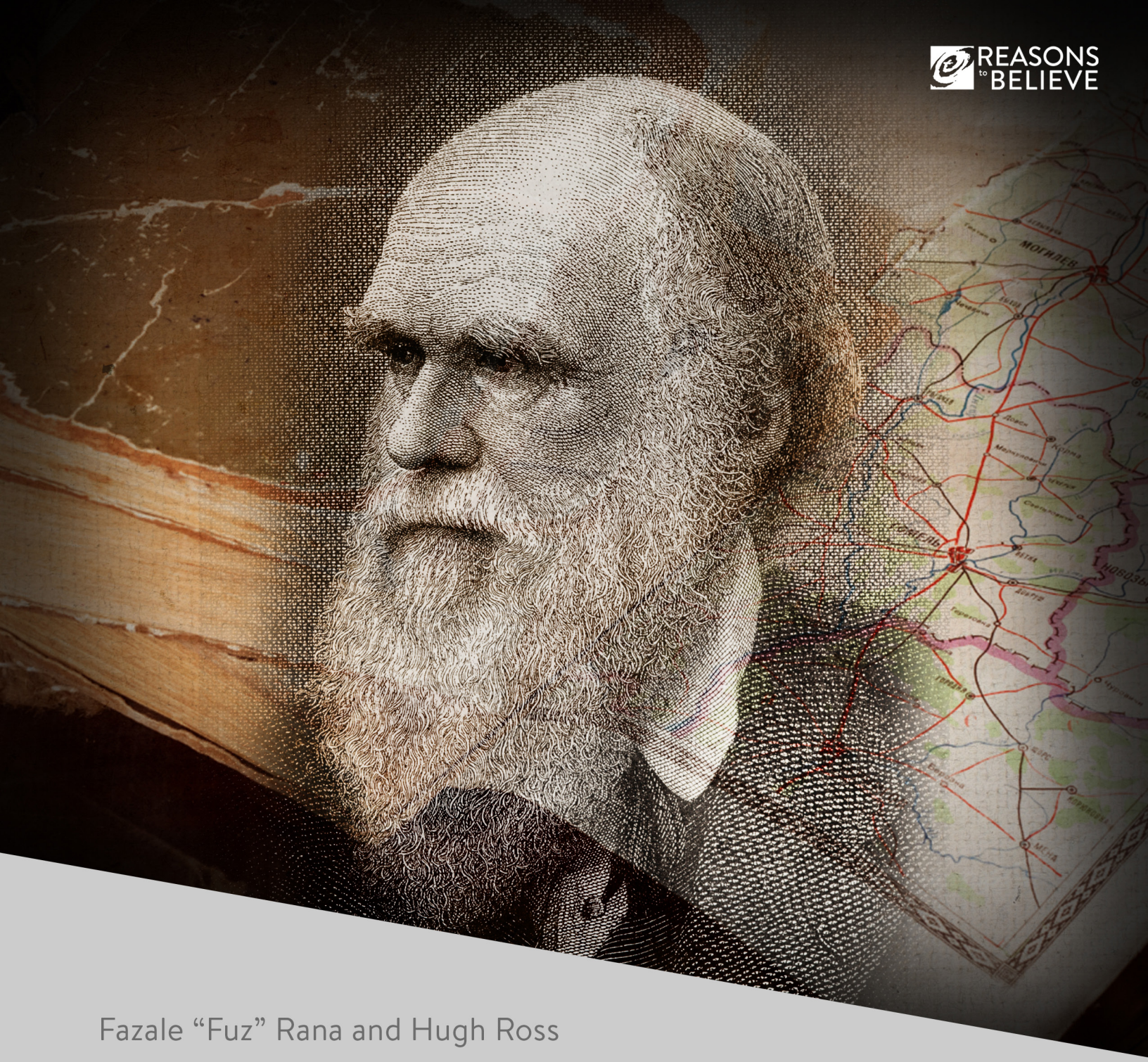

Fazale “Fuz” Rana and Hugh Ross

WHAT *DARWIN* DIDN’T KNOW

Would Modern Biology Have Changed Darwin's Mind about His Theory of Evolution?

A sage once said, "It's not what you *know* you don't know that's the problem; it's what you *don't know* that you don't know."

When Charles Darwin proposed his theory of biological evolution, there was a lot of biology he didn't know. Some of what he didn't know, he recognized. Yet, there was much biology that Darwin didn't know that he didn't know.

Over the course of the last 160 years, scientific research has yielded important understanding about life's origin, history, and characteristics. These advances provide the framework for modern biology. In fact, *most* of contemporary biology's central ideas were discovered after Darwin advanced his theory of evolution. Ironically, these advances also raise questions about the sufficiency of evolution to fully account for the design and history of life.

In light of these contemporary insights, it can be fun to speculate: If Charles Darwin had known then what we know today about biology, would he have posed his now-familiar theory? It's hard to say. But discovering what Darwin didn't know has been enough to cause a significant number of scientists around the world, representing a range of scientific disciplines, to question—and challenge—key aspects of evolutionary models.

THE ORIGIN OF LIFE

According to an evolutionary perspective, life's history began when the first cells arose from nonliving matter through a process of chemical evolution (abiogenesis). Darwin didn't address the origin of life in his seminal work, *On the Origin of Species*. However, in an 1871 letter to his friend Joseph Hooker, Darwin speculated that the first spark of life may have taken place in a "warm little pond, with all sorts of ammonia and phosphoric salts, light, heat, electricity, etc., present, that a proteine [sic] compound was chemically formed ready to undergo still more complex changes."

Still, it took until the 1920s for Russian biochemist Alexander I. Oparin and British geneticist J. B. S. Haldane, working independently, to develop and present a scientific hypothesis for abiogenesis. The Oparin-Haldane hypothesis described detailed pathways from simple molecules on primordial Earth to the first living entities.

In the 1950s, scientists envisioned a primordial atmosphere devoid of oxygen. Reducing gases—hydrogen, ammonia, methane, and water vapor—were thought to dominate. Oparin and Haldane speculated that energy discharges within this gas mix formed simple organic (prebiotic) molecules that accumulated in Earth's oceans and enriched the primordial soup, where, presumably, chemical reactions led stepwise to life's first forms.

At that time, Stanley Miller provided what many considered the first experimental verification of this hypothesis. By passing an electrical discharge through a reducing gas mixture in the laboratory, Miller produced several amino acids and other organic compounds. His success launched the origin-of-life research program and became standard textbook fare.

These now famous spark-discharge experiments initiated a series of similar experiments by others that seemingly produced ongoing support for Oparin's and Haldane's ideas. (This area of origin-of-life research is called prebiotic chemistry.) Delighted with Miller's accomplishment, many scientists at that time predicted the origin-of-life problem would soon be solved.

