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Answers to common misconceptions about biological evolution

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Chapter 1: Introduction

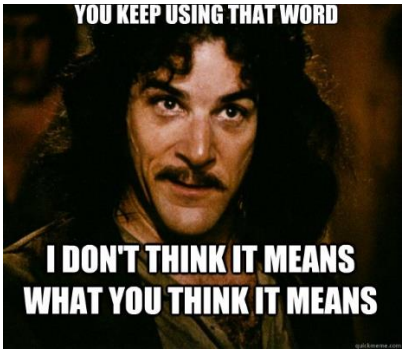
"*When you have an established scientific emergent truth, it is true whether or not you believe in it*." Neil deGrasse Tyson, Science in America.

Very few people outside of a particular scientific discipline can actually say they understand it, because most do not have the training to "speak the language." They are then not particularly bothered by its tenets and predictions. Of all the major branches of science, however, evolutionary biology is an exception to this generalization because even though people are not versed in the field, they sometimes have a negative, knee-jerk objection. This objection is often because they are told that evolution conflicts with their faith-based beliefs. To the contrary, it is actually the case that most of the world's religions accept evolution, especially theistic evolution, where life was created and then evolved. However, to a few who do not understand the biology of evolution, even this is unacceptable.

In this book we identified a number of misconceptions that we think at least some of the general public has about evolutionary biology. Our intent is to present how evolutionary scientists approach these specific questions and what their consensus of the evidence shows to be true. We hope that those who have heard of the misconceptions we address will come to appreciate the evidence that scientists actually discovered and interpreted.

Chapter 2: Evolution is "just a theory"

"*Let us demand that educators around America teach evolution not as fact, but as theory.*" Mike Pence, Vice President of the United States



Evolution is and has been one of the most heavily debated topics between the scientific community and the religious community. A common "flaw" many opposers of evolution are quick to call attention to, is that the theory of evolution is just that, a theory. Creationists and skeptics alike have all tried to pick apart the entirety of Darwin's and his successors' work on the accusation that a theory alone is not truth; this is the view point of the current vice president of the United States Mike Pence, Ken Hamm (the president and founder of Answers in Genesis, the Creation Museum, and the Ark Encounter), and even my own grandmother. I will admit that evolution is a theory, but we must first acknowledge that the term theory is not universally understood. For the general lay public, a theory is seen as conjecture, a summation of hunches, or even just instinct alone. As such, one might believe that scientists cannot observe or test that "hunch" we call evolution.

The definition of theory, as it applies to evolution and as defined by the National Academy of Science (NAS) is, "A well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences and tested hypotheses." One should not mistake a theory with a hypothesis. A hypothesis is a proposed explanation using limited evidence that can be tested using the scientific method. A theory has already been repeatedly tested, confirmed and has a wealth of supporting evidence. Theories allow you to make predictions based on principles that can be tested. That is, they represent established scientific platforms from which new research directions can be explored and our understanding of the topic expanded. Theories then, are the backbone of scientific understanding.

It could be asked then, why use the word theory at all? Why not call it the 'law' or 'fact' of evolution? Many may believe theories are less than scientific laws or facts, but they are actually higher up on the "hierarchy of science" (Not Just a Theory 2008) because they are a summation of laws and facts combined. Theories are used as a way of making sense of the laws and facts that we are presented with; they offer up explanations behind the science. Take for example, Newton's laws of physics. Most of us have been introduced to them as a group─ the three laws of physics. That is because Newton's laws go together in conjunction with the theory of gravity. Many are dumbfounded by the notion that gravity itself is "just" a theory. People cannot understand how something that has been verified with numerous amounts of proof

everyday can still remain a theory and not a fact, and that is because in science theories are not something that can be proven, just invalidated.

Other theories include Maxwell's theory of electromagnetism in 1873 (electric and magnetic fields travel as waves which move at the speed of light). His theory combined the principles of light speed, magnetism, and electricity into his theory of electromagnetism (AZoOptics 2015). Most importantly, his discoveries showed how waves of light were 'self-propagating', meaning they carried themselves over distances. This theory lead to the first radios, telephones, and is still directly responsible for many of the forces used in modern cell phones. Evolutionary theory is no exception, and it comes with numerous predictions that can be investigated and tested; such as natural selection, sexual selection, and common descent.

One of the most widely contested predictions of the theory of evolution is that all living organisms have descended from one common ancestor. Yup, that's right, we share common genes with a banana, though we live very different lives. LUCA is the affectionate name of the last organism that was common to all life on Earth (it stands for last universal common ancestor). Evidence can be found in the fossil record, comparative anatomy, comparative genetics, development and embryology, biogeography, and phylogenetic studies (Genovese, n.d.). The genetics don't lie. Scientists who have compared genomes across the three domains of life (archaea, bacteria, and eukaryotes), have discovered around 500 genes that ALL living organisms share (Tyson, 2007). These 500 or so genes have survived in us, in all living things, for billions of years! We share many basic molecular components functioning within cells with organisms we may never even notice (Genovese, n.d.). These genetic similarities link us to the past. And as more evidence is found it further confirms the prediction of a common descent.

We see transitions from one kind of animal to another throughout the layers of the fossil record. Transitional fossils further act as evidence that supports the theory of evolution. With transitional fossils we are able to physically see the gradual change within a species group over time. The fossils show us evolutionarily intermediates states, states that bridge ancestral forms and their descendants. That is, transitional fossils provide us with evidence for change over time (University of California, Berkeley 2017). All due to natural selection, of course.

