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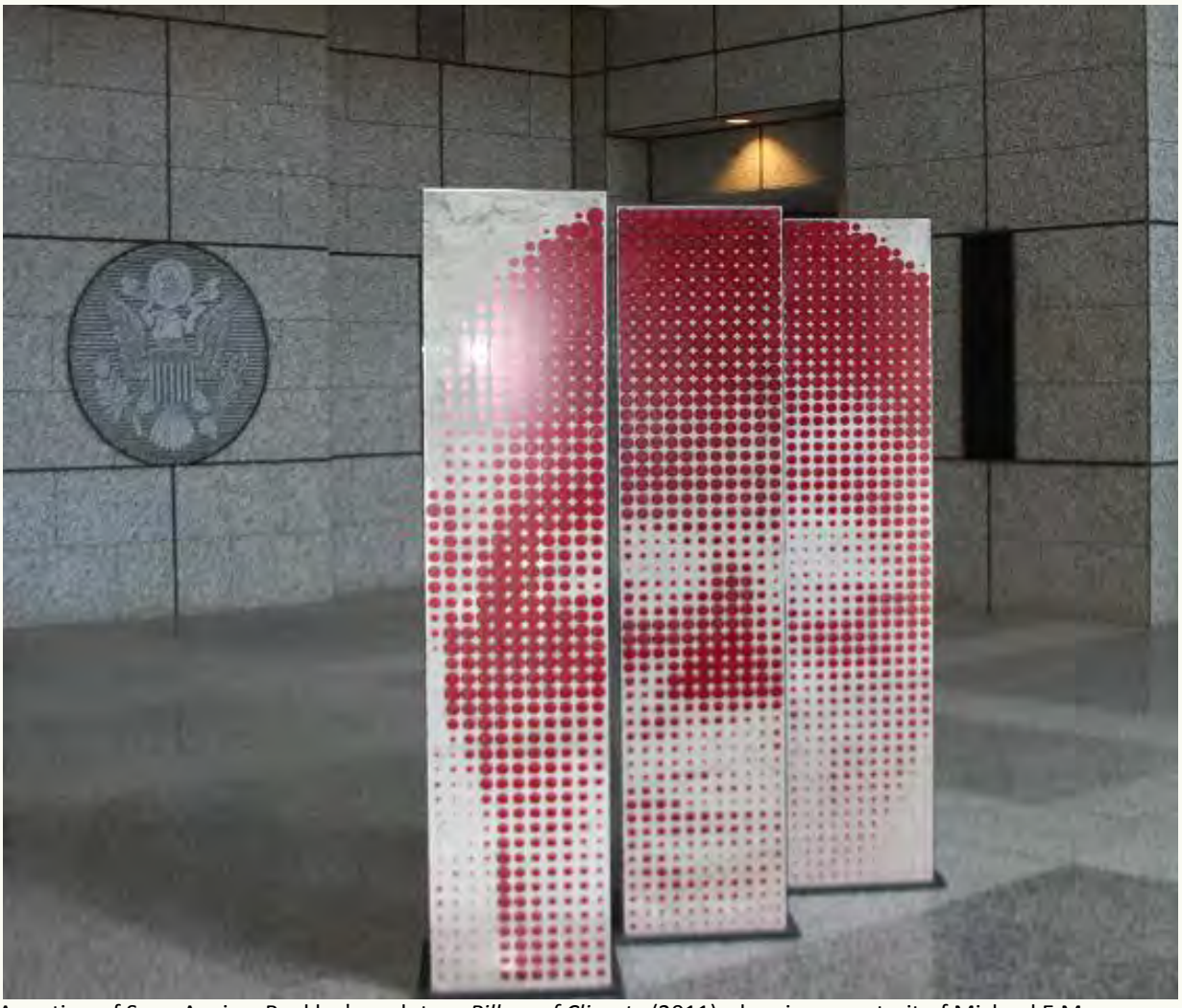

A section of Sean Aguirre Buckley's sculpture *Pillars of Climate* (2011), showing a portrait of Michael E Mann, physicist, climatologist, and director of the Earth System Science Center at Pennsylvania State University.

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FEATURE

Talking Animals, Silly Jokes, and Natural Selection: Eugene Byrne and Simon Gurr's *Charles Darwin: A Graphic Biography*

Daniel J Glass

When it comes to certain forms of print media, the dividing line between educational and recreational reading material has—until recently—been rather sharp. The image of a young boy sneakily reading a comic book in school by hiding it within his textbook is such an archetypally classic part of our culture that one can clearly envision it in a Norman Rockwell painting, whether or not such a painting actually exists. Current rock star and former sixth-grade teacher Gene Simmons has often described how he was foiled when he tried to use a Spider-Man comic as a teaching tool in the early 70s (Anonymous 2012). Beginning several decades ago, however, with the advent of "respectable," non-fiction graphic novels like *Maus* (Spiegelman 1991) and *Persepolis* (Satrepi 2004), the line began to blur, and graphic novels gradually became a medium which could be legitimately used in the classroom by reputable teachers. For a variety of reasons (see Karp 2011), graphic novels can and should be used in the classroom, and the science classroom is no exception. *Darwin: A Graphic Biography* (Byrne and Gurr 2013) is, as its name suggests, a biography of the renowned scientist in graphic novel form, and it can be confidently added to the burgeoning library of such works that can be of great benefit to grade school classrooms learning about science and science history.

In general, the graphic novel (which is like a comic book but usually thicker and published as a novel—often containing a full story—rather than as a periodical) is an ideal way to engage adolescent readers who have graduated from children's books but are not yet ready to delve into phone-book sized tomes with tiny writing and few pictures. It is for this reason that *Darwin: AGB* is a useful addition to the lineup of existing Darwin biographies, even though these number in the dozens. Young grade schoolers already have Alice B McGinty's (2009) *Darwin: With Glimpses into His Private Journal & Letters*, with colorful illustrations by Mary Azarian. By the time they are in their early 20s, students of science history will have developed the upper body strength to heft the 800-page *Darwin: The Life of a Tormented Evolutionist* (Desmond and Moore 1991), one of the definitive biographies of the great man. For the in-betweeners, though, *Darwin: AGB* fits the bill exactly; it is fun enough to engage teen readers and can be read in a single sitting, but is also surprisingly deep in terms of biographical and scientific details.

The first impression the reader gets of the book is, of course, its artwork. The illustrations are black-and-white, but the expressive inking and shading give it energy and clarity. The story is mainly told via third-person narration in text boxes with occasional comic-style word and thought bubbles to illustrate various points or conversations between Darwin

and his colleagues. The book opens with a frame story in which a television crew consisting of a gorilla, a chimpanzee, and an orangutan is filming a nature program in Madagascar (the narrative mercifully sidesteps the issue of whether it takes place in a post-human *Planet of the Apes*-style society). With the hosts of the show struggling to become excited about the orchid they're profiling, it falls to Helen the aye-aye (a remarkable species of nocturnal lemur) to explain why the flower, *Angraecum sesquipedale*, is so special. (The frame story featuring a number of naïve listeners with little knowledge of the subject matter is an effective device for the scientific graphic novel [see also Hosler 2011], since it allows a natural mechanism for anticipating questions and objections that young readers are likely to have.)

As it happens, the nectar of this orchid is at the bottom of a very long hollow spur and thus—as first noted by Darwin—could only be consumed by a theoretical insect with an extraordinarily long proboscis. Such a creature had to exist, Darwin reasoned, or else the orchid species would rarely be pollinated. Twenty-one years after Darwin's death, such a moth was indeed discovered, confirming Darwin's prediction and standing as yet another testament to his brilliance. The apes are impressed by the story, but admit to not really knowing who Darwin is, despite him being the subject of the show they are recording. And thus begins the actual biography portion of the book, as the erudite aye-aye whips out a clipboard and glasses, corrects a few initial misconceptions that the apes have about Darwin (including the obstinate canard about humans being descended from modern apes or monkeys), and launches into the life and times of Charles Darwin.

Any comprehensive biography should include some background on the historical and intellectual climate into which the protagonist is extruded, and *Darwin: AGB* happily does not neglect this context. Darwin's birth in the story is preceded by a run-down of the prevailing pre-Darwinian hypotheses which natural selection supplanted. Both scientific and religious perspectives are mentioned, and the Judeo-Christian creation story is recounted, although the authors acknowledge that almost every society has a competing origin myth.

