipline's insights to the solution of problems that morphologic evolutionists, including paleontologists who have documented the history of life on earth, have struggled with for years. In examining those ten inventions, Lane demonstrates the tools, old and new, of evolutionary probing, and he lays out the key elements of these hypotheses with facts and strong inference.

Not everyone will agree with Lane's top ten, but he very carefully states his reasons for choosing these over other evolutionary developments. In any case, his ten are all critical, important evolutionary innovations in the history of life. If you don't agree with his ten inventions, note carefully how he deals with each of them, then apply some of the same reasoning to your own choices. His choices counter the views of creationists (including "intelligent design" proponents) without making a specific issue of them. He lets the science do that; hence the rebuttal is even more convincing.

Morphologists have hinted at solutions for many of Lane's top ten for a long time as well. Yet, the biochemical evidence—especially when integrated with evidence from a wide range of other fields, including cell biology, physiology, evolutionary biology, paleontology, geology, behavior, and molecular biology—makes for truly compelling reading.

Lane's writing is smooth and clear, unencumbered by fancy words or innumerable indirect objects and passive voice, and as a result is tremendously exciting. Some readers may struggle with some of the technical terms and phrases, but Lane generally explains all these very well. I could easily see what he was aiming for, and even for the parts with which I disagreed, the book was difficult to put down without thinking about the implications of his ideas for my own field and those of others. This is a book of well-developed hypotheses that may need further testing or even alternatives, but the informed reader will go away from it with a feeling not just of excitement but also with the creativity to make further and deeper inroads into these ten as well as other evolutionary innovations.

For each of his ten great inventions, Lane devotes a chapter of a little more than twenty-five pages. They fall into three groups. The first group of chapters—Origin of Life, DNA, Photosynthesis, Complex Cells, and Sex—considers the development of life from the chemicals of life through to fully operational eukaryotic cells. The second group—Movement, Sight,

and Hot Blood—deal with what might be called the eukaryotic or metazoan traits. The third group—Consciousness and Death—focuses on two things humans think about a lot.

Constructing and evolving a complex cell is complicated and involves many steps, but the enormous times available (millions of years) and biochemistry makes these steps almost inevitable. First, the biochemicals of life must come together. Lane thinks that this happened in the early hydrothermal vents along the ocean ridges, some 3.8+ billion years ago. Not only are the required elements present there, but also the geologic conditions near the hydrothermal vents supply an energy source, and the vesicles and tubules in the basalt and in the encrusted build-ups of minerals around the vents provide suitable containers for these elements to mix and to form into a cell of the same size. Not everyone would agree with this model for the origin of life, but it is a popular one based on finds of the last part of the twentieth century.

Other alternatives remain viable too. Darwin's "warm little pond" full of the right chemicals and energy is still is favored by some. Tide pools, while not ponds, provide a reasonable model with a constant means of concentrating elements by tidal renewal and evaporation, with solar energy driving the reactions. Even on an early earth, probably millions of tide pools existed, where, over a few hundred thousand years, protocells and primitive cells could have emerged. Other possibilities exist too, but Lane tells us up front that we will read his views. And his view of the origin of life, whether right or wrong, stimulates more careful thought about other hypotheses, and hence is good science.

The DNA chapter, like all of them, starts with a vignette, this time of Watson and Crick debating and reworking their ideas in the Eagle Pub near Cambridge University. While these various stories are well known to many of us, they are written and connected to the following text in such intriguing ways that their retelling is not boring. They add to Lane's story.

As for DNA, Lane admits that his ideas are far from conclusive because many parts of the tale remain to be understood completely. He is, however, satisfied that the main ideas are plausible, and the chemical reactions involved are well known. Those ideas and facts make an exciting hypothesis worthy of further testing.

The chapter on photosynthesis in part tells the story of why oxygen is so important for most of life as we know it and for Earth too as we know it. Without oxygen, we'd have a different world with a very different biota. Mars, for example, has very little oxygen, and no sign yet of life. It is one of these different worlds. Photosynthesis, of course, is the source of the oxygen in Earth's atmosphere. The oxygen is generated in the process of stripping electrons from water molecules, and using those to form sugars from CO_2. Bacteria, algae and plants then use those sugars to manufacture more of their own cells. The photosynthetic process is enormously complex, but Lane enumerates the evolutionary steps as generally understood, including the final step, which involves a single mutation, making the process of oxygenic photosynthesis work.

By complex cell, Lane means a eukaryotic cell, differing in significant ways from bacterial or archaeal cells. In fact, eukaryote cells are a mix of those two genetically different prokaryotic cells and some others originating from early evolving cell types that shared among themselves many of their structures through gene exchange. For example, the mitochondria, necessary for generating the energy used in cells of eukaryotes, are prokary-

otes long ago incorporated into the early cells genetically and morphologically. How this happened is debatable, but the genetic signatures can be traced well back in deep time to those bacteria.

Still, this would not be a eukaryote cell—it needs a nucleus. The origin of the nucleus is also much debated, but Lane cuts through those debates to get at the biochemical necessity of having a nucleus with complex folds and holes in its membrane designed to protect genes from the protein-building ribosomes—simple and elegant, but not Darwinian. The complex cell evolved by the insertion somehow of one or more prokaryotes inside another one and the development of the nucleus—two accidents of early biology, Lane asserts. But such accidents may have occurred multiple times in the early prokaryote-dominated world, given the great amount of available time and propensity for gene exchanges in these groups.

Sex is commonly thought of as a feature of metazoans and higher-plants. However, it is actually a characteristic of eukaryotes in general. All eukaryotes, from simple single-celled forms to complete multicellular types such as humans, practice sex. Single-celled eukaryotes are commonly thought to be asexual, but that is simply not true. Most of them do divide asexually but at some point in their life cycles they undergo sexual reproduction. So why sex? Sex randomizes genes and produces variation, and it sorts bad from good mutations. From that variation springs all the differing kinds of eukaryotes. It is also what makes natural selection work so well among eukaryotes.

While movement seems to many to be chiefly a metazoan character, even single cells, for example *Amoeba*, move about in their search for food, for protection, for mating, and in response to conditions in their habitats. Lane acknowledges all of this, but his attention is chiefly on animals. Once animals develop locomotion, then active predation is possible, and that changes entire ecosystems. Lane, taking his lead from paleontology, thinks that these changes followed the Permo-Triassic mass extinction event, 251 million years ago. Prior to that, animals were more or less fixed on the substrate, so when very active motility evolved, it changed the biota for the rest of time.

All of this motility is generated biochemically by well-known processes, and it requires muscles, at least in animals. The muscles that do this can be traced back through animals to pre-bilaterians. For the rest of the eukaryotes that move, like the primitive slime molds, their intracellular motions are driven by the same two biochemicals as those in animal muscles—myosin binds with actin pulling itself along. These are the fundamental biochemicals whose gene sequences are 95% identical across all eukaryotes, differing only slightly here and there in their operations, according to Lane. How they operate in muscles and cells is different, and those differences are fascinating evolutionarily. Motility is clearly under strong selection.

