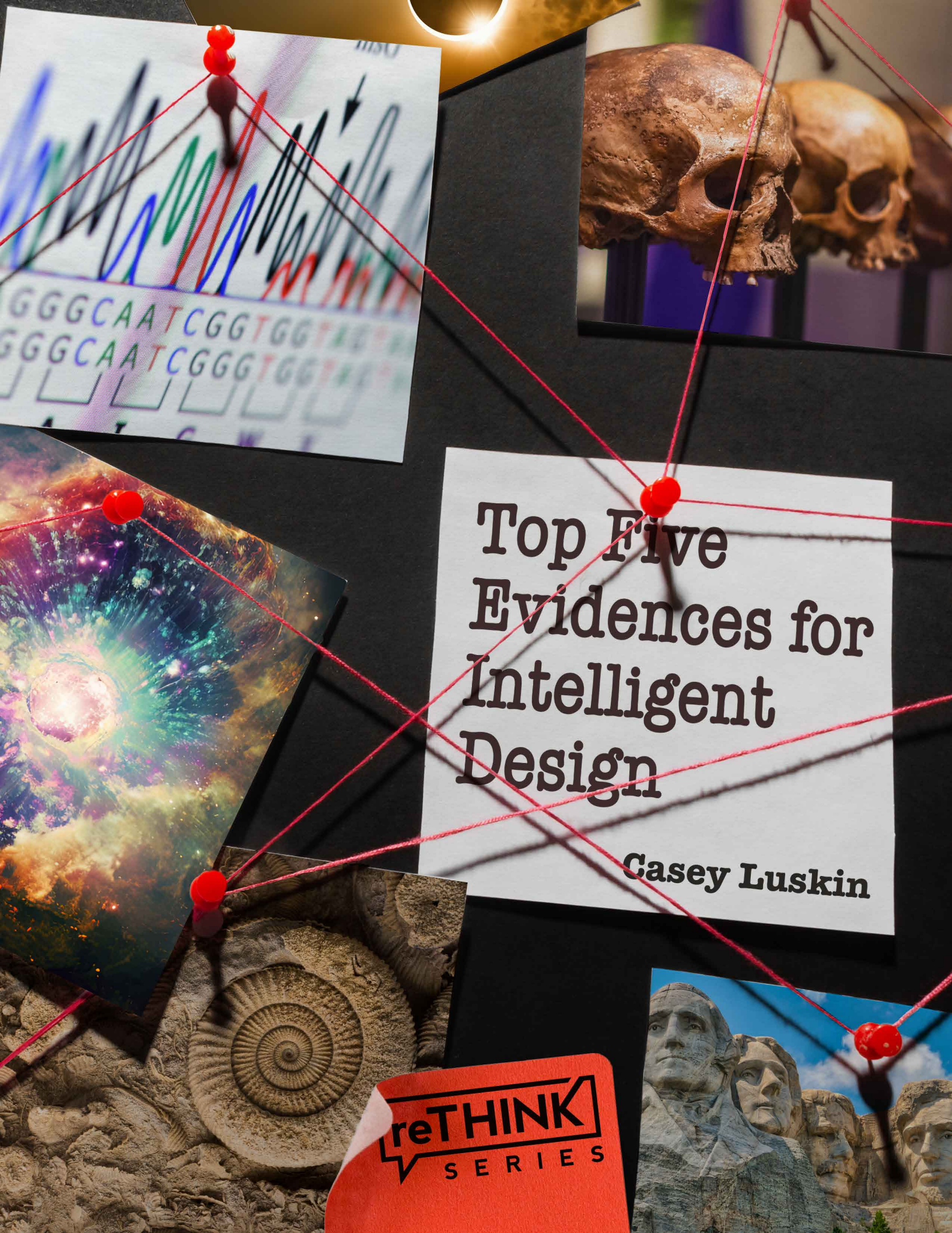
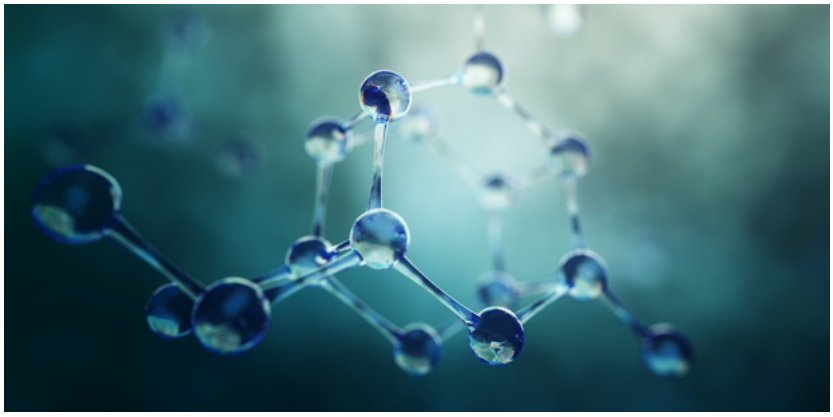

Top Five
Evidences for
Intelligent
Design
Casey Luskin
reTHINK
SERIES

INTRODUCTION



INTELLIGENT DESIGN (ID) IS A scientific theory that applies in multiple scientific disciplines, including biology, cosmology, physics, chemistry, and my own field, geology. The theory of ID holds that many features of the universe and life are best explained by an intelligent cause rather than blind mechanisms such as natural selection. We detect design when an intelligent cause is the best explanation because intelligence is superior to other known causes in accounting for the observed evidence. For example, many natural features are best explained by an intelligent cause because they contain a type of information and complexity that in our experience comes only from intelligence.

A THEORY OF INFORMATION

ID THEORISTS START BY OBSERVING how intelligent agents act when they design things. By doing this, we learn that intelligent agents generate high levels of information. As the information theorist Henry Quastler observed, the "creation of information is habitually associated with conscious activity."[1] There are various ways of defining information, but the type of information that indicates design is generally called *specified complexity*, or *complex and specified information* (CSI for short). Let's briefly discuss this term.

Roughly speaking, something is complex if it is unlikely. But complexity or unlikelihood alone is not enough to infer design. To see why, imagine that you are dealt a five-card hand for a poker game. Whatever hand you receive is going to be very unlikely. Even

if you get a good hand, like a straight or a royal flush, you're not necessarily going to say, "Aha! The deck was stacked." Why? Because unlikely things happen all the time. We don't infer design simply because of something's being unlikely. We need more—according to ID theorist William Dembski, that is *specification*. Something is specified if it matches an independent pattern.

As geologist, I naturally think in geological terms. To understand specification, imagine visiting the mountains of North America. First, you come across Mount Rainier, a huge, dormant volcano in the Pacific Northwest. This mountain is unique; in fact, if all possible combinations of rocks, peaks, ridges, gullies, cracks, and crags are considered, its exact shape is extremely unlikely and complex. But you don't infer design simply because Mount Rainier has a complex shape. Why? Because you can easily explain its shape through the natural processes of erosion, uplift, heating, cooling, freezing, thawing, weathering, etc. There is no special,

independent pattern to the shape of Mount Rainier. Its complexity alone is not enough to infer design.

Now you visit a different mountain—Mount Rushmore in South Dakota. This mountain also has a very unlikely shape, but its shape is special. It matches a pattern—the faces of four famous Presidents. With Mount Rushmore, you don't just observe complexity; you also find specification. No natural geological processes can shape a mountain into such shapes precisely matching the faces of these Presidents. Thus, you would infer that its shape was designed (Figure 1).

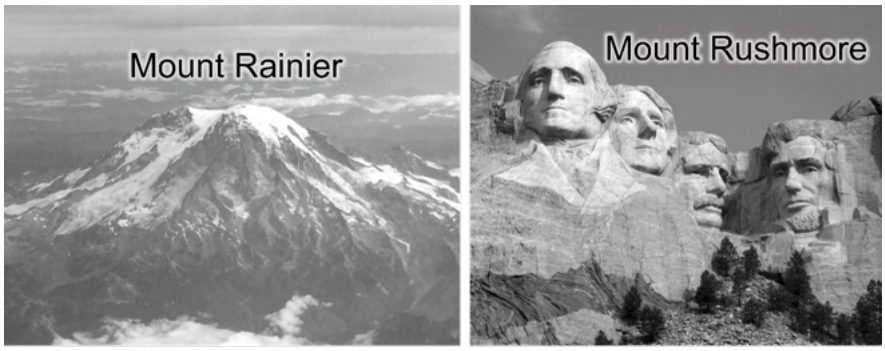


Figure 1. *Which of these two mountains has a shape that allows us to detect design? Mount Rainier (left) has an unlikely (complex) shape, but it's not specified, so we do not detect design. In contrast, Mount Rushmore (right) has a shape that is both highly complex and specified, which is best explained by intelligent design.*

INTELLIGENT DESIGN AS SCIENCE[2]

INTELLIGENT DESIGN IS A historical science which detects design by using what ID theorist Stephen C. Meyer and other philosophers of science call an "inference to the best explanation."[3] Under this method, we compare the explanatory utility of causes and mechanisms known to be at work in the world around us, and determine which one best explains the evidence. To give a very simple example of this kind of reasoning, you observe that your dog is barking at the front door. There are two main possible explanations: (1) There's someone at the front door, or (2) Your dog wants to go outside. You open the front door and there's no one in sight. But as soon as you open the door your dog runs out and escapes. (You probably should have held on to him by his collar!) The

best explanation for why your dog barked at the door is thus (2).

Intelligent design, like the competing theory of Darwinian evolution, is also what we call a historical science. Put simply, and following a principle articulated by a founder of the modern field of geology, Sir Charles Lyell, historical scientists study and observe causes at work in the present day (such as intelligent agents, or alternatively, evolutionary mechanisms). They then seek to use these causes to explain the historical record. By observing the effects of present-day causes, investigators can make testable and falsifiable predictions about what we should expect to find today if a given cause was at work in the past. When these predictions are fulfilled, we have positive evidence that a particular cause was at work. The cause that accounts for the most data is inferred to be the most likely to be correct. Again, this is how historical scientists make an inference to the best explanation.

A common objection to intelligent design is that it is not science. However, it is as much a science as is Darwinian theory. We can see that ID is science because it uses the scientific method to make its claims. The scientific

method is commonly described as a four-step process involving observation, hypothesis, experiment, and conclusion. ID uses this precise method:

- ***Observation:*** ID theorists begin by observing that intelligent agents commonly produce high levels of CSI, and that they alone are capable of producing high CSI.
- ***Hypothesis:*** ID theorists hypothesize that if a natural object was designed, it will contain high CSI.
- ***Experiment:*** Scientists perform experimental tests upon natural objects to determine if they contain high CSI. For example, mutational sensitivity tests show enzymes are rich in CSI: they contain highly unlikely orderings of amino acids that match a precise sequence-pattern that is necessary for function. Another easily testable form of CSI is irreducible complexity, wherein a system requires a certain core set of interacting parts to function. (As we'll see below, evolutionary mechanisms struggle to explain the origin of irreducibly complex systems.) Genetic

knockout experiments show that some molecular machines are irreducibly complex. (We'll explore these examples in more detail shortly.)

- ***Conclusion:*** When ID researchers find high CSI in DNA, proteins, and irreducibly complex molecular machines, they conclude that the best explanation is that such structures were designed.

However, as I mentioned at the outset, ID is much broader than biology. The laws of physics and chemistry, for example, show evidence of design because they are finely tuned to allow life to exist. We'll also explore this concept in more detail shortly. So let's dive into the top five lines of scientific evidence where we find that intelligent design is the best explanation. Of course, there are other such powerful lines of evidence, but these seem particularly worthy of note.

1. THE ORIGIN OF THE UNIVERSE[4]

THE FAMOUS KALAM COSMOLOGICAL argument is a three-part argument developed by Muslim and Christian scholars arguing that the universe requires a first cause:

- Anything that begins to exist has a cause.
- The universe began to exist.
- Therefore, the universe has a first cause.

The step in the argument that science can address is the middle one—evidence that the universe began to exist. That evidence comes in two major pieces—(i) the redshift and the Doppler effect, and (ii) the discovery of microwave background radiation.

In 1927, Belgian astronomer Georges Lemaître theorized that the universe began with a single explosion from a densely compacted state. That explosion eventually became known as the Big Bang. The Big Bang is a

model of the universe's origin that holds it is finite in size and age. According to this theory, the universe—including all space and time—originated with a single powerful expansion event, and is still expanding.

Two years after Lemaître introduced his theory, astronomer Edwin Hubble published a study supporting it. Hubble's study indicated that all galaxies are receding from one another and that the universe is, in fact, expanding. How did Hubble make this discovery?

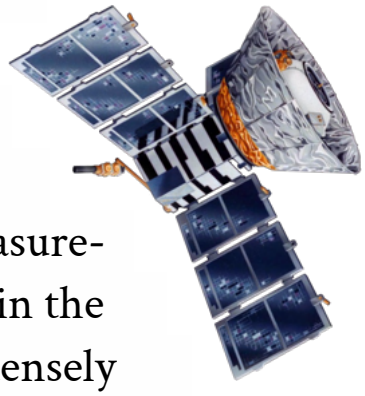
The next time an ambulance drives past with its siren blaring, pay attention to the pitch of the sound. As the ambulance approaches, the pitch is high, but then as it screams past, the pitch suddenly drops. That is called the *Doppler effect*. The Doppler effect states that sound waves are heard with a higher frequency when the source of the sound is moving toward you, but with a lower frequency when it is moving away from you. Although light waves behave differently from sound waves, a similar effect takes place—also called the Doppler effect.

Light waves coming from an approaching object will have their frequency shifted up

toward the blue end of the spectrum of visible light. Correspondingly, light waves coming from a receding object are stretched to a lower frequency, and thus shifted down toward the red end—a phenomenon known as *the redshift*. Hubble's research confirmed that galaxies are receding from one another by discovering a disproportionately high level of red light coming from virtually every galaxy. If every observable galaxy is moving away from every other, the universe is expanding.

Final confirmation of the Big Bang model came when scientists discovered the precisely predicted *microwave background radiation* left over from this massive, explosive event. In 1948, physicist George Gamow provided a way to settle the controversy between the Big Bang and Steady State theories. He and other cosmologists theorized that if the universe began with a Big Bang, there should be radiation left over from the explosive event. This radiation was discovered in the 1960s. However, the debate continued because the measurements were made using earthbound instruments with limited accuracy.