Since the Genesis story is the most common religious rival of Darwinian theory in Western society, it is understandable that it is the only creation myth profiled; yet, I would have preferred that at least one other creation story from another religion have been detailed. When the biblical creation is portrayed as the main alternative to Darwinian evolution, there is an unintended possibility that readers, especially young ones, may infer that this particular religious origin story is somehow more salient than the hundreds of other such creation myths which are less well-known in our culture. It is this fallacious line of thinking which is behind the "teach the controversy" objection to evolution education—a flawed notion based on the premise that there are only two competing explanations for the complexity of life, one based on the Bible and one based on Darwin. Bobby Henderson (2005) satirically exposed the faulty reasoning behind this assumption with his open letter to the Kansas State School Board insisting that his preferred origin story, divine creation by a Flying Spaghetti Monster, also be taught in school science classes. In *The Magic of Reality* (2012), Richard Dawkins attacks this problem by describing the origin myths of many religions—Tasmanian aborigine, Norse, and a number of others—without affording one any higher status than any of the rest. The recognition that scientific explanations of biodiversity are pitted against a plethora of mutually contradictory religious creation myths is far less likely

to breed a "teach the controversy" mindset than the perception that evolution and Genesis creation are the only two players on the field.

Nevertheless, this is a negligible issue, especially in light of the things that *Darwin: AGB* does well. William Paley's "watchmaker" argument is discussed to emphasize the puzzle that Darwin's theory of naturally selection eventually solved. The concept of artificial selection, in relation to dog breeds, is broached early in the book—long before natural selection is described. This tactic serves as a foot in the door in that it introduces the idea of species unambiguously changing over time to young readers, who are likely to accept it without controversy and spend the next 68 pages digesting it, so that natural selection comes as an obvious extension of that principle when it is finally presented. This is the same way Darwin himself eased his audience into the idea of natural selection in the *Origin* (Darwin 1859), and it remains an effective way to force the reader either to accept that some species have changed visibly in the course of human history or to insist that poodles and chihuahuas have roamed the earth since the Garden of Eden.

In a surprisingly sophisticated maneuver for such a book, *Darwin: AGB* devotes quite a bit of ink to the cultural changes happening during the Industrial Revolution and how this movement reflected the intellectual climate of scientific and technological advancement that set the stage for the nineteenth-century study of evolution not only by Darwin but also his intellectual predecessors. *Darwin: AGB* gives the famous scientist all the credit he's due for his work on natural selection, but also reminds readers that he did not single-handedly invent the theory of evolution through common descent. The book doesn't mention the ancient Greek thinkers like Anaximander and Empedocles, who are often considered early advocates of evolutionary concepts (Sedley 2007), but it does discuss a few of the pre-Darwinian evolutionists such as Lamarck. Charles's grandfather Erasmus is given two whole pages, more focus than I had ever seen allotted to the man in any evolution course. Erasmus wrote about evolution in poetic verse, founded the famous English intellectual club the Lunar Society (famous members included James Watt and Joseph Priestley), and had many children from two different marriages. The illustration accompanying the latter point shows Erasmus Darwin surrounded by children and admiring women, giving us a thumbs up and a cheeky wink, just one example of how Gurr's illustrations can make biographical history fun and vital.

Of course, the meat of *Darwin: AGB* is the illustrated biographical history of Darwin himself. The immediate goal is to make Darwin—whom most teenagers know, if at all, only from old photographs of a stern-looking, even melancholy, white-bearded guy—relatable. This is not as hard as it may seem, as Darwin was a fascinating man with a self-deprecating sense of humor, a wide variety of interests, and a self-admitted childlike sense of wonder. One of the obvious sources of the anecdotes in the book is Darwin's own autobiography (Darwin 1887), originally written for his family and published posthumously. As is often claimed—more frequently but less accurately—about fellow celebrated genius Albert Einstein (Isaacson 2007), Darwin did well in some scholarly pursuits, such as chemistry, but poorly in others, like math and the classics. One of the most endearing stories is one in which a young Darwin, who had a passion for beetling, was on an insect-collecting jaunt one day and already carrying a rare beetle in each hand when he came across a third specimen. Rather than release one of the two beetles, Darwin put one between his teeth so he could pick up the third, but the insect surprised the legendary scientist by releasing

a noxious spray of acid down his throat, causing him to lose all three. While *Darwin: AGB* identifies the offender as a bombardier beetle, whose defensive fluid is boiling hot, Darwin (1846) merely refers to it as an unknown carabid (a member of the ground beetle family, which includes bombardier beetles) a number of which have non-boiling defense sprays (Eisner and others 1963), which may mean a non-bombardier species is a more likely culprit, given Darwin's (1846) failure to remember the species and the fact that he does not note any long-term injury from the incident (Darwin 1846, 1887).

Another fun Darwin fact is that although he was a naturalist, he was by no means a puritanical environmentalist, trembling for fear of disturbing the ecosystems he investigated. He was an avid hunter in his youth, and while a student at Cambridge he was a member of the Glutton Club, which dined on exotic animals; the group switched to more standard cuisine after one unpleasant night when they tried to eat an old brown owl. During his voyage on the *Beagle*, he and the crew ate many of the Galápagos tortoises that provided such powerful evidence for speciation. The crew also dined on most of an elusive rhea specimen before Darwin realized what he was doing in time to save some of the remains for scientific study. These and many other fun details bring Darwin's story to life, particularly the voyage on the *Beagle* and the peculiar character of Captain Robert FitzRoy (who almost rejected Darwin as a traveling companion because of the shape of his nose).

After the *Beagle* voyage, of course, comes Darwin's gradual discovery of his theories. Any worthy biography about a notable scientist must delve into some science so the reader can understand the context behind and the importance of the scientist's contributions to the field. If you read a biography on Albert Einstein, you'll surely encounter some relativity, statistical mechanics, and quantum physics. If you read about Galileo, expect to learn about observational astronomy, telescopes, sunspots, and extraterrestrial moons. By the same token, in this biography about Charles Darwin, Byrne and Gurr present a great primer on natural selection that is accessible for young readers. In the same way that a basic understanding of Newtonian physics is critical for appreciating why Einsteinian physics is different, *Darwin: AGB* discusses Lamarck's view of evolution as progressing up a "ladder" toward increasing perfection and contrasts that to Darwin's view of evolution as more akin to a bush or tree.

After taking us through the journey of discovery that Darwin himself went through, including many of the findings and observations that he made, *Darwin: AGB* presents a simple, two-page explanation of the natural selection process. The book then covers the publication of the *Origin*; the surrounding furor; some criticisms of Darwin's theory and the evidence-based rejoinders to these; and the final years of Darwin's life. This brings me to my only real complaint about *Darwin: AGB*, which is that Darwin's post-*Origin* life is barely covered at all. The great scientist dies a mere ten pages after the publication of his most famous work, and most of these pages are about the science of evolution rather than Darwin's later years. Several of his books after the *Origin* are briefly mentioned, but these descriptions are shoehorned in rather than fully fleshed out. In a way, it is an understandable decision to focus on Darwin's most exciting years, the ones that led up to his most enduring scientific contribution. But the book's title identifies it as a biography, which carries the implication that the subject's entire life will be chronicled. I was eager to see how this book would cover Darwin's personal life during his rarely recounted twilight years—including his feud with author Samuel Butler—so was disappointed as I neared the end

of the book and noted the disparity between the number of years remaining in Darwin's life and the number of pages left in the volume. Perhaps the authors felt that the target audience would not care to read about the protagonist once he aged beyond relatability, and in all fairness, this may have been a prescient decision. At any rate, readers interested in these years have the option of picking up the formidable biography by Desmond and Moore (1991), which emphatically does *not* skimp on any details.

On the whole, *Darwin: A Graphic Biography* is more or less exactly what it should be: a fun, humorous, well-illustrated, fact-packed story of the life and work of one of the most well-known scientists in history. While it appears to be aimed at early adolescents, with its talking animals and silly jokes, the density of text and information may mean that teenagers and even young adults may get the most out of it. Given the increasing acceptance of comic books as teaching tools, *Darwin: AGB* would certainly be appropriate as part of a grade school curriculum covering well-known scientists and their work, perhaps alongside other graphic novels about the likes of Isaac Newton, Albert Einstein, and—who knows?—maybe one day, even Bruce Banner.

