BONUS CHAPTER

WHICH EVOLUTIONARY HURDLES RECOGNIZED BY DARWIN STILL REMAIN

REASONS TO BELIEVE

reasons.org

Bonus Question: Which Evolutionary Hurdles Remain?

Nobody likes to be wrong. I sure don't. And when we are wrong, it can be hard to admit it. I find it difficult to acknowledge my own errors sometimes, if truth be told.

I doubt many of us would go so far as to help *someone else* discover our mistakes.

Yet, identifying ways that your ideas might be proven wrong—"falsified," to use scientific lingo—is at the heart of science. For a scientific theory to be useful, it must be falsifiable. Good scientists invite others to prove their ideas wrong. They even go so far as to help them by making predictions based on their own theories. If the predictions are satisfied, then it bodes well for the theory. But if the predictions fail, then it means that the theory, as it stands, is wrong and needs to be abandoned or modified.

Charles Darwin was an exemplary scientist. In his seminal work *On the Origin of Species*, Darwin devoted an entire chapter to "difficulties" with his theory of biological evolution, highlighting observations that seemingly counted against his idea. Darwin noted several problems for his theory caused by patterns in the fossil record. Two features of the fossil record he considered most troubling were (1) the abrupt appearances of biological groups the first time they occur in the fossil record and (2) the absence of transitional forms.

One feature of the fossil record that particularly concerned Darwin was what we refer to today as the Cambrian explosion, the relatively sudden appearance—in a geological instant—of somewhere between 50%–80% of all known animal phyla. This event took place around 520 million years ago. 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.[1]

To resolve the discrepancy between the fossil record and his theory of evolution, Darwin appealed to the fossil record's incompleteness. Paleontology was in its infancy in Darwin's time. He argued that as more geological layers were characterized and studied, newly unearthed fossils would provide evidence for graduation of evolutionary transitions and the missing transitional forms. In other words, Darwin believed the Cambrian explosion was an artifact of an incomplete fossil record.

Indeed, over the last 150 years, paleontologists have found a treasure trove of fossils that document a rich history of life on Earth. Evolutionary biologists point to these fossils as a key piece of evidence supporting biological evolution. The fossil record verifies that past life was different from life today, and that simple life preceded complex. For many scientists, these general features of the fossil record indicate that life must have evolved.

Despite the fossil discoveries that have taken place since *On the Origin of Species* was published, the overall features of the fossil record still look much the same as they did in Darwin's day. When many new biological groups appear, they do so explosively, followed by stasis. This pattern is seen in the rock formations at the base of the Cambrian, indicating that the Cambrian explosion was a real occurrence in life's history, not an artifact of an incomplete fossil record. It's also a highly enigmatic occurrence—at least for the evolutionary paradigm. At the Cambrian explosion, life essentially transitions from colonial aggregates of cells with tissue-grade organization to animals with complex body plans replete with integrated organ systems. Most paleontologists acknowledge this leap in complexity, but I think it is safe to say that no one has an evolutionary explanation for the origin of animal body plans and, consequently, for the Cambrian explosion.

Key Transitions Left Unexplained

While the evolutionary framework has real explanatory power, there are things it can't explain. In fact, when it comes to many of the key transitions in life's history, this framework, as it currently stands, comes up short. A survey of the scientific literature highlights some of the hurdles that lie ahead for the evolutionary paradigm. Minimally, current evolutionary theory cannot account for:

- The origin of life
- The origin of eukaryotic cells
- The origin of body plans
- The origin of language

Until it can make sense of these transitions the evolutionary paradigm stands, at best, as a partial explanation for life's origin, history, and design. In other words, those of us who are reluctant to embrace the paradigm's grand and all-inclusive claims are justified in our skeptical stance.

It is beyond the scope of this chapter to detail all the reasons why the evolutionary paradigm fails to explain these key events in life's history. Instead, I'll present relevant statements from respected experts who are trying to account for these four transitions in life history. (For a detailed analysis of these transitions, see the book *Thinking about Evolution* by Roberts, Rana, Dykes, and Perez.) In each case, the scientists making these statements are deeply entrenched in the evolutionary paradigm and are not friendly to intelligent design or creation theories.