Finally, in the early 1990s, precise measurements from NASA's Cosmic Background Explorer (COBE) satellite indicated that the universe was filled with radiation having the exact properties predicted by the Big Bang theory. The COBE measurements confirmed that all matter in the early universe exploded from a densely compacted state. Scientists now had conclusive evidence that the universe had a beginning. As astrophysicist Neil F. Comins explained it:



> Detection of the cosmic microwave background is a principal reason why the Big Bang is accepted by astronomers as the correct cosmological theory.[5]

What all this means is that there is very strong evidence that the universe had a beginning. If the universe had a beginning, then it had a first cause. And if it had a first cause, then it makes sense to ask what kind of first cause is necessary to explain the origin of the universe. It must be:

- A cause outside of the universe.

- Capable of generating all the matter and energy in the universe.
- Capable of generating all the order we see in the universe (more on this coming up).

That's quite a job description—one that no known material cause or set of material causes appears capable of accomplishing. The need for such a powerful and intelligent first cause strongly suggests a purposeful design behind the origin of the universe.

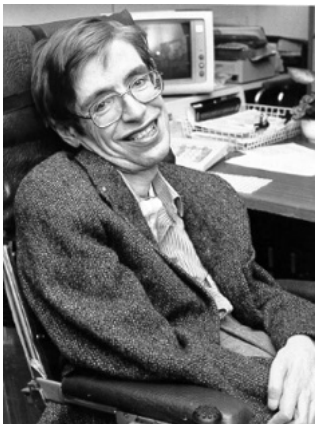
It All Started with Information

The origin of the universe at the Big Bang can also be understood as a massive explosion of information.[6] Cosmologists have tried to develop quantum mechanical models to describe the origin of the universe. They might claim they have explained that origin, but these models always assume that a universe somehow already exists. After all, an equation is just an abstract mathematical entity and no equation can ever create a universe by itself! Thus, the famed cosmologist Stephen Hawking wrote:

> Even if there is only one possible unified theory, it is just a set of rules and equations. What is it that breathes fire into

> the equations and makes a universe for them to describe? The usual approach of science of constructing a mathematical model cannot answer the questions of why there should be a universe for the model to describe. Why does the universe go to all the bother of existing?[7]

The Kalam argument shows that some external cause is needed to actually generate the universe and "breathe fire into the equations," as Hawking put it. But let's be generous and grant a nascent universe to our cosmologist friends.



Stephen Hawking

When cosmologists appeal to quantum mechanical models for the origin of the universe, they have tried to unite quantum mechanics with general relativity. This has yielded an equation called the Wheeler-Dewitt equation, which predicts that if the universe exists, it will exist at a certain time and will have certain properties (mass and curvature). To solve this equation, one must define the boundary conditions. But information is required to define these boundary conditions—i.e.,

describing the properties of the initial singularity that became our universe.

At this hypothetical stage of the beginning, there is no universe yet existing to define these boundaries. So cosmologists must introduce information to decide how the equations will be solved. Just solving the equations requires information. But they must be solved in a way such that the universe is a place that can support life.

For example, the universe must be isotropic (looking the same in all directions) and have a particular homogeneity that allows matter to clump into things like galaxies, stars, and planets (which are necessary for life to exist). All of this requires cosmologists to solve these equations in ways that assume that the universe had just the right properties to support life. This massive infusion of information is called fine-tuning—and as I will explain in the next section, it too points to intelligent design.

2. The Fine-Tuning of the Universe

THE TERM 'BIG BANG' CONJURES images of an explosion, and usually when we think of an explosion we imagine a highly chaotic, stochastic event that destroys order rather than creating it. The Big Bang was not that kind of an "explosion." It's much better understood as a "carefully controlled expansion event," where all the matter and energy in the universe were expanding from an initial state of unimaginably high energy and density. However, matching that energy was control and guidance through natural laws that were designed to yield a habitable universe—a home where life could exist. In physics and cosmology, this careful control is what we call "fine-tuning."

Fine-tuning is found when nature exhibits some unlikely property that matches an exact value or state that is a necessary

requirement for the existence of life. Many physical laws and constants of the universe are "finely tuned" and "just right" in order for life to exist. A hypothetical illustration that's often given is pretending one has a "universe-making machine" with knobs that can be adjusted to change the values of the fundamental laws and constants of nature. The knobs must be set to precise—"finely tuned"—values for a life-friendly universe to exist.

Consider some of the finely tuned factors that make our universe possible:

- If the ***strong nuclear force*** were slightly more powerful, then there would be no hydrogen, an essential element of life. If it were slightly weaker, then hydrogen would be the only element in existence.
- If the ***weak nuclear force*** were slightly different, then either there would not be enough helium to generate heavy elements in stars, or stars would burn out too quickly and supernova explosions could not scatter heavy elements across the universe.

- If the ***electromagnetic force*** were slightly stronger or weaker, atomic bonds, and thus complex molecules, could not form.
- If the value of the ***gravitational constant*** were slightly larger, one consequence would be that stars would become too hot and burn out too quickly. If it were smaller, stars would never burn at all and heavy elements would not be produced.

The following examples gives a sense of the degree of fine-tuning that must go into some of these values to yield a life-friendly universe:

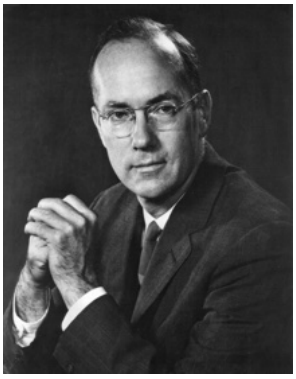
- Strength of the electromagnetic force:[8] 1 part in 25
- Strength of the strong nuclear force:[9] 1 part in 200
- Ratio of the masses of a neutron to a proton: [10] 1 part in 1,000
- Ratio of the weak nuclear force to the strong nuclear force:[11] 1 part in 10,000
- Initial expansion rate of the universe:[12] 1 part in 10^{17}
- Mass of a quark:[13] 1 part in 10^{21}

- Initial density of the universe:[14]
  1 part in 10^{24}
- Value of the gravitational constant:[15]
  1 part in 10^{35}
- Ratio of the electromagnetic force to gravity:[16] 1 part in 10^{40}
- Cosmic mass density at the Planck time:[17]
  1 part in 10^{60}
- Value of the cosmological constant:[18]
  1 part in 10^{90}
- Initial entropy of the early universe:[19]
  1 part in 10 to the power of 10^{123}

The last item in the list—the initial entropy of the universe—shows an astounding degree of fine-tuning. We don't even have words or analogies to convey numbers this small! What all this shows is an incredibly, astronomically precise, purposeful care and planning that went into the crafting of the laws and constants of the universe, gesturing unmistakably to intelligent design. As the late Nobel Prize-winning physicist Charles Townes stated:

> Intelligent design, as one sees it from a scientific point of view, seems to be quite

> real. This is a very special universe: it's remarkable that it came out just this way. If the laws of physics weren't just the way they are, we couldn't be here at all. The sun couldn't be there, the laws of gravity and nuclear laws and magnetic theory, quantum mechanics, and so on have to be just the way they are for us to be here.[20]



Charles Townes

But how do we explain this fine-tuning? The finely tuned laws and constants of the universe are an example of specified complexity in nature. They are complex in that their values and settings are highly unlikely. They are specified in that they match the specific requirements needed for life. And what, in our uniform experience, is the only known cause of high levels of specified complexity? Intelligent design.

Responding to the Multiverse

Materialists, those who permit only material causes in explanations, cannot deny that the laws of nature are specified for life. But they seek to make them inevitable—i.e., less unlikely or less complex—by invoking a

multiverse. Under the multiverse proposal, if there exists a potentially near-infinite number of different universes, each with different values for its physical laws and constants, then just by chance one might happen to get the rare finely tuned parameters and conditions needed for life. In essence, they seek to increase the odds of winning the cosmic lottery by inventing as many universes as are needed to make the existence of a universe that permits life more likely. We happen to occupy the one that permits complex life.

But the multiverse is no solution to the problem of fine-tuning—in fact it introduces many new problems.

The Multiverse Requires MORE Fine-Tuning

The most fundamental defeater to the multiverse is this: *the mechanisms and explanations invoked to explain the multiverse themselves require fine-tuning.* That means that no matter how much you think the multiverse allows you to explain away or escape fine-tuning, it actually pushes the question back and requires MORE fine-tuning—exacerbating the problem it set out to solve.[21]

The Multiverse Is Not Observable and Not Science

Another major problem with the multiverse is that it is not scientifically observable. What we can observe is our universe—but we can't observe anything outside the universe. That is because, as cosmologist George Ellis explained in *Scientific American*, any potential parallel universes would "lie outside our horizon and remain beyond our capacity to see, now or ever, no matter how technology evolves," and thus "we have no hope of testing it observationally."

Scientific analyses include a requirement that is violated by the multiverse concept: science should be testable. Ellis further explains in *Nature* that although some versions of the multiverse make testable predictions, in the final analysis the multiverse is not testable: "Billions of universes—and of galaxies and copies of each of us—accumulate with no possibility of communication between them or of testing their reality." Because of this testability problem, multiverse theories cannot be part of proper scientific explanations.

The Multiverse Destroys Scientific Reasoning

Another danger of "multiverse thinking" is that it would effectively destroy the ability of scientists to study nature. A short hypothetical illustration shows why.

Imagine that a team of researchers discovers that 100 percent of an entire town of 10,000 people got cancer within one year—a "cancer cluster." For the sake of argument, say they determine that the odds of this occurring just by chance are 1 in $10^{10,000}$. Normally, scientists would reason that such low odds establish that chance cannot be the explanation, and that there must be some physical agent causing cancer in the town.

Under multiverse thinking, however, one might as well say, "Imagine there are $10^{10,000}$ universes, and our universe just happened to be the one where this unlikely cancer cluster arose—purely by chance!" Should scientists seek a scientific explanation for the cancer cluster, or should they just invent $10^{10,000}$ universes where this kind of event becomes probable? The multiverse advocate might reply, "Well, you can't say there aren't $10^{10,000}$ universes out there, right?" Right—but that's

the point. There's no way to test the multiverse, and science should not seriously consider untestable theories. Multiverse thinking makes it impossible to rule out chance, which essentially eliminates the basis for drawing scientific conclusions.

Boltzmann Brains Challenge the Multiverse

Another idea that helps illustrate how multiverse thinking could spell the end of rational inquiry is Boltzmann brains. Multiverse advocates claim that if any universe just happens to get the right parameters needed for life, then life will by necessity arise. That means if we happen to live in such a universe, it's not so "lucky" that we're here to see it. If we didn't live in that universe we wouldn't be present to appreciate our lucky position at all. The problem of so-called Boltzmann brains shows why we actually must be quite lucky after all.

According to quantum theory, some very weird things can happen. One such surreal thing, which for present purposes you'll just have to take on faith, is a brain popping into existence, just by chance. This is a Boltzmann brain, named for physicist Ludwig

Boltzmann. This brain has false memories and thinks it's capable of understanding science and discerning the inner workings of the universe—when it's really just hallucinating the whole thing. In fact, you yourself might be such a "Boltzmann brain"! How could you disprove it? Stephen Meyer explains that initially, multiverse cosmologists believed that their mechanism for generating a "multiverse" would always lead to far fewer "Boltzmann brains" than natural brains. If so, that would mean it's much more likely that we have real brains and can trust our senses. However, "This proposed solution turned out not to work." As Meyer explains, referring to concepts from cosmology having to do with the multiverse, its initial inflation, and what's called the inflaton field:

> The physicists proposing it soon realized that, in any given sector of the inflating space, the inflaton field would produce astronomically more extremely young or short-lived universes than extremely old universes such as ours… Why is this a problem? Because many such Boltzmann brains with false memories would arise by spontaneous quantum fluctuations in the

> young universes in the time that it would take for one or a few conscious intelligent forms of life (i.e., natural brains with real memories and accurate sense perceptions) to evolve in one of the relatively few old universes. Thus, the activity of the inflaton field would ensure that most observers would be Boltzmann brains in universes too young to permit the kind of evolution needed to produce ordinary observers with reliable memories.[22]

In other words, under inflationary models of the multiverse, it's far more likely that you are a Boltzmann brain hallucinating this article, and hallucinating everything else you think you know, than a natural brain trying to understand the world we live in. If that's the case, then once again multiverse thinking has destroyed our ability to do science, and undermined all other knowledge, too.

Moreover, Boltzmann brains only need one lucky localized patch of life-friendly space, whereas natural brains need an entire universe friendly to life in order for them to evolve. Because the former is much more likely to occur than the latter, this means that if we are indeed real, natural brains observing

a universe within a multiverse, then we truly must be quite lucky after all.

Cut Down by Ockham's Razor

Ockham's razor is a logical principle named for the philosopher William of Ockham, widely accepted by scientists. It holds that the simplest explanation tends to be the correct one. What is the simplest explanation: (1) that the fine-tuning of the universe is the result of a near-infinite number of unobservable universes spawned by an unknown mechanism of unexplained origin, or (2) that we can trust our observations of our universe and the special, life-friendly conditions of our cosmos are the result of intelligent design?

The multiverse isn't the simplest explanation for the fine-tuning of the laws of nature because this fine-tuning indicates high levels of complex and specified information, which is best explained by intelligent design. Thus, to summarize the argument:

- The laws of nature exhibit an incredibly precise degree of fine-tuning that is required to produce a life-friendly universe.
- There is currently no physical explanation for this fine-tuning.