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FEATURE

Teaching Evolution for a Future Scopes

James J Krupa

One day in my fourth grade class, a classmate handed me a book for children. I cannot recall the title. This illustrated book had many drawings; those that I remember were of geological formations, fossils, Charles Darwin, Neanderthals, and dinosaurs. Sitting at my desk in the back of the class, I was mesmerized as I studied this book. My teacher noticed I was not paying attention and rushed to the back, seizing the book. Flipping the pages, she realized what the book covered and became red-faced and furious. Enraged to the point of spitting, she rebuked me: "The biggest mistake your parents made was not tying a rope around your neck the day you were born and throwing you in the Missouri River." (I grew up near the river in Omaha, Nebraska.) In part because of these words, I became fascinated with the anti-evolution attitude in the United States. As a high school student and as an undergraduate, any time I had an assigned essay with open topic, I wrote on the history of the anti-evolution movement. Dismay with the anti-evolution attitude in this country is one of the reasons I became a teacher and evolutionary biologist.

In many ways, it is amazing that of all states, I ended up in Kentucky and at the University of Kentucky. Kentucky is where Ken Ham's Answers in Genesis organization is located. This is one of the best funded anti-science, anti-evolution organizations in the country. Kentucky is also the home of the Creation Museum and soon the "Ark Park," featuring a supposed replica of Noah's Ark, both run by Answers in Genesis. Answers in Genesis is a constant presence in Kentucky, with its associates giving creationist lectures throughout the state, including on the University of Kentucky campus. I have always felt part of my job is to provide a countervoice to Ken Ham's words. Thus I have given over eighty public presentations on evolution and made all my classes evolution-based in presentation.

From a historical perspective, it is also amazing that I ended up here because the first effort to pass anti-evolution laws (led by William Jennings Bryan) was in Kentucky in 1921. A bill was proposed that would make teaching evolution illegal, with most of the attack directed towards the state's flagship university. A great president and great teachers at the University of Kentucky were responsible for stopping the anti-evolution bill from becoming law as well as inspiring a student at the university to himself defend academic freedom in Dayton, Tennessee. President Frank McVey saw this bill as a threat to the University of Kentucky as well as to academic freedom. Three faculty members joined McVey in one of the most contentious battles in Kentucky's history. William Funkhouser was a zoologist and evolutionary biologist, Arthur Miller was a geologist who taught the evolution class, and Glanville Terrell was a philosopher. Through their efforts these four individuals helped defeat the anti-evolution bill (defeated in the legislature by a 42 to 41 vote), putting their jobs on the line to do so. Consequently, the movement turned its attention towards Tennessee. At the time, John Thomas Scopes was a student at the University of Kentucky watching

the efforts of his three favorite teachers: Funkhouser, Miller, and Terrell. The reason the Scopes trial occurred is in part due to these great teachers. When I reread Scopes's memoir *Center of the Storm*, I am reminded why we must always try to be the best teachers we can: we may have a future John Scopes taking our classes. Scopes's words in the passage from his book below stand out.

> Teachers rather than subject matter also rekindled my interest in science. I saw Dr William Delbert Funkhouser and decided immediately to take a course under him before I even knew what he taught. He was a man without airs, who could have passed for a grocer or some other businessman, but he taught zoology so flawlessly that there was no need to cram for the final examination; at the end of the term there was a thorough, fundamental grasp of the subject in bold relief in the student's mind, where Funkhouser had left it. (Scopes and Presley 1967:29)

Since 1995, I have taught over 23 000 students, most in introductory, non-majors biology (basic biology and human ecology). Recalling the idea that "education is the kindling of a flame, not the filling of a vessel," I am ever mindful that my classes may be the last chance to instill an appreciation of science and understanding of evolution. I am constantly searching for ways to light that flame.

Several editorials have appeared in *The American Biology Teacher* and *Science* arguing that evolution should be the foundation on which a biology class is built rather than taught as a unit at the end of the semester. I embrace this approach and it is why I present evolution early in the semester and then have it as a thread woven throughout the class for the rest of the semester.

A method amenable to large-class teaching and advocated by inspirational biology teachers from Louis Agassiz (Krupa 2000) to EO Wilson (2002) is both ancient and obvious, yet increasingly overlooked by modern pedagogy: storytelling! Paraphrasing Agassiz, the best lectures are of topics the teacher knows best and is most passionate about. As a long-time devotee of this approach (see Krupa 2000, 2013 for more discussion), I am convinced that my rapport with students and their retention of the central lessons are both maximized when I am most passionately engaged in relating my best stories. It is in this way that I feel I may help students appreciate science and evolution.

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About the author

James J Krupa is Professor of Biology at the University of Kentucky. He received the Evolution Education Award from the National Association of Biology Teachers in 2012, in recognition of his innovative classroom teaching and community education efforts to promote the accurate understanding of biological evolution; the present essay is adapted from his personal statement submitted as part of the award application process.

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FEATURE

People and Places: Cabazon Dinosaurs

Randy Moore

FIGURE 1. *The Cabazon dinosaurs were originally called "Claude Bell's Dinosaurs" and "Cabazon Dinosaurs", but today are officially named "World's Biggest Dinosaurs". The dinosaurs, which are seen by 12 million people annually from Interstate 10, are 13 miles west of Palm Springs, in Cabazon, California.*

"The World's Biggest Dinosaurs" in Cabazon, California, were built by Claude K Bell (1897–1988), an artist and sculptor at Knott's Berry Farm in southern California (Figure 1). Bell began building his first dinosaur—the 150'-long, 45' tall (46 meters long; 15 meters tall) apatosaur "Dinny"—in 1964 to attract attention to the Wheel Inn Café, which Bell had opened in 1958. It took eleven years to finish the 150-ton Dinny, which he made from construction materials salvaged from nearby Interstate 10. Bell spent $300 000 on his dinosaurs, most of which paid for their giant metal grids that were later covered with shotcrete (spray concrete). Bell was helped by ironworker and engineer Gerald Hufstetler, but did not use any construction companies or contractors. Dinny was painted by a friend of Bell's for $1 and a case of Dr Pepper®.

Behind Dinny is Mr Rex, a four-story concrete tyrannosaur that Bell completed in 1986, after seven years of work. Visitors can climb into Mr Rex's mouth for a panoramic view of the area through his teeth. Bell's dinosaurs have appeared in numerous videos, commercials, and movies (for example, *Pee-Wee's Big Adventure*). Bell hoped also to build a wooly mammoth, a sabre-toothed tiger, and a slide down Mr Rex's tail, but his death in 1988 ended construction.

Bell's original park had no overt religious agenda. In the museum and gift shop in Dinny's belly, Bell had sculpted "Cro-Magnon Man 30 000?". "Neanderthal Man 150 000?","Peking Man 200 000", and "Java Man 400 000?". However, Bell's family sold the dinosaurs in the 1990s, and by 2005 they were owned by Orange County developer George Kanter, who now uses the attraction to "help the young and old explore what is known and not known about dinosaurs, man, and the creation of the world in a practical, factual, and fun way" by learning "factual information provided by scientists around the world" about "facts regarding the history of the world, dinosaurs, and man."

This means creationism. Indeed, Bell's dinosaurs are now used to promote young-earth creationism while discrediting evolution. As Ashley Powers (2005) noted, Kanter transformed Bell's dinosaurs "from a tourist stop to a place of worship." In the building containing animated dinosaurs, exhibits show chimps riding dinosaurs, claim that dinosaurs are unrelated to birds, and argue that apatosaurs are alive in Africa and South America. A nearby exhibit claims that "Java Man" was a "post flood human" misrepresented by Eugène Dubois, that "creationists think that Neanderthals were humans who lived after the biblical Flood and during the rapid ice age which followed", that fossils of humans "are compatible with the concept of special creation", and "the millions of years postulated by old-earth advocates never happened".

Visitors can buy stuffed dinosaurs that proclaim "Don't swallow it! The fossil record does not support evolution!" A large exhibit claims that the "evolutionary origin of life is impossible", and there are many signs and banners claiming that dinosaurs were produced "By Design, not by chance!" (Figure 2). The website for the attraction links with anti-evolution organizations such as Answers in Genesis, claims that dinosaurs are mentioned in the Bible (for example, "behemoth" in Job 40) and were aboard Noah's Ark, and argues that "the theory of Darwinian evolution is fundamentally and fatally flawed." The website also includes testimonies of several creationists who claim, among other things, that there is "still no evidence for evolution". Readers are urged to learn more about creationists such as Henry Morris, Steve Austin, Duane Gish, Andrew Snelling, and Jonathan Wells.