As Lane points out, sight is a rare thing in the biological world. Even among animals, sight has evolved perhaps only six times, leaving the other thirty-two animal phyla totally blind. And the question of the evolution of sight, of course, resulted in the long battle over human eyes that creationists have waged with evolutionists: How could such a complex and unique structure evolve? “Easily” may not be the right word; perhaps “readily” is better, especially when vision is probably strongly selected. Indeed, vision of some sort has evolved

in algae, protozoans, starfish, bivalves, snails and cephalopods, in some kinds of "worms," and of course in vertebrates, because sensing light is an advantage in the environments in which they live.

True eyes appear in the great Cambrian radiation and probably propelled it significantly, as the ability to see changed the way organisms dealt with one another and their surroundings. But, interestingly, all sight is dependent on the light-sensitive protein rhodopsin, and all "eyes," whether they are complex human eyes or simple spots on single-celled algae, possess rhodopsin, as explained by Lane. And, again, the rhodopsin in all these organisms can be traced by gene sequencing from humans all the way back to algae in the early history of earth that used them to track the sun in order to photosynthesize more efficiently. The complexity of sight, then, resides not in the basic way it is done, but in the wide variety of ways to impinge light on the protein. Such inventions include simple sheets of rhodopsin, to pits with rhodopsin covering the internal surface so that shadows are detectable or the eye spots on the exposed mantle of several bivalves, to highly complex calcite lenses of trilobite compound eyes or of the similar lenses on the arms of brittle stars, to the unique organelles of some dinoflagellates that are eye-like structures within their single cells.

Many kinds of eyes exist among eukaryotes, and they evolved readily when rhodopsin could be used to sense light. Selection for light detection is strong, either in a general way to keep oriented to increasingly better vision for hunting or avoiding predators, as among metazoans. Sight is a predictable result of evolution. And the eye does not require an "intelligent designer"—it was developed by natural selection in a number of different ways.

In fact, the focus on human eyes in the creationist argument is fallacious indeed, for the human eye is not perfect at all. Indeed, the octopus eye seems to be constructed better because the neural wiring makes sense, whereas the human eye is wired backwards. The putative designer was not a very good engineer. Natural selection is not about perfection; it only has to produce structures that are good enough to provide a slight selective advantage. That's why we have so many different eyes among the eukaryotes; any kind of eye is an advantage for those organisms that have them.

As Lane ascends from simple through complex cells to animals, "hot blood" becomes a driving force in evolution and Lane's eighth great evolutionary invention. It's been well debated, especially in dinosaur paleontology. Indeed, Lane capitalizes on that debate:

> It's a curious thing, but I've noticed there are few aspects of biology that we feel so chauvinistic about, we hot-bloods. The fury and spleen vented ... about whether dinosaurs, for example, were hot-blooded or cold-blooded is hard to understand rationally; it is a visceral distinction, perhaps something to do with our dignity, whether we would rather be eaten by giant lizards, or clever, scheming, fast-moving beasts, against whom we must pit our wits to survive. (p 206)

His passage evokes memories of *Jurassic Park*, and the popularity of that movie, seen by well over two billion people, certainly reinforces Lane's opinions about how we think about dinosaurs, at least among little kids regardless of age. Lane goes on to explain that "hot blood" is not about temperature, but rather about stamina. Hot blood keeps animals going for longer times in their chases for prey, for mates, from predators, and so on.

The source of heat for these things can come from several sources, including a couple of internal ones, but internal heat generation comes at a large cost to the animal. Lane examines hot blood through a variety of avenues: physiology and anatomy of living animals, anatomy and inferred behavior of fossils, paleoenvironments, food preferences, atmospheric composition (that is, O_2, CO_2, and CH_4), and paleoclimates. Lane describes how all of these fit together in a general way to lead to hot blood, but a lot more remains to be understood about the history and the science of hot blood. The basics of the evolution are known, but this chase is not yet finished. It will be exciting to see how it too turns out.

Life Ascending ends with two evolutionary inventions that are particularly human. The first, consciousness, immediately brings religion into view. Lane notes that Pope John Paul II, although accepting evolution, still considered the human mind beyond the domain of science. Lane does not. He accepts that the mind is intimately connected with the brain, and that both evolved and therefore are subject to scientific analyses across many disciplines. Religion, Lane writes, is not what his book is about and he does not get into that in any detail. Yet he believes that the mind is so marvelous and majestic that it should be scientifically investigated, and also because it bears on the understanding of mental illnesses as well.

Consciousness is difficult to define, partly because all organisms can sense their environments—although only mammals and some birds seem to do it with self-awareness and with feelings (check with your dog about this). An autobiographical awareness and a sense of the future, especially death, separate humans from the rest of mammals. We are unique. That uniqueness, Lane writes, is no reason to set aside science, especially the evolutionary understanding of the brain and all that it entails for us. Lane admits that science does not know a great deal about it yet, and he even notes that this chapter is different from the other nine in that it does not provide a clear picture of how consciousness evolved. The brain and consciousness arose through natural selection, of that Lane is positive. His question then is, how, biochemically, does that work? As he says, no one can answer that question yet, but he shows how neuroscientists are approaching the problem. That makes for interesting reading and firms up the evolutionary view of how we came to be rather than the contrary view that it was all done for us by some supernatural being or force. Clearly, feelings and consciousness are electrical impulses somehow sensed and stored in the brain with various biochemicals. There is no soul.

Death is the tenth and last evolutionary invention on this trek through the ascendancy of life. It is a central fear humans have, and that fear has generated many myths that continue to obscure the science, at least for the general public. We have conceived of happy places we will go when we die if we conform to certain views in life, or of bad places if we do not conform to those views, or how we will return in yet another life, or as a ghost. We search for a way to extend life so we need not die, and we have paid dearly for it in energy (the legend of Ponce de León searching fruitlessly for the Fountain of Youth captures our imaginations for that very idea of longevity), money, technology (cryogenics), and religiosity. Yet we are stuck with a maximum life span of about 120 years, although very few humans come close to that.

Of course, an evolutionary reason set in our biochemistry is responsible. According to Lane, it is, again, about sex. We invest a lot in early sex, allowing many genetic diseases

to terrorize us in late life that are not subject to selection because they do not appear until after reproduction is finished. The story told by Lane is not yet complete either, but the chapter is rewarding in its examination of not just death but of ageing and later life and what we can do about it. Lane thinks we may not be able to increase our life span, but we can certainly increase our health span, if only medical science will fully embrace evolutionary biology.

And so Lane ends, noting in the Epilogue:

> To doubt that life evolved … is to doubt the convergence of evidence, from molecules to men, from bacteria to planetary systems. It is to doubt the evidence of biology, and its concordance with physics and chemistry, geology and astronomy. It is to doubt the veracity of experiment and observation, to doubt the testing in reality. It is, in the end, to doubt reality. (p 287)

Well said.