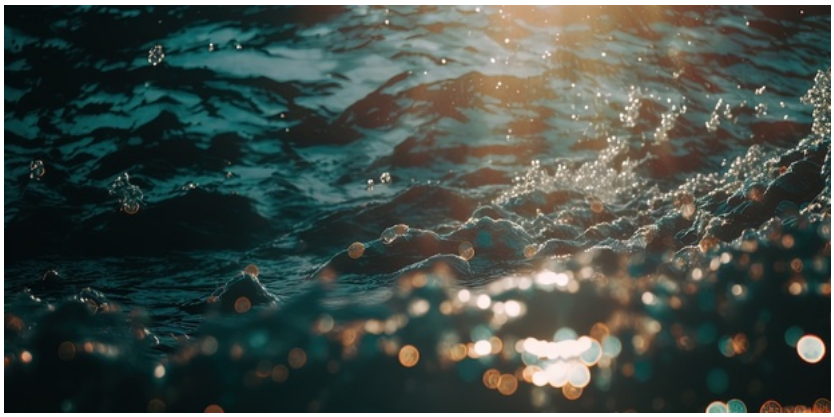
- We can observe our universe, and no others.
- This fine-tuning represents astronomically high levels of specified complexity embedded in the laws of nature.
- Invoking a multiverse is not only untestable, but it would effectively increase the amount of specified complexity (fine-tuning) necessary to account for life, rather than explaining its origin.
- And what, in our uniform experience, is the only known cause of high levels of specified complexity? The answer is intelligent design.

It's important to appreciate that the fine-tuned laws of nature are necessary conditions, but not sufficient, for the existence of life. Invoking these laws alone to create or cause the existence of life is like saying, "A cake is caused by flour, eggs, milk, and an oven." Special ingredients and appliances are needed for cake, but they are not sufficient to "create" or cake or "cause" it to exist. You also need someone to assemble the ingredients in the right order—i.e., to add information to the

system. In other words, a baker is also required.

Fine-tuning is thus required for life's existence, but it is not enough to produce life. Something else is required to arrange biomolecules in the right configurations and add information to life. Both the fine-tuning (necessary condition) and the information (sufficient condition) are necessary. We'll get to that next.

3. THE ORIGIN OF LIFE



INFORMATION IS ALL AROUND US. As you read a book, your brain processes information stored in the shapes of ink on the page. When you talk to a friend, you communicate information using sound-based language, transmitted through vibrations in air molecules. Computers work because they

receive information, process it, and then give useful output.

Everyday life would be nearly impossible without the ability to use information. But could life itself exist without it? One of the greatest scientific discoveries since the 1950s is that life is fundamentally built upon information. An insightful paper in the journal *Interface* explains that the key defining property of life is its information:

> Although it is notoriously hard to identify precisely what makes life so distinctive and remarkable, there is general agreement that its informational aspect is one key property, and perhaps the key property.[23]

Life is chock-full of information, and information forms the chemical blueprint for all living organisms, governing the assembly, structure, and function at essentially all levels of cells. Cosmologist Carl Sagan once observed that the "information content of a simple cell" is "around 10^{12} bits, comparable to about a hundred million pages of the *Encyclopedia Britannica*."[24] As one prominent origin-of-life researcher stated: "The problem of the origin of life is clearly basically equivalent to

the problem of the origin of biological information."[25] But where does all this information come from?

Information in the Cell

As noted previously, intelligent design begins with the observation that intelligent agents generate large quantities of information—what we often call complex and specified information. Studies of the cell reveal vast quantities of information in our DNA, stored biochemically through the sequence of four nucleotide bases (adenine, thymine, cytosine, and guanine) in the DNA molecule. No physical or chemical law dictates the ordering of the nucleotide bases in our DNA, and the sequences are highly improbable and complex. Yet the coding regions of DNA exhibit very unlikely sequential arrangements of bases that match the precise pattern necessary to produce functional proteins. Experiments have found that the sequence of nucleotide bases in our DNA must be extremely precise in order to generate a functional protein.

But just how precise must an amino acid sequence be in order to generate a functional protein? Though this question was

"ignored"[26] by evolutionary biologists for decades, ID theorists were among the first to perform experiments to directly assess this question. Protein scientist Douglas Axe performed mutagenesis experiments on beta-lactamase enzymes in bacteria to determine how specified their amino acid sequence must be to function and published his results in the *Journal of Molecular Biology*. Axe found that the odds of a random sequence of about 150 amino acids generating such a stable, folded, functional enzyme are less than 1 in 10 to the 77th power.[27] In other words, our DNA contains very high CSI—an unlikely sequence that is precisely specified to match what is needed to produce functional proteins.

This high CSI is tell-tale sign that an intelligent agent was at work. However, the ID-skeptic will immediately propose that such complex features might be produced by natural processes. A rough calculation shows how difficult this would be. Approximately 10^{40} individual organisms have lived over the entire history of the Earth.[28] If we were to grant the incredibly generous assumption that *every single organism* that has ever lived was somehow gifted with a brand-new sequence of about

150 amino acids, randomly arranged such that a functional gene might arise, then we would still be short by about 10^{37} trials to generate a single functional protein similar to the one Axe investigated.

Yet the first forms of cellular life would have required far more than a single functional gene. The simplest-known free-living form of life is a bacterium that requires a genome of over 500,000 base pairs long, encoding 438 protein-coding genes and 35 RNA-coding genes.[29] The origin of anything resembling what we know as cellular life would have therefore required a massive amount of information—again, evidence that an intelligent agent was at work.

Thus, as nearly all molecular biologists now recognize, the coding regions of DNA possess a high information content. Even the staunch Darwinian biologist Richard Dawkins concedes that "biology is the study of complicated things that give the appearance of having been designed for a purpose."[30] Atheists like Dawkins believe that unguided natural processes did all the "designing." But intelligent design theorist Stephen Meyer notes, "in all cases where we know the causal

origin of 'high information content,' experience has shown that intelligent design played a causal role."[31] Meyer has explained this argument in detail in a peer-reviewed paper:

> We have repeated experience of rational and conscious agents—in particular ourselves—generating or causing increases in complex specified information, both in the form of sequence-specific lines of code and in the form of hierarchically arranged systems of parts… Our experience-based knowledge of information-flow confirms that systems with large amounts of specified complexity (especially codes and languages) invariably originate from an intelligent source—from a mind or personal agent.[32]

Yet what is at the heart of life? A language-based code in our DNA, full of specified complexity.

Computer-Like Information Processing in the Cell

The information in the "minimal cell" described above required 531,000 pairs of nucleotide bases in the bacteria's DNA. But just having the information in that DNA isn't

enough to make life possible. By itself, a DNA molecule is useless. You also need some kind of machinery to read the information in the DNA and produce some useful output. A lone DNA molecule is like having a DVD—and nothing more. A DVD might carry information, but without a machine to read that information, it's all but useless (maybe you could use it as a Frisbee). To read the information in a DVD, we need a DVD player. In the same way, our cells are equipped with machinery to help process the information in our DNA.

The machinery that reads the commands and codes in our DNA is analogous to how a computer reads and processes commands in computer code. Many authorities have recognized the computer-like information processing of the cell and the computer-like information-rich properties of DNA's language-based code. Bill Gates observes, "Human DNA is like a computer program but far, far more advanced than any software we've ever created."[33] Biotech guru Craig Venter says that "life is a DNA software system,"[34] containing "digital information" or "digital code," and the cell is a "biological

machine" full of "protein robots."[35] Richard Dawkins has written that "the machine code of the genes is uncannily computer-like."[36] Francis Collins, the leading geneticist who headed the human genome project, notes, "DNA is something like the hard drive on your computer," containing "programming."[37]

But the computer analogy only goes so far. That's because cells are so much more complex than human technology. Cells contain what some have called "wetware"[38]—"molecules that interact in complex webs, or circuits" which "perform logical operations that are analogous in many ways to electronic devices but have unique properties."[39] As a Yale University Press book puts it:

> The computational units of life—the transistors, if you will—are its giant molecules, especially proteins. Acting like miniature switches, they guide the biochemical processes of a cell this way or that. Linked into huge networks they form the basis of all of the distinctive properties of living systems. Molecular computations underlie the sophisticated decision making of single-cell organisms such as bacteria and amoebae. Protein

> complexes associated with DNA act like microchips to switch genes on and off in different cells—executing "programs" of development. Machines made of protein molecules are the basis for the contractions of our muscles and the excitable, memory-encoding plasticity of the human brain.[40]

Machines in the Cell

Cells are thus constantly performing computer-like information processing. But what is the result of this information-processing in the cell? It's machinery. The more we discover about the cell, the more we learn that it functions like a miniature factory, replete with motors, powerhouses, garbage disposals, guarded gates, transportation corridors, CPUs, and much more. Bruce Alberts, former president of the U.S. National Academy of Sciences, has stated:

> The entire cell can be viewed as a factory that contains an elaborate network of interlocking assembly lines, each of which is composed of a set of large protein machines... Why do we call the large protein assemblies that underlie cell function protein machines? Precisely because, like

> machines invented by humans to deal efficiently with the macroscopic world, these protein assemblies contain highly coordinated moving parts.[41]

There are hundreds, if not thousands, of molecular machines in living cells. In discussions of ID, the most famous example of a molecular machine is the bacterial flagellum. The flagellum is a micro-molecular propeller assembly driven by a rotary engine that propels bacteria toward food or a hospitable living environment. There are various types of flagella, but all function much like a rotary engine made by humans, as found in some car and boat motors. Flagella also contain many parts that are familiar to human engineers, including a rotor, a stator, a drive shaft, a U-joint, and a propeller. As one molecular biologist writes, "More so than other motors the flagellum resembles a machine designed by a human."[42] But there's something else that's special about the flagellum.

ID theorists often discuss "irreducible complexity," a concept developed and popularized by biochemist Michael Behe of Lehigh University. Irreducible complexity is a form of specified complexity. It exists in systems

composed of "several interacting parts that contribute to the basic function, and where the removal of any one of the parts causes the system to effectively cease functioning."[43] Because natural selection only preserves structures that confer a functional advantage to an organism, such systems would be unlikely to evolve through a Darwinian process. Why? Because there is no evolutionary pathway where they could remain functional during each small evolutionary step. According to ID theorists, irreducible complexity is an informational pattern that reliably indicates design. That is because in all irreducibly complex systems in which the cause of the system is known by experience or observation, intelligent design or engineering played a role in the origin of the system:

> Molecular machines display a key signature or hallmark of design, namely, irreducible complexity. In all irreducibly complex systems in which the cause of the system is known by experience or observation, intelligent design or engineering played a role in the origin of the system… Indeed, in any other context we would immediately recognize such

> systems as the product of very intelligent engineering. Although some may argue this is merely an argument from ignorance, we regard it as an inference to the best explanation, given what we know about the powers of intelligent as opposed to strictly natural or material causes.[44]

A Simpler Origin of Life?

Origin-of-life theorists are aware that it is exceedingly unlikely that a living cell with all of its information and complex machinery could arise by chance chemical reactions. They are also aware that prior to the origin of life there was no replication, meaning Darwinian evolution could not have been at work. The only mechanisms available would have been blind chemical processes and chance. Researchers therefore propose that the first life was a "simpler" self-replicating molecule which arose by chance and blind chemical reactions. The most popular proposal for the first self-replicating molecule is RNA—where life was first based upon RNA carrying both genetic information (akin to modern DNA) and performing catalytic

functions (akin to modern enzymes), in what is termed the *RNA world*.

There are many problems with the RNA world hypothesis,[45] but most the fundamental problem is its inability to explain the origin of information necessary to create this first self-replicating RNA molecule. Such a molecule is still hypothetical. But theorists suggest it would have had to be at least 100 nucleotides long, if not between 200 and 300 nucleotides in length.[46] Undoubtedly the sequence of nucleotide bases in this molecule would have to have been highly specified for self-replication to be possible. How did the nucleotide bases in RNA become properly ordered to produce life? There are no known chemical or physical laws that can do this.

To explain the ordering of nucleotides in the first self-replicating RNA molecule, origin-of-life theorists have no explanation other than blind chance. ID theorists call this obstacle the information sequence problem, but even mainstream origin-of-life theorists have also observed the great unlikelihood of naturally producing a precise RNA sequence required for replication. Chemist Robert Shapiro put the problem this way:

> A profound difficulty exists, however, with the idea of RNA, or any other replicator, at the start of life. Existing replicators can serve as templates for the synthesis of additional copies of themselves, but this device cannot be used for the preparation of the very first such molecule, which must arise spontaneously from an unorganized mixture. The formation of an information-bearing homopolymer through undirected chemical synthesis appears very improbable.[47]

Elsewhere, Shapiro noted, "The sudden appearance of a large self-copying molecule such as RNA was exceedingly improbable" with a probability that "is so vanishingly small that its happening even once anywhere in the visible universe would count as a piece of exceptional good luck."[48] A 2020 paper in *Scientific Reports* similarly notes, "Abiotic emergence of ordered information stored in the form of RNA is an important unresolved problem concerning the origin of life" because "the formation of such a long polymer having a correct nucleotide sequence by random reactions seems statistically unlikely."[49] Harvard chemist and origin-of-life researcher

Steven Benner refers to the "Information-Need Paradox," where self-replicating RNA molecules would be "too long to have arisen spontaneously" from available building blocks,[50] thus raising a serious challenge to the RNA world: generating an RNA molecule capable of catalyzing its own replication is *much less likely* than generating RNA molecules that catalyze the destruction of RNA. This suggest a grave theoretical difficulty where RNA world theorists are faced with a "chemical theory that makes destruction, not biology, the natural outcome."[51] Benner further states that "The hard part is finding a molecular system where the imperfections in the replicates are themselves replicable," a scenario he calls "RIRI" (replication involving replicable imperfections), which is necessary for the origin of life.[52] But he explains that the origin of such a replicator faces serious obstacles:

> An enormous amount of empirical data have established, as a rule, that organic systems, given energy and left to themselves, devolve to give uselessly complex mixtures, "asphalts." Theory that enumerates small molecule space, as well as

> Structure Theory in chemistry, can be construed to regard this devolution a necessary consequence of theory. Conversely, the literature reports (to our knowledge) exactly zero confirmed observations where RIRI evolution emerged spontaneously from a devolving chemical system. Further, chemical theories, including the second law of thermodynamics, bonding theory that describes the "space" accessible to sets of atoms, and structure theory requiring that replication systems occupy only tiny fractions of that space, suggest that it is impossible for any non-living chemical system to escape devolution to enter into the Darwinian world of the "living."[53]

The aforementioned paper in *Scientific Reports* proposed a solution to these quandaries, but the solution shows just how intractable the problem of the origin of life's information is for materialists: It concluded that because the formation of a single self-replicating RNA molecule is prohibitively unlikely in the observable universe, and therefore the universe must be far larger than we observe—an "inflationary universe" that

increases the probabilistic resources until such an unlikely event becomes likely. This is just like the materialist response to the fine-tuning of physics: When the observed complexity of nature appears to indicate design, they invent multiverses to overcome probabilistic difficulties. When RNA world theorists appeal to the origin of life's version of the multiverse to avoid falsification, it's clear that their project has fatal problems.