FIGURE 2. *Throughout the attraction, visitors learn that dinosaurs were created "by design, not by chance!".*

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Randy Moore is the HT Morse–Alumni Distinguished Professor of Biology at the University of Minnesota. His most recent book (with coauthor Sehoya Cotner) is *Understanding Galápagos: What You'll See and What It Means* (New York: McGraw-Hill, 2003).

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FEATURE

The Religious and Political Climate: Getting Past the Antediluvian

Dennis S Ross

The Bible's Noah never imagined his story's becoming a prop for global warming denial. Yet in today's religious and political climate, Noah's tale is the foil in Congress—a pretext for rejecting science-based climate protection.

First, let's agree that global warming is happening right now, that we are the cause and the impact is staggering. With nine of the ten hottest recorded years occurring since 2001 (Krugman 2012) and the first six months of last year bringing the highest recorded temperatures in the contiguous United States since 1895 (*The New York Times* 2012), once stable polar glaciers are melting, oceans are rising, and there's more rain and snow. Continued global warming will contribute to even higher seas, stronger hurricanes and storms, more frequent droughts, scarcer fresh water and spread of disease, like mosquito-borne malaria (National Geographic Society 2012a).

Global warming is one consequence of the accumulation of carbon dioxide from burning fossil fuels in cars, factories, and power plants along with other gases that combine with methane from agriculture and landfills, along with additional gases from refrigeration and industrial processes (National Geographic Society 2102b). In the midst of this grim environmental reality, climate change deniers unfortunately capture much attention and sway, to the point of undermining attempts to protect the earth. At the same time, a religious theme behind their science-denial is often overlooked. Let's consider this negative religious approach.

For instance, US Senator James Inhofe (R–OK) said:

> It's not whether or not we're going through a global warming period. We were. We're not now. You know God's still up there. We're now going through a cooling spell. And the whole issue there was, is it man-made gases, anthropogenic gases, CO_2, methane. I don't think so. (Stoll 2009)

In other words, even if the earth is getting warmer, no need for us to worry. "You know God's still up there," as if tinkering with some heavenly thermostat to get us to Goldilocks's ideal temperature: not too hot, not too cold, but just right. Inhofe went deeper in his recent book, *The Greatest Hoax: How the Global Warming Conspiracy Threatens Your Future* (Inhofe 2012), relying on the Bible's story of the Great Flood to support this science denial, as do others.

Recalling Noah's tale (Genesis 6:9 to 9:29), God decided to destroy a corrupt and lawless humanity—all except for righteous Noah. God told Noah about the upcoming Flood and

instructed Noah to build an ark to save himself, his family, and animals. The rains came and the world flooded. After the rain ended, the water subsided and the land dried, the ark's inhabitants—human and animal—set off to repopulate the earth. God placed a rainbow in the sky as a sign of a promise—a Covenant—never to destroy people like that again. Inhofe refers to Genesis 8:22:

> As long as the earth remains
> there will be springtime and harvest,
> cold and heat, winter and summer,
> day and night.

The senator concludes, "He [God] promised to maintain the seasons and that cold and heat would never cease as long as the earth remains" (2012:71), as if the planet will always be there for us, as is, no matter how hot we make it or how much we foul it. This line of thought goes way beyond the Bible's intention; God made no such promise. Of note, former presidential candidate and former senator Rick Santorum (Kapur 2012) and Representative John Shimkus (R–IL) (*Daily Mail* 2010) have offered similar science-denying arguments.

The bow set in the clouds

It's tempting to ignore the rhetoric as naive, ignorant, or silly—but that would be a dangerous mistake. These science deniers have achieved high national office, which confers the power to maintain bad policies and defeat or delay the implementation of good ones. For example, Inhofe is ranking minority member of the US Senate Committee on Environment and Public Works and serves on the Subcommittee on Clean Air, Climate Change, and Nuclear Safety (Inhofe 2012b). Shimkus serves on the House Energy and Commerce Committee and chairs the Subcommittee on Environment and the Economy (Shimkus 2012). And former senator Santorum may yet have a long and successful political career. This is all to say that policy makers charged with protecting the climate are instead using their positions to codify personal religious beliefs that would both violate church–state separation and undermine the stability of the environment that hosts us all.

In response, let's begin by pointing out that many, many religious leaders respect scientific consensus. Religious global warming deniers speak as if they are the sole and authentic voice of faith, but they are neither. The reality is that people from a wide spectrum of religions and denominations are proud to reconcile science and religion—and they are among the most effective counter voices. When the opposition is religious, the proper respondent is a religious respondent. When one faith says Noah's story teaches us not to worry about global warming and another faith strongly disagrees, we have appropriately re-framed this debate as a religious quarrel that policymakers have no business entering to play umpire, decide which religion is correct, establish that faith as the winner, and enshrine those faith teachings as law. Rather, under church–state separation, our government must craft science-based policy. Of course, people are free to interpret the Bible as they wish and hold these religious beliefs in the home, the heart, or their houses of prayer. And they are free to express those beliefs in the public forum and with policy makers—it's the American way. But it's not the American way for Congress or state legislatures to push science aside on the assumption that if we hit a problem, God will save us.

Let's also recognize the proper place for faith. I often hear it said that religious people should stick to religion and keep away from policy. The reality is that religious expression is perfectly legal—government regulations provide for limited advocacy by religious leaders and institutions (Internal Revenue Service 2009). In addition, every American has a right—really responsibility—to voice an opinion; I don't lose my freedom to speak just because I am a rabbi. Even as we honor the boundaries between religion and government, there is a positive and appropriate role for religious voices in public life. What's more, religious people are here to stay—those of us who respect science and those who don't. There's wisdom in learning how to deal with organized religion, because we are not going away.

It is important to recognize the big differences among religious advocates. Typically, religious climate change and science deniers cite their faith's teachings as the final word, expecting policy makers to enact legislation just because their religion says so. In contrast, I believe that religious arguments—mine or anyone else's—are never the final word in crafting policy. Religious perspectives are just one factor among many, including the US Constitution and, in this case, science. Religion does have a voice, and religious people are among the most effective spokespersons when it comes to clarifying the appropriate, but limited, role of faith in public life.

Called to stewardship

We don't have to go very far to deepen and strengthen working partnerships between the science community and like-minded religious groups. For instance, the National Religious Partnership for the Environment is an alliance of faith groups—the Coalition on the Environment and Jewish Life, the United States Conference of Catholic Bishops, the National Council of Churches of Christ (which includes many "mainline" Protestant denominations, and churches in the Anglican, Eastern Orthodox and African American traditions), and the Evangelical Environmental Network. The members all recognize the reality and dangers of global warming. The Partnership is a great example of the wide spectrum of religious leaders and people of faith who love the Bible and respect science, all at the same time.

The Partnership's mission statement affirms a nuanced biblical, theological and religious argument:

> Called to be the Creator's special stewards, human beings have a unique responsibility for the rest of creation. As wise stewards, we are summoned not only to mold creation's bounty into complex civilizations of justice and beauty, but also to sustain creation's fruitfulness and preserve its powerful testimony to its Creator.
>
> We confess that too often we have perverted our stewardly calling, rampaging destructively through creation rather than offering creation and civilization back in praise to the Creator. For this our sin, we repent, gratefully acknowledging that the Creator is also the Redeemer who promises to renew all things. In grateful obedience to this our marvelous God, we resolve to make our homes, our faith communities and our societies centers for creation's care and renewal, healing the damaged fabric of the creation which God entrusted to us. (National Religious Partnership for the Environment 2013)

The Partnership represents many millions of faithful—religious folks from diverse denominations and communities across the nation—who lovingly reconcile religious teaching and scientific finding about earth care.

The word "stewardship" is central to a proper religious and spiritual relationship to the earth. The Creation story places Adam and Eve—representing all humanity—in charge, and includes earth care as a fundamental human responsibility. A Covenant of climate stewardship speaks to the spiritual, religious and moral responsibility for earth. In plain language, our faiths teach that we made this mess, that we are making it worse, and that it is up to us to fix it: the onus is on us.

The seas rose in Noah's time and they rise again today, although at a much slower rate that, we hope, leaves time to act. Building a wooden ark won't save us. But we can make an ark of our earth with policies that protect our environment, so that we, our earth and all that live on it, will endure.