Nick Lane's book is a rewarding read for anyone interested in evolution. Instructors of evolution will find a great deal in it to convey to their students, for it brings much to the field that we have generally omitted. It counters the unreal assumptions of those who doubt evolution by throwing nonsense and trivia at it. The book is a reading requirement for well-armed evolutionists who confront the myths and dogma of creationism and "intelligent design". Here are the answers in biochemistry, genetics, morphology, and other sciences to disarm those who doubt reality. For doubters, evolutionary biology, as shown by Lane, will require some careful reading, a little work at understanding, and a lesson or two in logic; probably few of them will accept that challenge. Our work in NCSE will go on until scientific literacy reaches everyone, and that too seems improbable, at least for the time being.

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About the author

Jere H Lipps studies geology, paleontology, and marine biology in order to understand the evolutionary history of life on earth and on other bodies in our solar system (Mars, Europa). His work has taken him to Antarctica and all the other continents to study fossil or marine animal and protist occurrences. Currently he is looking at the evolution of Neogene whales and the role of symbiosis in the evolution of reefs. He is a long-time member of NCSE and was presented with its Friend of Darwin Award in 1993. He is an emeritus professor at University of California, Berkeley, and a curator in the Museum of Paleontology there.

Author's address

Jere H Lipps
The John D Cooper Archaeological and Paleontological Center
Santa Ana CA 92701
jlipps@fullerton.edu

REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

Published bimonthly by the National Center for Science Education

REPORTS.NCSE.COM
ISSN 2159-9270

FEATURE

People and Places: Sue Hicks (1895–1980)

Randy Moore

FIGURE 1. *The grave of Sue Hicks, Madisonville, Tennessee. Photograph: Randy Moore..*

Sue Kerr Hicks (1895–1980) was born in 1895 in Madisonville, Tennessee, into a legal-minded family; his father was a successful attorney in Madisonville, and his uncle had written the first manual of Chancery law in Tennessee. Hicks was named for his mother Susan, who had died during his birth. Hicks graduated from Hiwassee College and the University of Kentucky, and began practicing law in Dayton, Tennessee, with his older brother Herbert Hicks, who had been appointed acting Rhea County Attorney.

In March 1925, Hicks talked with Dayton school board superintendent Walter White about the Butler Act, which banned the teaching of human evolution in Tennessee's public schools. When Hicks and a group of Dayton's businessmen decided to test the Butler Law as a way of stimulating the local economy, Hicks—a friend of John Scopes—volunteered to prosecute Scopes, if Scopes would cooperate. During the Scopes trial, most of Hicks's announcements were procedural.

When Bryan died five days after the Scopes Trial, Hicks delivered a stirring eulogy at Bryan's memorial service in Dayton. He accompanied Bryan's body as far as Chattanooga on its way to Arlington Cemetery in Virginia. During the trip to Chattanooga, Hicks met Bryan's nephew Jennings Bryan, who promised Hicks that moving to Florida would enable him to make a lot of money.

Hicks accepted the advice, turned his law practice over to his brother Herbert, and moved to Miami, where he practiced law for four years. He then returned to Dayton, where he served as a judge and was active in various civic organizations. In 1935, Hicks defeated Walter White for a seat in the state legislature. Fifty years after the trial, Hicks claimed that the Scopes Trial was conceived not by George Rappleyea at Robinson's Drug Store, but instead in his Dayton law office by him and Walter White.

Hicks considered Inherit the Wind to distort the historical record and had to be dissuaded by his family from buying television time to set the record straight. Hicks later became a folk hero when he inspired Chicago writer Shel Silverstein to write "A Boy Named Sue," a song popularized in 1969 by Johnny Cash's live recording At San Quentin.

Sue Hicks died on June 17, 1980, and was buried in Haven Hill Memorial Gardens in Madisonville, Tennessee (Figure 1).

About the Author

Randy Moore is the HT Morse–Alumni Distinguished Professor of Biology at the University of Minnesota. His latest book, coauthored with Sehoya Cotner, is *Arguing for Evolution: An Encyclopedia for Understanding Science* (Santa Barbara [CA]: Greenwood, 2011).

Author's address

Randy Moore
University of Minnesota, MCB 3-104
420 Washington Avenue SE
Minneapolis MN 55455
rmoore@umn.edu

REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

Published bimonthly by the National Center for Science Education

REPORTS.NCSE.COM
ISSN 2159-9270

REVIEW

Among the Creationists: Dispatches from the Anti-Evolutionist Front Line

by Jason Rosenhouse
New York: Oxford University Press, 2012. 256 pages

reviewed by Taner Edis

Jason Rosenhouse, who teaches mathematics at James Madison University, might at first seem an unlikely person to be interested in the creationism/evolution wars. Creationism is a constant nuisance for biologists and geologists, and to a lesser degree for other natural scientists. Social scientists can find creationism to be a fascinating part of the American cultural landscape. But the denial of evolution rarely interferes with the life of a mathematician. And yet, as not only a mathematician but a Jewish atheist coming from a very different background than a typical conservative Christian troubled by evolution, Rosenhouse has produced one of the most readable, interesting, and different books about creationism that has appeared in many years.

Rosenhouse appears to have been drawn to investigate creationism largely because it was so strange to him at first. *Among the Creationists* contains many fascinating stories of his encounters with young-earth creationists and "intelligent design" proponents; indeed, the book is structured around a series of recent anti-evolution conferences he attended. These conferences frame both Rosenhouse's observations about creationism in the context of conservative religion and the deeper intellectual questions prompted by these adventures among the creationists.

Rosenhouse's blend of personal observation and probing investigation of scientific and philosophical questions is what makes the book such a delight. Precisely because creationism can appear so absurd from an academic standpoint, there is a danger of ignoring the intellectual concerns that animate creationists, or to treat evolution-deniers as fundamentalist caricatures. Rosenhouse never falls into such traps. He is invariably respectful of anti-evolutionary ideas—while being careful to explain exactly why they fail, he makes a genuine effort to understand the intellectual appeal they hold for many creationists. For example, starting with describing the well-funded, professionally presented Creation Museum in Kentucky, Rosenhouse goes on to explore theological concerns about evil in the world and the notion of a "curse" on creation. And then, he goes on to address why theologically liberal attempts to endorse evolution as a way of distancing a creator from the suffering in our world seem unconvincing—both to conservative Christians and to those standing outside the Christian tradition such as Rosenhouse himself.

Such discussions illustrate one of the most impressive aspects of *Among the Creationists*. The literature on evolution, theology, and philosophy is immense. And yet, in the space of a handful of pages, Rosenhouse invariably touches on almost all the important arguments,

cites representative and up-to-date examples from the relevant literature, and concisely and with a minimum of jargon presents his own conclusions. Not all his readers will always agree—I had my occasional minor gripes, even though our views on creationism and the significance of Darwinian evolution for debates concerning the reality of supernatural agency are very similar. But it would be hard to find fault with how Rosenhouse guides readers through this complicated intellectual landscape.