In this way, materialists struggle to explain the origin of life. A 2019 paper admits it is one of the great unanswered questions in science:

> The origin of life is among the most fundamental open questions in science. It can be difficult for even practicing scientists to agree on the object of inquiry, standards of evidence, or even their own disagreements.[54]

Intelligent Design Resolves the Origin of Life

That, as I said, was written in 2019—decades after we learned about how important explaining the origin of information is to understanding the origin of life. Indeed, recent

decades of biological research have shown that life is fundamentally based upon:

- A vast amount of complex and specified information encoded in a biochemical language.
- A computer-like system of commands and codes that processes the information.
- Irreducibly complex molecular machines and multi-machine systems.

Where, in our experience, do language, complex and specified information, programming code, and machines come from? They have only one known source: intelligence.

But it's vital to grasp that the similarities between life's information, on one hand, and written language and computer code, on the other, is not just an analogy. The physicist and information theorist Hubert Yockey wrote that the relationship instead is one of mathematical identity:

> It is important to understand that we are not reasoning by analogy. The sequence hypothesis [the idea that an exact ordering of symbols encodes the information in DNA] applies directly to the protein

> and the genetic text as well as to written language and therefore the treatment is mathematically identical.[55]

In *Signature in the Cell*, Stephen Meyer likewise explains the identical properties of computer code and linguistic texts—both products of intelligent design—and the information in DNA:

> Biological information, such as we find in DNA and proteins, comprises two features: complexity and functional specificity. Computer codes and linguistic texts also manifest this pair of properties ("complexity" and "specificity"), what I have referred to… as specified information. Although a computer program may be similar to DNA in many respects and dissimilar in others, it exhibits a precise identity to DNA insofar as both contain specified complexity or specified information.
>
> Accordingly, the design argument developed here does not rely on a comparison of similar effects, but upon the presence of a single kind of effect—specified information—and an assessment of the ability of competing causes to

> produce that effect. The argument does not depend upon the similarity of DNA to a computer program or human language, but upon the presence of an identical feature in both DNA and intelligently designed codes, languages, and artifacts. Because we know intelligent agents can (and do) produce complex and functionally specified sequences of symbols and arrangements of matter, intelligent agency qualifies as an adequate causal explanation for the origin of this effect. Since, in addition, materialistic theories have proven universally inadequate for explaining the origin of such information, intelligent design now stands as the only entity with the causal power known to produce this feature of living systems. Therefore, the presence of this feature in living systems points to intelligent design as the best explanation of it, whether such systems resemble human artifacts in other ways or not.[56]

Information—produced by the action of intelligence—was therefore necessary to generate the first life. But that's not the only time that new information must have been infused

into living organisms to build new types of biological complexity.

4. THE ORIGIN OF ANIMALS

JUST AS WRITING NEW SOFTWARE requires new programming code, so too building new forms of life requires new information—new code—in the DNA of living organisms. The fossil record reveals that many new forms of complex animal life with diverse body plans have appeared over Earth's history. Curiously, when these new body plans appear, they often do so abruptly, in a pattern of "explosions," where new types of organisms arise suddenly without clear direct evolutionary precursors. This repeated pattern of explosions of new types of body plans shows the need for massive infusions of information into the biosphere throughout the

history of life—further testifying to intelligent design.

The Cambrian Information Explosion

Perhaps the most famous "explosion" in the history of life is the Cambrian explosion, where most of the major living groups of animals (called "phyla") appear in the fossil record in a geological eyeblink—lasting five to ten million years, and possibly less.[57] Before the Cambrian period, very few fossils having anything to do with modern phyla are found in the record. Yet during the Cambrian diverse animals ranging from arthropods to echinoderms to brachiopods to annelids to chordates (vertebrates) to mollusks first appear in the fossil record.[58] One invertebrate zoology textbook puts it this way:

> Most of the animal phyla that are represented in the fossil record first appear, "fully formed" and identifiable as to their phylum, in the Cambrian some 550 million years ago. These include such anatomically complex and distinctive types as trilobites, echinoderms, brachiopods, molluscs and chordates. Earlier, Precambrian, fossil animals are not numerous, but it is possible that cnidarians

> and segmented worms are represented, although the resemblance of several Ediacaran fossils to living animal groups may be only superficial. Some to all of these Precambrian forms, it has been argued, are not even animals as that term would be generally understood. The fossil record is therefore of no help with respect to understanding the origin and early diversification of the various animal phyla...[59]

The magnitude of the Cambrian explosion, and the challenge it poses to Darwinian theory, cannot be understated:

> Darwin saw the abruptness of appearance of the breathtaking diversification of forms during the Cambrian as a challenge to his theory… Darwin hypothesized that the apparent suddenness and diversity of forms during the Cambrian may be an illusion, resulting from the incomplete fossil record of his time… Nevertheless, now, 150 years after *The Origin [of Species]*, when an incomparably larger stock of animal fossils has been collected, Darwin's gap remains, the abrupt appearance of Cambrian fossils is a reality, and we are

> still wondering about the forces and mechanisms that drove it. Despite the fact that, from time to time, a small number of students have questioned the reality of the Cambrian explosion on the same ground as Darwin, today's consensus is that Cambrian explosion is a scientific fact and "The Cambrian explosion is real and its consequences set in motion a sea-change in evolutionary history."[60]

The Cambrian explosion thus represents the origin of major groups of animals—which would have required the origin of thousands of new genes[61] and immense amounts of genetic and epigenetic information. Stephen Meyer explains that only the action of an intelligent agent can explain the rapid origin of new information needed to build the new forms of animal life that appeared abruptly during the Cambrian explosion:

> Intelligent agents have foresight. Such agents can determine or select functional goals before they are physically instantiated. They can devise or select material means to accomplish those ends from among an array of possibilities. They can then actualize those goals in accord with a

preconceived design plan or set of functional requirements. Rational agents can constrain combinatorial space with distant information-rich outcomes in mind.[62]

Intelligent agents sometimes produce material entities through a series of gradual modifications (as when a sculptor shapes a sculpture over time). Nevertheless, intelligent agents also have the capacity to introduce complex technological systems into the world fully formed. Often such systems bear no resemblance to earlier technological systems—their invention occurs without a material connection to earlier, more rudimentary technologies. When the radio was first invented, it was unlike anything that had come before, even other forms of communication technology. For this reason, although intelligent agents need not generate novel structures abruptly, they can do so. Thus, invoking the activity of a mind provides a causally adequate explanation for the pattern of abrupt appearance in the Cambrian fossil record.[63]

A Pattern of Explosions

Yet the Cambrian explosion is hardly the only example of the "explosive," "abrupt," or "sudden" appearance of new types of organisms in the history of life. In fact, this pattern of explosions and abrupt appearance tends to dominate the fossil record and the history of life, witnessed in the following examples:

- ***Great Ordovician Biodiversification Event:*** "While during the Cambrian explosion numerous phyla and classes representing basic body plans originated," writes paleontologist Walter Etter, "the Ordovician radiation was manifested by an unprecedented burst of diversification at lower taxonomic levels."[64] He continues, "The almost exponential increase in diversity was much more rapid during this Great Ordovician Biodiversification Event (GOBE) than at any other time [from the Cambrian to the present]," noting the increase was "for the most part abrupt."
- ***Fish:*** In 2022 the *New York Times* reported that "Jawed fish explode into the fossil record 419-359 million years ago during a period known as the age of fish, or the Devonian."[65] Regarding the origin of

major fish groups, Columbia University geoscientist Arthur Strahler wrote that, "This is one count in the creationists' charge that can only evoke in unison from paleontologists a plea of *nolo contendere* [no contest]."[66]

- ***Plants:*** A paper in *Annual Review of Ecology and Systematics* explains that the origin of land plants "is the terrestrial equivalent of the much-debated Cambrian 'explosion' of marine faunas."[67] Regarding angiosperms (flowering plants), scientists refer to a "big bloom" or "explosion"[68] event. As one paper states, "[a]ngiosperms appear rather suddenly in the fossil record . . . with no obvious ancestors for a period of 80-90 million years before their appearance."[69]
- ***Insects:*** The Carboniferous period is widely recognized as having heralded the "Carboniferous insect explosion"[70] where "insect diversity exploded, with a 'sudden appearance' of winged insects with very diverse feeding resources, e.g., carnivorous, plant suckers, leaf eaters, detritivores, gall-makers, etc."[71] Another paper states: "Fossil insects are completely

absent from the Late Devonian and Early Carboniferous, and a significant diversity of palaeopterous and neopterous species appeared suddenly in the earliest Late Carboniferous."[72]

- ***Tetrapods:*** The fossil record shows an "explosion" of tetrapods (four-legged vertebrates) when terrestrial vertebrates appear.[73]
- ***Marine reptiles****:* Paleontologists have cited a "rapid evolution"[74] of mosasaurs in the Cretaceous, and ichthyosaurs have been said to have "evolved astonishingly rapidly"[75] in the Triassic. Similarly, a paper in *Science* cited "rapid evolution of body size in ichthyosaurs" and "fast increases in disparity measures in early ichthyosaurs" which "reflect rapid lineage diversification."[76]
- ***Dinosaurs:*** An article in *Science* acknowledged that tracing the evolutionary origin of major dinosaur groups "has been a major challenge for paleontologists."[77]
- ***Birds:*** A prominent ornithology textbook and a paper in the journal *Science* observe the "explosive evolution" of major living

bird groups.[78] Similarly, a paper in the journal *Evolution* notes an "explosion of avian speciation"[79] and a paper in *Trends in Ecology and Evolution* argues that this "explosive" appearance of bird groups is akin to a "big bang."[80]

- ***Mammals:*** Similarly, many authorities cite an "explosion" or "explosive diversification" of major mammal groups in the Tertiary.[81] Paleontologist Niles Eldredge notes that "there are all sorts of gaps: absence of gradationally intermediate 'transitional' forms between species, but also between larger groups—between, say, families of carnivores, or the orders of mammals."[82] For example, a paper in *Current Biology* notes that that "Cetacean [whale] diversity was obtained through three key periods of rapid evolution" where the "Highest evolutionary rates are seen during the initial evolution of stem whales" as "The evolution of cetaceans (whales, dolphins, and porpoises) involves one of the most extreme transitions of any vertebrate lineage."[83]

Can Neo-Darwinian Evolution Explain the Pattern?

This pattern in the fossil record has stymied many evolutionary biologists who expected to find gradual transitions between forms of life rather than abrupt explosions. As the great paleontologist Stephen Jay Gould once put it: "The absence of fossil evidence for intermediary stages between major transitions in organic design, indeed our inability, even in our imagination, to construct functional intermediates in many cases, has been a persistent and nagging problem for gradualistic accounts of evolution."[84] Anthropologist Jeffrey Schwartz further explains this failed prediction of Darwinism:

> We are still in the dark about the origin of most major groups of organisms. They appear in the fossil record as Athena did from the head of Zeus—full-blown and raring to go, in contradiction to Darwin's depiction of evolution as resulting from the gradual accumulation of countless infinitesimally minute variations.[85]

Some evolutionary scientists were undaunted and sought to explain the pattern of abrupt appearance of new animal forms in the

fossil record using a model called punctuated equilibrium. Under this view, evolutionary change occurs in small populations and over relatively short geological time periods that are generally too rapid to allow for transitional forms to become fossilized.[86] But this model has many problems.[87]

For one, punctuated equilibrium predicts that with respect to the fossil record, evidence confirming Darwinian theory will not be found. Would you believe someone who claimed to capture fairies and leprechauns on video, but when asked to produce the film, declares "Well, they are on camera but they are too small or too fast to be seen"? That doesn't make for a compelling explanation.

But the biggest problem with punctuated equilibrium is that it requires too much genetic change too quickly. Punctuated equilibrium compresses the vast majority of evolutionary change into small populations that lived during comparatively short segments of time—allowing too few opportunities for novel, beneficial traits to arise. Yet studies of the mathematics of evolutionary change (called population genetics) combined with research into the complexity

of proteins and other biochemical features reveal that the problem is actually much worse for standard evolutionary mechanisms: *Even if there were many millions of years available for complex traits to arise, even this would not be enough time for neo-Darwinian mechanisms to produce the observed complexity of life.*

The Mathematical Refutation of Neo-Darwinism

Darwinian evolution can usually work fine provided that one small step (e.g., a single point mutation) along an evolutionary pathway can give some advantage that helps an organism survive and reproduce. The theory of ID has no problem with this, and acknowledges that Darwinian mechanisms can generate various types of small-scale changes within organisms.

But what about cases where many steps, or multiple mutations, are necessary to gain some evolutionary advantage? Here, Darwinian evolution faces severe limits on what it can accomplish. Evolutionary biologist Jerry Coyne affirms this when he states: "natural selection cannot build any feature in which intermediate steps do not confer a net benefit

on the organism."[88] Likewise, Darwin wrote in *The Origin of Species*:

> If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down.[89]

That is, as Darwin himself suggested, natural selection gets stuck when a feature cannot be built through "numerous, successive, slight modifications"—that is, when a structure requires multiple mutations to be present before providing any advantage for natural selection to select—what we call a "multi-mutation" trait. Coyne and Darwin deny that there any multi-mutation traits, yet these seems to be precisely what are required for new animal body plans to arise.

The standard evolutionary view is that new body plans evolve due to mutations affecting genes expressed early in development. Yet experiments on developing animals show that when mutations are induced in genes that guide early animal development, the outcome is lethal and the organism dies.[90] Thus, to generate new animal body plans, multiple coordinated mutations would be necessary

that would kill the animal before it was ever born.[91]

That is at the macro level of organismal form. At the biochemical level, proponents of intelligent design have done additional research showing that many features could not be produced by Darwinian mechanisms. In 2004, biochemist Michael Behe co-published a study in *Protein Science* with physicist David Snoke demonstrating that if multiple mutations were required to produce a typical functional bond between two proteins, then "the mechanism of gene duplication and point mutation alone would be ineffective because few multicellular species reach the required population sizes."[92]

In 2008, Behe's critics tried to refute him in the journal *Genetics*, but instead ended up validating his arguments. The critics found that in a population of organisms like humans, producing a feature via Darwinian evolution that required *only two mutations* before providing an advantage "would take > 100 million years." The authors acknowledged that such an evolutionary change would be "very unlikely to occur on a reasonable timescale."[93] Yet the fossil record shows that new

species and taxonomic groups appear abruptly, where millions of years are not available for their evolution. Such multi-mutation features are thus very unlikely to evolve under such circumstances in humans and other animals that have small population sizes and long generation times.