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REVIEW

Earth: The Operator's Manual

by Richard B Alley
New York: WW Norton, 2011. 479 pages

reviewed by Daniel Bedford

I recently had the unnerving experience of trying to discuss climate science with a devout global warming skeptic. It was difficult to converse rationally about the subject with him, and impossible for me to dislodge the many inaccurate ideas that I was presented with. My interlocutor had recently read one of the many works of misinformation dressed up to look like real science, and, lacking a grounding in science himself, had chosen to accept every word of it as true. This person was (and is) highly intelligent and well-educated, and therefore found himself in good (or at least, extensive) company: survey research has shown that, while American public opinion about global warming is polarized along broadly partisan political lines, they become more polarized with higher levels of education and higher levels of general science literacy (see, for example, Kahan and others 2012). Evidently, our psychological defense mechanisms are hard at work deflecting ideas we disagree with and welcoming those that fit our preconceptions. At the same time, public knowledge of the science specifically of global warming is alarmingly low, with one recent poll finding 52% of those surveyed (a broad cross-section of the American public) scoring an F on a 42-question test (Leiserowitz and others 2010). Evidently, strong opinions on global warming are being formed in the absence of a good understanding of the science of the issue. In this environment of low levels of knowledge and high levels of polarization, where more education seems only to polarize people further, what hope is there for any attempt to raise the level of public understanding of climate science?

Enter Richard Alley, the Evan Pugh Professor of Geosciences at Pennsylvania State University, eminent geologist, glaciologist, and climate scientist, outstanding science communicator, aptly described as "a cross between Woody Allen and Carl Sagan" by the *New York Times*'s Andrew Revkin. Alley's expertise runs broad and deep, but he arguably made his name in climate science by analyzing ice cores from Greenland in the 1990s to help understand natural changes in Earth's climate; and he arguably made his name in climate science communication with the critically acclaimed popular-audience book about this research, *The Two-Mile Time Machine* (Alley 2000). His latest book, *Earth: The Operator's Manual*, tackles human-induced climate change more explicitly, and addresses possible ways that humanity might use to escape the corner we seem so intent on painting ourselves into. Given a general climate (pun intended) of intimidation of many leading climate scientists, Alley is brave to plunge into these potentially dangerous waters where science, policy, and advocacy overlap. Here be dragons.

Does he succeed? In a word, yes. This is a terrific book. It is a much more detailed and elaborate version of the PBS television documentary of the same name (available via the

PBS website and at http://earththeoperatorsmanual.com/, essential viewing for anyone interested in the subject, or in communicating it effectively). The book is organized into three sections. "The burning question" examines the history of humanity's relationship to energy sources, raising the intriguing possibility that we are human partly because of our use of energy, in the form of cooking; "Learning while we burn" is an extensive discussion of climate science and how past climate changes clearly show that carbon dioxide has been "the biggest control knob" of Earth's climate machine over geologic time; and "Ten billion smiling people" addresses the range of solutions to the climate-energy conundrum. Throughout, there is an emphasis on the processes of science and how and why science ultimately produces reliable information—certainly more reliable than the metaphorical brother-in-law, who appears in two chapter titles as a stand-in for misinformants of all stripes. There is a very wide range of material here, and, while Alley is a heavyweight climate scientist, he writes with a lightness of touch and flair for analogy and metaphor that make the book a relatively easy read. Nonetheless, it carries more than enough depth and detail to be satisfying, and the extensive endnotes will make this a valuable reference work for anyone teaching about climate change, specialist and non-specialist alike. That said, Alley makes his subject as simple as possible but no simpler. *Climate Change for Dummies* this ain't—but nor is it an impenetrable piece of technical literature. For the popular audience, then, the book should appeal to those who are intelligent, well educated, and science literate—some of whom, as the surveys mentioned earlier attest, are among the most skeptical about global warming, and most need to hear the book's message.

Given this skepticism, and given our innate tendency to avoid or reject information we disagree with, what are Alley's chances of preaching to those outside the choir? Certainly, he stacks the odds in his favor. Without downplaying the seriousness of the climate crisis, he avoids polemics and maintains a refreshing can-do optimism about humanity's ability to meet the coming climate and energy challenges. I was particularly inspired by the idea that "[y]ou, and Einstein, and Beethoven, and Michelangelo, taken together, use or used less energy than a single chandelier" (p 18–19) in terms of the energy needed to keep our bodies going. The observation that people, at least in rich countries, have already mastered a challenge comparable to decarbonizing the economy—building adequate sewerage and clean water systems—is similarly encouraging. This fundamental optimism, combined with a recognition of the importance of the individual and the prospects for a solution springing from free markets, are consistent with a right-of-center political outlook, and may make the book more palatable to those who might otherwise tend to reject it out of hand. It might not hurt that Alley explicitly identifies himself as a church-going Republican, either.

The book is not perfect. The graphics and photographs are sometimes effective, but sometimes rather haphazard and not integrated well into the text; there is a very occasional lapse in the clarity of writing and explanation. But these problems are so minor in comparison to the book's accomplishments that it seems almost churlish to mention them. As a source of information for those seeking to know more about global warming and what we can do about it—or as a source of persuasion for those who think they already know everything they need to—this book may well be the best, most authoritative, comprehensive, and concise, single volume for the intelligent lay reader currently available.

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REVIEW

Living in a Dangerous Climate: Climate Change and Human Evolution

by Renée Hetherington
Cambridge: Cambridge University Press, 2012. 272 pages

reviewed by Miriam Belmaker

Living in a Dangerous Climate is a wide-ranging book with high ambitions. Hetherington makes a case for the reality of human-induced climate change and warns of its likely effects on the dominance of the human species on earth today. She calls for the immediate action of not only the scientific community but also the private sector to address the continuing climate change and environmental degradation in order to prevent the ongoing shifts that would lead to irreversible damage to human demography, health, and even future evolution. As if that weren't enough, she also systematically connects the climate change we are presently experiencing with the climate changes that have shaped us as a species.

In order to make her case, Hetherington pulls together a wide and impressive range of evidence. The first three chapters describe human evolution from the rise of the genus *Homo*, and its emergence from Africa 1.8 million years ago, through the evolution of our own species, *Homo sapiens*, and the Upper Paleolithic revolution, to the colonization of the Americas and Australia. She relates the speciation of the various species and extinction of the archaic *Homo* species to their inability to adapt to climatic change. In contrast, the success of *Homo sapiens* is related to our resilience to climate change and ability to overcome the extreme changes in environmental conditions that occurred during the last glacial. She suggests that not only were modern humans adapted to climate change but also climate changes were the main triggers to some of the key events to social and biological changes in human evolution. These include the advent of agriculture and the rise (and fall) of complex urban societies. Thus it can be said that we as a species are the product of climate change.

But the question arises: If we are so adaptable, have survived so many glacial and interglacial cycles, and have become what we are because of climate change, why is this present turn of climate so dangerous or different from the previous ones? After presenting her detailed outline of the history of human evolution and the relationship to Plio-Pleistocene climate change, Hetherington puts forth her hypothesis to explain the apparent paradox. In this hypothesis, she argues that humans, which were once resilient and adaptable in the face of a very large amplitude of climate change, have become limited in their flexibility, static and specialized. This resulted (and is resulting in) in their adverse response to the increase in climate change in the Holocene and particularly in the upcoming millennia.

In the final chapters, Hetherington makes a case why humans should take action now to prevent the catastrophic changes that are likely to occur in human demography and health as well as the damages to the ecosystem if such actions were not to be taken.

Much of the focus in similar books has been put on either learning from the past (that is, presenting evidence that human fossil species are indeed adapted to climate change) or looking at the present evidence for recent climate change and the effects on the modern human population. There are few books that try to bridge the gap, offering an explanation of how a single evolutionary and biological model may explain how a very adaptable and versatile species can evolve to become so susceptible to climate change in the course of its own evolution. I believe that the hypothesis presented in this book is one of the crucial hypotheses relating to climate change today.

In the heat of the controversy over the validity, origin, and intensity of climate change today, many have rejected climate change as anthropogenic or as having a crucial impact on life on earth in general or on humans in particular. These climate change naysayers have suggested that the current climate change is just another phase in the natural cycle of climatic changes observed in the past. If this is the case, they contend or intimate, humans, as a highly adapted species that evolved in an ever-changing climate, will both survive and perhaps become adapted better to this natural and even expected climate change.

The fallacies in the naysayers' arguments are obvious for those who are familiar with the intricacies of climate change, human evolution, and the relationship between the two. However, as explained pointedly in the book, these arguments have remained in the academic sphere and have not penetrated to the public. Calling for greater and immediate action against current global warming and the effects of the current anthropogenic climate change, Hetherington offers a plausible explanation of how the current climate change can pose a real threat to humans, despite their past adaptive evolutionary history. Therein lie her book's greatest strengths.