Since Rosenhouse does not just present his encounters with creationists but uses creationism as a device to develop his own views on science and religion, the result is not always identical to the liberal consensus view endorsed by organizations such as the NCSE. Since evolution is culturally controversial in the United States, defending science education relies on a complex, sometimes awkward, political coalition. Polls suggest that even Americans who accept evolution usually have a non-Darwinian process in mind. Doubtless many of them imagine evolution to be an explicitly guided, progressive process. So support for evolution education is in some respects remarkably shallow, relying on the acquiescence of a religiously liberal population that dislikes fundamentalist attitudes but dubiously tries to respect both the current state of natural science and deep-seated intuitions of intelligent design manifested in life. As Rosenhouse explores the significance of creation and evolution for supernatural beliefs, he directly and indirectly ends up criticizing liberal guided-evolution views as much as overt opposition to evolution.

Therefore *Among the Creationists* perhaps inadvertently also raises some difficult questions. Public arguments over creation and evolution are motivated primarily by politics or defense of a conservative Christian subculture, not really about science. And so, those of us who want to preserve the integrity of science education, or who just want a quiet life, feel most comfortable asserting a standard liberal consensus view. And yet, gently but firmly, Rosenhouse makes it clear that much in this liberal consensus—its hard boundaries between science and nonscience, its assertion of a cheap compatibility between Darwinian evolution and an anthropomorphic God in charge—is intellectually very shaky.

So, on the one hand, I would love to recommend a book such as *Among the Creationists* to anyone interested in the creationism/evolution wars. Even readers professionally interested in creationism will find much that is fresh in Rosenhouse's writing. And others, for example bright college students intellectually intrigued by the debate that surrounds them, will find *Among the Creationists* to be very readable and to the point. Rosenhouse's forthright examination of exactly the sorts of questions students wrestle with would, I think, be invigorating, regardless of whether they agree with him.

But on the other hand, I have a paranoid streak, and I do want a quiet life. Though I agree with Rosenhouse that the liberal consensus view on science and religion has many intellectual flaws, it also seems politically indispensable to maintain a coalition in favor of teaching evolution. So even after reading Rosenhouse, I harbor contradictory hopes. I hope that those around me who have serious scientific and philosophical interests in the phenomenon of creationism read *Among the Creationists* and seriously engage with its arguments. I think that more often than not they will find Rosenhouse to be persuasive. But I also hope that politically, the liberal consensus remains strong enough to do its job. Rosenhouse's subtle undermining of this consensus, even though I largely agree with him, leaves me somewhat worried.

But then, a good book should be thought-provoking. It should, perhaps, leave readers with a few uncomfortable questions. Rosenhouse succeeds admirably.

About the author

Taner Edis is Professor of Physics at Truman State University, and *RNCSE*'s associate editor for physics. He regularly writes on American and Islamic versions of anti-evolutionary thought.

Author's address

Taner Edis
Department of Physics
Truman State University
Kirksville MO 63501

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Published bimonthly by the National Center for Science Education

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ISSN 2159-9270

REVIEW

Seeking God in Science: An Atheist Defends Intelligent Design

by Bradley Monton
Peterborough (Ontario): Broadview Press, 2009. 180 pages

reviewed by Matthew H Haber

On December 20, 2005, Judge John E Jones III ruled against the Dover Area School District in the lawsuit brought against it by Tammy Kitzmiller and ten other local parents regarding the incorporation of intelligent design (ID) into the school curriculum (*Kitzmiller v Dover Area School District*, 400 F Supp 2nd 707 [2005]). Philosopher of science Bradley Monton soon posted an essay on-line critical of Jones's ruling. Just as the philosopher Larry Laudan had voiced concern over the reasoning in Judge Overton's 1982 ruling in *McLean v Arkansas*, Monton raised doubts over the demarcation criteria embedded in Judge Jones's ruling. Monton's essay generated a bit of a stir, coming under fire from philosophers of science and biologists while receiving praise from ID advocates. *Seeking God in Science: An Atheist Defends Intelligent Design* is an expansion of Monton's essay, a reply to his critics, and an attempt to locate himself in this rather messy debate.

My focus here is on Monton's treatment of ID in biology. Admittedly, this covers only a portion of Monton's book, and, to be fair, the weakest part of it. Monton is a philosopher of physics and religion, and the strength of the book is clearly the extraordinarily clear and entertaining sections reflecting his expertise. Furthermore, despite the provocative title, Monton accepts contemporary evolutionary theory as the best available explanation for biological phenomena and diversity, asserting that "intelligent design should be dismissed on the grounds that the empirical evidence for the claims just isn't there" (p 58). Though this endorsement carries reservations about the conceptual underpinnings of evolutionary theory, it also serves to set Monton apart from other ID proponents.

Seeking God in Science, and my reaction to it, is conflicted. At times it productively challenged me; on other occasions it left me confounded. Many difficult arguments are cleanly dissected, with premises on full display for examination; others rest on unspoken or unexamined (and often tenuous) assumptions. Monton explicitly states and applies the criteria of evaluation in any given section of *Seeking God in Science*, yet these criteria shift from one section of the book to another.

Monton's main thesis is that "intelligent design needs to be taken more seriously than a lot of its opponents are willing to" (p 7). This suggests that ID critics have not taken it seriously enough. To the contrary, a strong case can be made that ID gets much more attention and its ideas are considered far more seriously than similarly empirically-lacking challenges to contemporary evolutionary theory (such as Rupert Sheldrake's morphic resonance theory). H Allen Orr (2005) and Sahotra Sarkar (2007), among many others, have done admirable

jobs addressing the biological claims of ID in both accessible and technical outlets. The most prominent ID book, Michael Behe's *Darwin's Black Box*, received reviews in leading scientific journals, including *Nature*, *American Scientist*, and *The Quarterly Review of Biology* (Coyne 1996, Dorit 1997, Blackstone 1997). ID proponents, for the most part, have greeted these responses with deflection, continuing to push the same tired old examples without effectively confronting any of the contrary evidence or explanations. It is no wonder that the critics have often not continued to pursue the matter. But this disengagement should not be mistaken for a failure of ID critics to take it seriously—for Monton's assertion to be credible there must be serious material that has not received its due. Instead, like ID advocates, Monton here seems to conflate "take seriously" with "accepting" or "adopting".