Even in organisms like bacteria which have large populations and rapid reproduction, we find that Darwinian evolution faces severe limits. In a 2010 peer-reviewed study, protein scientist Douglas Axe calculated that when a multi-mutation feature requires *more than six mutations* before giving any benefit, it is unlikely to arise in the whole history of the Earth—even in the case of bacteria.[94] Other experiments led by pro-ID biologists Ann Gauger and Ralph Seelke broke a gene in the bacterium *E. coli* required for synthesizing the amino acid tryptophan. When the bacteria's genome was broken in just one place, random mutations were capable of "fixing" the gene. But when just two mutations were required to restore function, Darwinian evolution became stuck, unable to restore the full function.[95]

Another research paper, by Axe and Gauger, found that merely converting one enzyme to perform the function of a closely related enzyme—the kind of conversion that evolutionists claim can happen easily—would require *a minimum of seven* mutations.[96] Yet this exceeds the limits of what Darwinian can produce over the Earth's entire history, as calculated by Axe's 2010 paper. A follow-up study by Gauger, Axe, and biologist Mariclair Reeves bolstered this finding by attempting to mutate additional enzymes to perform the function of a closely related protein.[97] After inducing all possible single mutations in the enzymes, and many other combinations of mutations, they found that evolving a protein, via Darwinian evolution, to perform the function of a closely related protein would take over 10^{15} years—over 100,000 times longer than the age of the Earth!

Michael Behe has made additional findings that challenge the creative power of Darwinian evolution. In a paper published in *The Quarterly Review of Biology*, he reviewed types of biochemical changes that tend to occur when we observe Darwinian processes at work. He found they almost always involve

breaking or diminishing function at the molecular level:

> The rate of appearance of an adaptive mutation that would arise from the diminishment or elimination of the activity of a protein is expected to be 100-1000 times the rate of appearance of an adaptive mutation that requires specific changes to a gene.[98]

Behe's conclusion makes sense: There are far more ways to break a complex system then there are to improve it. Darwinian mechanisms tend to follow the path of least resistance—and as such they are far more likely to break or diminish existing functions than they are to create new ones. A process which destroys functions much faster than it creates them is unlikely to generate new body plans.

A Case Study: Whales

Stephen Jay Gould wrote once wrote that "the extreme rarity of transitional forms in the fossil record persists as the trade secret of paleontology."[99] However, on rare occasions it is claimed that transitional fossils do exist which document how some new type of

animal evolved. A prime example is whales, where some evolution proponents claim that fossils showing a transition from land mammals to whales provide a "poster child for macroevolution."[100]

At this point, it's important to recognize that intelligent design does not reject all aspects of evolution. Evolution can mean something as unarguable as (1) "life has changed over time," or it can entail more controversial ideas, like (2) "living organisms share common ancestry," or (3) "natural selection acting upon random mutations produced life's diversity."

ID certainly does not conflict with the observation that life has changed over time (meaning 1), nor is it necessarily in conflict with the view that organisms are related by common ancestry (meaning 2). However, the seriously contested evolutionary viewpoint today is neo-Darwinism (meaning 3), which contends that life's *entire* history was driven by unguided natural selection acting on random mutations—as well as other forces like neutral evolution and genetic drift—a collection of blind, purposeless process with no directions or goals. It is this specific neo-

Darwinian claim that ID directly challenges. And in the abrupt appearance of living organisms and the DNA needed to build new body plans, we find that ID provides the best explanation whereas neo-Darwinian mechanisms are mathematically refuted. Indeed, this seems to be the case with whales—an instance where some of the most compelling supposed transitional fossils are said to be found.

Biologists have proposed that a great many changes would have been necessary to convert a land mammal into a whale, including:

- Emergence of a blowhole, with musculature and nerve control.
- Modification of the eye for permanent underwater vision.
- Ability to drink sea water.
- Forelimbs transformed into flippers.
- Modification of skeletal structure.
- Ability to nurse young underwater.
- Origin of tail flukes and musculature.
- Blubber for temperature insulation.

Each of these changes would necessarily involve many mutations, including multiple mutations required to arise before a selective advantage was given. Whale evolution thus runs into a "waiting time" problem, where there is insufficient time for the necessary complexity to arise.[101] The fossil record shows that the evolution of whales from small land mammals took place in less than 10 million years.[102] That may sound like a long time, but based upon the calculations we saw in the previous section, it's far too short. Indeed, whales have long generation times and small population sizes comparable to humans, meaning that evolving new traits in such an organism is akin to evolving new traits within humans: producing a trait that requires just two mutations to provide an advantage could take over 100 million years![103] Biologist Richard Sternberg thus concludes regarding whale evolution: "Too many genetic re-wirings, too little time."[104]

Whale origins therefore provide an intriguing case study for evolution: In this rare instance where there actually are fossils that potentially show intermediate traits, unguided neo-Darwinian evolution is

invalidated by the short amount of time allowed by the fossil record for the transition to take place. If the "poster child" of macroevolution doesn't hold up to scrutiny, what does this tell us about other cases where evolutionists tout supposed transitional fossils? And what mechanism can account for the abrupt appearance of new complex biological features?

Intelligent Design as the Best Explanation

Collectively, these results from both inside and outside the ID research community indicate that many biological features—from protein-protein interactions to molecular machines to new body plans—would require many mutations before providing any advantage to an organism. This is not only beyond the limit of what blind evolutionary mechanisms can create even over the entire history of the Earth, but it points to high CSI being prevalent throughout living systems.

But these studies go further and show that high CSI cannot be generated by standard evolutionary mechanisms which are blind and unintelligent—and this is true even when there are many millions of years available for

the evolutionary process. The "abrupt appearance" of new types of organisms in the fossil record exacerbates the problem. It shows that the amount of time available to produce new types of organisms is far too short for standard evolutionary mechanisms to explain the origin of the complex and specified information necessary to build new types of animals—and this is true even in cases when we have supposed "transitional fossils." Some other mechanism is needed which can account for the rapid appearance of information in living organisms.

If blind evolution cannot build CSI-rich features and new body plans in the time available in the fossil record—or even over the whole history of the Earth—then what can account for these features? Some non-random process is necessary that can "look ahead" and find the complex combinations of mutations to generate these complex features. That process must be intelligent design. Why? Because only intelligent agents are capable of employing will, forethought, and intentionality to find rare solutions to complex problems and then to rapidly implement that solution in the form of a digitally encoded blueprint that is

"fully formed" and ready to function in the world.

To put it in biological terms, again, generating new body plans requires new code, but only intelligent agents can rapidly generate the new functional information in the DNA code required to build new body plans. Stephen Meyer explains in *Darwin's Doubt*:

> Intelligent agents, due to their rationality and consciousness, have demonstrated the power to produce specified or functional information in the form of linear sequence-specific arrangements of characters. Digital and alphabetic forms of information routinely arise from intelligent agents. A computer user who traces the information on a screen back to its source invariably comes to a mind—a software engineer or programmer. The information in a book or inscription ultimately derives from a writer or scribe. Our experience-based knowledge of information-flow confirms that systems with large amounts of specified or functional information invariably originate from an intelligent source.[105]

Moreover, this pattern of explosions shows that fully functional blueprints are developed before the design is implemented. This is consistent with how humans design technology. A car company, for example, will only introduce a car into the market after it has been designed, built, and is ready to function for the consumer. Or a software designer will not release a program for use until it compiles and performs its intended function. In the same way, the explosions in the history of life show that organisms are introduced into the biosphere fully functional and "fully formed"—indicating that a mature blueprint has already been developed and implemented prior to the origin of the organism. This again is characteristic of how intelligent agents design things, as Stephen Meyer explains:

> Intelligent agents have foresight. Such agents can determine or select functional goals before they are physically instantiated. They can devise or select material means to accomplish those ends from among an array of possibilities. They can then actualize those goals in accord with a preconceived design plan or set of

functional requirements. Rational agents can constrain combinatorial space with distant information-rich outcomes in mind.[106]

"Top-down" causation begins with a basic architecture, blueprint, or plan and then proceeds to assemble parts in accord with it. The blueprint stands causally prior to the assembly and arrangement of the parts. But where could such a blueprint come from? One possibility involves a mental mode of causation. Intelligent agents often conceive of plans prior to their material instantiation—that is, the preconceived design of a blueprint often precedes the assembly of parts in accord with it. An observer touring the parts section of a General Motors plant will see no direct evidence of a prior blueprint for GM's new models, but will perceive the basic design plan immediately upon observing the finished product at the end of the assembly line. Designed systems, whether automobiles, airplanes, or computers, invariably manifest a design plan that preceded their first material instantiation. But the parts do not generate the

whole. Rather, an idea of the whole directed the assembly of the parts.[107]

Intelligent design therefore stands alone as the best explanation for the information needed to explain the abrupt appearance of complex, fully functional animal features and body plans that we repeatedly observe in "explosions" throughout the history of life. But there's one instance of abrupt appearance of a type of organism that stands out from the others.

5. THE ORIGIN OF HUMANS

HUMANS BELONG TO THE SPECIES *Homo sapiens* (meaning "wise man" in Latin), and studies of the fossil record reveal that a significant example of abrupt appearance is found in the origin our own genus, *Homo*. In 2015, two leading paleoanthropologists reviewed the hominid fossil evidence in a major

scientific volume titled, *Macroevolution.* They acknowledged the "dearth of unambiguous evidence for ancestor-descendant lineages," and stated:

> The evolutionary sequence for the majority of hominin lineages is unknown. Most hominin taxa, particularly early hominins, have no obvious ancestors, and in most cases ancestor-descendant sequences (fossil time series) cannot be reliably constructed.[108]

This problem applies to the origin of *Homo*. From the first appearance of *Homo erectus*, our genus was very humanlike, and differed markedly from prior hominids. Yet *Homo erectus* appears *abruptly*, without apparent evolutionary precursors. An article in *Nature* explains:

> The origins of the widespread, polymorphic, Early Pleistocene *H. erectus* lineage remain elusive. The marked contrasts between any potential ancestor (*Homo habilis* or other) and the earliest known *H. erectus* might signal an abrupt evolutionary emergence some time before its first known appearance in Africa at ~1.78 Myr.

> Uncertainties surrounding the taxon's appearance in Eurasia and southeast Asia make it impossible to establish accurately the time or place of origin for *H. erectus*… Whatever its time and place of origin, and direction of spread, this species dispersed widely, and possibly abruptly, before 1.5 Myr.[109]

The genus *Homo* is typically thought to have evolved from a genus of apelike species called *Australopithecus,* but Bernard Wood writes in *Proceedings of the National Academy of Sciences* that, "The origin of our own genus remains frustratingly unclear. Although many of my colleagues are agreed regarding the 'what' with respect to *Homo,* there is no consensus as to the 'how' and 'when' questions."[110] Similarly, a 2016 paper admits: "Although the transition from *Australopithecus* to *Homo* is usually thought of as a momentous transformation, the fossil record bearing on the origin and earliest evolution of *Homo* is virtually undocumented." While that paper argues that the evolutionary distance between *Australopithecus* and *Homo* is small, it nonetheless concedes that "By almost all accounts, the earliest populations of the *Homo* lineage emerged

from a still unknown ancestral species in Africa at some point between approximately 3 and approximately 2 million years ago."[111] Yet the technical literature reveals that the origin of our genus *Homo* required radical changes in the hominid body plan, and the earliest members of *Homo*, namely *Homo erectus*, show unique and previously unseen features that contributed to this "abrupt" appearance.

The literature reports an "explosion,"[112] "rapid increase,"[113] and "approximate doubling"[114] in brain size associated with the appearance of *Homo*. Similarly, a study of the pelvic bones of australopithecines and *Homo* found "a period of very rapid evolution corresponding to the emergence of the genus *Homo.*"[115] One *Nature* paper noted that early *Homo erectus* shows "such a radical departure from previous forms of *Homo* (such as *H. habilis*) in its height, reduced sexual dimorphism, long limbs and modern body proportions that it is hard at present to identify its immediate ancestry in east Africa"[116]—or anywhere else for that matter. Another review likewise notes the "seemingly abrupt appearance of *H. erectus*."[117] A paper in the *Journal of Molecular Biology and Evolution* found that *Homo* and

Australopithecus differ significantly in brain size, dental function, increased cranial buttressing, and expanded body height, visual, and respiratory changes. The paper stated:

> We, like many others, interpret the anatomical evidence to show that early *H. sapiens* was significantly and dramatically different from… australopithecines in virtually every element of its skeleton and every remnant of its behavior.[118]

Noting these many differences, the study called the origin of humans, "a real acceleration of evolutionary change from the more slowly changing pace of australopithecine evolution" and stated that such a transformation would have required radical changes: "The anatomy of the earliest *H. sapiens* sample indicates significant modifications of the ancestral genome and is not simply an extension of evolutionary trends in an earlier australopithecine lineage throughout the Pliocene. In fact, its combination of features never appears earlier." These rapid and unique changes are termed "a genetic revolution" where "no australopithecine species is obviously transitional."[119]

For those considering the evidence unconstrained by an evolutionary paradigm, it's not obvious that this transition took place at all. The stark lack of fossil evidence for the hypothesized transition is confirmed by three Harvard paleoanthropologists:

> Of the various transitions that occurred during human evolution, the transition from *Australopithecus* to *Homo* was undoubtedly one of the most critical in its magnitude and consequences. As with many key evolutionary events, there is both good and bad news. First, the bad news is that many details of this transition are obscure because of the paucity of the fossil and archaeological records.[120]

As for the "good news," they admit: "Although we lack many details about exactly how, when, and where the transition occurred from *Australopithecus* to *Homo,* we have sufficient data from before and after the transition to make some inferences about the overall nature of key changes that did occur."[121] In other words, the fossil record shows ape-like australopithecines ("before"), and human-like *Homo* ("after"), but not fossils documenting a transition between them. In

the absence of intermediates, we're left with inferences of a transition based strictly upon the assumption of evolution—that an undocumented transition must have occurred somehow, sometime, and someplace. They assume this transition happened, even though we do not have fossils documenting it.