MILLER'S EXPERIMENT DIDN'T MATTER

Today, few textbooks acknowledge that most origin-of-life researchers consider Miller's experiment irrelevant. Strong evidence revealing a primordial atmosphere composed of carbon dioxide, nitrogen, and water has changed the scientific consensus. This gas mixture does *not* yield organic compounds in laboratory prebiotic simulation experiments—a devastating blow to the evolutionary scenario.

In the May 2, 2003, issue of *Science*, Jeffrey Bada and Antonio Lazcano (Miller's long-time collaborators) acknowledged the change in perspective even as they commemorated the 50th anniversary of that renowned experiment. While explaining the experiment's historical interest, Bada and Lazcano commented, "Contemporary geoscientists tend to doubt that the primitive atmosphere had the highly reducing composition used by Miller in 1953."

UNWARRANTED RESEARCHER INVOLVEMENT

The changed perspective on Miller's experiment highlights a problem that has plagued prebiotic chemistry from the start, but which origin-of-life investigators only now widely acknowledge. It's called the problem of unwarranted researcher involvement.

It's one thing for researchers to carry out a chemical reaction in the lab to determine if it might—*in principle*—contribute to chemical evolution. This *is* what Stanley Miller accomplished. It's another thing entirely to conclude that the reaction would've been productive under the conditions of the early Earth. In other words, origin-of-life researchers must demonstrate that the reactions they discover and study in the lab are geochemically relevant.

Today, origin-of-life researchers are concerned that few, if any, prebiotic experiments conducted over the last 70 years are geochemically relevant. Some origin-of-life researchers even fear that they've unwittingly involved themselves in the design and execution of their experiments to the degree that they are actively contributing to the success of the reaction.

Ideally, humans would not intervene at all in any prebiotic study, but this ideal isn't possible. Researchers must involve themselves in the experimental design out of necessity, but also to ensure that the study results are reproducible and interpretable. If researchers don't set up the experimental apparatus, adjust the starting conditions, add the appropriate reactants, and analyze the product, then by definition the experiment would never take place.

However, when it comes to the geochemical relevance of prebiotic reactions, the highly controlled conditions of the laboratory become a liability. It goes without saying that the conditions of early Earth were uncontrolled and chemically and physically complex. A pristine, lab-like setting didn't exist. And, of course, origin-of-life researchers weren't present to oversee the processes and guide them to their desired ends.

In an article published in *Nature Communications* on December 12, 2018, origin-of-life scientist Clement Richert complains,

> It is not easy to see what replaced the flasks, pipettes, and stir bars of a chemistry lab during prebiotic evolution, let alone the hands of the chemist who performed the manipulations.

While most origin-of-life researchers may be uncomfortable with the idea of divine intervention, the scientific evidence from seven decades of work in prebiotic chemistry consistently points in that direction. The flip side of the problem of unwarranted intervention is the case for a Creator. Ironically, work in prebiotic chemistry designed to validate chemical evolution (and, ultimately, Darwin's idea of abiogenesis in a "warm little pond") provides empirical evidence that intelligent agency plays an indispensable role in transforming simple chemicals into the first cells. Though he embraces an evolutionary history for life, Simon Conway Morris concludes in his book *Life's Solution*,

> Many of the experiments designed to explain one or other step in the origin of life are either of tenuous relevance to any believable prebiotic setting or involve an experimental rig in which the hand of the researcher becomes for all intents and purposes the hand of God.

NO SOUP FOR YOU

Equally problematic for chemical evolution is the lack of evidence for a prebiotic soup. If life arose from a chemical stew, then Earth's oldest rocks should bear that soup's chemical residue. Yet, according to origin-of-life researcher Noam Lahav in his book *Biogenesis*,

> So far, no geochemical evidence for the existence of a prebiotic soup has been published. Indeed, a number of scientists have challenged the prebiotic soup concept, noting that even if it existed, the concentration of organic building blocks in it would have been too small to be meaningful for prebiotic evolution.

Simply put: life could not have arisen from a primordial soup that did not exist.

FIRST LIFE APPEARS EARLY, SUDDENLY, AND WITH COMPLEXITY

Two key expectations for life's start have been the long timescale required for nonlife to produce life and the relative simplicity of life's first forms. Researchers have traditionally maintained that a percolation time of hundreds of millions of years (or possibly even a billion) would be necessary for abiogenesis. They also theorize that the first life to emerge would be extremely simple, evolving toward complexity over time.

Scientists recently uncovered unequivocal evidence that as soon as Earth became even remotely capable of sustaining life, life appeared. The oldest rock formations discovered to date measure about 3.9 billion years old. Numerous fossil and chemical markers left by the first living entities in these rocks indicate that life was present about 3.8 billion years ago. (There is some evidence—albeit controversial—that life may have already been present on Earth around 4.2 to 4.4 billion years ago!)

It's unlikely that Earth could've sustained life continuously for the first 600 million years or so. Earth was most likely a molten planet the first few hundred million years of its existence. Chemical evolution would've been impossible under these conditions. Evidence indicates that after the early part of the Hadean era, Earth may have cooled sufficiently to allow a crust to form and for oceans to exist temporarily. These periods of calm most likely would've been interrupted by massive impactors striking the planet. Some of these impact events would've volatilized the oceans and reverted the planet to a molten state, thus frustrating chemical evolution, and possibly extinguishing life.

Astronomers now have evidence that, just prior to 3.8 billion years ago, a gravitational perturbation in the solar system sent millions of asteroids and comets toward the inner solar system. This event is known as the late heavy bombardment; it resulted in Earth experiencing more than 17,000 collisions that vaporized the planet's oceans and melted its entire rock surface and subsurface. Any potential life would've been obliterated. Then, as soon as Earth recovered, life appeared.

A leading authority on early life, J. William Schopf, states in his book *The Cradle of Life* that "no one had foreseen that the beginnings of life occurred so astonishingly early."

What's more, these first life-forms, though single-celled bacteria, were metabolically and biochemically complex. Elsewhere in *Cradle of Life*, Schopf details the problem complex early life creates for naturalistic origin-of-life explanations:

> [I] would prefer a simpler evolutionary story, one that told us these oldest fossil organisms were capable only of primitive ways of living and that advanced metabolic lifestyles evolved much later. But the evidence seems strong, and what one might "prefer" shouldn't matter.

While early, sudden, and complex life makes little sense from an evolutionary perspective, a creation explanation seems reasonable. If God introduced first life on Earth, it would appear instantaneously and abundantly in a complex form.

Though Darwin thought that a type of chemical evolution could explain life's origin, it's safe to say that today most origin-of-life researchers readily acknowledge that they don't have any understanding, whatsoever, of how life originated. In his book on the origin-of-life titled *The Fifth Miracle*, astrobiologist Paul Davies confesses that "many investigators feel uneasy stating in public that the origin of life is a mystery, even though behind closed doors they admit they are baffled."