However, in the attempt to bridge such a wide range of topics, *Living in a Dangerous Climate* falls short in the detailed explanations of the theory, as well as in the details of many of the facts it discusses. For example, in the case of human evolution or paleoanthropology, trying to tell the story of four million years of human evolution and the relationship to local ecology in two short chapters is a nearly impossible task. Perhaps in the attempt to be brief, it became too brief, or new evidence came to light after this book was published. Nonetheless, the result was the same: critical data are missing. Similarly, the material is not focused: reading these chapters, it is unclear whether the important part is supposed to be the synthesis of human evolution and climate change or the short history of human evolution.

While professionals in the field may find the book a bit condensed and lacking in detail, this book is an excellent read for the general reader who is looking for a general book to explain why our climate change is indeed anthropogenic despite suggestions by others to the contrary, and to do so within the broader context of the effect of climate change on human evolution.

About the author

Miriam Belmaker is Assistant Professor of Anthropology at the University of Tulsa. Her research focuses on environmental change primarily in the past two million years and how it affected hominid biological and cultural evolution.

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REVIEW

Global Weirdness: Severe Storms, Deadly Heat Waves, Relentless Drought, Rising Seas, and the Weather of the Future

by Climate Central
New York: Pantheon, 2012. 240 pages

reviewed by Anne U Gold

With an average temperature of 12.9°C (55.3°F) for 2012, the National Oceanic and Atmospheric Administration (NOAA) recently announced that 2012 was officially the warmest year on record in all contiguous 48 states based on 118 years of temperature records dating back to 1895. The year was also notable for droughts in the Midwest, destructive wildfires in the West, and Hurricane Sandy in the Northeast. Americans across the nation are experiencing these changing weather patterns and the associated extreme events—patterns that have been predicted by climate scientists as a result of increasing carbon dioxide concentrations in the atmosphere.

The evidence is convincing, but many struggle when asked to explain climate change in simple words or have difficulty holding their ground in discussions with climate change deniers. The book *Global Weirdness*, produced by Climate Central, a non-partisan, non-profit organization of leading scientists and journalists, was written to address these situations. It explains the basic climate system, the greenhouse effect, and the consequences of a changing climate, as well as solutions and adaptation strategies, in sixty simple, easy-to-understand, and concise essays. Most are two to three pages long with compelling titles like "Carbon dioxide is like a planetwide sweat suit (sort of)." The authors of the book, Emily Elert and Climate Central's staff science writer Michael Lemonick, lay out the current state of knowledge about climate change, with explanations of the underlying science based on peer-reviewed publications and reports. The scientific facts were checked by five Climate Central staff scientists and twenty-two outside scientists with expertise spanning the breadth of climate science.

The book, including its title, was inspired by Thomas Friedman's 2010 *New York Times* column "Global weirding is here," in which he encouraged the scientific community to produce a report about the reality of climate change that could be titled "What we know" and that was accessible to sixth graders. Climate Central has taken on this task, and the result is impressive. The authors have deliberately chosen a non-alarmist tone (the subtitle "Severe Storms, Deadly Heat Waves, Relentless Drought, Rising Seas and the Weather of the Future" is probably among the most alarmist phrases in the book).

The authors avoid jargon and explain technical terms ("anthropogenic climate change, from the Greek words for 'man' and 'caused'") and processes in an easy-to-understand way, using simple comparisons. For instance:

> To understand the difference [between weather forecasting and climate modeling], think about trying to predict whether a coin flip will come up heads or tails. It's impossible to do that for a single flip (which is something like the weather forecast for next month). But you can safely predict that if you repeat the coin toss a thousand times, you will get about five hundred heads and five hundred tails. (p 127)

Similarly, the authors use plain language and references to people's lives (ocean acidity is likened to carbonated soda drinks). Facts are not cited in the text, and instead a twelve-page reference list is included. Only in a few key places do the authors directly cite the source of their information, like John Tyndall's work which proved the existence of a greenhouse effect in the late nineteenth century, or key reports like the National Research Council's *America's Climate Choice*s.

The authors are cautious in their presentation of material about which climate scientists are not certain; they explain the reason for the uncertainty, making the facts that scientists do know even more convincing. Occasionally, their non-alarmist language feels somewhat out of place given the dramatic content the authors are describing. However, the choice to avoid bias will likely serve the book well and allow it to actually be used in sixth-grade classrooms. The book is not a call to action but a great introduction to the facts around climate change.

The sixty short essays are organized in four sections, starting with the background "What the science says," containing chapters on past climate change, the greenhouse effect, misconceptions about the ozone hole, the role of the sun and volcanoes, ocean acidification, and sea level rise, among others topics. Using a similarly careful, well-researched style, the authors turn in the second section to "What's actually happening" and describe present CO_2 levels compared to the geological past, a sea level rise of 20 cm (8 inches) since 1900, a temperature increase of 0.7°C (1.3°F) since 1900, increased growing seasons, extreme weather events, and coral bleaching, among other measurable impacts. The section "What's likely to happen in the future" starts out with an explanation of climate modeling and its strengths and limitations, and then discusses sea level rise predictions, storm surges, hurricanes (likely to be fewer but more powerful), health effects (such as deaths due to heat waves and respiratory problems because of ultraviolet concentrations), species extinction, fresh water and food scarcity, and related security issues, among other topics. The last section is solution-oriented ("Can we avoid the risks of climate change?"), adding some hope after the previous discussion of our changing climate. The authors summarize different renewable energy sources and discuss nuclear energy, ethanol fuel, and carbon sequestration (unfortunately, they use the popular euphemism "clean coal" even though there is no such thing as clean coal), before discussing carbon taxes and futuristic technologies to address global warming. The book finishes off with an epilogue that explains the Intergovernmental Panel on Climate Change (IPCC), its statute, its mission, the working groups, and the review process.

The authors don't shy away from placing famous controversial topics in the debate about climate change—like the hockey stick graph, stolen e-mails, and mistakes in the IPCC report—into an appropriate context. They also explain in plain language the exact meaning of terms like "global warming" and "climate change," terminologies from the IPCC report (such as "likely"), and why the year 2100 is typically used for climate predictions. They

sprinkle interesting tidbits throughout the book, such as the fact that polar bears were the first animal to be put on the endangered species list just because of future predictions of changes in its habitat (melting Arctic sea ice) and anticipated dramatic consequences for polar bear populations, instead of actual numbers of population reduction.

Unfortunately, the book includes neither a table of contents nor an index, which makes it difficult to use as a reference or for looking up topics as they arise in discussions. The ten figures included in the book are presented with small-font and hard-to-read black-and-white graphics. They form a drastic contrast to the simple and intriguing language of the written text and are a disappointment.

My biggest concern with the book is that it lacks a clear target audience. Climate experts may be unlikely to read the book because it lacks new information, despite the fact that they may be intrigued by the simple explanations of complex topics. Teachers might not use the book in the classroom because it lacks sufficient structure to organize lessons on the topics (such as a table of contents), despite the fact that the material presented is easy to grasp and scientifically robust. And I am skeptical that climate change deniers will pick up this book, despite the fact that the material would challenge their beliefs.

Despite this concern, there is no question that *Global Weirdness* is an interesting read for readers of all ages and backgrounds. The fast-reading chapters are perfect for the bedside (or bathroom); they would make good homework assignments for middle-or high-school students; and if you can get your climate skeptic relatives to read the second section of the book, "What the science says," that might be a first step towards their rethinking their positions.

In summary, this is an important book that helps the climate science community talk about their work using understandable and compelling language.

About the author

Anne U Gold completed a doctoral degree in paleoclimatology. The focus of her work is on understanding regional variability of climate patterns and reconstructing Quaternary climate change. She has taught many undergraduate and graduate earth science classes. She is now working in the Education and Outreach Group at the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado, Boulder, on various climate education projects.

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REVIEW

Overheated: The Human Cost of Climate Change

by Andrew T Guzman
New York: Oxford University Press, 2013. 280 pages

reviewed by Amy E Lesen

Effective communication about climate change is arguably one of the most urgent needs of our time, but explaining such a complex scientific concept to the lay public and policymakers has remained a difficult challenge. Many have suggested that scientists need help with climate communication, such as Pidgeon and Fischhoff (2011), who state, "The execution of this task will require sustained interdisciplinary collaboration between natural, social and decision scientists."