Scientific theories make testable predictions. In evolutionary biology, the theory of natural selection suggests that populations will change over time, as individuals with superior, heritable traits leave more offspring than individuals without these traits. Heritable means that the trait is passed from the parent to the offspring, and some traits are consistently passed down (Evolution and Natural Selection, 2010). Given competition for limited resources, populations are predicted to change over time in response to changing condition. For example, after a devastating drought in 1977 on Daphne Major in the Galapagos only large seeds were left for birds to feed on and those with larger beaks were better able to open those seeds, they mated, and their offspring's beaks were 4% larger than previous generations(Tyson, 2007). These changes were directly observable and scientifically documented, and were not just a hunch. Evolution is a theory, like that of gravity, which makes predictions that have been confirmed for over 100 years.

Evolutionary changes can arise through sexual selection which Darwin introduced in his book *Descent of Man*. Sexual selection is a preference by one sex for certain traits found in individuals of the opposite sex. One's mind might think to the bright feathers of the males of many bird species. Bright feathers can indicate health and resources for choosey females ready to

reproduce (Ehrlich, 1998). Don't believe me? Peacocks, known for the extravagant feathers in their "train" (these feathers are often confused with the bird's tail, which is a series of drab grey feathers), are sexually selected by peahens (who look much more drab) by how flamboyant the feathers of the train are. In an experimental study it was found that by cutting off a small number of "eyes" from the peacock's train feathers, a male's chance for mating was significantly reduced (Tyson, 2007). Because one trait confers an advantage in acquiring mates and is therefore more frequent in the population of the next generation, sexual selection is occurring, as predicted by Darwin. Once again, the evidence supports a prediction of the theory of evolution. It's a great hallmark!

Scientific discovery is based on an established set of rules. Evidence is observable, hypotheses are testable, and new evidence can overturn existing ideas. Evolution is no exception. If you have doubts that evolution is responsible for the diversity of life on Earth, you would have to produce observable evidence and testable hypotheses that contradict genetics, comparative anatomy, the fossil record, and 100s of years of work by evolutionary biologists. The scientific evidence is clear and strong. This does not mean that we know everything about life on Earth, there is much more that we don't know. But just because something is not currently understood, the scientific method will likely provide future solutions, as it has numerous times in the past. In fact, scientists perform experiments and form hypotheses just to prove each other wrong. That being said, tremendous evidence has been found that confirms the theory of evolution. Every day experiments and observations confirm predictions made by evolutionary theory. The theory of evolution, then, is anything but a guess. It is a theory.

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Chapter 3: Evolution does not explain the origin of life.

Scientists have always contemplated about how the first living thing came about, and there is an assortment of speculations as to how life originated. Whether through faith or science, people have an established their own opinions. There is a misconception that evolution has failed to answer the question of how the first living thing on Earth arose, and that by extension this disproves the theory of evolution. Unfortunately, there is a lapse in this logic. It is true that scientists cannot definitively say what the answer to this question is (because, quite frankly, they don't know). There are proposed theories that could explain the beginning of life, but evidence that has been collected has not formed a general consensus about a single hypothesis. This does not disprove evolution nor indicate that scientists will not someday have an established answer. Imagine that at one point in history you remarked "the earth is flat and no amount of scientific data will change my mind." Silly would only begin to describe your adherence to that view. What a scientist would have said is "In my opinion the best available evidence suggests that the earth is flat, but if new evidence is discovered that the earth is spherical, I will change my opinion."

It is important to recognize that the theory of evolution explains how living things have changed over time, but it has never been about explaining the beginning of life. In principle, they are related ideas but in practice two different avenues of research. For living things to change over time, there first needs to be living things. To understand the present theories of the origin of life, it is important to have basic knowledge of genetic material (the traits we pass on to our children). The genetic material that is in every living thing is made up of deoxyribonucleic acid, or DNA, ribonucleic acid, or RNA, and proteins. A living thing can be described as a cell or conglomeration of cells that uses energy and reproduces. DNA consists of four chemical bases that hold the genetic information for life and heredity and is stored in every cell in an organisms' body (U.S. National Library of Medicine, 2017). RNA acts as a messenger that carries instructions given by DNA to make proteins within cells. Finally, proteins, which are made up of small units called amino acids, are essential in a cell because they play major roles as structural components, enzymes, cell signaling, and antibody functions in complex organisms (RNA society).

There are a few theories that could explain how life originated. Scientists consider Deep sea thermal vents, abiogenesis, and RNA beginnings as some of the most common hypotheses of the origin of life (Choi, 2016). The idea of life forming in deep sea thermal vents might have been a result of boiling temperatures and high pressure, which could accelerate the process of non-living molecular building blocks coming together, like amino acids and nucleic acids, to form life, or at least a precursor of life (M.B., 1998). Abiogenesis is the theory that life began spontaneously from simple, inorganic matter. It might seem improbable to think that life began from nothing, but it is hypothesized that given the right conditions at the right time, inorganic molecules could have come together to make simple forms of life that gradually became more complex (Rogers, 2014). So, you've explained complex rocks, but how do they become living? Is it the ability to use energy and replicate? Another possible theory is that early life relied on RNA, because it can function both as a messenger and as the carrier for hereditary information. Similarly, it suggests that life began with simple, molecular RNA blocks that gradually gave rise to more complex molecules and organisms (Wächtershäuser, 2014).