To be fair, Monton generally acknowledges the weakness of ID's biological arguments, preferring instead to focus on what he describes as physics-based ID arguments. This is not surprising. Monton is a philosopher of physics and religion, and his extremely clear presentation of these arguments is where the book shines. Perhaps these are the arguments that Monton suggests ID critics have failed to take seriously. Yet by Monton's own admission, these arguments constitute only a small part of the ID corpus. If ID advocates do not seriously pursue these arguments, it is a bit unclear why their critics ought to—especially when those critics are biologists and philosophers of biology. Furthermore, the physics-based arguments *are* taken seriously. They are very much in line with familiar design arguments in the philosophy of religion. Of course, these arguments also typically have very little to do with evolutionary biology, and so aren't likely to be regarded as relevant by those concerned with the study of evolution.

There *is* a good reason why a broader audience ought to pay attention to ID arguments: they may well be right! Monton is on surer footing when he stops worrying about who should pay attention to what, and simply tackles the ID arguments he finds most compelling. As would be expected of a good philosopher of science, Monton frames his treatment of these arguments in the context of a discussion of how scientific theories are assessed. What is it that makes a theory a good theory? Here, though, the treatment is a bit uneven, with Monton at times considering whether ID *may be true* and at other times considering whether it is *plausible*. Subtle though this distinction may be, it is a vitally important one that dictates how we assess theories (and for what purposes). Plausibility, after all, is a higher bar than merely not having been shown to be false. For Monton, roughly, plausibility is expressed in terms of the probability assigned to a belief (or theory). How high that probability must be in order for the belief or theory to be considered plausible, at times, gets run together with whether it is possible, that is, has a non-zero probability. The upshot is that sometimes arguments are assessed by whether they raise the probability of their conclusion at all, as opposed to raising it to some threshold or against competing views.

Monton also does an excellent job of offering extremely clear explications of ID arguments, especially in chapter 3: "Some somewhat plausible intelligent design arguments". Monton clearly and forcefully considers the premises here and identifies where finer distinctions are in order—just what philosophers do well. This is typical of Monton's style, and is also on display in his consideration of ID critics' arguments. Lazy dismissals of ID are, rightly, simply not tolerated. Unfortunately this same standard of analysis is more unevenly applied to biological-based ID arguments—just those of concern to readers here. The most glaring example, to my mind, was the quick acceptance of the presumption that if there

were a God, that God would intervene with evolutionary processes, thus undermining naturalistic biological accounts of evolution (p 110–111). This presumption would benefit from the same standard of analysis that Monton brings to the arguments of ID critics. There are many theist positions that do not posit such an interventionist divine being. Why does it matter that Monton fails to adequately consider theist positions compatible with evolutionary theory? It goes to the mode of assessment of theories used by Monton. Ignoring these positions distorts how we adjust our degrees of belief in and assignments of probability to ID and non-ID views. Effectively, this takes all the probability we might assign to theist positions and attributes it to ID. But that biases the outcome in favor of ID. If only some theistic positions are compatible with (let alone entail) ID, then Monton is overestimating the probability of ID and it is less plausible than he presents—and he presents ID as barely plausible to begin with.

Monton reports that a motivation for writing this book and his advocacy for including ID in public school curricula is his own experience teaching the debate in his philosophy courses. I can empathize with Monton here, as I have also been struck by the depth of understanding my philosophy students come away with about evolution after reading Darwin's *Origin of Species*, along with Paley's *Natural Theology* and contemporary ID literature. So I take his recommendations seriously, though ultimately I was unpersuaded. I think, for example, that we'd be better off simply advocating that students read Darwin and his peers directly, rather than bother with contemporary ID. The latter, I've found, simply adds very little to the discussion.

In the end, Monton has produced a novel book among ID advocates. Of the books advocating for ID, this is among the best. It has the advantage of being less obviously entangled in the cultural and political battles that typically pervade such texts (though some of the score-settling grows tiresome). The exposition is clear, the arguments penetrating, and it is a crisp, good read.

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About the author

Matthew H Haber is Assistant Professor of Philosophy at the University of Utah.

Author's address

Matthew H Haber
Department of Philosophy
University of Utah
215 S Central Campus Dr, CTIHB 455
Salt Lake City UT 84112
matt.haber@utah.edu

REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

Published bimonthly by the National Center for Science Education

REPORTS.NCSE.COM
ISSN 2159-9270

REVIEW

American Genesis: The Evolution Controversies from Scopes to Creation Science

by Jeffrey P Moran
New York: Oxford University Press, 2012. 191 pages

reviewed by Adam Laats

How can so many seemingly normal people doubt the legitimacy of the modern evolutionary synthesis? Many observers might agree with Richard Dawkins (1989), who famously declared, "It is absolutely safe to say that if you meet somebody who claims not to believe in evolution, that person is ignorant, stupid or insane (or wicked, but I'd rather not consider that)."

Whether or not they embrace Dawkins's brand of in-your-face atheism, many mainstream scientists and their allies can only scratch their heads in befuddlement when they hear the scientific claims of scientific creationism or "intelligent design". As with the National Center for Science Education's Project Steve, non-creationists point to the overwhelming number of informed scientists who have declared for evolution. In the light of such overwhelming evidence for the validity of the modern evolutionary synthesis, how could anyone doubt it? As a scientific matter, the case is open and shut.

Only … it isn't. As anyone familiar with the anti-evolution impulse in the United States is aware, nearly half of adults agree that human beings were created in pretty much their current form at some time in the last ten thousand years. If more proof were needed, we can look to the continuing controversies over the teaching of evolution in public schools, or at the near unanimity of creationist belief among leading Republican presidential hopefuls in the 2012 primaries.

Jeffrey Moran's new book offers a compelling explanation of the durability of America's antievolution impulse. Like other recent works, notably Michael Lienesch's *In the Beginning* (2007) and my own *Fundamentalism and Education in the Scopes Era* (2010), Moran examines the history of antievolutionism as more than just religion, more than just science. As Moran explains, ideas about evolution offer a unique "mirror, however distorted, of [American] culture itself" (p 24).

The most intriguing sections of *American Genesis*, accordingly, offer readers more than just a clear and compelling brief history of the American antievolution "impulse" (p x). Moran demonstrates the ways that anti-evolutionism has been both a bellwether and an influence on broader trends in American culture. In the first three chapters, Moran's book approaches antievolutionism as a question not only of religion and science, but also of gender, region, and race.

With gender and women's roles in public life, for instance, he shows how "an aggressively traditionalist antievolution impulse" collided with "a culture undergoing rapid changes in its social and sexual orientation" (p 28–29). In the 1920s, the new phenomenon of women voters encouraged some politicians to fight public atheism and evolution in the schools. Moran cites one wag who explained in 1925 that the anti-evolution crusade would not be so dangerous "were it not for the fact that the Nineteenth Amendment has added so many to the electorate who are intensely controlled by their emotions and sentiments" (p 41).

American Genesis sheds similarly well-needed light on the connections between antievolution sentiment and regional identities. Especially with the Scopes Trial in small-town Dayton, Tennessee, by the 1920s antievolutionism came to be associated with stereotypes of Southern isolation and ignorance. Moran treats the subject with the care it deserves, noting that many leading fundamentalist institutions were based in the North and many Southerners fought long and hard to have more evolution taught in their schools. Nevertheless, as defended by such home-grown intellectuals as the Southern Agrarian movement of the 1930s, antievolutionism soon came to be a central part of the Southern stereotype.