LIFE IN A TINY PACKAGE

Darwin embraced the protoplasmic theory—the idea that the cell consists of only a wall surrounding a nucleus and a homogeneous, jelly-like protoplasm. This understanding made early evolutionary explanations of abiogenesis plausible. Biologists and chemists easily envisioned chemical routes that could produce the single ingredient believed to form the cell's interior substance.

However, as the new field of biochemistry developed throughout the nineteenth century, this concept waned. With the discovery of enzymes capable of catalyzing myriad chemical reactions, scientists fully recognized the cell's protoplasm as a complex heterogeneous system.

BIOCHEMICAL COMPLEXITY AND ORGANIZATION

Over the last century, advances in biochemistry have continued to affirm the complexity of life at a molecular level. Even the simplest bacterium requires close to 2,000 distinct types of proteins in its "protoplasm" to exist as a living entity. Not only are the cell's chemical systems irreducibly complex, but they also display an extraordinary degree of order undergirded by an elegant, sophisticated logic.

Even nontheists agree that life's chemical systems appear designed. The late Francis Crick, who shared the Nobel Prize for discovering the structure of DNA, cautioned in his autobiography, *What Mad Pursuit*, that "biologists must constantly keep in mind that what they see was not designed, but rather evolved." By all appearances, life's chemistry looks like the product of a Creator.

Toward this end, biochemists have discovered that the salient characteristics of living systems are identical to features immediately recognizable as the product of human designers. This close match revitalizes William Paley's Watchmaker argument for God's existence and, in doing so, compels the logical conclusion that life's most fundamental processes and structures stem from the work of an intelligent Agent.

In his 1802 work, *Natural Theology*, William Paley surveyed a range of biological systems, highlighting their similarities to human-made designs. Human designs are contrivances—things produced with skill and cleverness—and they come about via the work of human agents. Thus, Paley argued, because biological systems are contrivances, they, too, must come about via the work of a Creator.

Myriad examples of cellular contrivances do, indeed, exist. Chief of these are proteins called molecular motors.

MOLECULAR MOTORS AND MACHINES

Many proteins function as molecular-level machines. Remarkably, these protein machines are replete with drive shafts, camshafts, turbines, clamps, lever arms, bushings, stators, and rotors. We know from experience that motors and machines arise from the work of human designers. They are contrivances. When we see analogs to the devices that we build throughout the cell, what should we conclude about their ultimate origin?

BIOCHEMICAL INFORMATION AND THE GENETIC CODE

Common experience also teaches that information and codes always emanate from a Mind. Biochemists have learned that biochemical systems are information systems. The information is harbored in the nucleotide sequences of DNA and RNA, and in the amino acid sequences of proteins. This insight suggests that biochemical systems, too, must come from a Mind. Moreover, the recognition by information theorists that the structure of biochemical information bears an uncanny similarity to the structure and design of human languages lends strength to this conclusion.

Additionally, recent findings indicate that optimally fine-tuned rules—necessary to give meaning to the information stored in DNA—are actually built into the genetic code.

In *Life's Solution*, evolutionary biologist Simon Conway Morris marvels that the genetic code displays "eerie perfection" and a "startling degree of optimization." These two features are expected if the genetic code and biochemical information come from a Creator.

Some scholars have noted that Darwin's *On the Origin of Species* is a rebuttal to Paley's *Natural Theology*, where Paley presents the Watchmaker argument. While Paley appeals to a Mind to explain biological designs, Darwin argues that natural selection serves as a type of "blind" Watchmaker. Yet, neither Paley nor Darwin had any idea of the true complexity and elegance of cellular chemistry and the remarkable similarity between the human-made systems, objects, and devices and the structure and operation of biochemical systems—similarities that vindicate Paley's argument.

LIFE'S HISTORY

The fossil record as known in Darwin's day offered scant support for evolution, and he knew it. In *On the Origin of Species*, Darwin devoted a chapter to the theory's "difficulties," highlighting two features he considered most troubling: (1) the abrupt appearances of biological groups the first time they occur in the fossil record, and (2) the absence of transitional forms. Darwin lamented,

> There is another and allied difficulty, which is much more serious. I allude to the manner in which species belonging to several of the main divisions of the animal kingdom suddenly appear in the lowest known fossiliferous rocks. . . . To the question why we do not find rich fossiliferous deposits belonging to these assumed earliest periods prior to the Cambrian system, I can give no satisfactory answer.

FOSSIL RECORD FINDS

Convinced that the fossil record was incomplete and poorly studied, Darwin expected gradual evolutionary transformations and missing transitional forms to be uncovered over time as paleontologists continued collecting and analyzing evidence. Paleontologists have, indeed, found a treasure trove of fossils that document a rich history of life on Earth. Generally, paleontologists point to these fossils as key pieces of evidence in support of biological evolution. The fossil record verifies that past life was different from life today, and simple life preceded complex. For many scientists, these general features indicate that life must have evolved.

Despite all discoveries, however, the overall features of the fossil record still look the same today as in Darwin's time. When new biological groups appear, they show up explosively, then undergo little change. Explosive innovation occurred when life first appeared, when the first complex cells originated, and when animal body plans arose.

BIOLOGICAL BIG BANGS

Prior to 575 million years ago, microbes were the overwhelmingly dominant life-forms. Before that time Earth's conditions, especially the low atmospheric oxygen levels, simply would not have allowed for the existence of complex animal life-forms.

When the environment became conducive to advanced life, two explosive events marked the appearance of complex multicellular animal life. The first, known as the Avalon explosion, occurred 575 million years ago. In this event, Ediacaran life-forms arose suddenly at the geological moment when the atmospheric oxygen level jumped from less than 1 percent to 8 percent. These life-forms included a variety of sponges and jellyfish and other enigmatic organisms. All the anatomical designs for the Ediacara were fully present at that time. After about 36 million years, though, the Ediacara experienced a serious decline, the reasons for which scientists are still investigating.

Following the Ediacaran extinction (539 million years ago) a second, much more dramatic event, the Cambrian explosion, occurred. Arguably, in a time window of less than 410,000 years the transition from Ediacaran organisms to Cambrian animals occurred. This event is called the Cambrian explosion. During this event somewhere between 50 and 80 percent of all animal phyla appeared. These animals are similar to the creatures we see on Earth today. Many of the animals that appear during the Cambrian event don't have an apparent connection to the Ediacaran fauna. Instead of relatively simple organisms originating at the base of the Cambrian then evolving toward increased intricacy, complex animals appeared early and suddenly.

The animals that appeared during the Cambrian explosion would've required a minimum atmospheric oxygen level of 10 percent. Remarkably, they appeared suddenly at the same time atmospheric oxygen first rose to 10 percent.

In other words, as soon as physical and chemical conditions permitted, complex animals appeared rather suddenly in the fossil record.