There are other theories among the scientific community, such as panspermia, which is the idea that life, in the form of simple molecules, came from outer space by hitching a ride on meteors (Klyce). These meteors then collide into earth spewing out the extraterrestrial material across the world from the impact. How it is thought that these molecules or simple organisms found themselves on these meteors is not yet clear. Once the simple organisms have formed or landed on earth they were able to adapt to the environment by slow changes or mutations. Eventually forming more complex molecules and organisms. Again, this takes a *very* long time for things to change over time.

So far there is no consensus in the scientific community about which theory is the most likely, or which theory most agree with. Many theories are put forth in the scientific community but there isn't a theory that has proven to be the origin of life. What scientists can agree on is that evolution is always working (very slowly) and it had to start somewhere. To think that evolution is not the process responsible for the diversity of life we see on earth is in direct conflict with all the scientific evidence that has been gathered in the last 200 years. For every scientific discovery, it is possible to look to an earlier point in time where it was considered to be impossible. Hence, it is far too early to suggest that science will not provide an answer to how life arose in the first place.

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Chapter 4: If humans evolved from monkeys, why are there still monkeys?

Ask any fifth grade student which animal they are most closely related to and you will hear a resounding response—"Monkeys!" We grow up learning this bit of information along with the order of the planets in our solar system and the knowledge that dinosaurs used to walk the earth. This information comes from experts. We tend to accept it as true despite the obvious fact that no one alive on earth today has seen dinosaurs for themselves or has traveled far enough into space to see each planet from the window of a rocket ship. A peek through a telescope, particularly a powerful telescope, can provide the evidence we need to confirm the order of the planets in our solar system. Likewise, a trip to a natural history museum with a dinosaur bones exhibit proves that these creatures lived on earth at one point. Understanding evidence is key to our search for truth in matters that we have been told to believe.

The question as to why chimps still exist if humans evolved from them actually contains several misconceptions that evidence and greater understanding can make clear. First, evolutionary change can happen in two ways. First, a lineage can change over time and individuals of that lineage will appear differently as they track environmental change. Secondly, species often split into two species, a process known as speciation. Each "daughter" species is usually found in different areas (termed allopatry), and each accumulates differences over time, becoming new species. There are literally thousands of examples of this process, where two species obviously evolved from one.

This second process is the one that involves humans and chimps. We can ask, "are we sure that humans and chimps are even related?" Humans and chimpanzees do share a significant amount of DNA—98-99% by most estimates (Fujiyama et al., 2002). When DNA sequences are analyzed from the great apes, we find that humans are most closely related to chimpanzees (and bonobos), as you'd expect if they only differ at 1 to 2% of their genes. Humans and chimps also share other genetic characteristics, which show that they are each other's nearest evolutionary relatives. Thus, humans and chimps share a common ancestor that lived six to seven million years ago (Young et al., 2015).

The misconception then can be explored by asking "what did this common ancestor look like?" Certainly this common ancestor was ape-like by modern standards. However, fossil records indicate that this ancestor did not functionally resemble modern chimps, nor humans. That is, both humans and chimpanzees have evolved significantly since the two diverged from this common ancestor (Almecija et al., 2013). An ancient fossilized femur indicates that the last common ancestor of humans and apes likely walked on all fours using its palms and had smaller hands and straighter fingers than modern chimps. This femur provides evidence that chimps and humans shared a common ancestor, but importantly, that the two lineages evolved independently throughout the ensuing millions of years after they separated from their common ancestors.

For example, human cells have 23 pairs of chromosomes whereas chimp cells have 24. Critics of the human-chimp common ancestry point to this as evidence against evolution, but scientists have found a simple explanation for this genetic difference - at one point in time, two chimp chromosomes combined into one. In fact, a 2005 study found that human chromosome 2 contains a sequence that is a 99.99% match for sequences present in two chimp chromosomes (Hillier et al., 2005). This finding provided a logical explanation for the missing chromosome—at some point after the divergence from the human-chimp common ancestor, these chromosomes fused together in humans and remained separate in chimps.

Part of the reason that the question of why chimps still exist if humans evolved from them is even asked has to do with the physical appearance of chimps. It is worth noting that the degree of evolution, especially in terms of anatomical change, appears to have been much greater along the human line than along the chimp line. This is apparent simply by noting that modern day chimps resemble the other great apes a lot more than people do. But, this does not mean that humans and chimps did not share a common ancestor, only that there was more rapid anatomical evolution along the lineage leading from the human-chimp common ancestor to modern humans, than there was from the common ancestor to modern chimps. That is, as we have noted, chimps are not the same genetically or anatomically as their common ancestor with people. Thus, tongue-in-cheek, we could look at the fact that humans and chimps are "sister species" and say that chimps evolved from humans. But, this might be an insult to chimps…

The bottom line is this: humans did not evolve from chimps. No evolutionary biologist ever said so. Humans and chimps evolved from a common ancestor that neither of them resemble today. The evidence from anatomy, fossils and DNA shows clearly that human and chimp lineages continued to evolve after they separated from a common ancestor six to seven million years ago. Clearly their common ancestor that looked more ape-like than human-like by modern standards, as a result of more rapid and extensive anatomical and behavioral changes in the lineage leading to humans. It often happens that evolutionary rates between species evolving from a common ancestor are not equivalent, and many mechanisms are possible. For humans and chimps, Richard Wrangham (2009) published an intriguing theory for why humans underwent such radical anatomical and behavioral changes: cooking.

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Chapter 5: Are humans still evolving?