Another part of that regional stereotype was the firmly entrenched ideology of white supremacy. Moran describes the way antievolutionism played out among African Americans, especially African American intellectuals. On one hand, African Americans tended to be just as likely to believe in the literal truth of the Bible creation story as whites (p 76). On the other, secular intellectuals worked to depict the Scopes trial as just another irruption of white Southern intolerance. Thinkers such as WEB DuBois, George Schuyler, William Pickens, Kelly Miller, and William N Jones also concluded that Southern white supremacists feared the racial egalitarianism implicit in some readings of evolutionary doctrine. As Moran has done in earlier work, this racial perspective casts significantly new light on the nature of the antievolution impulse.

The only downside to this important new perspective is Moran's relative lack of attention to developments about race, gender, and region in the antievolution impulse since 1930. These three chapters focus almost exclusively on the 1920s with just a few pages tacked on about more recent developments. Happily, the last two chapters delve more thoroughly into recent antievolution developments.

In "Descent with modification," Moran explores three themes that have been central to the antievolution impulse since the 1920s. As he correctly points out, antievolutionists have consistently been concerned with more than just the scientific claims of evolution. Instead, they have been animated by "the primacy of Jesus, the centrality of man in the universe, and a fear of social disorder" (p 91). Each theme was just as important to prosecutors in the Scopes trial as it has been to some "intelligent design" proponents in the twenty-first century. This focus among antievolutionists has led to some of the cultural stalemate that has occurred in generations of creation/evolution debates. Discussions often use the language of geology or biology, while antievolutionists really often care more about soteriology.

Of course, antievolutionists are no more monolithic than are mainstream scientists. In his final chapter, Moran offers a detailed description of recent debates between antievolutionists. As the debates between Howard Van Till, Denis Lamoureux, and Phillip Johnson reveal, there are many ways to oppose naturalistic evolution.

Thanks to its nuanced approach to this complicated subject, *American Genesis* makes an important addition to the historical literature on the antievolution impulse. Readers hoping to make sense of this powerful American cultural tradition will do well to start with this slim volume. There is something here for everyone, from professional historians and scientists to concerned citizens of all backgrounds.

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About the author

Adam Laats is Assistant Professor in the Graduate School of Education, Binghamton University (SUNY). He is the author of *Fundamentalism and Education in the Scopes Era: God, Darwin, and the Roots of America's Culture Wars* (New York: Palgrave Macmillan, 2010). He blogs about the meanings of American fundamentalism at I Love You but You're Going to Hell (http://iloveyoubutyouregoingtohell.org).

Author's address

Adam Laats
Graduate School of Education
Binghamton University (SUNY)
PO Box 6000
Binghamton NY 13902
alaats@binghamton.edu

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Published bimonthly by the National Center for Science Education

REPORTS.NCSE.COM
ISSN 2159-9270

REVIEW

Evolution and Religion in American Education: An Ethnography

by David E Long
New York: Springer, 2011. 203 pages

reviewed by Steve Watkins

As those who teach evolution in public schools or at secular universities are well aware, it is a sharply polarizing topic. David E Long conducted ethnographic research as to why such polarization occurs, and in his *Evolution and Religion in American Education* he addresses a set of underlying challenges for those who teach evolution. Much of Long's research delves, in effect, into a question recently posed by Karl Giberson: "Why do tens of millions of Americans prefer to get their science from Ken Ham, founder of the creationist Answers in Genesis, who has no scientific expertise, rather than from his fellow evangelical Francis Collins, current Director of the National Institutes of Health?" Long's book provides some important and troubling answers to such questions.

Long conducted his ethnographic research at a state university in the greater Cincinnati, Ohio, metropolitan area that includes Indiana and Kentucky. While he uses the pseudonym "Mason-Dixon State," it is not hard to guess which actual state university Long researches. His ethnography includes interviews with students, college professors, and high school teachers. At issue is the cultural tension in both teaching and learning evolution in the American educational system. Focusing primarily on education in the science classroom, Long probes areas of resistance to evolution among students and teachers. What he discovers is a deep-seated anxiety toward evolution that causes a "shut-down" in the minds of many Christian students—especially those whom he identifies as "exclusivists," whose belief system is in no way open to the possibility of evolution.

One aspect of Long's research that is in short supply in the literature on the cultural warfare between creationism and evolution is his exploration of the existential anxiety which has been established in the minds of many students before they ever get to a university. For those teaching at universities drawing from rural and exurban contexts (not to exclude others), this book helps to explain such negative prejudice against evolution. Existential anxiety results from larger epistemological and ontological categories that have been reinforced through a dichotomous "logic" repeated at home, church, student religious organizations, and sometimes, in the science classroom itself. For example, Long describes a common dilemma: "Typical of students in this social category [exclusivist Christians], evolution posed problems for their faith's authority in that it forced a decision between competing ontical claims" (p 57).

Long interviews science teachers at the secondary level as well as college professors. At the high school level, many science teachers feel pressure against teaching evolution—

sometimes this comes through anecdotal comments by administration or co-workers and at other times it derives from a sense of community resistance to the topic. In some cases, the teachers were creationists who shied away from teaching evolution. In other cases, teachers adopted a "teach all the theories" approach where the topic of evolution provoked a discussion that inevitably led to any number of positions being raised—including creationist positions. At the college level, a different set of dynamics emerged which adversely affected instruction in evolution. Many introductory courses in biology for non-science majors were taught by adjunct faculty who did not have any expertise in evolutionary biology. Numerous adjuncts had only introductory exposure to evolution themselves.

Long's research sheds light on some important issues in the breakdown of teaching evolution. Most importantly is the deep-seated anxiety that many students experience when the word "evolution" is uttered. "Evolution," for these students, is not the scientific account of the diversification of life; it is a pernicious and nefarious attempt to undermine the foundations of morality, religion, and society. Unfortunately, the cultural warriors have been successful in similarly redefining key terms that turn into "banners" that are used to demonize evolution: "theory," "truth," "macro versus micro-evolution," "missing links," and so on. Trained scientists cringe to hear terms like these misused in so ferocious a manner. Perhaps addressing such terminological issues is at least a starting point for science educators in dealing with the cultural warfare that circulates so many inaccuracies, and reinforces such deep anxieties, about evolutionary science.

Like any ethnographic study, this one is limited. Long investigated just one college in a conservative region, which also happens to be located less than a half-hour drive from the Creation Museum in northern Kentucky. But keeping these facts in context, the study is a positive contribution to the complexities involved in the teaching of evolution.