Similarly, the great evolutionary biologist Ernst Mayr recognized the abrupt appearance of our genus:

> The earliest fossils of *Homo*, *Homo rudolfensis* and *Homo erectus*, are separated from *Australopithecus* by a large, unbridged gap. How can we explain this seeming saltation? Not having any fossils that can serve as missing links, we have to fall back on the time-honored method of historical science, the construction of a historical narrative.[122]

Another commentator proposed the evidence implies a "big bang theory" of the appearance of *Homo*.[123]

This large, unbridged gap between the apelike australopithecines and the abruptly appearing humanlike members of the genus *Homo* challenges evolutionary accounts of human origins. What can account for the abrupt

appearance of the humanlike body plan in the fossil record? As we saw in the previous section, generating new body plans requires new information and code in our DNA, and the abrupt appearance of new complex forms requires that information to arise very rapidly. Only intelligent agents are capable of rapidly generating the large amounts of genetic information and code required to create new fully formed blueprints that determine body plans. The best explanation for the rapid infusion of genetic information needed to abruptly generate new body plans is intelligence.

The Unique Design of the Human Mind

The origin of humanity implicates intelligent design not just because of the abrupt appearance of our unique body plan but also due to the specialness and sudden emergence of the human mind. Researchers have recognized an "explosion" or "revolution"[124] of modern humanlike culture in the archaeological record between 50,000 to 100,000 years ago, showing the abrupt appearance of human creativity,[125] technology, art,[126] and even paintings[127]—implying the rapid emergence of self-awareness, group identity, and

symbolic thought.[128] One review of Paleolithic archaeology even dubbed this the "Creative Explosion."[129] This striking observation alone testifies to the design of the human mind in the history of our species.

Evolutionary psychology (often called "evo psych") is a field that attempts to explain the origin of the human mind in evolutionary terms, but it has struggled to explain some of the most important aspects of human behavior that show we are unique compared to animals. For example, the explosion of modern humanlike creativity in the archaeological record reflects the fact that humans are the only species that uses complex language. One paper explains that, "Language is a uniquely human ability..."[130] and the technical literature acknowledges severe difficulties in accounting for the evolutionary origin of human language. Multiple leading paleoanthropologists admitted in an article in the journal *Frontiers in Psychology* that we have "essentially no explanation of how and why our linguistic computations and representations evolved" since "nonhuman animals provide virtually no relevant parallels to human linguistic communication."[131] The article

concludes: "the most fundamental questions about the origins and evolution of our linguistic capacity remain as mysterious as ever."[132] Similarly, MIT professor and linguist Noam Chomsky observes that the uniqueness of human language makes it difficult to explain its evolutionary origin:

> Human language appears to be a unique phenomenon, without significant analogue in the animal world… There is no reason to suppose that the "gaps" are bridgeable.[133]

Evo psych has also struggled to explain the origin of human moral, intellectual, and religious behaviors in Darwinian terms. Former Harvard evolutionary psychologist Marc Hauser argues that "people are born with a moral grammar wired into their neural circuits by evolution."[134] Humans *do* appear hard-wired for morality, but one of the greatest challenges to evolutionary psychology stems from the fact that our most "moral" behaviors involve helping *someone else* to survive rather than, as might be expected under a Darwinian view, providing some evolutionary benefit to ourselves.

The Origin of Human Morality and Religion

Evolutionary psychologists have sought to envision a myriad of scenarios where it could somehow be evolutionarily beneficial to help someone else. For example, in kin selection, you help other members of your family survive, because they share some of your genes, and in helping them survive, some of your own genes are passed on. Or according to the principle of reciprocal altruism, sharing food with others evolved because your friend might share food with you later when you're hungry. This helps you and your kin survive and pass on your genes. Or, sometimes people even perform charitable acts in public simply to earn the praise and respect of others, bolstering their own evolutionary success. This is christened competitive altruism. National Academy of Sciences member Philip Skell explains why these kinds of unpredictive and contradictory explanations are unpersuasive:

> Darwinian explanations for such things are often too supple: Natural selection makes humans self-centered and aggressive—except when it makes them altruistic and peaceable. Or natural

> selection produces virile men who eagerly spread their seed—except when it prefers men who are faithful protectors and providers. When an explanation is so supple that it can explain any behavior, it is difficult to test it experimentally, much less use it as a catalyst for scientific discovery.[135]

Disturbingly, under these staple evo psych concepts, there's really no such thing as truly selfless love. Instead, humans exhibit "altruism"—seemingly unselfish behavior that is actually programmed to give kickbacks to your selfish genes. Yet human behaviors that appear to be truly selfless and "loving" are the most difficult for evo psych to explain.

Specifically, Darwinian evolution cannot explain extreme acts of human kindness. Regardless of background or beliefs, upon finding strangers trapped inside a burning vehicle, people of all cultures will risk their own lives to help them escape—with no evolutionary benefit to themselves. Evolutionary biologist Jeffrey Schloss explains that Holocaust rescuers took great risks which offered no personal biological benefits:

> The rescuer's family, extended family and friends were all in jeopardy, and they were recognized to be in jeopardy by the rescuer. Moreover, even if the family escaped death, they often experienced deprivation of food, space and social commerce; extreme emotional distress; and forfeiture of the rescuer's attention.[136]

Francis Collins gives the example of Oskar Schindler, the German businessman who risked his life "to save more than a thousand Jews from the gas chambers."[137] As Collins points out, "That's the opposite of saving his genes."[138] Schloss adds other examples of "radically sacrificial" behavior that "reduces reproductive success" and offers no evolutionary benefit, such as voluntary poverty, celibacy, and martyrdom.[139]

Explaining the origin of religion has likewise been a major challenge for evolutionary psychologists to explain. A common explanation is group selection, where shared religious beliefs helped foster group cohesion which aids in survival. But isn't religion about much more than mere group cooperation? How do you explain the evolutionary origin of total religious devotion to a deity? Which "selfish

genes" drive young males into monasteries to pray, where they will have no offspring and receive no plaudits from the public, from whose eyes they are hidden? What about the religious ascetic who chooses to die at the hands of his worst enemies, believing that his own death will save them? How do those behaviors help you "pass on your genes"? Evo psych explanations of religion fail to capture the totality of the religious experience, and struggle to explain many religious beliefs and behaviors that are strikingly non-adaptive.

It is here, too, that a design-based model seems superior to a Darwinian one. The demands of Darwinian evolution are simple: survive and spread your genes. But if human behavior evolved along strictly Darwinian lines alone, why have humans exhibited through the ages selfless behavior that does not lead to evolutionary success—i.e., spreading one's genes—but to the exact opposite result? If human morality evolved, why do humans around the world have internal moral compasses that whisper of selfless love as the "right" option—speaking loudest at some of our most selfish moments?

Moreover, many of humanity's most impressive charitable, artistic, and intellectual abilities outstrip the basic requirements of natural selection. If life is simply about survival and reproduction, why have humans "evolved" the ability to compose symphonies and other forms of music, write literary epics, investigate quantum mechanics and explore the mysteries of the universe through science, worship God, and create grand buildings like cathedrals or museums? Of course, intelligence helps us survive, but why would the genius necessary to fly to the Moon be required among our ancestors whose only requirements were to survive and reproduce in the African savannah a million years ago? Contrary to neo-Darwinism, the evidence indicates that human beings aren't mere "survival machines." *Humans appear designed for much higher purposes.*

Human Beings: A Paragon of Design

From our unique body plan to our special linguistic abilities to our unparalleled intellectual and creative capacities to our totally unprecedented moral and religious sensibilities, there is nothing like the human species found among other animals. For the moment,

consider human uniqueness from an evolutionary perspective. Such gaps between humans and chimpanzees strongly suggest that many genes and genetic changes would be necessary to convert an apelike creature into a human being. Are neo-Darwinian explanations up to this task?

Recall that in the previous section we saw that a study in *Genetics* found that because of the long generation time of humans and our historically small population sizes, to obtain only two specific mutations via Darwinian evolution "would take > 100 million years"—which authors the admit was "very unlikely to occur on a reasonable timescale."[140] The exact timespan the study calculated for such a change was 216 million years, which is far greater than the amount of time—just 4 to 6 million years[141]—since we are said to have diverged from our supposed most recent common ancestor with chimpanzees.

To further appreciate this challenge, consider a seemingly simple example of a necessary evolutionary change: expanding the size of the human braincase. A study in *Nature* proposed that a single mutation which inactivated a protein could cause "marked size

reductions in individual muscle fibres and entire masticatory muscles" leading to "loss of masticatory strength," which could have loosened jaw muscles, allowing our brains to grow larger.[142] A widely circulated news story, titled "Missing link found in gene mutation," framed the finding this way: "an ancient genetic mutation for weaker jaws helped increase brain size, a twist that first separated the earliest humans from their apelike ancestors."[143] At first glance the story sounds reasonable, but there's a lot more to it. A leading paleoanthropologist quoted in the article noted that this mutation alone could never have provided a selectable advantage, and would have required additional changes:

> The mutation would have reduced the Darwinian fitness of those individuals… It only would've become fixed if it coincided with mutations that reduced tooth size, jaw size and increased brain size. What are the chances of that?[144]

We thus have a situation where multiple coordinated mutations would be necessary to provide a very modest advantageous change like increasing the size of the braincase in humans. Yet it is estimated that genetic

differences between humans and chimps amount to some "35 million base-pair changes, 5 million indels [sequences of multiple nucleotide bases] in each species, and 689 extra genes in humans."[145] In addition to our intellectual and neurological differences, these genetic differences must encode multiple physiological and anatomical differences, including differences in timing of development, teeth, musculature and physical strength, diet, mode of locomotion, neck structure, rib cage structure and gait, shoulder design, pelvis and hip orientation, inner ear canals, hands (made for tool use rather than knuckle walking), jaws, and hair.[146]

Thus, when we consider the profound genetic, physiological, cognitive, and behavioral differences between humans and chimps—if any of those traits required merely two or more mutations to arise in humans before providing an advantage, it would require over 200 million years to evolve by unguided Darwinian mechanisms within a species. To reiterate, if just two of the 35 million individual base-pair differences between humans and chimps were both required in order to produce some evolutionary advantage in

humans, then this trait could never evolve by unguided neo-Darwinian mechanisms in the time available from the fossil record.

So, what *can* account for the origin of the human species? Producing a human being—with its unique body plan and unprecedented linguistic, intellectual, and behavioral abilities—would have required immense amounts of information. Only an intelligent agent could produce the information needed to explain the rapid origin of the genetic and epigenetic information necessary to explain the abrupt appearance of such a complex species, unique among creatures that have ever lived.

Moreover, the moral, intellectual, artistic, and religious behaviors of the human species show that there are special purposes for human existence on this planet that go far beyond mere survival and reproduction. Humans are the ones that write scientific papers about apes—not the other way around. We are special and were designed for *higher* purposes.

CONCLUSION

Scientific discoveries have shown that life—our very existence—is fundamentally based upon:

1. A universe that requires a super-powerful cause that exists outside of itself.

2. Exquisite fine-tuning of universal laws and constants to yield a habitable universe.

3. A vast amount of complex and specified information digitally encoded in a biochemical language in our DNA which is algorithmically processed through a computer-like system of information processing where cellular machinery reads, interprets, and executes the commands programmed in DNA to produce irreducibly complex molecular machines composed of finely tuned proteins.

4. A repeating pattern of abrupt appearance of groups of animals with complex body plans requiring new code in our DNA—thousands of tightly coordinated new genes and immense amounts of new genetic and epigenetic information.

5. Unique moral, intellectual, artistic, and religious behaviors in our human species which go far beyond what is required for mere survival and reproduction.

Thus, some of the most important questions investigated by science—the origin of the universe, the life-friendly fine-tuning of the universe, the origin of life, the origin of animals, and the origin of human beings—are best answered by intelligent design. Yet intelligent design is much more than a well-supported scientific conclusion. It also provides a useful paradigm that can guide scientific research, has already guided scientific research, and has the exciting potential to do so even more in the future.[147]

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Notes

[1] Henry Quastler, *The Emergence of Biological Organization* (Yale University Press, 1964), 16.

[2] This section is intended to be a very rough outline of how we detect design. For more detailed explanations of how intelligent design operates as an historical science and detecting design via inferences to the best explanation and complex and specified information, please see: William Dembski, *The Design Inference: Eliminating Chance Through Small Probabilities* (Cambridge University Press, 1998); Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (HarperOne, 2009); Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (HarperOne, 2013); Stephen Meyer, *Return of the God Hypothesis: Three Scientific Discoveries that Reveal the Mind Behind the Universe* (HarperOne, 2021).

[3] Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (HarperOne, 2009), 154.

[4] Parts of this section are taken from Gary Kemper, Hallie Kemper, and Casey Luskin, *Discovering Intelligent Design: A Journey into the Scientific Evidence* (Discovery Institute Press, 2013).

[5] Neil F. Comins, *Discovering the Essential Universe*, 4th ed. (New York: W. H. Freeman, 2009), 406.

[6] For a detailed discussion of this issue, see Part IV of Stephen C. Meyer, *Return of the God Hypothesis: Three Scientific Discoveries that Reveal the Mind Behind the Universe* (HarperOne, 2021).

[7] Stephen W. Hawking, *A Brief History of Time: From the Big Bang to Black Holes* (Bantam, 1988), 184.

[8] Ekström et al., "Effects of the Variation of Fundamental Constants on Population III Stellar Evolution," *Astronomy & Astrophysics*, 514: A62 (2010); Epelbaum et al., "Dependence of the Triple-Alpha Process on the Fundamental Constants of Nature," *European Physics Journal A*, 49: id 82 (2013).

[9] Csótó et al., "Fine-Tuning the Basic Forces of Nature Through the Triple-Alpha Process in Red Giant Stars," *Nuclear Physics A*, 688/1–2: 560-562 (2001).

[10] Geraint Lewis and Luke Barnes, *A Fortunate Universe: Life in a Finely Tuned Cosmos* (Cambridge University Press, 2016), 79.