The story of the peppered moth is one that many introductory biology courses use to explain the concept of evolution. It is utilized due to the fact that a change in gene frequency can easily be seen over relatively few generations. If you are not familiar with the experiment, the basis is that in the midst of the Industrial Revolution in England, smoke from factories darkened the bark on tree trunks. The once camouflaged peppered moth with its bark-toned wings became rare and a darker version became more common. Not incidentally, the new wing color matched the bark on the darkened trees.

It is clear that gene frequency changed in the pepper moth as a result of a changing environment. The moths obviously changed due to a shift in environment, so let us examine the ways that humans also are change to better suit a modern environment.

As the world morphs away from prairies and more towards skyscrapers, humans, like all organisms, evolve to better fit their surroundings. This means that some basic survival behaviors of common shared ancestors are lost, or at least suppressed, over time and more complex mechanisms are expressed within human physiology, anatomy, and psychology. Wisdom teeth illustrate a way that humans have maximized their efficiency due to a major diet shift. Biologists believe that human's third sets of molars aided our ancestors with eating leaves - which requires more chewing and teeth grinding (Hullinger 2015). Today, we cook our food and eat more meat, which reduces the need for larger jaws and an extra set of molars. Since we last shared a common ancestry with chimpanzees, human jaw sizes have been gradually decreasing, but the gene that is in control of the production of our wisdom teeth is still active in many people.

Princeton researcher Alan Main noted that the oldest fossils missing wisdom teeth are from China 300,000 years ago, suggesting the mutation that that suppresses wisdom tooth formation in about 35% of humans today might be rather old (Main 2013). Scientists predict that wisdom teeth will eventually disappear altogether, signaling that we are in the midst of evolutionary process (Hullinger 2015). Even though wisdom teeth are not a life or death component, growing teeth that can cause infections or complications later on in life are unfavorable, leading to a decreased gene frequency for wisdom teeth.

Another example of humans evolving can be seen by performing a simple test. Placing your pinky and thumb together will reveal whether you possess the forearm muscle *palmaris longus* or if you are one of the few who are missing it. Studies show that in Caucasians (it is variable in different populations) 16% of those tested were missing the muscle in one arm and 9% had an absence in both arms, making this muscle one of the most variable in humans (Thompsen 2012). Do not be alarmed if you are missing this forearm muscle, though, as it does not give any more strength to the forearm. In fact, it is seen as a remnant of human's ancestors that were quadrupedal (used four legs to walk) instead of bipedal (using two legs to walk) to stabilize themselves on their forearms (Capdarest-Arest 2014). A reason for this change could be that genes controlling the development of this muscle are being suppressed in some people due to humans adapting to their new, self-created environment. This slow but present change is an indication that we are undergoing evolutionary changes of the forearm in our lifetime.

Evolutionary changes occur in humans as a result of sexual selection as well. Sexual selection usually occurs due to the fact that females put a large amount of effort into reproduction and only produce a limited quantity of eggs, while males produce an over-abundance of sperm and are not required to put in much effort past copulation. This creates a dynamic for females to be "choosy" and select the male with the most attractive features. Classically, men with behaviors to protect the family like survival skills, protective characteristics, and hunting ability were most desirable. Over time, as human society has changed to monogamy, men have needed to rely less on family protection and hunting, and more on family raising and holding a job. This, in turn, leads to women desiring more caring traits than masculine when compared to past centuries. This is evident, as a study shows women prefer less "masculine" characteristics, but more "feminine" ones like larger eyes and wider lips (Perrett 1998). That is, women might be selecting for better parent skills as opposed to better hunters. This is evident biologically, as studies have shown that sexual dimorphism, or a difference in appearance between the two sexes, has decreased in the last 100 thousand years, according to fossil record. Again, this is another strong indicator of an evolutionary change due to a larger abundance in the gene frequency of "feminine" characteristics.

A final example of human evolution is seen in the ability to digest lactose, a relatively new ability in humans. Lactose is the sugar in milk that is digested by the enzyme lactase. You may have heard of this sugar when people are lactose-intolerant, or have digestive issues when they ingest dairy products. Most mammals, including humans, were designed to only drink their mother's milk as a baby, but then wean off of it in their first few years because the production of the enzyme lactase diminishes with age. Humans in many cultures follow this trend, but in some cultures, such as Europe, lactase persistence can be seen (Gerbault 2011). This is the opposite of lactose intolerance in which the enzyme lactase is produced through life instead of stopping at a young age. Lactase persistence has not always been present and greatly differs throughout different populations in the world. This can be explained by the differences we see in different cultures, as very high rates of lactase persistence are found in pastoralist societies and very low rates in non-pastoralist societies. The reason for this change is biological, as just a single nucleotide (or C,T,A,G letter in your DNA) determines your lactose-digesting fate. You may think that there is a dairy-digesting gene that has evolved and then spread throughout the world, but this is not the case. The ability to digest lactose actually is controlled by different mechanisms in different populations. Thus, rather than a simple "genetic switch" being thrown that permits lactase to be produced after childhood, it suggests that the trait actually arose multiple times (Gerbault 2011). Different populations could have had different reasons for gaining this mutation, as in requiring the nutrition of milk during famine, gaining Vitamin D in areas of little sunshine, or just a product of culture. The fact that different populations evolved the trait to better suit their environment shows how strong of a force evolution is and that it is clearly a force in humans.