A challenge for lay readers of this book is Long's use of continental philosophy, especially some of the ontological categories in Martin Heidegger's *Being and Time*. More specifically, Long draws heavily from Hubert Dreyfus's interpretation of and commentary on Heidegger. For readers without a basic familiarity with such ideas, I would suggest reading some introductory works on Martin Heidegger, Edmund Husserl, and phenomenology in tandem with Long's book. While these areas may be too technical for readers who do not possess a fair amount of philosophical background, phenomenology is an area of crucial importance in untangling the tremendous confusion of many American students toward evolution. This aspect of Long's work is one of its greatest strengths.

Another strength of this book is Long's identification of a conceptual clash between competing epistemologies (systems of knowledge). Many students and teachers simply aren't aware of Stephen Jay Gould's call to view science and theology as "non-overlapping magisteria." The result is an existential blindspot that simply should not exist—even for people of faith. Long's book challenges educators on two fronts: to find ways to stress the separation of faith from science (Gould) and to work hard to clarify important key terms as mentioned above. As Long suggests, these tasks may be among our most difficult challenges.

About the author

Steve Watkins is working on his PhD in Humanities at the University of Louisville. His area of research is fundamentalist cultures, especially of the young-earth creationist variety.

Author's address

Steve Watkins
3556 Donegal Ct
Covington KY 41015
steve.watkins@fuse.net

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Published bimonthly by the National Center for Science Education

REPORTS.NCSE.COM
ISSN 2159-9270

REVIEW

Darwinism and the Divine: Evolutionary Thought and Natural Theology

by Alister E McGrath
Chichester (UK): Wiley-Blackwell Press, 2011. 298 pages

reviewed by Bruce H Weber

In recent decades in America, there has been a "war" between science and religion in terms of creationists' objections to the teaching of evolution in public schools and more currently efforts to include "intelligent design" in the science curriculum; such efforts have remained polarizing and polemical. This has led to a perception among some in the general public that evolutionary theory and theology are antithetical to each other. However, there are a number of theologians who are scientifically literate, often with advanced degrees in the sciences in addition to their theological and philosophical education, such as John Polkinghorne, Arthur Peacocke, Christopher Southgate, John Haught, and Alister McGrath, as well as theologically literate scientists, such Francisco Ayala, John Barrow, and Simon Conway Morris, who see the potential for a productive dialogue between scientists and theologians, especially with regard to evolution.

In *Darwinism and the Divine*, Alister McGrath, Professor of Theology and Head of the Centre for Theology, Religion & Culture at King's College, London, and formerly Professor of Historical Theology at Oxford University, provides a highly readable introduction to the history of natural theology and its relationship to the sciences, particularly contemporary Darwinism, expanding upon the 2009 Hulsean Lectures he gave at Cambridge University. This well-documented volume engagingly introduces the reader to both natural theology and the implications of Darwinian evolution while providing guidance to the extensive primary and secondary literature dealing with these topics.

McGrath begins by addressing what natural theology was, and is, in light of the "demarcation problem" between science and philosophy more generally. He views natural theology as a project to work toward a principled engagement with and a deeper understanding of the nature of reality as rigorously informed by both science and theology. Natural theology is not a scientific metanarrative but one of several important strands of the human engagement with reality. The dialogue between theology and science under the rubric of natural theology can facilitate mutual understanding through critical and positive discourse.

After defining terms and setting the problems, McGrath addresses the history of English natural theology from 1690 to 1850, which provided the context for the presentation and assessment of Darwin's theory of evolution by natural selection. In just 133 pages McGrath presents a clear yet nuanced account of the scientific, theological, cultural and political contexts in which English natural theology emerged, and also narrates its development. After the turmoil of the English Reformation, the Civil War, the Restoration, and the Glorious

Revolution of 1688, there was a desire for reconciliation of a potentially disruptive dispute between contending factions and world views, including those between science and religion. Assuming that nature was rational and comprehensible, natural theology emerged as part of the Newtonian synthesis through the writings of Richard Hooker, Francis Bacon, and Thomas Browne, and was codified by John Ray in his *Wisdom of God*, as well as by Bernard Nieuwentyt's *The Religious Philosopher* and William Derham's *Physico-Theology*, the latter of which introduced the notion of natural contrivances, upon which William Paley drew.

Paley came toward the end of more than a century of such natural theological thinking and was not original in his basic argument; however, Paley was an excellent writer and utilized biological examples effectively to strengthen the notion of design in nature. His argument to design was based upon the subtle and complex functional structures observed in biological systems; Paley challenged his reader to provide a natural explanation for such design instead of inferring the existence of a divine designer. To illustrate this, he used his famous metaphor of a watch, whose existence could only be explained by a watchmaker. The argument from design then deduced that the beneficial contrivances in nature reflected the character of the divine designer. Paley had an enormous impact on English culture after the publication of his *Natural Theology* in 1802, despite the fact that David Hume had already critiqued the argument to and from design. Scientific advances in the first part of the 19th century began to put pressure on natural theology, in response to which the Bridgewater Treatises were commissioned and published in the 1830s through a bequest from the Earl of Bridgewater. These were very successful, selling over 60 000 copies over several decades.

Charles Darwin read Paley and indeed structured his argument in *On the Origin of Species* in a similar manner to Paley even as he answered Paley's challenge with his theory of evolution by natural selection. McGrath provides a brief but insightful account of Darwin's thinking, as well as the reaction both scientific and popular to Darwin, drawing upon the riches of Darwinian scholarship of the past half century; here as elsewhere the reader can be guided to an extensive primary and secondary literature via the extensive endnotes. By 1859, many scientists and theologians realized that there were both scientific and theological problems with the design argument and a number of evangelical Christians, including Asa Gray in the United States, were open to Darwin's theory and saw it as providing a way to see purpose in nature through the action of the laws of nature. McGrath deals with some of the controversy that arose in reaction to Darwin, but breaks off the historical account with the eclipse of natural theology in the latter part of the 19th century.

In the other major section of the book, McGrath moves to the 20th century, briefly summarizing the rise of the Modern Evolutionary Synthesis (also known as neo-Darwinism) during the 1920s through 1940s that fused natural selection with population genetics. His main topic, however, is the fate of natural theology. He follows the revival, in the first fifth of the twentieth century, of concepts such as teleology (without design) as presented by Harvard chemist Lawrence Henderson, who was a bibliophile and who revived interest in the Bridgewater Treatises, carefully distinguishing natural purpose and function from design imposed from outside nature in his books *The Fitness of the Environment* and *The Order of Nature*. McGrath then reviews how natural theology has been revived both by scientists such as Joseph Needham and Simon Conway Morris as well as theologians such

as John Haught and Christopher Southgate who draw upon St Augustine and St Thomas Aquinas, whose theological positions are less circumscribed than those of the English natural theologians, and which can be interpreted as consistent with a process of evolution in which creation unfolds over time. Indeed, Darwin can be seen as making theologians address afresh theodicy and the problem of suffering and evil. McGrath even explores ways in which apparent random quantum events might be influenced undetectably to science by God. Of course, evolutionary phenomena and theory have been taken, especially by Daniel Dennett and Richard Dawkins, as refuting any theistic stance and supporting atheism. McGrath addresses these challenges and argues that the science does not prove or disprove any philosophical position but rather requires careful thinking to ensure that any philosophical position is coherent and consistent with the science. It is regrettable that McGrath does not address the ferment in contemporary evolutionary theory such as the synthesis of evolutionary and developmental biology ("evo-devo") as explored by Sean Carroll and Scott Gilbert, among others, or the application of complex systems dynamics to address emergent phenomena in evolution, as suggested by Stuart Kauffman, Terrence Deacon, or Philip Clayton, for example.