The events surrounding the Cambrian explosion are highly enigmatic for evolutionary biologists. For example, during the Cambrian explosion it seems as if evolution is running in the wrong direction. Paleontologists Douglas Erwin, James Valentine, and John Sepkosski have observed, "The major pulse of diversification of phyla occurs before that of classes, classes before that of orders, and orders before that of families."

Evolutionary biologists struggle to account for the explosive appearance of animals. It flatly contradicts the idea that life transitioned from simple to complex in a gradual branching, tree-like fashion. Paleontologist Kevin Peterson said that "although the Cambrian explosion is of singular importance to our understanding of the history of life, it continues to defy explanation." Peterson and his colleagues Michael Dietricy and Mark McPeek added, "Elucidating the materialistic basis for the Cambrian explosion has become more elusive, not less, the more we know about the event itself."

In *The Blind Watchmaker* atheist Richard Dawkins admits the problem yet simply disregards it: "The Cambrian strata of rocks, vintage about 600 million years, are the oldest ones in which we find most of the major invertebrate groups. And we find many of them already in an advanced state of evolution, the very first time they appear." If, however, a Creator orchestrated life's history, explosive appearances are exactly what's expected.

The Avalon and Cambrian explosions are not the only mass originations in the fossil record. Every major extinction event was soon followed by a mass origination event. Asteroid and comet strikes, nearby supernova, gamma-ray bursts, and the eruptions of super volcanoes precipitated the extermination of anywhere from 40 to 90 percent of all species on Earth. Remarkably, in all instances, as soon as Earth's conditions stabilized, new life-forms appeared rapidly with optimal ecological relationships.

"TRANSITIONAL FORMS"

Even Darwin questioned if "by this theory innumerable transitional forms must have existed, why do we not find them embedded in countless numbers in the crust of the earth?" Though transitional intermediates are still relatively rare in the fossil record, evolutionary biologists point to exceptional examples of "transitional forms" as *proof* that life evolves on its own. These forms are used to construct scenarios such as the transformation of a raccoon-like creature into a whale, the evolution of feathered dinosaurs into birds, and the transition of so-called "fishapods" from lobe-finned fish to tetrapods, the first land-dwelling vertebrates.

In all three instances, it looks as if paleontologists have uncovered a convincing series of transitional intermediates that document progressive change. These fossils seem to provide just what Darwin was looking for: support for a strictly naturalistic explanation of life's history.

However, closer examination reveals problems with each of these evolutionary accounts. For the fishapod and whale series, the transition from water to land and land to water, respectively, happened rapidly—in 10 million

years or less. This short time frame is counterintuitive considering the extensive anatomical and physiological changes that would've been necessary for an aquatic animal to adapt to life on land or vice versa.

Another challenge to the evolutionary account is the co-occurrence of many fishapod and whale intermediates in the fossil record. Instead of appearing in a sequential fashion, these creatures appear to have coexisted and overlapped. In other words, the patterns observed in the fossil record don't describe a linear evolutionary change over time.

The transitional fossils also seem out of order. In the case of fishapods, more primitive forms show up in the fossil record *after* more advanced forms. The same is true for the feathered dinosaurs, touted as transitional intermediates, supposedly linking theropod dinosaurs and birds. Feathered dinosaurs existed well after the first true bird (*Archaeopteryx*) appeared around 150 million years ago. This problem, dubbed the temporal paradox by paleontologists studying bird origins, makes little sense in an evolutionary framework.

BIOLOGICAL CONVERGENCE

Because evolutionary processes are contingent and undirected, Darwin recognized that their very essence makes outcomes unpredictable and nonrepeatable. He noted in a later edition of *On the Origin of Species*,

> It is incredible that the descendants of two organisms, which had originally differed in a marked manner, should ever afterwards converge so closely as to lead to a near approach to identity throughout their whole organisation. If this had occurred, we should meet with the same form, independently of genetic connection, recurring in widely separated geological formations; and the balance of evidence is opposed to any such an admission.

Given the vagaries of evolutionary mechanisms, Darwin couldn't fathom how radically different organisms might evolve toward the same biological form. In other words, he didn't think evolutionary processes could generate duplicate outcomes (convergence).

The late evolutionary biologist Stephen Jay Gould shared the same sentiment. Gould argued in his book *Wonderful Life* that chance governs biological evolution at its most fundamental level. Evolutionary pathways consist of a historical sequence of chance genetic changes operated on by natural selection, which also consists of chance components. As a consequence, if evolutionary events could be repeated, the outcome would be dramatically different every time. The inability of evolutionary processes to retrace the same path makes it highly unlikely that the same biological and biochemical designs would appear repeatedly throughout nature, especially among unrelated organisms.

Support for Darwin's and Gould's ideas came in 2008 from Richard Lenski's research group at Michigan State University. Their Long-Term Experimental Evolution Project showed that populations of the bacterium *Escherichia coli* do not repeatedly evolve toward the same outcome.

In his day, Darwin saw little evidence for convergence; today, such evidence abounds. In *Life's Solution*, Conway Morris describes numerous examples of design convergence at the organismal level. In my book *The Cell's Design* I offer more than 100 examples of convergence in biochemical systems. From an evolutionary standpoint, it

appears as if evolution did repeat itself time and time again. Yet all indications say that it should not.

Biological convergence potently challenges the validity of biological evolution. It also points to the work of a Creator. Designers and engineers frequently reapply successful strategies when faced with related problems. It's prudent and efficient for an inventor to reuse the same designs wherever possible.

FAINT SUN PARADOX

In Darwin's day, scientists presumed that the Sun was a constant energy source. At the time, the Sun did not factor into Darwin's hypothesis for the origin of species. Darwin is not alone. Likewise, evolutionary biologists, geneticists, and paleontologists today do not factor possible changes in the Sun into their explanations for the history of Earth's life.

During Darwin's lifetime, the only known source for the Sun's radiation output was gravitational collapse. Physicists, notably Lord Kelvin, calculated that the Sun's energy output must've been constant throughout the history of Earth's life.

It's now indisputably established that 99 percent of the Sun's energy output arises from the nuclear fusion of hydrogen into helium and the remaining 1 percent from the nuclear fusion of helium into carbon, nitrogen, and oxygen. Helium, carbon, nitrogen, and oxygen are all much denser than hydrogen. Therefore, ongoing nuclear fusion causes the density in the Sun's core to continuously increase. This increasing solar core density results in the Sun's nuclear furnace burning ever more efficiently.

Today, the Sun is 19–24 percent more luminous than it was at the time of life's origin, 3.8 billion years ago (see figure).