So although we may picture evolution in something as clear-cut as Darwin's Finches or the peppered moth, evolution is occurring within our own species as well. Through gaining mechanisms and behaviors to cope with our current environment like adapting to a modern diet, walking upright, and changing parental duties with mothers and fathers sharing family responsibilities, humans are evolving. As time goes on humans will change their environment

and evolution will follow for people to have the best chance of survival and reproduction in their human-altered modern world.

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Chapter 6: Evolution leads to immoral behavior in people

If someone annoys you, why don't you just kill them? If you come across someone smaller and weaker than you, why not beat them up and take their valuables? What's stopping you from having sex with your best friend's partner? If you're religious, you might say you don't do these things because God tells us not to. Conversely, if you don't believe in God, and instead believe that the primary goal of organisms, including humans, is to compete with one another to spread their own genes, what promotes you to be kind to and help others (isn't that an evolutionary waste of time?), and what prevents you from committing crimes that would improve your chance of creating more progeny? After all, isn't the goal to make the largest genetic contribution to the next generation as possible?

It's understandable why some people are uncomfortable with the idea that the behavior of humans, like all other animals, was shaped by natural selection to promote the spreading of one's own genes. After all, it's easy to find examples of hideously immoral behavior for the sake increasing reproductive success in nature: male ducks are known to force copulations with unwillingly females, male lions kill the cubs of the previous dominant male when coming into a new pride, and female spiders eat their mates to provide nutrients for their offspring. It's scary to think that human behavior may be governed by the same rules--that we should do everything we can to increase our genetic contribution to the next generation, even if it means developing a taste for our hubby's flesh (though I do seem to recall reading an article like that in Cosmo….).

The good news is natural selection doesn't always take the most obvious route to attaining reproductive success. When you think of the phrase "survival of the fittest," the first thing that comes to mind is probably the strongest individuals fighting each other for access to mates and other resources, while the weakest ones die of starvation or get consumed by predators, rarely (if at all) being reproductively successful. However, in reality, natural selection is a *little* more nuanced than that. The best strategy isn't always to look out for number one and screw over everybody else you may consider to be competition. Sometimes it pays to cooperate--especially if you live in groups with other members of your species.

There's many evolutionary reasons for people to behave altruistically (and not badly). If the goal of life is to pass on your family's genes, it is beneficial to take care of your relatives. You and your siblings share roughly 50% of the same genes; helping them succeed is in your best interest genetically. You should also probably help your partner especially after you have a child; since human infants are born totally helpless, they have a better chance of survival and living a healthy life if they have two parents cooperating to raise them (or at least in our evolutionary past). Behaving altruistically may even help you attract a partner--women may find generosity attractive in men, as it indicates that he has the means and the kindness to give to her and her offspring.

Altruism can also be beneficial through reciprocity to individuals that are not even kin--if you help someone now, they'll be more likely to help you in the future. This is particularly important in hunter-gatherer societies, where hunters often come up empty handed. If each hunter relied on his own ability to catch something to eat, he and his family would go hungry

most nights. Instead, when one hunter catches something, he shares it with others who have failed, with the agreement that when he fails they will share with him.

Of course there will be cheaters in the system--those who try to take more than they give, to take what is not theirs, those who murder and rape. But, we have evolved to deal with this too. At best, we may refuse to continue to cooperate with cheaters, at worst, we may imprison them for an extended period of time or life (a consequence that can be seriously detrimental to your reproductive success).

So, do we only give to others so that they will give to us, and do we only refrain from hurting others so that we won't be punished? Sometimes (you can probably think of examples in your own life) you've done something nice for someone in order to benefit yourself (maybe you've done the dishes before asking your mom for money to go out), or not done something out of fear of the consequences (ever wanted to knock someone's teeth out?). But we've also evolved to feel good when we help out others and feel bad when we hurt them, just as we've evolved to feel good when we have sex (we're usually not thinking "I'm only doing this to create offspring so I can have more genes in the next generation") and feel bad when our attempts to have sex are thwarted ("Darn it! I didn't get *anyone* pregnant tonight!").

Ultimately our brains (and thus our behavior) are shaped by selfish genes that continue on only if they get themselves into the next generation. But selfish genes don't always program selfish behavior. For us, to be selfish is to be altruistic.

The bottom line is that evolutionary biologists do not commit immoral acts at a rate higher than religious people. In fact, it's the reverse. If we make the tenuous assumption that all evolutionary biologists are atheists (as opposed to agnostics), here are some data to put in perspective the fact that accepting the scientific facts of evolution does not lead people to immoral acts:

"Of the prisoners *willing to give their religious affiliations* (and that's an important caveat), **atheists make up 0.07% of the prison population." (**From http://www.patheos.com/blogs/friendlyatheist/2013/07/16/what-percentage-of-prisoners-are-atheists-its-a-lot-smaller-than-we-ever-imagined/). However, the percentage of athesist sin the genral population is estimated at between 0.7% and 1.6%. Hence, atheists are underrepresented in the US Federal prison population.

Chapter 7: Intelligent design: Creation Science in new clothing

"Black as midnight, black as pitch, blacker than the foulest witch", not only a memorable line from the movie "Legend", but also the first thought to run through my head the second they cut the power to the lights. In a cavern, roughly 180 feet underground, I and about 20 other tourists on the "Hidden Passages" tour found ourselves surrounded by complete, uninterrupted darkness. A darkness so pure I couldn't even see the outline of my own hand when it was mere inches from my face. After a few audible gasps and a quick camera flash, the lights were back on. My eyes strained, attempting to readjust to the light. In front of me, an impressive and intricate display of stalagmites and stalactites formed a large column known as the "King's Throne". As we made our way through the winding corridors of Natural Bridge Caverns in San Antonio, Texas, I marveled at the pristine springs that littered the cave floors, clear and still as glass. I "oohed" and "awed" at the 'soda straw' stalactites that hung from the ceiling like crystal chandeliers. I stared in wonderment at the waves of 'cave ribbon' that lined the walls of the cavern. Overwhelmed by the natural beauty of these 20-million-year-old limestone formations that surrounded me, I found myself thinking, "Wow, there must be a God, this is just too perfect"!