With respect to the origin of life, astrobiologist and physicist Paul Davies and collaborator Sara Imari Walker summarize the current state of origin-of-life research this way:

> Of the many open questions surrounding how life emerges from non-life, perhaps the most challenging is the vast gulf between complex chemistry and the simplest biology: even the smallest mycoplasma is immeasurably more complex than any chemical reaction network we might engineer in the laboratory with current technology.[2]

With regard to the endosymbiont hypothesis—the leading evolutionary model for the origin of eukaryotic cells—Hungarian evolutionary biologist Eörs Szathmáry and István Zachar write in a critical review:

> The integration of mitochondria was a major transition, and a hard one. It poses a puzzle so complicated that new theories are still generated 100 years since endosymbiosis was first proposed by Konstantin Mereschkowsky and 50 years since Lynn Margulis cemented the endosymbiotic origin of mitochondria into evolutionary biology. . . . One would expect that by this time, there is a consensus about the transition, but far from that, even the most fundamental points are still debated.[3]

With respect to the origin of body plans, Douglas Erwin and James Valentine, two leading authorities on the Cambrian explosion, express this concern about the current evolutionary framework:

> One important concern has been whether the microevolutionary patterns commonly studied in modern organisms by evolutionary biologists are sufficient to understand and explain the events of the Cambrian or whether evolutionary theory needs to be expanded to include a more diverse set of macroevolutionary processes. We strongly hold to the latter position . . . The move from micro to macro forms a discontinuity.[4]

Finally, anthropologists struggle to provide an evolutionary explanation for the genesis of language in modern humans, a feature that some anthropologists think makes human beings unique and exceptional. Linguistic anthropologist Chris Knight writes:

> Language evolved in no other species than humans, suggesting a deep-going obstacle to its evolution. One possibility is that language simply cannot evolve in a Darwinian world—that is, in a world based ultimately on competition and conflict. The underlying problem may be that the communicative use of language presupposes anomalously high levels of mutual cooperation and trust—levels beyond anything which current Darwinian theory can explain . . . suggesting a deep-going obstacle to its evolution.[5]

I've been careful not to "cherry-pick" the scientific literature to make my point. These perspectives come from review articles (or a graduate textbook, in one case) written by experts in each of these respective areas of evolutionary biology and origin-of-life research. These articles serve to provide an overview of a significant number of studies. And, these statements provide an honest and forthright assessment of the current state of affairs in these disciplines.

Biology's Big Bangs

How should we think about these abrupt transitions in the fossil record? Bioinformatics expert Eugene Koonin analyzed these transitions, producing results that compound the challenges faced by the evolutionary paradigm. According to Koonin, when key transitions took place in life's history, they happened explosively. There were no intermediate grades documenting the innovations from lower regimes of biological complexity to higher ones. Koonin dubs these transitions "Biology's Big Bangs."[6]

Koonin's analysis requires that evolutionary scientists reimagine the landscape of life's history. Instead of life unfurling in a gradual, branching, tree-like fashion, the data indicates that the major transitions happened rapidly. Based on phylogenetic studies, Koonin demonstrated that biological innovations occurred abruptly in life's history without any trace of intermediate forms. Examples include the origins of

1. protein folds,
2. cells,
3. bacteria and archaea (and major divisions within these domains),
4. eukaryotes (and major eukaryotic divisions), and
5. animal phyla.

Though, these major transitions appear to occur rapidly, the diversification that follows takes place in a slow, tree-like manner.

Koonin's conclusion is not surprising for scientific investigators working in these disciplines. A large body of data affirms the idea that the major transitions in life's history are, in fact, best described as "big bangs."