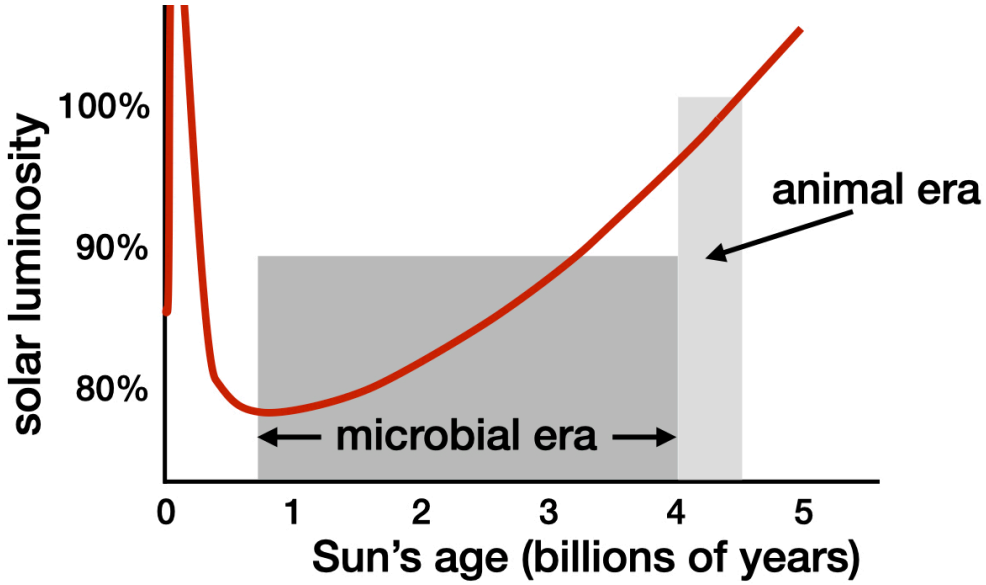

Figure: Sun's Luminosity History
Diagram credit: Hugh Ross

A 2 percent change in solar luminosity normally would cause all life on Earth to become extinct, either through a runaway freezing of all Earth's surface water or a runaway evaporation of all Earth's surface water. A 1 percent change would mean the end of advanced plants and animals. This catastrophe was prevented by a perfectly measured and timed drawdown of Earth's greenhouse gases combined with a perfectly measured and timed change in Earth's albedo (reflectivity). As the Sun increased in brightness, the quantity of greenhouse gases in Earth's atmosphere decreased and Earth's albedo changed so that the temperature on Earth remained optimal for life.

The drawdown of Earth's greenhouse gases plays, by far, the biggest role in compensating for the Sun's increasing luminosity. That drawdown occurs through two processes: the silicate-carbonate cycle and the burial of organic carbon. The silicate-carbonate cycle is initiated by rain and dew falling on exposed silicates (the continents are predominantly silicate rock) and generating a chemical reaction that converts silicates and carbon dioxide (a powerful greenhouse gas located in the atmosphere) into carbonates and sand.

Different life-forms regulate how much silicate rock gets exposed to falling rain and dew, how much dew forms, and how much rain falls from clouds. For example, shrubs and trees possess root systems capable of penetrating the upper six meters (20 feet) of bedrock, thereby greatly expanding the silicate surface area that is exposed to liquid water. These same shrubs and trees are able to access and use water stored in bedrock, converting most of this water into transpiration (exhalation of water vapor to the atmosphere through their stomata). This transpiration increases rates of precipitation. The increased precipitation accelerates the silicate-carbonate cycle, which draws more carbon dioxide from the atmosphere.

Microbes, plants, and animals all take carbon dioxide from the atmosphere, either directly or indirectly, to manufacture organic carbon compounds. The burial of the bodies of these organisms by floods, landslides, volcanic eruptions, or other tectonic events prevents the decay of the bodies and the release of carbon dioxide to the atmosphere.

Ensuring the just-right kinds, diversity, and abundance of life on Earth at just-right times and places guarantee that greenhouse gases are removed from Earth's atmosphere at just-right rates to compensate for the Sun's increasing luminosity. Furthermore, life is so abundant and ubiquitous on Earth's surface that it substantially affects Earth's albedo, both altering the cloud cover and the reflectivity of Earth's surface. Thus, Earth's life compensates for the Sun's increasing luminosity in four different ways: (1) regulating the silicate-carbonate cycle, (2) altering the organic carbon burial rate, (3) changing the atmospheric chemistry and cloud cover, and (4) changing Earth's reflectivity.

It's not just the Sun's luminosity that changes with respect to time. The kinds of radiation emitted by the Sun changes in dramatic ways over its history. Similarly, the Sun's flaring activity and luminosity variability change over its history. These changes affect which kinds of life can thrive on Earth at which times. Such changes pose a challenge to ensuring that just-right life is present on Earth to compensate for the Sun's increasing luminosity.

Unless all four of life's compensating factors for the Sun's increasing luminosity are at just-right levels at all times throughout the past 3.8 billion years, life on Earth could not thrive and most likely becomes permanently extinct. The presumed evolutionary processes that account for changes in life's diversity possess no inherent knowledge of the future physics of the Sun.

Only a Mind who knows the future physics of the Sun, Earth, and Moon will know which life must be present on Earth at which times. For life to persist for 3.8 billion years on Earth, Someone who knows and understands the present and future physics of the Sun, Earth, and Moon must periodically remove certain life-forms from Earth that are no longer able to compensate for the changes in the Sun and replace that life with just-right life-forms at just-right times in just-right amounts, diversity, and locations.

Given the pace at which the Sun's luminosity is increasing, mass extinction events quickly followed by mass speciation events must occur at a rate of about once every 30–35 million years. The fossil record bears witness to this rate of mass extinction and mass speciation events and how—in each mass extinction event—just-right life is removed from Earth at the just-right time and—in each mass speciation event—just-right life appears on Earth at the just-right time.

THE ORIGIN OF HUMANITY

While Darwin carefully avoided discussion of humanity's beginnings in *On the Origin of Species*, his book *The Descent of Man* offered a detailed account. He claimed that, like all species, humanity evolved gradually from earlier primates. He wrote, "In a series of forms graduating insensibly from some ape-like creature to man as he now exists, it would be impossible to fix on any definite point when the term 'man' ought to be used."

With that speculation, Darwin did the unthinkable; he interpreted humanity in a fully materialistic fashion. According to this view, not only humanity's physical makeup, but also all that constitutes human nature emerged through natural selection. Darwin argued that humans must have evolved from an apelike animal based on anatomical comparisons and embryological similarities among mammals.

While Darwin lacked direct evidence for his views on human evolution, he did make a prediction about the discovery of fossil intermediates documenting the evolution of our own species. In *The Descent of Man*, he speculates, "It is, therefore, probable that Africa was formerly inhabited by extinct apes closely allied to the gorilla and chimpanzee; and as these two species are now man's nearest allies, it is somewhat more probable that our early progenitors lived on the African continent than elsewhere."