[11] Martin Rees, "Large Numbers and Ratios in Astrophysics and Cosmology," *Philosophical Transactions of the Royal Society London A*, 310: 317 (1983); Geraint Lewis and Luke Barnes, *A Fortunate Universe: Life in a Finely Tuned Cosmos* (Cambridge University Press, 2016), 78.

[12] Paul Davies, *Superforce: The Search for a Grand Unified Theory of Nature* (Simon & Schuster, 1985), 184.

[13] Luke Barnes, "The Fine-Tuning of the Universe for Intelligent Life," *Publications of the Astronomical Society of Australia*, 29 (4): 529-564 (2012); Stephen Meyer, *Return of the God Hypothesis: Three Scientific Discoveries that Reveal the Mind Behind the Universe* (HarperOne, 2021), 137, 472.

[14] Geraint Lewis and Luke Barnes, *A Fortunate Universe: Life in a Finely Tuned Cosmos* (Cambridge University Press, 2016), 167.

[15] Ibid., 109.

[16] Paul Davies, *The Accidental Universe* (Cambridge Univ. Press, 1982), 71-73.

[17] Ibid., 89; John Leslie, *Universes* (Routledge, 1989), 29.

[18] John Leslie, in *Universes* (Routledge, 1989), pp. 5, 31, gives a value of 1 part in 10^{120}. But the best estimates today for the fine-tuning of the cosmological constant is 1 part in 10^{90}. See the Extended Research Notes for *Return of the God Hypothesis* at https://returnofthegodhypothesis.com/book/notes/.

[19] Roger Penrose and Martin Gardner, *The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics* (Oxford University Press, 2002), 444-445; John Leslie, *Universes* (Routledge, 1989), 28.

[20] Charles Townes quoted in Bonnie Azab Powell, "'Explore as much as we can': Nobel Prize winner Charles Townes on evolution, intelligent design, and the meaning of life," UC Berkeley News Center (June 17, 2005), https://www.berkeley.edu/news/media/releases/2005/06/17_townes.shtml.

[21] See Brian Miller and Stephen Meyer, "Physicist Sabine Hossenfelder Challenges the Evidence for Cosmological Fine-Tuning," *Evolution News* (October, 2020), https://evolutionnews.org/2020/10/physicist-sabine-hossenfelder-challenges-the-evidence-for-cosmological-fine-tuning/; or Bruce Gordon, "Balloons on a String: A Critique of Multiverse Cosmology," in *The Nature of Nature*, eds. Bruce Gordon and William Dembski (ISI Books, 2011), 558-585.

[22] Stephen Meyer, *Return of the God Hypothesis: Three Scientific Discoveries that Reveal the Mind Behind the Universe* (HarperOne, 2021), 401-402.

[23] Sara Imari Walker and Paul C. W. Davies, "The algorithmic origins of life," *Interface*, 10: 20120869 (2013).

[24] Carl Sagan, "Life," in *Encyclopedia Britannica: Macropaedia Vol. 10* (Encyclopedia Britannica, Inc., 1984), 894.

[25] Bernd-Olaf Küppers, *Information and the Origin of Life* (MIT Press, 1990), 170.

[26] H. Allen Orr, "The Genetic Theory of Adaptation: A Brief History," *Nature Reviews Genetics*, 6: 119-127 (February, 2005).

[27] Douglas Axe, "Extreme Functional Sensitivity to Conservative Amino Acid Changes on Enzyme Exteriors," *Journal of Molecular Biology*, 301: 585-595 (2000); Douglas Axe, "Estimating the Prevalence of Protein Sequences Adopting Functional Enzyme Folds," *Journal of Molecular Biology*, 341: 1295-1315 (2004).

[28] Michael Behe made this calculation in *The Edge of Evolution* (Free Press, 2007), p. 64, based on a paper in *Proceedings of the National Academy of Sciences* which predicted approximately 10^{30} prokaryotes are formed on earth each year. See Whitman et al., "Prokaryotes: The Unseen Majority," *Proceedings of the National Academy of Sciences*. 95: 6578-6583 (1998). Since prokaryotes represent the vast majority of living organisms, if we multiply 10^{30} organisms / year times by 10^{10} years, which is roughly twice the age of the earth, we get 10^{40} organisms.

[29] See Clyde A. Hutchison III et al., "Design and synthesis of a minimal bacterial genome," *Science*, 351: aad6253-1 (March 25, 2016); John I. Glass, Chuck Merryman, Kim S. Wise, Clyde A. Hutchison III, and Hamilton O. Smith, "Minimal Cells—Real and Imagined," *Cold Spring Harbor Perspectives in Biology*, 9: a023861 (2017).

[30] Richard Dawkins, *The Blind Watchmaker* (W. W. Norton, 1986), 1.

[31] Stephen C. Meyer, Marcus Ross, Paul Nelson, and Paul Chien, "The Cambrian Explosion: Biology's Big Bang," in *Darwinism, Design, and Public Education*, J. A. Campbell and S. C. Meyer eds. (Michigan State University Press, 2003), 323-402.

[32] Stephen C. Meyer, "The origin of biological information and the higher taxonomic categories," *Proceedings of the Biological Society of Washington*, 117: 213-239 (2004).

[33] Bill Gates, N. Myhrvold, and P. Rinearson, *The Road Ahead: Completely Revised and Up-To-Date* (Penguin Books, 1996), 228.

[34] J. Craig Venter, "The Big Idea: Craig Venter On the Future of Life," *The Daily Beast* (October 25, 2013), https://www.thedailybeast.com/the-big-idea-craig-venter-on-the-future-of-life.

[35] Quoted in Casey Luskin, "Craig Venter in Seattle: 'Life Is a DNA Software System'," *Evolution News* (Oct. 24, 2013), https://evolutionnews.org/2013/10/craig_venter_in/.

[36] Richard Dawkins, *River Out of Eden: A Darwinian View of Life* (Basic Books, 1995), 17.

[37] Francis Collins, *The Language of God: A Scientist Presents Evidence for Belief* (Free Press, 2006), 91.

[38] See Dennis Bray, *Wetware: A Computer in Every Cell* (Yale University Press, 2009).

[39] Ibid., x.

[40] Ibid., x-xi.

[41] Bruce Alberts, "The Cell as a Collection of Protein Machines: Preparing the Next Generation of Molecular Biologists," *Cell*, 92: 291-294 (Feb. 6, '98).

[42] David J. DeRosier, "The Turn of the Screw: The Bacterial Flagellar Motor," *Cell*, 93: 17-20 (April 3, 1998).

[43] Michael J. Behe, *Darwin's Black Box: The Biochemical Challenge to Darwinism* (Free Press, 1996), 39.

[44] Scott Minnich & Stephen Meyer, "Genetic analysis of coordinate flagellar and type III regulatory circuits in pathogenic bacteria," *Proceedings of the Second International Conference on Design & Nature, Rhodes, Greece*, M.W. Collins & C.A. Brebbia eds. (Wessex Institute of Technology Press, 2004).

[45] See for example Stephen C. Meyer, *Signature in the Cell* (HarperOne, 2009).

[46] Jack W. Szostak, David P. Bartel, and P. Luigi Luisi, "Synthesizing Life," *Nature*, 409, 387-390 (January 18, 2001); Tomonori Totani, "Emergence of life in an inflationary universe," *Scientific Reports*, 10: 1671 (2020).

[47] Robert Shapiro, "A Replicator Was Not Involved in the Origin of Life," *IUBMB Life*, 49: 173-176 (2000).

[48] Robert Shapiro, "A Simpler Origin for Life," *Scientific American* (June 2007): 46-53.

[49] Tomonori Totani, "Emergence of life in an inflationary universe," *Scientific Reports*, 10: 1671 (2020).

[50] Steven A. Benner, "Paradoxes in the Origin of Life," *Origin of Life and Evolution of the Biosphere*, 44: 339-343 (2014).

[51] Ibid.

[52] Ibid.

[53] Ibid.

[54] C. Mariscal et al., "Hidden Concepts in the History and Philosophy of Origins-of-Life Studies: A Workshop Report." *Origins of Life and Evolution of Biospheres*, 49(3): 111-145 (2019).

[55] Hubert P. Yockey, "Self Organization Origin of Life Scenarios and Information Theory," *Journal of Theoretical Biology*, 91: 13-31 (1981).

[56] Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (HarperOne, 2009), 386.

[57] For a discussion of the length of the Cambrian explosion, see Casey Luskin, "How 'Sudden' Was the Cambrian Explosion," in *Debating Darwin's Doubt*, ed. David Klinghoffer (Seattle: Discovery Institute Press, 2015), 75-88.

[58] Many of these phyla are documented in Figure 2.5 of Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (HarperOne, 2013), p. 32 and accompanying text and citations. Meyer allows the possibility that mollusks appeared in the Precambrian, but a good case can be made that these Precambrian fossils are not mollusks and that mollusks first appear in the Cambrian explosion. See Casey Luskin, "On the Cambrian Explosion, Keith Miller's BioLogos White Paper Falls Short," *Evolution News* (December 29, 2016), https://evolutionnews.org/2016/12/on_the_cambrian/; and series by Günter Bechly, https://evolutionnews.org/tag/kimberella-series/, first introduced at Günter Bechly, "Was *Kimberella* a Precambrian Mollusk?," *Evolution News* (Sept. 3, 2020), https://evolutionnews.org/2020/09/was-kimberella-a-precambrian-mollusk/.

[59] R. S. K. Barnes, P. Calow, and P. J. W. Olive, *The Invertebrates: A New Synthesis,* 3rd ed. (Blackwell Scientific, 2001), 9-10.

[60] Nelson Cabej, *Epigenetic Mechanisms of the Cambrian Explosion* (Academic Press / Elsevier, 2020), ix.

[61] Jordi Paps and Peter W.H. Holland, "Reconstruction of the ancestral metazoan genome reveals an increase in genomic novelty," *Nature Communications*, 9: 1730 (2018); Peter Heger, Wen Zheng, Anna Rottmann, Kristen A Panfilio, and Thomas Wiehe, "The genetic factors of bilaterian evolution," *eLife*, 9: e45530 (2020).

[62] Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (HarperOne, 2013), 362-363.

[63] Ibid., 373, 375.

[64] Walter Etter, "Patterns of Diversification and Extinction," in *Handbook of Paleoanthropology: Principles, Methods, and Approaches*, ed. Winfried Henke and Ian Tattersall, 2nd ed. (Springer, 2015), 51-415.

[65] Asher Elbein, "Fossilized Fish Reveal Earliest Known Prequel of 'Jaws'," *New York Times* (September 28, 2022), https://www.nytimes.com/2022/09/28/science/jaws-fish-fossils-china.html.

[66] Arthur Strahler, *Science and Earth History: The Evolution/Creation Controversy* (Prometheus, 1987), 408-409.

[67] Richard M. Bateman, Peter R. Crane, William A. DiMichele, Paul R. Kenrick, Nick P. Rowe, Thomas Speck, and William E. Stein, "Early Evolution of Land Plants: Phylogeny, Physiology, and Ecology of the Primary Terrestrial Radiation," *Annual Review of Ecology and Systematics*, 29: 263-292 (1998).

[68] David Grimaldi and Michael S. Engel, *Evolution of the Insects* (Cambridge University Press, 2005), p. 302; Michael Krauss, "The Big Bloom—How Flowering Plants Changed the World," *National Geographic* (July 2002): 102-121, https://web.archive.org/web/20150107144430/http:/ngm.nationalgeographic.com/ngm/0207/feature6/; Stanley A. Rice, *Encyclopedia of Evolution* (Checkmark, 2007), 70.

[69] Stefanie De Bodt, Steven Maere, and Yves Van de Peer, "Genome Duplication and the Origin of Angiosperms," *Trends in Ecology and Evolution*, 20: 591-597 (2005).

[70] Shanti Menon, "Insects of the Oxygeniferous," *Discover Magazine* (Aug. 31, 1995), https://www.discovermagazine.com/planet-earth/insects-of-the-oxygeniferous.

[71] André Nel, "A glance at the deep past history of insects," *Insects: Friends, foes, and models/Insectes : amis, ennemis et modèles /C. R. Biologies,* 342: 247-278 (2020).

[72] Michael S. Engel and David A. Grimaldi, "New light shed on the oldest insect," *Nature*, 204: 627-630 (February 12, 2004).

[73] Jennifer A. Clack, *Gaining Ground: The Origin and Evolution of Tetrapods* (Indiana University Press), 278, 327; Thomas S. Kemp, *The Origin of Higher Taxa: Palaeobiological, Developmental, and Ecological Perspectives* (Oxford University Press

and University of Chicago Press, 2016), 157.

[74] Michael J. Everhart, "Rapid Evolution, Diversification and Distribution of Mosasaurs (Reptilia; Squamata) prior to the K-T Boundary," *Oceans of Kansas Paleontology* (June 11, 2010), http://oceansofkansas.com/rapidmosa.html.

[75] Michael Marshall, "Largest ever animal may have been Triassic ichthyosaur super-predator," *New Scientist* (December 29, 2022).

[76] P. Martin Sander et al., "Early giant reveals faster evolution of large body size in ichthyosaurs than in cetaceans," *Science*, 374: eabf5787 (December 24, 2021).

[77] Michael Balter, "Pint-Sized Predator Rattles the Dinosaur Family Tree," *Science*, 331: 134 (January 14, 2011).

[78] Frank Gill, *Ornithology*, 3rd ed. (W. H. Freeman, 2007), p. 42; Alan Feduccia, "Explosive evolution in tertiary birds and mammals," *Science*, 267 (5198): 637-638 (February 3, 1995).

[79] Bhert-Anjan S. Bhullar et al., "A molecular mechanism for the origin of a key evolutionary innovation, the bird beak and palate, revealed by an integrative approach to major transitions in vertebrate history," *Evolution*, 69 (7): 1665-1677 (2015).

[80] Alan Feduccia, "'Big bang' for tertiary birds?," *Trends in Ecology and Evolution*, 18 (4): 172-176 (April 2003).