Life's First Appearance on Earth

One of the most provocative discoveries related to the origin-of-life question is the evidence that life first appeared remarkably early in Earth's history. The oldest rocks yet discovered on Earth date at around 3.8 billion years old. Based on a wide range of fossil and geochemical evidence recovered from these rock formations, it appears as if life originated on Earth at that same time—3.8 billion years ago. (Some of this evidence is described in a book I coauthored with Hugh Ross, *Origins of Life*.)

The geochemical and fossil evidence shows that Earth's first life was microbial in nature. Though morphologically simple, the geochemical data indicates this life was biochemically diverse and complex. The evidence suggests that the first life-forms engaged in a wide range of metabolic activities, including photosynthesis, methanogenesis, methanotrophism, and sulfur disproportionation.

Traditionally, planetary scientists regarded early Earth as a hot and molten planet from the time of its formation (4.5 billion years ago) until ~3.8 billion years ago. During the Hadean era of Earth's history, oceans were absent on early Earth, making their first appearance around 3.8 billion years ago. Scientists believe a number of factors contributed to the hell-like environment of our early planet, most notably the large impactors striking Earth's surface. Researchers believe that some of these impact events were so energetic they volatilized liquid water on the planet's surface and melted the surface and subsurface rock. In light of this scenario, it would be impossible for life to originate much earlier than 3.8 billion years ago. To put it another way, if the traditional understanding of early Earth's history is valid, then complex microbial ecologies must have appeared abruptly—within a geological instant. It is practically impossible to fathom how the explosive appearance of early life could happen via evolutionary mechanisms.

More recently, planetary scientists have revised their view of early Earth. In this framework, early Earth was molten only for the first 200–300 million years of its history, after which time, oceans became permanent (or maybe semipermanent) features on the planet's surface. The basis for this revised view is the discovery of zircon crystals, dating between 4.2–4.4 billion years ago. Geochemical signatures within these crystals suggest that they formed in an aqueous setting, implying that oceans were present on Earth before 3.8 billion years ago.

But this revised scenario doesn't offer much support for an evolutionary approach to life's origin. Around 3.8 billion years ago, a gravitational perturbation in the early solar system sent asteroids toward Earth. Some estimates suggest Earth experienced more than 17,000 impacts during this time. This event, called the late heavy bombardment (LHB), was originally considered to be a sterilization event. Any life present on Earth prior to the LHB would have been obliterated. That being the case, it appears, again, as if complex microbial ecologies appeared on Earth suddenly, within a geological instant.

Yet some planetary scientists have challenged the notion that the LHB sterilized the early Earth. They posit that life on the planet's *surface* would have been destroyed, but life in some environments, such as hydrothermal vents, could have survived. In other words, there would have been refugia areas where organisms can survive unfavorable conditions) on Earth that served as "safe houses" for life, ushering it through the LHB.

Ultimately, though, pushing life's origin back to more than 4 billion years ago doesn't solve the problem of a sudden origin of life—it merely displaces it to another window of time in Earth's history. Origin-of-life researchers have studied geochemical evidence suggesting that life was present on Earth between 4.2 and 4.4 billion years ago.[7] Given that the earth was molten for at least the first 200–300 million years of its existence, that still doesn't leave much time for life to originate.

Origin of Eukaryotic Cells

When it comes to the origin of complex, eukaryotic cells, fossil evidence seems to indicate that they made their first appearance around 2 billion years ago. But the mode and tempo for the origin of eukaryotic cells is not what one would expect if their origin occurred via evolutionary processes. (The endosymbiont hypothesis describes the evolutionary origin of these cells, but the problems confronting this model are legion. For details about the scientific shortcomings of the endosymbiont hypothesis, see *Thinking about Evolution* by Roberts, Rana, Dykes, and Perez.)