When Darwin published *The Descent of Man*, paleontologists had already discovered Cro-Magnon (prehistoric human) fossils dated 35,000 years old. These human remains, however, did little to support Darwin's theory, nor did the first Neanderthal specimen discovered in 1856. Dating anywhere from 40,000 to 100,000 years in age, the Neanderthal fossil remains showed many similarities with modern humans. (Neanderthals also possess other distinctive features such as an elongated skull and pronounced brow ridges.) Scientists still lacked intermediate forms—fossils that could demonstrate the gradual transition from apelike creatures into modern humans and thus corroborate Darwin's idea.

The first so-called ape-human intermediate interpreted from the fossil record wasn't discovered until 1890 on the Indonesian island of Java. This species (initially dubbed *Pithecanthropus erectus*) later became known as *Homo erectus*.

In 1924, anthropologist Raymond Dart uncovered a small skull described as having a blend of ape and human features that appeared to belong to humanity's most primitive predecessor. This fossil, nicknamed the Taung Child, was formally classified as *Australopithecus africanus*. In the late 1950s, Louis Leakey unearthed the first

Homo habilis specimen in East Africa. Paleontologists considered this species (the first to use stone tools) to be the connection between the more primitive apelike *Australopithecines* and *H. erectus*.

Then the floodgates opened. In the ensuing decades, paleontologists unearthed numerous hominin fossils—a wide range of species—and their accompanying archaeological remains. These discoveries occurred throughout East, Central, and South Africa, Asia, the Middle East, and Europe—and they continue to come forth. Each new hominin appears to fill in the evolutionary tree and clarify the pathway that human evolution took over the last 6 million years.

EVOLUTIONARY DEAD ENDS

But if the hominin fossil record is to provide genuine support for human evolution, the features of the fossil record must extend beyond the existence of hominins. We should be able to: (1) clearly establish evolutionary relationships among the hominids in the fossil record, and (2) identify a clear evolutionary pathway leading to modern humans. Neither of these criteria have been met.

Evolutionary biologists have no idea how human evolution proceeded—assuming it did at all. Even the diagrams produced by different paleoanthropologists often reflect sharp disagreements about hominins' evolutionary relationships. Chaos often ensues whenever researchers discover new fossil specimens or identify a new hominin fossil species. Instead of bringing resolution to the debates, these new discoveries usually create greater dissension and add to the uncertainty. It's not uncommon to read headlines like "New Hominin Find Rewrites Human Evolution" or "New Hominin Discovery Shakes Human Evolutionary Tree."

This chaos should prompt a reasonable person to question if the evolutionary model is, indeed, the proper framework for understanding the natural history of the hominins. In science, if a theory is valid, new discoveries bring clarity and greater consensus. When the theory lacks validity, new discoveries cause problems—as is the case for human evolution.

Another serious problem confronting paleoanthropologists arises when they try to interpret the hominin fossil record from an evolutionary vantage point: their inability to identify a clear pathway through the fossil record that leads to the emergence of modern humans. Today paleoanthropologists interpret every hominin species depicted in biology textbooks as part of the evolutionary ascent of humans to be side branches and dead ends, including:

- Neanderthals
- *Homo erectus*
    - Peking Man
    - Java Man
- *Homo antecessor*
- *Homo habilis*
- *Australopithecus afarensis*
    - Lucy
- *Australopithecus africanus*
    - Taung Child

The fact is that no paleoanthropologist knows the evolutionary pathway that led to the emergence of modern humans. How can we say with confidence that human evolution is a fact?

Another problem with interpreting the hominin fossil record from an evolutionary standpoint is the inability of paleoanthropologists to identify common ancestors. Standard evolutionary models name *Homo heidelbergensis* as the last common ancestor for humans and Neanderthals, with Neanderthals and humans serving as representatives for two separate evolutionary branches. There is a lack of evidence supporting this interpretation, despite its prominence. For example, recent fossil finds now have some paleoanthropologists even questioning the existence of *H. heidelbergensis*. If this hominin species didn't exist, then which hominin was the last common ancestor leading to humans and Neanderthals?

This mystery shows little promise of being solved anytime soon.

POPULATION PROBLEM

As a rule of thumb, the likelihood that a mammal species will become extinct instead of adapting to changes in its environment depends on its effective population size. The smaller the effective population size, the more likely it will go extinct. The likelihood that a mammal species will evolve is also inversely related to the species' average adult body mass, average generation time (time between birth and reproduction for an individual species member), and reproductive rate. This rule of thumb doesn't bode well for the prospect of hominin evolution.

Analysis of Neanderthal DNA shows pervasive inbreeding within isolated population groups. Estimates based on features of Neanderthal genomes suggest that their population rarely exceeded 10,000 individuals. Their populations were most likely divided into small, isolated, inbred groups widely separated from one another. Other population size estimates based on heterozygosity (a measure of genetic diversity within genomes) for Neanderthals and Denisovans imply that it was unlikely that effective population sizes exceeded 5,000 individuals for each of these two hominins, respectively.

Paleoanthropologists have also used Neanderthal fossils and artifacts independently to estimate Neanderthal population sizes. It appears that throughout the ~360,000 years that Neanderthals existed, their populations would've ranged from 1,000 to 70,000 individuals.

A research team consisting of geneticists and anthropologists concludes, "Patterns of mtDNA protein evolution are consistent with the notion that the effective population size of Neanderthals was small and not only among late Neanderthals but over a longer period of their existence."

In other words, Neanderthals had low effective population sizes (perhaps less than 10,000), relatively large body sizes, generation times of a couple of decades, and, typically, only a single progeny per female. These features force questions about the capability of the hominins to undergo evolutionary changes beyond the variation caused by microevolutionary mechanisms (see "Microevolution vs. Macroevolution") before going extinct. The hypothesis that modern humans, Neanderthals, Denisovans, and the other hominid species descended from a common ancestor is questionable.

WHO WERE THE HOMININS?

So, how do we explain the hominins from a creation model/intelligent design standpoint? One approach acknowledges that hominins were real creatures that lived in the distant past. Based on what we can infer from the fossil and archaeological records, hominins appear to have been remarkable creatures that walked erect and possessed some limited level of intelligence and emotional capacity. Such traits allowed these animals—like Neanderthals, *H. erectus*, and "Lucy"—to employ crude tools and even adopt some measure of "culture," in the same vein as baboons, gorillas, and chimpanzees. Still, there is no evidence to suggest the hominins were spiritual beings, made in God's image. This status applies exclusively to human beings, *Homo sapiens sapiens* (see "Different in Kind, Not Degree").

The hominins may be thought of as animals like the great apes. Anatomical, physiological, biochemical, and genetic similarities with human beings are expected to varying degrees. But since the hominins were not made in God's image, they are clearly distinct from humanity, particularly in their behavior, technology, culture, and cognitive capacity. These creatures simply existed for a time, then went extinct.

DIFFERENT IN KIND, NOT DEGREE

Darwin regarded human beings as the outworking of natural and sexual selection. In his view, we're not special. We're not fundamentally different from any other creature. In *The Descent of Man* he writes, "The difference in mind between man and the higher animals, great as it is, certainly is one of degree and not of kind."