It is an opportune time for the publication of *Overheated: The Human Cost of Climate Change*, written by Andrew Guzman from the University of California, Berkeley, School of Law. In the book's foreword, Guzman makes it plain that he thinks the human dimensions of climate change have not been well communicated to the public, and the main thesis of the book is that citizens will not put pressure on political leaders to act on climate change until they understand the real, tangible, and quite dramatic ways climate change will affect human populations. Guzman is clear that his areas of expertise are economics, international law, and global policy, and he gives a brief but honest discussion about the misgivings many academics have about those who delve outside their fields of study. In contextualizing the book with candor about his aims, and with transparency about the limits of his scientific knowledge, Guzman doesn't try to pretend the book is something it's not, such as an exhaustive analysis of climate science.

As an academic trained in environmental science, I have been led to be suspicious of many books about climate change by the lack of balanced, fact-based popular writing on the subject. Guzman's forthrightness about his aims and expertise would not have calmed my misgivings if *Overheated* were full of scientific inaccuracies. The book manages to avoid being overly reductive to the point of fallaciousness. In the first two chapters, Guzman summarizes key aspects of climate change science, and gives the lay audience some understanding of how scientists have assembled the current body of knowledge and consensus. He also addresses, point by point, the arguments of skeptics, and it is obvious he is conscious of writing to a lay audience that has been bombarded with a disproportionate amount of climate denial in the media. He gives the reader tools for forming a basic understanding of what climate scientists know and how they have come to know it. He also directly discusses scientific uncertainty, important because an inaccurate portrayal of that uncertainty is one of the main weapons in the arsenal of climate change deniers. He chooses two degrees Celsius as the prediction for future warming, the estimate upon which the rest of the book rests. In discussing his reasons for choosing two degrees C, Guzman admits that this is a conservative number that probably "dramatically underestimates what the future has

in store for us." By choosing a fairly conservative estimate, he powerfully reminds us that even the remarkable human suffering we will read about in the rest of the book is a best-case scenario, and is on the less extreme end of what will likely unfold in years to come.

The next four chapters are the meat of the book, as Guzman focuses on four important aspects of how climate change does and will affect human populations: (1) relative sea level rise and flooding; (2) drought, famine, and access to potable water; (3) war, civil unrest, and terrorism; and (4) human health. Over these chapters, Guzman builds an argument that climate change is currently already causing a great deal of human affliction and social upheaval that will only get worse, using examples in recent and current events from the United States and around the world. One aspect of Guzman's approach that is also useful is that he attempts to clear up some frequent sources of confusion and misconception. As one example, Guzman begins the chapter on flooding with the inevitable overview of the events in New Orleans following Hurricane Katrina, and in the process he talks about the distinction between weather and climate, and the relationship between severe weather events and climate change, probably the most commonly misunderstood aspect of climate change for the public.

Guzman uses a tone that is, to my mind, as urgent and dramatic as these very real problems deserve. He has already made clear that his aim is to wake people up to the seriousness of the problem, and he can't accomplish his goal by being understated. He rises to the occasion, saying that climate change will "make everyday acts that we take for granted, including drinking and breathing, more dangerous" and (in the final line of the book), that inaction in response to climate change "will trigger human tragedy on a scale the world has never seen." If we accept Guzman's thesis that people will not act unless they appreciate the gravity of the situation, then we must also agree that his tactics are sound: make the strongest and most dramatic case possible, supportable by concrete data, that humanity is already suffering because of climate change, and that this turmoil will increase markedly as the earth continues to warm.

The major criticism I have of the book is Guzman's heavy-handedness in using comparisons with everyday phenomena to explain some of the concepts in the book. The premise of the entire first chapter is a game called *KerPlunk!* where players remove sticks one by one from a plastic tube until, little by little, a group of marbles falls, which he uses to illustrate climate change dynamics and tipping points. When debunking the claims of climate change deniers, he explains the scientific consensus on climate change by using the metaphor of how one would seek the opinions of multiple auto mechanics to solve a problem with a car's transmission. I understand and agree that using these types of metaphors can be an effective way to explain complex concepts or to make a point. But after Guzman likened parents requiring their children to use bicycle helmets to society weighing the risks of climate change, and compared geoengineering mitigation to experimental surgery, I had grown weary of metaphor. In his overuse of this writing strategy, I'm afraid he skirts the line between helpful explanation and cheesy condescension.

In the book's last chapter, Guzman discusses the possible array of human responses to climate change, from denial and procrastination to various mitigation and policy strategies. Guzman chooses 350 parts per million (ppm) as a policy target for atmospheric carbon dioxide levels, citing the well-publicized work by James Hansen and colleagues (2008) in

which they argue that the earlier target of 450 ppm is far too high. As I write, this week the National Oceanographic and Atmospheric Administration reported that the atmospheric CO_2 level measured at the Mauna Loa observatory is closely approaching 400 ppm, so Guzman's choice to go with the 350 ppm target certainly highlights the urgency of the situation facing us. The final chapter is really a call to action, and not a thorough analysis of climate change policy, but again we must remind ourselves that call to action, not comprehensiveness, was his stated aim from the beginning. My greatest hope for this book is that it is widely read by the public, not just by those of us who are already believers, and that it does indeed help convince our fellow citizens and leaders that climate change is real and anthropogenic, and requires swift global action.

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REVIEW

The Inquisition of Climate Science

by James Lawrence Powell
New York: Columbia University Press, 2011. 232 pages

reviewed by John R Mashey

The Inquisition of Climate Science is an excellent, well-written book for the general audience which gives readers a broad view of organized attacks on climate science over the last few decades.

Anti-science campaigns try to induce the public to reject inconvenient science or at least confuse people enough to avoid unwanted actions. Such campaigns create strange alternate universes. As readers of *RNCSE* will know, evolution anti-science seems driven by an ideology associated with some religions, engendering an alternate universe where biology does not work. For financial gain, cigarette companies funded tobacco anti-science to create a universe that ignores medical science.

Climate anti-science combines considerations of both finance and ideology—in this case extreme free-market fundamentalism, which goes beyond a preference for free markets to a categorical rejection of most government actions, such as safety or environmental laws. In the resulting alternate universe, physics, statistics and biology do not work, and human-induced global warming is a giant hoax created by a cabal of climate scientists trying to create a world government … or something like that.

Chapters 1–3 of Powell's book provide a quick tour, with many examples, into the alternate universe of climate anti-science, its organizations, and prominent people. Some of this might seem too zany to be true, but on the basis of much personal research and writing on this topic, I think that it is accurate, with one quibble. Powell writes with reference to Galileo,

> At least the Roman Inquisition had an alternative theory of the solar system: Ptolemy's earth-centered astronomy from the second century CE. Even today's creationists and disciples of intelligent design have their Bible to fall back on. The modern inquisitors have not even that much: they have no alternative theory to explain the observed facts of global warming. (p 3)

Some of them have no such theory, because they reject the observed facts. But the rest have many explanations—the sun, cosmic rays, undersea volcanoes, urban heat islands, or maybe just natural cycles for which no physical explanation is known—which, however, lack scientific credibility and often contradict each other. Skeptical Science (http://www.skepticalscience.com/) catalogs such attempted explanations.

Chapters 4–6 spend just 18 pages to explain the science of the greenhouse effect and its history, starting in the 1800s, highlighting key developments of the last half-century and

ending with "All You Really Need to Know in One Chart." The discussion is accurate but properly brief, because the book's focus is anti-science. For the next level of depth on the science, a good general-audience book is Archer (2009).

Organizations that support climate anti-science overlap slightly with those that attack evolution, but overlap considerably with those that learned the techniques of creating doubt about science from the cigarette companies. Chapter 7 of *The Inquisition of Climate Science* addresses the tobacco tactics, and chapter 8 shows how ideologically-driven climate anti-science followed suit. Chapter 9 discusses some key "think tanks," typically non-profit "public charities" that act more like public relations agencies or lobbyists, who often learned doubt-creation through involvement with the tobacco industry. Powell notes that these think tanks have employed tactics similar to those of creationists in trying to insert anti-science into schools and harass teachers. I think that such tactics led teachers to ask for help from NCSE, which responded by adding staff with climate expertise. Chapter 10 focuses on ExxonMobil's campaigns, often involving the funding of think tanks and front groups, against climate science.

Chapter 11 notes some of the ways in which the media have failed to cover this story well. Powell charges that the media often gives anti-science marketing equal time with credible science, thus confusing the public.