This of course isn't the first time I've thought this. I thought it when I saw the Grand Canyon for the first time. I thought it as I white-water rafted down the Snake river, and again as I hiked through Yellowstone National Park. It came to mind as I biked through the Bavarian Alps. And I think it every time my skis cut through fresh snow covering Mt. Hood or anytime I see the ocean. My point is that, like our planet, some things are so perfect, so magnificent, that scientific reason alone seems incapable of explaining it. That's where the theory of Intelligent Design (ID) comes in.

Intelligent Design is the idea that certain features of life and the universe are not best explained by undirected processes such as natural selection. Rather they are believed to be the creation of some intelligent entity. Does this sound familiar? If you said yes, you're not alone. Often, critics of ID argue that the ideas and theories surrounding ID strongly reflect those found in Creationism. In fact, the modern assemblage of advocates for Intelligent Design is largely made up of Christians that maintain traditional Creationistic views and believe the "intelligent entity" to be God.

So, what exactly sets ID apart from Creationism? According to Intelligentdesign.org, "unlike creationism, the scientific theory of intelligent design does not claim that modern biology can identify whether the intelligent cause detected through science is supernatural". Furthermore, ID advocates often argue that one of the defining distinctions between Creationism and ID lies in their belief that Earth was created more than 10,000 years ago, which does not fall in line with the beliefs of strict Creationists, or "young-earthers," who believe the earth to be 6,000 years old. Supporters also maintain that, unlike Creationism, ID does not attempt to tie together science and religious text to defend or prove the legitimacy of creation as it was described in the Old Testament. Instead, the theory of ID, as per Intelligentdesign.org, "is simply an effort to empirically detect whether the "apparent design" is genuine design (the product of an intelligent cause) or simply the product of an undirected process such as natural selection acting on random variations".

Unfortunately, there are a few glaring holes in the arguments attempting to justify ID as a true scientific theory. Most obvious is the theory itself. Founded on the observation that "intelligent agents produce complex and specified information (CSI)". Intelligentdesign.org goes on, stating that "design theorists hypothesize that if a natural object was designed, it will contain high levels of CSI". Ok, but what is CSI? Well, CSI is based on a complicated theorem, which, upon further review, is unmeasurable. CSI is really an attempt to dress up creationism in impressive-sounding scientific jargon to evade scrutiny from the average layperson who lacks the tools to pick apart what it all really means.

And there is another biological fallacy in the ID claim "natural selection is an undirected process acting on random variations." It is true that environments change and that organisms must adapt for their lineage to survive, Darwin's survival of the fittest. It is also true that mutations, the source of variation, are thought to be random with respect to need. Thus, it is in essence a lucky happenstance when a mutation provides the raw material for successful evolutionary change. But, given how many organisms there are and the size of genomes, there are a great many beneficial mutations (see essay on mutations). But are mutations always coming to the rescue? Given that over 99% of all species that ever existed are extinct, the obvious answer is no. So, the quote that began this paragraph can now seen to be a rather major misunderstanding of how evolution works.

Prior to entering the cavern at Natural Bridge Caverns, tourists were provided with a brief history of the geological masterpiece. We were lectured on the two basic types of caves, "active" and "relict". Relict caves are abandoned, inactive caves that no longer have streams of water flowing through them. However, because water still flows through the caverns at Natural Bridge, they are continuously growing, therefore they are classified as a "active caves/caverns".

Much like a relict cave, Creationism is rapidly being abandoned. Thanks to advancements in science and technology, an ever-growing fossil record, and globalization, people now have access to endless sources of better and better information that allow them to formulate their own conclusions. Because of this, relict concepts like Creationism are becoming antiquated, and the (many) attempts at requiring teaching of intelligent design alongside evolution in classrooms have never come to fruition, as courts ruled that ID is not based in the scientific method. The advent of Intelligent Design is an attempt at breathing new life into a dying ideology. By attempting to mask it as a scientific theory, ID is more likely to be adopted by younger generations, because unlike Creationism, ID does not outwardly claim God as the "intelligent entity" behind intelligent design. However, upon closer inspection the margins separating ID and Creationism start to disintegrate, and what you're left with is the realization that God and "intelligent entity" are one in the same.

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Chapter 8: Macroevolution – great moments in the evolution of life

One of the great moments in modern science was J.J. Thomson's discovery of the electron in 1897. At the time, scientists knew about electricity and even worked with it by passing voltage through cathode tubes. Great debate occurred over whether the resulting rays in the tubes were waves or streams of particles until J.J Thomson placed one of the cathode tubes in a magnetic field (PBS). When he did this, the rays bent to one side which indicated to him that the rays were made of small particles. By further studying how far magnetic and electric fields deflected the rays, Thomson was able to propose a mass to charge ratio for the newly discovered particles known today as electrons (NobelOrg). Now the electron is an integral and universally accepted component of our understanding of the world, yet a noteworthy characteristic of the electron's existence should be stated—no one has ever seen one.