This impoverished view of humanity has shaped physical anthropology for over 150 years. Yet, today a growing number of evolutionary anthropologists acknowledge that humans do appear to be different in kind from other animals, not just in degree. This view is referred to as human exceptionalism. One proponent is evolutionary psychologist Thomas Suddendorf. In his book *The Gap* he writes,

> We reflect on and argue about our present situation, our history, and our destiny. We envision wonderful harmonious worlds as easily as we do dreadful tyrannies. Our powers are used for good as they are for bad, and we incessantly debate which is which. Our minds have spawned civilizations and technologies that have changed the face of the Earth, while our closest living animal relatives sit unobtrusively in their remaining forests. There appears to be a tremendous gap between human and animal minds.

Anthropologists believe that symbolism accounts for the gap between human and great ape minds. Humans effortlessly represent the world with discrete symbols. We denote abstract concepts with symbols. This ability has interesting consequences when coupled with our abilities to combine and recombine those symbols in a near-infinite number of ways to create alternate possibilities. Our capacity for symbolism manifests in the form of language, art, music, and even body ornamentation. And we desire to communicate the scenarios we construct in our minds with other human beings.

There also appears to be a gap between human minds and the minds of the hominins, such as Neanderthals, who preceded us in the fossil record. It's unlikely that Neanderthals possessed language—and, hence, symbolism—because their crude "technology" remained stagnant for the duration of their time on Earth. Neanderthals first appear in the fossil record around 250,000 to 200,000 years ago and disappear around 40,000 years ago. They existed on Earth longer than modern humans have. Yet, our technology has progressed exponentially, while

Neanderthal technology remained largely static.

According to Ian Tattersall, Noam Chomsky, and their coauthors of an August 26, 2016, article published in the journal *PLoS Biology*:

> Our species was born in a technologically archaic context, and significantly, the tempo of change only began picking up after the point at which symbolic objects appeared. Evidently, a new potential for symbolic thought was born with our anatomically distinctive species, but it was only expressed after a necessary cultural stimulus had exerted itself. This stimulus was most plausibly the appearance of language. . . . Then, within a remarkably short space of time, art was invented, cities were born, and people had reached the moon.

Symbolism and our open-ended generative capacity could be understood as scientific descriptors of the image of God for those who hold to a structuralist view. Accordingly, the image of God refers to unique attributes that humans possess—such as rationality and morality—that are shared with God. The growing recognition of human exceptionalism bodes well for the biblical view of humanity's origin and nature, which teaches that humans are the crown of creation, unique among all creatures.

THE SCIENTIFIC POSSIBILITY OF ADAM AND EVE

Many people conclude that Darwin's ideas of human evolution leave no place for Adam, Eve, and the Garden of Eden. More recent work on the genetic diversity of human beings seems to affirm Darwin's view. These studies indicate to population geneticists that humanity must have originated from a starting population of several thousand individuals, not two. Accordingly, there is no other way to account for the extensive genetic diversity of people living around the world today.

Yet, good reasons to question these studies exist. For example, these results are based on highly idealized mathematical models that are sensitive to input parameters. Thus, the population numbers need to be viewed as rough estimates, at best. Additionally, there is no study that validates that these methods, when applied to known situations, produce accurate results for population size estimates. Studies in conservation biology suggest that these models don't predict genetic variability accurately when the original population size is known. So, why should they be able to predict the original population sizes of modern humans?

Equally provocative are other studies on human genetic diversity. These studies use two distinct genetic markers—mitochondrial and Y-chromosomal DNA—to gain insight into human origins and early history. Based on hundreds of studies, scientific consensus confirms that humanity originated perhaps as much as 100,000 years ago in or near East Africa. Mitochondrial and Y-chromosomal DNA markers trace that origin back to one man and one woman. In addition, this research indicates that humanity migrated rapidly around the world from somewhere in or near the Middle East.

Biologists refer to this as the "Out-of-Africa" hypothesis, or occasionally as the "Garden-of-Eden" hypothesis. It isn't certain if mitochondrial Eve and Y-chromosomal Adam are the biblical Adam and Eve. Nevertheless, it's true that this hypothesis aligns with the biblical account of human origins. If humanity's genesis happened as Scripture describes, then genetic diversity patterns should be close to those observed.

Despite the claims of population geneticists, science has failed to rule out the existence of Adam and Eve as humanity's sole progenitors.

MICROEVOLUTION VS. MACROEVOLUTION

The origin of species was one of the premier scientific questions in Darwin's day. In 1836, English scientist John Herschel stated that the replacement of extinct species by new ones was the "mystery of mysteries."

Darwin identifed a mechanism to account for the origin of new species. In the process, he demonstrated that species aren't fixed entities but can change through natural and sexual selection.

These two mechanisms—along with genetic drift and adaptive introgression (unknown to Darwin but discovered later by evolutionary biologists)—allow populations of organisms to adapt. This adaptation can occur in one of two ways: (1) through changes in standing genetic variation in the population with the frequency of the alleles in the population changing in response to environmental changes, or (2) through the introduction of new alleles altogether through mutations or hybridization.

In *On the Origin of Species*, Darwin argued that natural and sexual selection extrapolated over vast timescales could account for (1) the large-scale biological transformations, (2) the totality of life's diversity throughout Earth's history, (3) the biogeographical distribution of organisms, and (4) life's appearance of design.

Today, abundant evidence exists for microevolution and speciation (driven by natural and sexual selection, genetic drift, and introgression). Yet it isn't clear that merely extrapolating these mechanisms over vast time periods can explain large-scale evolutionary change (macroevolution). To put it another way, it isn't clear if natural and sexual selection, genetic drift, and introgression can account for biological novelty and innovation—particularly when life transitions from one regime of complexity to another.

These concerns have prompted some biologists to call for an extended evolutionary synthesis, acknowledging that current evolutionary theory is incomplete. While these calls don't necessarily invalidate the evolutionary paradigm, they do mean that we currently don't have valid mechanistic explanations for macroevolution and the origin of biological innovation and novelty.

These issues also mean that life scientists cannot legitimately enlist the sound and well-evidenced explanations for microevolution and adaptation in support of macroevolution. The skepticism that some intelligent design proponents and creationists express about the capacity of evolutionary mechanisms to fully account for the origin, design, and history of life is currently justified.

THE REFUSAL TO ABANDON EVOLUTION

In light of these problems (and a host of others) why would so many people, especially scientists, continue to embrace biological evolution? The answer to this question is complex and involves the consideration of several factors.

THE BEST EVIDENCE FOR EVOLUTION

Despite the scientific challenges to the evolutionary paradigm, many biologists remain convinced that life had

an evolutionary history because organisms that naturally group together display shared features. Biologists refer to these shared features as homologies. Most life scientists view homologies as prima facie evidence for biological evolution. Accordingly, the ancestral group harbored these features that, in turn, were retained in the organisms that descended and diverged from the ancestral group.