Having described the machinery behind climate anti-science, Powell spends the rest of the book (chapters 12–17) describing specific attacks on climate science and scientists, including disinformation, intimidation, and legal harassment. I know quite a few of the scientists mentioned in the book, and I've seen other examples of such attacks. For an example following publication of the book, see Johnson (2012) and Sinclair (2012) for a taste of the hate mail directed at the climate scientist Katharine Hayhoe.

Powell ends eloquently: "If deniers can vilify individual scientists and neutralize the field of climate science simply because of ideology and a conspiracy theory, what will be the next field of science—or art, or history, or literature, or medicine—that some group chooses to denounce?" (p 187).

Powell knows the subject well, but has not been directly involved in the climate fights, so his book offers a good perspective. Readers new to this topic will find *The Inquisition of Climate Science* a fine starting point. Later, the reader might study Oreskes and Conway (2010) for its in-depth history of four people important to climate anti-science. For recent accounts by climate scientists under attack, see Bradley (2011) or Mann (2012). Proctor (2012) is a detailed history of the tobacco industry, whose tactics and personnel have been inherited by climate anti-science. Finally, one might borrow a copy of Inhofe (2012) to read an example of anti-science writing by a US Senator. Read Powell first.

Readers might ponder the power of the organized doubt-creation detailed in this fine book. The Surgeon General reported in 1964 that cigarettes damage health, and the science was already clear. About 20% of adult Americans smoke—and most started as teenagers after that report appeared. The effects of their smoking on their health are tragic for them and for their families and not easily reversible, but people have reduced its prevalence in some places by legal actions in the face of strong tobacco industry tactics. People cannot likewise change the laws of physics, which show that increasing CO_2 will make significant and

mostly negative global changes to our planet. The current generation has a choice between bad and worse effects, not so much for ourselves, but imposed increasingly on each successive generation. The effects promise to be tragic for many.

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REVIEW

Waking the Giant: How a Changing Climate Triggers Earthquakes, Tsunamis, and Volcanoes

by Bill McGuire
New York: Oxford University Press, 2012. 303 pages

reviewed by Norman H Sleep

Bill McGuire's main thesis in *Waking the Giant* is that global climate change will trigger earthquakes, tsunamis, and volcanoes that will add to the major miseries of crop failures, acidification of the ocean, flooding of coastal cities, and unbearable heat over much of the planet. He provides numerous case studies, including those of his own fields, volcanoes and landslides. His conclusions are basically correct. The book admittedly concentrates on areas of the author's expertise, but focusing on some of the lesser vicissitudes compared to the direct effects of global warming has the air of worrying about the fate of the luggage in a plane crash.

Despite the title, McGuire does not advocate the animistic viewpoint that if you trouble Nature, Nature will take its revenge on you. Rather, he is acknowledging a time-honored truth known to experienced field geologists, mountain climbers, and bush pilots: that blindly proceeding into natural adversity is a recipe for disaster.

I suspect that general readers will find the book difficult, while working earth scientists may find it tedious. Most importantly, the well-known construct of self-organized criticality is implicitly invoked throughout the book but never explicitly explained. For the traditional example, consider a sand pile beneath a huge hourglass. Viewed at a distance, the sand self-organizes into a conical pile. New sand grains continually fall from above. The slopes are at the threshold of instability. Sometimes an individual grain tumbles down the slope; sometimes several grains and rarely even a landslide cascade downward. If one perturbs the system, say by tilting the hourglass, one side of the pile is stabilized and the other side destabilized. A large landslide is likely to be on the unstable side. If one shakes the hourglass, multiple landslides are likely. Overall, any very complicated strongly nonlinear system is likely to have domains at the threshold of instability, some of which will fail in large events if perturbed in the right way. The sand pile example, as correctly stated in the book, carries through to volcanoes that are basically large rubble piles and to land and marine landslides. It also carries through to earthquakes, as numerous faults are always at the threshold of failure. Climate may well misbehave in this manner, ending the relative stability that humanity has enjoyed over the last 6000 years. By explaining self-organized criticality clearly and explicitly, McGuire could have helped his reader understand the numerous examples of triggered instability in his book more thoroughly. As a quantitative scientist, I found these examples—all qualitative—to be tedious.

The book eschews equations and technical details. To be picky, using Olympic swimming pools and the like (p 242) as scales does not really help. (There are citations to technical papers at the end of the book.) As a result, it is not always clear without very careful reading whether a given issue involves self-organized criticality (for example, both sea level rise and sea level fall may trigger collapse of oceanic volcano edifices somewhere in the ocean and great tsunamis) or more deterministic processes (for example, the removal of glaciers from Iceland caused increased melting in the mantle and hence increased volcanism at the end of the most recent ice age). The book distinguishes between modulation (for example, where a volcano erupts preferentially in the spring rather than the fall, because deep processes control the long-term rate of eruption) and triggering (for example, where the collapse of an island edifice may not occur until millennia after a triggering event). But again this distinction is not well explained or delineated.

A few boxes with equations and numbers explaining the global carbon cycle, ocean circulation, temperature and pH, stress and strain, and frictional failure would have helped greatly, allowing McGuire to provide qualitative explanations. As an example, McGuire provides a qualitative account of how global warming tends to cause earthquakes: the melting of ice sheets leads to high water pressure and reduced lithostatic pressure, which props open cracks and allows ambient stresses to cause very large earthquakes. Liquid water typically exists beneath ice sheets at equilibrium with the load of the ice. When the ice melts, the ice load and fluid pressure at the land surface drops to essentially zero. Stresses, including lithostatic pressure in the subsurface, immediately decrease to the new equilibrium. Water pressure in the immediate aftermath of melting equals lithostatic pressure down to the depth of the thickness of the ice sheet times the ratio of ice to rock density. The crust is prone to earthquakes until this water pressure comes in equilibrium with surface by diffusion. Furthermore, quantitative calculations involving the permeability of the rock feasibly would provide an estimate of this diffusion time. Thus in this case, and in others, such quantitative modeling would bear on the issue of where and whether we are still at risk for such events.

The book correctly states that science can learn from past geological events. The end-Permian extinction and the Paleocene-Eocene thermal maximum were very probably associated with the release of buried reduced carbon into the environment. McGuire is a proponent of the effects of released methane in hydrates from ocean sediments. Although those effects have been overexaggerated elsewhere and McGuire is properly skeptical of estimates of the mass of presently available hydrates, the release of methane from hydrates is a real process. Still, the effect of ocean circulation on the release is poorly explained. Modern cold saline bottom water forms at high latitudes where sea ice freezes. Global sea surface warming and the flux of fresh water into the ocean may well halt this process, greatly changing ocean currents and climate. But the cold deep water above existing hydrates will stay in place for a significant time that could be calculated by numerical models. Here again McGuire's neglect of the quantitative side is visible.

McGuire's concentration on sudden flashy disasters overlooks gradual quiet ones. In particular, the effects of ocean acidification are barely mentioned. Organisms with calcium carbonate shells including coral reefs are likely to suffer greatly. Over 90% of marine shelling bearing organisms perished in the end Permian ocean. The calcite eyes of trilobites

dissolved and they wandered blindly to extinction. Unlike trilobites, we release buried carbon at our own volition.

The book may unfortunately provide fodder to the climate deniers, who are eager to seize upon minor errors that do not affect the real issue. For example, the book jacket shows devastation from the Japanese tsunami. While McGuire correctly debunks statements that attributed the earthquake and the resultant tsunami to climate change, the jacket still implies a gross misconception. Similarly, there are a few minor errors here and there: the Basin and Range Province is west, not east, of the Rocky Mountains (p 150) and the Columbia flood did not release 1 million cubic kilometers per second (p 151).

It is irresponsible, moreover, to cite old meeting abstracts as the support for major points in books for general audiences. McGuire cites one such abstract for the claim that impounded water behind a dam triggered the 2008 Sechuan earthquake (p 144–145), although he is somewhat critical. Another abstract discussing the putative future release of methane from the Arctic seafloor (p 268) passes with less examination. For the benefit of free exchange of ideas, scientific societies (such as the American Geophysical Union—the source of the cited abstracts) barely vet meeting abstracts before printing them, only ensuring that they are not totally incomprehensible, grossly off-topic, obscene, libelous, or selling a commercial product. When major claims first advanced in abstracts have not been repeated in publications in peer-reviewed journals, it is fair to assume that the authors themselves or peer reviewers for the journals have found those claims to be wanting.

The deficiencies of this book are correctable. I look forward to an improved second edition. As is, the book may be usable in a class setting where equations, physics, and geological insight are available.

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