Much of the work done on eukaryotic origins focuses on building evolutionary trees using genomic data. These studies reveal troubling findings for the paradigm: Evolutionary biologists can't uncover a branching pattern for the 6 major eukaryotic supergroups (Opisthokonta, Amoebozoa, Excavata, Plantae, Cercozoa, Alveolates). Instead of a branching tree-like pattern, the phylogeny for these supergroups resembles a star. (Evolutionary biologists describe this pattern as a polytomy.) This pattern indicates that when eukaryotes appeared on Earth, they achieved expansive diversity in a geological instant. (Nick Lane summarizes the challenges confronting evolutionary biologists who try to piece together the origin of eukaryotes in his book *The Vital Question: Energy, Evolution, and the Origins of Complex Life*.)[8]

The nature of the last eukaryotic common ancestor (LECA), the organism that gave rise to the major eukaryotic groups, confounds this problem. LECA was incredibly complex: it possessed a nucleus, chromosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, mitochondria, and a cytoskeleton.[9] In other words, LECA wouldn't have looked much different from a typical eukaryotic cell.

Also, LECA possessed a brand-new suite of proteins called eukaryotic signature proteins that have no homologs in bacteria or archaea. It looks as if these signature proteins appeared out of nowhere. In sum, it seems eukaryotic cells appeared without any transitional intermediates in what has been described as the eukaryotic big bang.[10]

Explosive Appearance of Body Designs

Likewise, the details surrounding the Cambrian explosion cause consternation for evolutionary biologists. For example, paleontologists have unearthed echinoderms, urochordates, hemichordates, chordates, and craniated chordates in the Chengjiang Cambrian site in China's Yunnan province. (The Chengjiang site consists of geological formations near the base of the Cambrian.) This finding is completely unexpected from an evolutionary vantage point. Here's how:

The most widely accepted evolutionary model has chordates arising from echinoderms through a urochordate transitional form and, in turn, craniated chordates arising from chordates. Echinoderms are also believed to have spawned hemichordates as an evolutionary side branch.[11] This scenario predicts that echinoderms, hemichordates, urochordates, chordates, and jawless fish *will appear sequentially* in the fossil record—and that the sequence should cover a long time span, given the extensive anatomical and physiological differences among these phyla and subphyla. Yet, scientists do not see a sequential progression, but rather a simultaneous appearance in the fossil record.

A similar problem was unearthed by researchers from Germany and China reporting on a fossil specimen from the Chengjiang site of an unusual animal called a lobopodian.[12] This creature looks like a segmented worm with legs culminating in hooked claws on each segment. The newly discovered organism, called *Diania cactiformis*, had armored appendages on its legs that resembled arthropod limbs. Evolutionary biologists believe that these lobopodians gave rise to arthropods. Based on the structure of this creature's limbs, the biologists argue that it represents a transitional form connecting lobopodians to arthropods. The problem with this interpretation is that there are more than 75 species of arthropods and around 10 species of lobopods that have been recovered from the Chengjiang sites. In other words, members of putative ancestral (lobopods) and descendent (arthropod) groups appear simultaneously, not sequentially, in the lower Cambrian.

Another problem the Cambrian explosion creates for life scientists committed to the evolutionary paradigm relates to the appearance of modern anatomical and physiological systems in Cambrian fossil specimens. Instead of discovering primitive biological systems—as expected—paleontologists find the opposite, sophisticated ones, as the following three examples attest.

Skeletal Designs

The Cambrian period marked the first appearance of animals with skeletons. A skeleton may be (1) internal or external; (2) rigid or flexible; (3) formed with one, two, or multiple elements; (4) comprised of rods, plates, and solid three-dimensional parts; (5) grown by accretion, molting, or remodeling; and (6) composed of different chemical materials such as silica, calcium carbonate, calcium phosphate, and chitin. In light of these characteristics, "skeletal space" (a mathematical space that defines all possible skeletal designs) consists of 182 possible skeletal designs.