However, common descent is not the only interpretation option for homologies. Common *design*—a concept friendly to creationism and intelligent design—is a viable explanation. There is a historical precedent for interpreting homologies as evidence for common design. Prior to the publication of Darwin's *On the Origin of Species*, many biologists interpreted homologies as reflecting an archetypical design that existed in the "mind" of the Creator. Sir Richard Owen—the most preeminent biologist of his time—developed an elaborate theoretical framework to explain shared biological features that centered around the archetype concept, presented in his work *On the Nature of Limbs*.

In Owen's view, the archetype existed only in God's mind and was manifested in the created order in the form of homologies. These features often reflected variations of the archetype. For Owen, the archetype represented teleology of a higher order. Owen marveled at the ability of the Creator to simultaneously satisfy the organism's functional needs within the constraints of the archetypical form.

Darwin owed a significant debt to Owen's thinking, but replaced Owen's archetype with a hypothetical common ancestor. Today, many people see shared biological features—whether they be anatomical, physiological, genetic, or biochemical—as undeniable evidence for common descent. But this is only true in a framework that embraces methodological naturalism. If those philosophical constraints are relaxed, then it's possible to see shared features as reflecting common design, not common descent.

PHILOSOPHY AND THE THEORY OF EVOLUTION

Philosophy assumes a hidden but important place in the operation of contemporary science. Methodological naturalism provides the framework for science. It's distinct from philosophical naturalism which asserts that the material, physical universe is all that exists. There is no supernatural. There is no reality outside of the universe itself. There is no God. As astronomer Carl Sagan once quipped, "The universe is all that was, is, and ever will be."

In contradistinction to philosophical naturalism, methodological naturalism claims to be metaphysically neutral on the question of God's existence. Still, when one engages in the scientific enterprise, it's necessary to suspend belief in God, regardless of one's personal convictions. The only allowed explanations for the universe and its phenomena are natural process, mechanistic explanations. One cannot appeal to the supernatural. This doesn't mean the supernatural doesn't exist; the supernatural is simply not given a place in the scientific project.

Sometimes methodological naturalism is called provisional atheism or benchtop atheism. Even if you believe God exists, your views cannot influence the way in which you conduct science. In other words, you must operate methodologically as if God does not exist. This restriction makes methodological naturalism functionally equivalent to philosophical naturalism. It renders science an inherently atheistic enterprise, though its practitioners may well believe God exists.

In effect, methodological naturalism restricts the available explanations for the universe and its phenomena

(such as the origin of life). Certain explanations are off the table a priori. Consequently, intelligent design/creationism cannot be part of the construct of science. For example, any explanation that states an intelligent agent is responsible for humanity's origin is prohibited. As a result, human evolution is the only available option for someone who's trying to account scientifically for the origin of humanity within a framework influenced by methodological naturalism.

The net effect is that biological evolution is true by default, regardless of the evidence at hand. No matter how much evidence exists challenging the evolutionary paradigm, it cannot be supplanted because no other alternative explanation is allowed.

Harvard biologist Richard Lewontin powerfully illustrates the grip methodological naturalism has on the scientific enterprise in an article published in the January 9, 1997, edition of the *New York Review*:

> We take the side of science in spite of the patent absurdity of some of its constructs, in spite of its failure to fulfill many of its extravagant promises of health and life, in spite of the tolerance of the scientific community for unsubstantiated just-so stories, because we have a prior commitment, a commitment to materialism. It is not that the methods and institutions of science somehow compel us to accept a material explanation of the phenomenal world, but, on the contrary, that we are forced by our *a priori* adherence to material causes to create an apparatus of investigation and a set of concepts that produce material explanations, no matter how counter-intuitive, no matter how mystifying to the uninitiated. Moreover, that materialism is an absolute, for we cannot allow a Divine Foot in the door.

THE NEED FOR A CREATION MODEL

Another reason many scientists refuse to abandon the evolutionary paradigm has to do with how Christians approach these matters. Often, Christians are quick to point out the problems, but fail to offer viable alternatives. Merely explaining the difficulties isn't enough and understandably puts evolution proponents on the defensive.

In *The Triumph of Evolution: And the Failure of Creationism*, paleontologist Niles Eldredge argues:

> Creation scientists have not managed to come up with even a single intellectually compelling, scientifically testable statement about the natural world. . . . So, in the end, there is as little of substance in the scientific creationists' treatment of the origin and diversification of life as there is in their treatment of cosmological time.

He goes on to complain that creationists refuse to pose testable hypotheses or make predictions worthy of science. Instead they devote their efforts to "attacking orthodox science in the mistaken and utterly fallacious belief that in discrediting science, . . . they have thereby established the truth of their own position."

To be taken seriously by the scientific and educational communities, Christians must present a positive case for creation and offer scientifically testable ideas. Many scientists and scholars from a variety of disciplines, particularly at Reasons to Believe (RTB), have been involved in developing a biblically based creation model.

This effort offers a comprehensive explanation for the record of nature that takes into account all the scientific disciplines and makes predictions, based on the creation model, about future scientific discoveries, allowing creation theory to be compared with new discoveries and scientifically tested. The key predictions of the RTB creation model can be found in Hugh Ross's book *More Than A Theory*.

Presenting the biblical account in the form of a testable model provides a powerful and exciting new approach. Such a scientific model not only demonstrates the truthfulness of the Bible but can also lead to scientific advances.

Not surprisingly, many recent discoveries validate the biblical description of the origin and history of life.

If only Darwin had known.

ABOUT REASONS TO BELIEVE

We at Reasons to Believe seek to dispel the idea that religious beliefs and scientific studies should be kept separate. Our scholar team, consisting of three PhD scientists and a philosopher-theologian, offers distinctive and fascinating insights on topics ranging from biblical creation to cutting-edge biotechnology.

Our intent is to create a space where ideas and ideologies can be explored fearlessly and where a spirit of curiosity is welcomed. We aim to present research and start a conversation—because people deserve respect and a safe forum for discussing their views.

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Hugh Ross is senior scholar and founder of Reasons to Believe (RTB), an organization dedicated to demonstrating the compatibility of science and the Christian faith.

With a degree in physics from the University of British Columbia and a PhD in astronomy from the University of Toronto, Hugh—initially a skeptic, always curious, and eventually a Christian—continued his research on quasars and galaxies as a postdoctoral fellow at the California Institute of Technology. After five years there, he transitioned to full-time ministry. In addition to founding and leading RTB, he remains on the pastoral staff at Christ Church Sierra Madre. His writings include journal and magazine articles, blogs, and numerous books—*The Creator and the Cosmos*, *Why the Universe Is the Way It Is*, and *Designed to the Core*, among others. He has spoken on hundreds of university campuses as well as at conferences and churches around the world.

Hugh lives in Southern California with his wife, Kathy.