SuperSTEM, one of the most powerful microscopes in existence, can resolve individual carbon atoms in a material—an absolutely ludicrous leap in magnification technology—yet to see an electron would require 100,000,000 times more magnification (Gaughan, n.d.). To put this into perspective, the SuperSTEM microscope can image objects one million times smaller than a human hair (Turk, 2015). To see an electron, the microscope would need to image objects one hundred trillion times smaller than a human hair (Gaughan, n.d.). So how do scientists know that electrons exist? The same way J.J. Thomson discovered them in the first place—with scientific evidence. Evidence through experimentation has propelled the electron from an idea in the 19th century to a universally accepted building block of life by the 20th century. Despite the fact that no one has ever seen an electron, the evidence supporting them is sufficient to standardize their existence. Consider what would happen if we applied this same line of thinking to the concept of macroevolution.

Evolutionary changes occur in lineages over time as species adapt to ever changing environments. Some of the changes are relatively minor, such as populations in different parts of species ranges becoming larger or smaller, darker or lighter. These changes are often called "microevolution." In fact, some creationists think that Noah only brought overarching "types" of animals aboard the ark, and that subsequent microevolution resulted in the post-flood diversification. For example, there are approximately 240 taxonomic families of birds living today (and many more in the fossil record), and potentially Noah only had to bring 480 different birds (a male and female of each family) that later evolved into the 10,000 species alive today. It is not clear how many beetles Noah would have needed as types, as today there are approximately 400,000 species; if he had taken a dozen, that would result in an enormous rate of evolutionary change to gain 399,988 new species in the last 2,400 years since the flood waters receded. Indeed, that would give a major role to microevolution.

At the other end of the spectrum of evolutionary change is macroevolution, or major evolutionary change. In particular, macroevolution accounts for the evolution of major kinds of plants and animals. That is, transitions from water to land, for example. In some popular literature, it is noted that no one has ever seen a butterfly evolve from a wasp. First, we must be clear that no evolutionary biologist has ever claimed that wasps evolved into butterflies. To understand more fully the validity of macroevolution, we must consider how the theory of natural selection leads to new species and how long that process takes before considering the evidence currently validating macroevolution. Perhaps in the 21st century, macroevolution is our version of the electron—an idea on the cusp of universal acceptance through evidence.

Four basic mechanisms drive evolution—mutation, gene flow, genetic drift, and natural selection. (mutation and natural selection are dealt with in other essays, genetic drift refers to the role of chance in genetic change, and gene flow refers to the genetic effects of individuals moving among populations) Darwin's theory of natural selection, the last of these four, proposes that more individuals are produced each generation than can survive, and genetic differences between individuals allow the organisms with more suitable traits for the environment to survive and reproduce, thereby passing on their traits that allowed their survival relative to others (McClean, 1997). In many populations, this phenomenon takes considerable amounts of time to yield results, so critics claim that natural selection is too slow to explain how one species "splits" into two through macroevolution. Supporters of the macroevolution theory point out that the proposed 3.8 billion years that life has been evolving on earth is plenty of time for natural selection to run its course and result in the widespread biodiversity that earth plays host to today. Understanding the specific patterns described under the umbrella of macroevolution provides context to the validity of the supporters' claims.

Macroevolution involves stasis, character change, speciation, and extinction (Berkeley). In other words, populations of organisms can go through time unchanged, develop new characters, become two new species, or become extinct. The third component of this list is likely the most controversial—one species becoming two species through evolution. Speciation events occur when two populations split to become two species, which is typically initiated by a geographical or environmental barrier that prevents them from coming into contact and hybridizing. For example, when the isthmus of Panama closed, species of snapping shrimp were isolated from one another by the new geographical barrier between the Atlantic Ocean and the Pacific Ocean. Modern genetic differences between the shrimp are quite apparent and even show that the shrimp began to evolve into different species before the final closing of the isthmus (Hurt, Anker & Knowlton, 2009). In general, comparing any two species' nucleotide sequences, the basic building blocks of the genetic code, provides a wealth of information about when and where speciation events may have occurred. In the case of the shrimp, there are many pairs of species where each member of the pair is isolated by the Isthmus of Panama. Thus, seeing evolutionary change over short time scales is readily apparent and in evidence everywhere biologists look. However, we have single-celled organisms and elephants, but no one witnessed the transition. Can shrimp evolution account for large-scale macroevolutionary changes? Are there any examples?

In the 1990s, scientists believed that modern whales evolved from land-dwelling mammal ancestors called mesonychid, and this belief was met with substantial opposition. In fact, DNA studies show that whales and hippos are each other's nearest living relatives, which is certainly not obvious from their anatomical features! Creationist advocate Michael Behe claimed, "It seems like quite a coincidence that all of the intermediate species that must have existed between the mesonychid and whale, only species that are very similar to end species have been found." The very next year, in 1994, researchers from the University of Michigan found transition fossils of whales and mesonychid ancestors in the desert of Egypt (Gingerich et al., 1994). These transition fossils indicated that major evolutionary changes happen slowly, over long periods of time. Furthermore, if major evolutionary changes in morphology are rapid (called saltational in evolutionary biology), transition fossils would likely not exist as the transition period itself would be too short to be documented in the fossil record. It cannot be emphasized enough that

the fossil record is not a dense book in which we can turn to a given page and see what was alive at the moment.