Interestingly, of these 182 possibilities, 146 appeared during the Cambrian event. In other words, according to the fossil record, more than 80% of all possible skeletal designs appeared in a geological instant.[13]

Neural and Circulatory Systems

Evidence reveals that the modern arthropod brain and circulatory system appeared during the Cambrian explosion as well, according to fossils of *Fuxianhuia protensa*. This shrimp-like arthropod lived about 520 million years ago. Paleontologists have identified two *F. protensa* specimens with modern optic lobes and brain structures and a modern cardiovascular system. Both specimens represent the earliest examples of nervous and cardiovascular systems known to date. Remarkably, both possess nervous and cardiovascular systems highly similar to those of modern-day arthropods such as insects, arachnids, and crustaceans.[14]

Compound Eyes

Paleontologists have discovered a trilobite with exceptionally well-preserved eyes in the Emu Bay Shale of Australia. To these scientists' amazement, the eyes of this arthropod look identical to the compound eyes of modern-day arthropods. In other words, arthropods appear suddenly in the Cambrian explosion with fully modern eyes.[15] These repeated fossil record observations do not fit seamlessly in an evolutionary paradigm.

Sociocultural Big Bang

Lastly, the origin of language, and, hence, features that make modern humans exceptional, also appear suddenly. Even though many anthropologists reject the notion of human exceptionalism, a growing minority of anthropologists and primatologists acknowledge that there is something special about human beings. We are different in kind, not merely degree, from other creatures.

Four qualities make us exceptional as human beings compared to other species, including the great apes and Neanderthals. These qualities are:

1. symbolism
2. open-ended generative capacity
3. theory of mind
4. our capacity to form complex social networks

As human beings, we effortlessly represent the world with discrete symbols. We denote abstract concepts with symbols. We use our ability to represent the world symbolically by coupling it with our ability to combine and recombine those symbols in a countless number of ways to create alternate possibilities. Our capacity for symbolism finds its expression in language, art, music, and even body ornamentation. In turn, we communicate the scenarios we construct in our minds to other human beings.

But there is more to our interactions with other humans than a desire to communicate. We seek to link our minds together and *can* do so because we possess a theory of mind. This means we recognize that other people have minds just like ours. This realization makes it possible for us to understand others' thoughts and emotions. We also have the capacity to create hierarchical categories that we use to place those people we know and encounter. By doing so, we form and live within complex social networks.

A growing body of data indicates that these qualities originated close to the same time that anatomically modern humans first appear in the fossil record. And when these qualities appear, they emerge suddenly without any evolutionary antecedent, as work on the origin of language illustrates.

Traditionally, evolutionary biologists thought that human language emerged gradually. Accordingly, hominids (such as *Homo erectus* and Neanderthals) possessed the physical and mental antecedents to modern humanity's complex language abilities. Yet, today, some anthropologists and linguists challenge the traditional view. Instead, they maintain that language is exclusive to modern humans and originated abruptly as a singular event. In other words, there was never a protolanguage that evolved into complex language expression. Instead, language was intrinsically complex at its inception.

This observation is not lost on linguist Noam Chomsky and paleoanthropologist Ian Tattersall (along with their collaborators), who wrote:

> By this reckoning, the language faculty is an extremely recent acquisition in our lineage, and it was acquired not in the context of slow gradual modification of preexisting systems under natural selection but in a single, rapid, emergent event that built upon those prior systems but was not predicted by them. . . . The relatively sudden origin of language poses difficulties that may be called 'Darwin's problem.'[16]

Is There an Evolutionary Explanation for Biology's Big Bangs?

Koonin proposes a mechanism to account for this pattern of rapid changes, positing that at certain periods in life's history, extensive genetic "scrambling" (horizontal gene transfer, recombination, fusion, fission, transposition) occurred. The vast majority of this genetic chaos proved nonproductive, but on rare occasions—by chance—a stable genetic combination emerged. These robust islands of genetic novelty led to a new regime of biological complexity.

As intriguing as it may be, Koonin's proposal raises concerns upon careful reflection:

- Why is this pattern of explosive innovation repeated throughout life's history?
- What causes the genetic scrambling to take place?
- Why doesn't this process happen continuously throughout life's history?
- Why should the mechanism Koonin envisions ever result in coherent changes leading to stable genetic islands that represent discontinuous increases in biological complexity?

A Signature for Creation?