[81] Peter D. Ward, *Out of Thin Air: Dinosaurs, Birds, and Earth's Ancient Atmosphere* (Joseph Henry Press, 2006), 224; David Grimaldi and Michael S. Engel, *Evolution of the Insects* (Cambridge University Press, 2005), 37; Stanley A. Rice, *Encyclopedia of Evolution* (Checkmark, 2007), 6; Edwin H. Colbert, *Evolution of the Vertebrates: A History of the Backboned Animals through Time* (John Wiley & Sons, 1969), 123; Niles Eldredge, *Macroevolutionary Dynamics: Species, Niches, and Adaptive Peaks* (McGraw Hill, 1989), 44; Robert A. Martin, *Missing Links: Evolutionary Concepts and Transitions Through Time* (Jones & Bartlett, 2004), 135, 139. 179; Marc Godinot, "Fossil Record of the Primates from the Paleocene to the Oligocene," in *Handbook of Paleoanthropology: Principles, Methods, and Approaches*, ed. Winfried Henke and Ian Tattersall, 2nd ed. (Springer, 2015), 1137-1259; Alan Feduccia, "Explosive evolution in tertiary birds and mammals," *Science*, 267 (5198): 637-638 (February 3, 1995); Maureen A. O'Leary, et al., "The Placental Mammal Ancestor and the Post–K-Pg Radiation of Placentals," *Science*, 339: 662-667 (February 8, 2013).

[82] Niles Eldredge, *The Monkey Business: A Scientist Looks at Creationism* (Washington Square Press, 1982), 65.

[83] Ellen J. Coombs et al., "The tempo of cetacean cranial evolution," *Current Biology*, 32: 1-15 (May 23, 2022).

[84] Stephen Jay Gould, "Is a new and general theory of evolution emerging?," *Paleobiology*, 6(1): 119-130 (1980).

[85] Jeffrey H. Schwartz, *Sudden Origins: Fossils, Genes, and the Emergence of Species* (John Wiley & Sons, 1999), 3.

[86] See Niles Eldredge and Stephen Jay Gould, "Punctuated Equilibria: An Alternative to Phyletic Gradualism," in *Models in Paleobiology*, Thomas J.M. Schopf ed. (Freeman, Cooper & Company, 1972), 82-115.

[87] For a more detailed discussion of problems with Punctuated Equilibrium, see Casey Luskin, "Punctuated Equilibrium and Patterns from the Fossil Record," *IDEA Center* (September 18, 2004), http://www.ideacenter.org/contentmgr/showdetails.php/id/1232, or Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (HarperOne, 2013), Chapter 6, "Punk Eek!," 136-152.

[88] Jerry Coyne, "The Great Mutator," *The New Republic* (June 14, 2007).

[89] Charles Darwin, *Origin of Species* (1859), Chapter 6, http://www.literature.org/authors/darwin-charles/the-origin-of-species/chapter-06.html.

[90] See for example Eric Davidson, "Evolutionary Bioscience as Regulatory Systems Biology," *Developmental Biology*, 357:35-40 (2011); Eric H. Davidson and Douglas Erwin. "An Integrated View of Precambrian Eumetazoan Evolution," *Cold Spring Harbor Symposia on Quantitative Biology*, 74: 1-16 (2010); Eric Davidson, *The Regulatory Genome: Gene Regulatory Networks in Development and Evolution* (Elsevier, 2006), 195.

[91] See Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (HarperOne, 2013), 255-270.

[92] Michael Behe and David Snoke, "Simulating Evolution by Gene Duplication of Protein Features That Require Multiple Amino Acid Residues," *Protein Science*, 13: 2651-2664 (2004).

[93] Rick Durrett and Deena Schmidt, "Waiting for Two Mutations: With Applications to Regulatory Sequence Evolution and the Limits of Darwinian Evolution," *Genetics*, 180: 1501-1509 (2008).

[94] Douglas Axe, "The Limits of Complex Adaptation: An Analysis Based on a Simple Model of Structured Bacterial Populations," *BIO-Complexity*, 2010 (4).

[95] Ann Gauger, Stephanie Ebnet, Pamela F. Fahey, and Ralph Seelke, "Reductive Evolution Can Prevent Populations from Taking Simple Adaptive Paths to High Fitness," *BIO-Complexity*, 2010 (2).

[96] Ann Gauger and Douglas Axe, "The Evolutionary Accessibility of New Enzyme Functions: A Case Study from the Biotin Pathway," *BIO-Complexity*, 2011 (1).

[97] Mariclair A. Reeves, Ann K. Gauger, Douglas D. Axe, "Enzyme Families—Shared Evolutionary History or Shared Design? A Study of the GABA-Aminotransferase Family," *BIO-Complexity*, 2014 (4).

[98] Michael J. Behe, "Experimental Evolution, Loss-of-Function Mutations, and 'The First Rule of Adaptive Evolution,'" *The Quarterly Review of Biology*, 85(4): 1-27 (December 2010).

[99] Stephen Jay Gould, "Evolution's erratic pace," *Natural History*, 86: 12-16 (May, 1977).

[100] J.G.M. Thewissen and Sunil Bajpai, "Whale Origins as a Poster Child for Macroevolution," *BioEssays*, 51: 1037-1049 (December, 2001).

[101] Steinar Thorvaldsen and Ola Hössjer, "Using statistical methods to model the fine-tuning of molecular machines and systems," *Journal of Theoretical Biology*, 501: 110352 (2020); Ola Hössjer, Günter Bechly, and Ann Gauger, "On the waiting time until coordinated mutations get fixed in regulatory sequences," *Journal of Theoretical Biology*, 524: 110657 (2021).

[102] Alan Feduccia, "'Big bang' for tertiary birds?," *Trends in Ecology and Evolution*, 18: 172-176 (2003).

[103] Rick Durrett and Deena Schmidt, "Waiting for Two Mutations: With Applications to Regulatory Sequence Evolution and the Limits of Darwinian Evolution," *Genetics*, 180: 1501-1509 (2008).

[104] Richard Sternberg, personal communication.

[105] Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (HarperOne, 2013), 360.

[106] Ibid., 362-363.

[107] Ibid., 371-372.

[108] Bernard Wood and Mark Grabowski, "Macroevolution in and Around the Hominin Clade," in: *Macroevolution: Explanation, Interpretation and Evidence*, S.

Emanuele and N. Gontier, eds. (Springer-Verlag, 2015), 345-376.

[109] Berhane Asfaw et al., "Remains of *Homo erectus* from Bouri, Middle Awash, Ethiopia," *Nature*, 416: 317-320 (March 21, 2002).

[110] Bernard Wood, "Did early Homo migrate 'out of' or 'in to' Africa?," *Proceedings of the National Academy of Sciences*, 108: 10375-10376 (2011).

[111] William H. Kimbel and Brian Villmoare, "From *Australopithecus* to *Homo*: the transition that wasn't," *Philosophical Transactions of the Royal Society B*, 371: 20150248 (2016).

[112] Stanley A. Rice, *Encyclopedia of Evolution* (Checkmark, 2007).

[113] William R. Leonard, J. Josh Snodgrass, and Marcia L. Robertson, "Effects of Brain Evolution on Human Nutrition and Metabolism," *Annual Review of Nutrition*, 27: 311-327 (2007); Susanne Shultz, Emma Nelson and Robin I. M. Dunbar, "Hominin cognitive evolution: identifying patterns and processes in the fossil and archaeological record," *Philosophical Transactions of The Royal Society B*, 367: 2130-2140 (2012); Franz M. Wuketits, "Charles Darwin, Paleoanthropology, and the Modern Synthesis," in *Handbook of Paleoanthropology: Principles, Methods, and Approaches*, W. Henke and I. Tattersall, eds., 2nd ed. (Springer, 2015), 97-125.

[114] Dean Falk, "Hominid Brain Evolution: Looks Can Be Deceiving," *Science*, 280: 1714 (June 12, 1998).

[115] François Marchal, "A New Morphometric Analysis of the Hominid Pelvic Bone," *Journal of Human Evolution*, 38: 347-365 (March, 2000).

[116] Robin Dennell and Wil Roebroeks, "An Asian perspective on early human dispersal from Africa," *Nature*, 438: 1099-1104 (December 22/29, 2005).

[117] Alan Turner and Hannah O'Regan, "Zoogeography: Primate and Early Hominin Distribution and Migration Patterns," in *Handbook of Paleoanthropology: Principles, Methods, and Approaches*, W. Henke and I. Tattersall, eds., 2nd ed. (Springer, 2015), pp. 623-642.

[118] John Hawks, Keith Hunley, Sang-Hee Lee, and Milford Wolpoff, "Population Bottlenecks and Pleistocene Human Evolution," *Molecular Biology and Evolution*, 17: 2-22 (2000).

[119] Ibid.

[120] Daniel E. Lieberman, David R. Pilbeam, and Richard W. Wrangham, "The Transition from *Australopithecus* to *Homo*," in *Transitions in Prehistory: Essays in Honor of Ofer Bar-Yosef*, J.J. Shea and D.E. Lieberman, eds. (Oxbow Books, 2009), 1-22.

[121] Ibid.

[122] Ernst Mayr, *What Makes Biology Unique?: Considerations on the Autonomy of a Scientific Discipline* (Cambridge University Press, 2004), 198.

[123] University of Michigan News Service (January 10, 2000) "New study suggests big bang theory of human evolution," UMich.edu, https://news.umich.edu/new-study-suggests-big-bang-theory-of-human-evolution/

[124] Ofer Bar-Yosef, "The Upper Paleolithic Revolution," *Annual Review of Anthropology*, 31: 363-393 (2002); Paul Mellars, "Neanderthals and the modern human colonization of Europe," *Nature*, 432: 461-465 (November 25, 2004); April Nowell, "From A Paleolithic Art to Pleistocene Visual Cultures (Introduction to two Special Issues on 'Advances in the Study of Pleistocene Imagery and Symbol Use')," *Journal of Archaeological Method and Theory*, 13: 239-249 (2006).

[125] Randall White, *Prehistoric Art: The Symbolic Journey of Humankind* (Harry N. Abrams, 2003).

[126] Stanley A. Rice, *Encyclopedia of Evolution* (Checkmark Books, 2007).

[127] Robert L. Kelly and David H. Thomas, *Archaeology*, 5th ed. (Wadsworth Cengage Learning, 2010).

[128] Ofer Bar-Yosef, "The Upper Paleolithic Revolution," *Annual Review of Anthropology*, 31: 363-393 (2002).

[129] Nicholas Toth and Kathy Schick, "Overview of Paleolithic Archaeology," in *Handbook of Paleoanthropology: Principles, Methods, and Approaches*, W. Henke and I. Tattersall, eds., 2nd ed. (Springer, 2015), 2441-2464.

[130] M. Carreiras et al., "An anatomical signature for literacy," *Nature*, 461: 983-986 (October 15, 2009).

[131] Marc D. Hauser, Charles Yang, Robert C. Berwick, Ian Tattersall, Michael J. Ryan, Jeffrey Watumull, Noam Chomsky, and Richard C. Lewontin, "The mystery of language evolution," *Frontiers in Psychology*, 5: 401 (May 7, 2014).

[132] Marc D. Hauser, Charles Yang, Robert C. Berwick, Ian Tattersall, Michael J. Ryan, Jeffrey Watumull, Noam Chomsky, and Richard C. Lewontin, "The mystery of language evolution," *Frontiers in Psychology*, 5: 401 (May 7, 2014).

[133] Noam Chomsky, *Language and Mind*, 3rd ed. (Cambridge University Press, 2006).

[134] Nicholas Wade, "An Evolutionary Theory of Right and Wrong," *New York Times* (October 31, 2006), http://www.nytimes.com/2006/10/31/health/psychology/31book.html.

[135] Philip Skell, "Why do we invoke Darwin?," *The Scientist*, 19: 10 (August 28, 2005).

[136] Jeffrey P. Schloss, "Evolutionary Accounts of Altruism & the Problem of Goodness by Design," in *Mere Creation; Science, Faith & Intelligent Design*, W.A. Dembski, ed. (Intervarsity Press, 1998), 237-261.

[137] David Van Biema, "God vs. Science," *Time* magazine (November 5, 2006), http://content.time.com/time/magazine/article/0,9171,1555132-1,00.html.

[138] Ibid.

[139] Jeffrey P. Schloss, "Emerging Accounts of Altruism: 'Love Creation's Final Law'?," In *Altruism and Altruistic Love: Science, Philosophy, & Religion in Dialogue*, S.G. Post, L.G. Underwood, J.P. Schloss, and W.B. Hurlbut, eds. (Oxford University Press, 2002).

[140] Rick Durrett and Deena Schmidt, "Waiting for Two Mutations: With Applications to Regulatory Sequence Evolution and the Limits of Darwinian Evolution," *Genetics*, 180: 1501-1509 (2008).

[141] Bernard Wood and Terry Harrison, "The evolutionary context of the first hominins," *Nature*, 470: 347-352 (2011).

[142] Hansell H Stedmanet al., "Myosin gene mutation correlates with anatomical changes in the human lineage," *Nature*, 428: 415-418 (2004).

[143] Joseph B. Verrengia, "Missing link found in gene mutation?," *NBC News* (March 24, 2004), https://www.nbcnews.com/id/wbna4593822.

[144] Ibid.

[145] Jon Cohen, "Relative Differences: The Myth of 1%," *Science*, 316 (5833): 1836 (June 29, 2007).

[146] L.T. Humphrey, M.C. Dean, and C.B. Stringer, "Morphological variation in great ape and modern human mandibles," *Journal of Anatomy*, 195: 491-513 (1999); Dennis M. Bramble and Daniel E. Lieberman, "Endurance running and the evolution of *Homo*," *Nature*, 432: 345-352 (November 18, 2004); Sergio Almécija, Jeroen B. Smaers & William L. Jungers, "The evolution of human and ape hand proportions," *Nature Communications*, 6; 7717 (2015); Matthew C. O'Neill, Brian R.

Umberger, Nicholas B. Holowka, and Peter J. Reiser, "Chimpanzee super strength and human skeletal muscle evolution," *Proceedings of the National Academy of Sciences USA*, 114 (28): 7343-7348; Mainá Bitar, Stefanie Kuiper, Elizabeth A. O'Brien, and Guy Barry, "Genes with human-specific features are primarily involved with brain, immune and metabolic evolution," *BMC Bioinformatics*, 20 (Suppl 9): 406 (2019).

[147] Describing a full *theory of intelligent design* is a subject beyond the scope of this monograph. It will be addressed in detail in a future work.