In his final chapter, McGrath considers the future of natural theology in the twenty-first century. He sees its role as providing a framework or lens through which the world and our action in it can be interpreted, revealing a, if not the, meaning of life as well as a rational faith. Given the historical narrative of natural theology, it might be more perspicuous to strive to develop, rather than a revival of natural theology, a theology of nature.

About the author

Bruce H Weber is Professor of Biochemistry Emeritus at California State University, Fullerton, as well as Robert H Woodworth Chair in Sciences and Natural Philosophy Emeritus at Bennington College, and is coauthor, with David Depew, of *Darwinism Evolving* (Cambridge [MA]: MIT Press, 1995) and coeditor, with David Depew, of *Evolution and Learning* (Cambridge [MA]: MIT Press, 2003).

Author's address

Bruce H Weber
Department of Chemistry and Biochemistry
California State University, Fullerton
Fullerton CA 92834-6866
bhweber@fullerton.edu

REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

Published bimonthly by the National Center for Science Education

REPORTS.NCSE.COM
ISSN 2159-9270

REVIEW

Evolution and Creationism: A Very Short Guide second edition

by Warren D Allmon
Ithaca (NY): Paleontological Research Institution, 2009. 128 pages

reviewed by Robert "Mac" West

When the Paleontological Research Institution opened its Museum of the Earth in 2003, its director Warren Allmon realized that the floor educators and volunteer docents needed accessible, accurate, and current information on evolution in order both to explain this essential process and to refute and correct the inevitable assaults by creationists. Thus he produced the predecessor to this little book. This volume updates the original, in terms of both new scientific advances and external legal and social events.

The book is direct and to the point, including a four-page glossary of essential terms, which appear in boldface where they occur first in the body of the text. At the outset, evolution is established as a legitimate science in a discussion of the scientific method and the process of science proceeding via testable hypotheses. This accurate use of terminology defuses the "only a theory" dismissal of evolution.

After a short history of evolutionary theory from Darwin to the present, the book presents the primary evidence for evolution, including observable small-scale changes, biogeography, comparative anatomy and vestigial structures, fossils, and genetics. It then addresses the causes of evolution, providing an effective and direct explanation of natural selection in the context of both genetic variation and the influence of external environments.

A chapter discusses the geologic time scale, clearly describing the importance of both physical positions (superposition and lateral correlation) and the roles of both radiometric and relative dating.

With the salient aspects of evolution well established, there is then a discussion of the history of creationism, highlighting the various legal challenges (including the significance of the results of the Dover trial of 2005), and the evolution of "intelligent design" creationism. This flows well into a commentary on the various public opinion polls that continually document that the majority of the U.S. population neither accepts nor knows much about evolution, despite the wording of the questions.

A commentary on the relationship of evolution to religious belief includes the diversity of "official" positions of several denominations and organizations.

The final chapters address the importance of evolution in education. Allmon discusses the multiple roles that evolution plays in understanding modern society and its development, noting that evolution underpins much of applied biology and is important in much of the

non-biological sciences, including fields such as astronomy, geology, and medicine, to say nothing of nonscientific fields. There is then a discussion of education issues, addressing the local control of education in the United States, leading to local and state school board issues such as those in Dover, Pennsylvania, Kansas, Texas, and so on; the phenomenon of frequently ill-prepared teachers; and the pressures that often are experienced by classroom teachers.

Chapter 12, "Some frequently asked questions," provides direct responses to common objections: that evolution is "only a theory," that evolution means that everything is "random," that there is "micro-evolution" but no evidence for "macro-evolution," and that religion and evolution are always in conflict. And the final commentary, "10 things everyone should know about evolution" (see below), is an excellent summary.

This is a direct, easy-to-read, and useful book, especially for those on the front lines of evolution education and public interpretation.

10 THINGS EVERYONE SHOULD KNOW ABOUT EVOLUTION

1. Evolution (descent with modification) is not the same as mechanisms or causes of evolution.
2. Scientists can study events and processes in the past, even when there was no human there to witness them, by the principle of extrapolation, which is also used in all scientific experiments and conclusions about phenomena that happen in the present.
3. There is a huge amount of evidence for evolution (descent with modification) from all areas of biology, and there has been no serious scientific debate about whether it is true since the 1880s. Evolution is as well supported as many other scientific conclusions we regularly call "facts," such as that the Earth goes around the Sun.
4. Very active scientific debate continues today about the mechanisms by which evolution occurs, but this does not imply any controversy about whether evolution occurs.
5. Since the 1940s, natural selection, the mechanism first proposed by Charles Darwin in 1859, has been accepted by most scientists as the most important mechanism of evolution.
6. Natural selection is simply an outcome of the struggle of variable individual organisms to survive and reproduce. Those individuals with inherited variations that allow them to be more successful in this struggle will, on average, leave more offspring in the next generation.
7. Natural selection does not guarantee progress or improvement in any absolute sense, nor does it include or imply any overarching plan. It only leads to better fit of organisms to their local environments.
8. Evolution is the central organizing and explanatory idea in modern biology, including medicine and agriculture. If it is incorrect, then so is much of our understanding of the rest of biology.
9. Evolution is important because it helps us understand and address many practical problems, such as resistance of germs and pests to medicines and pesticides, the structure and function of the genetic mechanisms of inheritance and development, the nature of many human diseases, and the ecological causes and consequences of species extinction.
10. Evolution by natural selection is not necessarily opposed to religion, nor is it a basis for rejecting all systems of ethics. It does, however, imply that the natural world, including humans, is explicable solely by reference to natural processes and phenomena, that any supernatural influence on nature is unobservable by and inaccessible to science, and that human ethics and values are derived from humans themselves.

[Reprinted with permission from Warren D Allmon, *Evolution and Creationism: A Very Short Guide*, second edition, p 113–114.]

About the author

Robert "Mac" West, a member of NCSE's board of directors, is a former director of the Carnegie Museum of Natural History in Pittsburgh and the Cranbrook Institute of Science in Bloomfield Hills, Michigan. He now operates Informal Learning Experiences, Inc.

Author's address

Robert "Mac" West
Informal Learning Experiences
1776 Krameria Street
Denver CO 80220