Could it be that these abrupt transitions reflect creation events? If the Creator did, indeed, intervene in life's history to effect biological innovations, what would life's history look like? What would the patterns in the fossil record be? At Reasons to Believe (RTB), we interpret biology's big bangs as evidence for creation. To be clear, this interpretation would be rejected out of hand by most in the scientific community because of their commitment to naturalistic explanations. Still, our model does account for the big bang events in life's history.

Interestingly, the pattern Koonin identifies is similar to the one predicted by RTB's creation model. The RTB model asserts that a Creator intervened repeatedly to bring about progressive changes in life's history. This intervention should produce discontinuities in life's history and take place without any trace of transitional forms. If nothing else, Koonin's analysis affirms that the patterns of the biosphere's history match RTB model predictions and validate the notion that a Creator must be responsible for life's history.

Endnotes

1. Charles Darwin, *On the Origin of Species by Means of Natural Selection* (New York: Collier Press, 1909), 360.
2. Sara Imari Walker and Paul C. W. Davies, "The Algorithmic Origin of Life," *Journal of the Royal Society Interface* 10, no. 79 (February 6, 2013), doi:10.1098/rsif.2012.0869.
3. István Zachar and Eörs Szathmáry, "Breath-giving Cooperation: Critical Review of Origin of Mitochondria Hypotheses," *Biology Direct* 12, no. 1 (August 14, 2017): id19, doi:10.1186/s13062-017-0190-5.
4. Douglas H. Erwin and James W. Valentine, *The Cambrian Explosion: The Construction of Animal Biodiversity* (Greenwood Village, CO: Roberts and Company, 2013), 10–11.
5. Chris Knight, "Puzzles and Mysteries in the Origins of Language," *Language and Communication* 50 (September 2016): 12–21, doi:10.1016/j.langcom.2016.09.002.
6. Eugene V. Koonin, "The Biological Big Bang Model for the Major Transitions in Evolution," *Biology Direct* 2 (August 20, 2007), doi:10.1186/1745-6150-2-21.
7. Elizabeth A. Bell et al., "Potentially Biogenic Carbon Preserved in a 4.1 Billion-Year-Old Zircon," *Proceedings of the National Academy of Sciences, USA* 112, no. 47 (November 24, 2015): 14518–21, doi:10.1073/pnas.1517557112.
8. Nick Lane, *The Vital Question: Energy, Evolution, and the Origins of Complex Life* (New York: W. W. Norton, 2015).
9. Lane, *The Vital Question*, 35–45.
10. Lane, *The Vital Question*, 35–45.
11. Cleveland P. Hickman, Sr. et al., *Integrated Principles of Zoology*, 6th ed. (St. Louis, The C. V. Mosby Company, 1979), 476–81.
12. Jianni Liu et al., "An Armoured Cambrian Lobopodian from China with Arthropod-Like Appendages," *Nature* 470 (February 24, 2011): 526–30, doi:10.1038/nature09704.
13. R. D. K. Thomas, Rebecca M. Shearman, and Graham W. Stewart, "Evolutionary Exploitation of Design Options by the First Animals with Hard Skeletons," *Science* 288, no. 5469 (May 19, 2000): 1239–42, doi:10.1126/science.288.5469.1239.
14. Xiaoya Ma et al., "Complex Brain and Optic Lobes in an Early Cambrian Arthropod," *Nature* 490 (October 11, 2012), 258–61, doi:10.1038/nature11495; Xiaoya Ma et al., "An Exceptionally Preserved Arthropod Cardiovascular System from the Early

Cambrian," *Nature Communications* 5 (April 7, 2014), article no. 3560, doi:10.1038/ncomms4560.

15. Michael S. Y. Lee et al., "Modern Optics in Exceptionally Preserved Eyes of Early Cambrian Arthropods from Australia," *Nature* 474 (June 29, 2011): 631–34, doi:10.1038/nature10097.
16. Johan J. Bolhuis et al., "How Could Language Have Evolved?," *PLoS Biology* 12, no. 8 (August 26, 2014): e1001934, doi:10.1371/journal.pbio.1001934.