In most cases comparisons of closely related species will not constitute evidence that most think of when they envision "macroevolution", but if one compares species farther apart on evolutionary trees, the differences are apparent. So, yes there is a connection between wasps and butterflies, as each is an insect, but there are many intermediate lineages as each is on a different branch of the insect tree of life. It is not a direct transition. A closer-to-home example of how major anatomical and behavioral changes can occur over a short period with little DNA change is the difference between chimpanzees and humans, who last shared a common ancestor on the order of 6 million years ago. This is a case in which one lineage (humans) underwent rapid evolutionary change relative to its sister species (chimp), but comparison of humans and chimps, reveals "macroevolution" at its finest.

Much like the whale-mesonychid evolutionary history, the divergence of human and chimpanzee lineages left transitional forms in the fossil record. Unlike the blatantly clear whale transition fossils, differences among the human-chimp fossils are subtler. By closely examining the ancient skulls of early humans compared to modern anatomical skulls, a clear shift in frontal lobe size and jaw-line structure is apparent. The Smithsonian institution houses a large collection of these skulls. If they are arranged from most ancient to most recent and a modern chimpanzee skull is placed one space beyond the most ancient human skulls on record, it nearly identically resembles the *Australopithecus africanus*, a known ancestor of humans (Theobald, 2000). The chimpanzee skull is a nearly irrefutable starting point for the progression of human skull development. Once again, this chronological progression of human skulls starting from an ape ancestor paints a picture of macroevolutionary change, especially when one views the two extremes.

When we consider the enormous (and unanimous) amount of evidence showing the validity of the theory of evolution, arguing that macroevolution is invalid because no one has ever seen it occur is at odds with all evidence. No one has ever seen a wasp evolve from a butterfly just as no one has ever seen an electron that resides in the atoms of these animals. However, the indirect evidence backing the existence of these ideas is sufficient enough to support their legitimacy, in both cases. Perhaps in the next century the public will accept macroevolution as readily as the electron.

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Chapter 9: Mutations are always bad, they do not lead to evolutionary success

Big budget fantasy films have become very popular in the last 15 years or so, and many come from adaptations of novels or comic books. Many of the origin stories of well-known super heroes, and villains in these films and books involve the character either being born with or acquiring some traits or features through "mutations." In Spiderman, Peter Parker is bitten by a radioactive spider which released "mutagenic enzymes" giving him his powers. In other fantasy films there are variations of plots involving mutated creatures and abhorrent figures created by scientists in labs or through other means. The majority of cases that portray mutations or mutants in popular culture often use the words with a negative undertone, or show dreadfully disfigured creatures. These depictions in pop culture of mutations lead one into almost instinctively thinking of them as detrimental, a feel likely shared by many.

These ideas of mutations from fiction can cause confusion about mutations in the real world. This confusion is amplified by groups who oppose evolution claiming that mutations cannot provide "new information". Those against evolution generally use the term mutations to refer to leaps between kinds of organisms such as an amoeba evolving into a fish and then state that there are no examples of such mutations. Perhaps we should first examine exactly what mutations are and how they are considered by evolutionary biologists.

To understand how an organism's features change it's important to understand how mutations work. Mutations change DNA (Deoxyribonucleic acid). DNA is what encodes the instructions for an organism including how it works and in part how it behaves. DNA is built from four subunits: cytosine, guanine, thymine, and adenine, and once there is a linear sequence of these subunits (also called bases), the DNA strand coils. Sets of three subunits specify a specific amino acid or the end of a protein. Certain parts of DNA encodes proteins while others do not. If one DNA base is substituted for another, it has a chance of changing some outward aspect of an organism. Some base substitutions in a triplet (also called a codon) do not change the amino acid that is placed into the protein, and hence are "neutral", neither bad nor good. Substitutions that result in a new amino acid being inserted into the protein can make it better at doing its job, the same, or worse (Population and Evolutionary Genetics, 1997).

Mutations are the "stuff" of evolutionary change. Mutations provide variability in populations which enables evolutionary change to occur (Loewe, 2010), such as when a species finds itself in a new or changing environment. Because mutations are heritable, any new traits can be passed from generation to generation. Differences in the genetic code are translated into differences in the ways individuals develop, look as adults, behave, and even think. Thus, the ultimate basis of an evolutionary change traces back to a mutation. Ultimately, mutations have led to millions of living species worldwide because without changes in DNA sequences we wouldn't have the vast differences in development and features that we observe today and throughout evolutionary history. Mutations are beneficial!

Perhaps some of the negative connotations about mutations stems from the fact that organisms also do not become perfectly adapted to their environments, in part because their environments are not static. They may move to a new environment, or their environment may change around them while traits which may have been useful to the old environment remain.

This is why we still have vestiges of previously adaptive traits that are on their way out, such as appendixes. It's important to remember that much of an organism's environment is also evolving. Viruses and bacteria evolve particularly quickly, rapidly adapting to their hosts' defenses so that we can never be quite rid of them. The reason we need a new flu shot every year is because of mutations in the influenza virus!

The reason mutations are sometimes misconstrued as only harmful or incapable of providing "new information" is also due to the randomness in which this all occurs. In particular, organisms do not encounter a new environment and then begin the mutation process. Instead, mutations occur at a constant rate, and even if an organism needs a "lucky" mutation to survive it will not, unless by random chance. Furthermore, an adaptation that helps you in one way can harm you in another. For example, seals are adept swimmers, but the same characteristics that make them agile in the water (stream lined body with reduced limbs formed into flippers) make them clumsy on land. Though they need to be good swimmers to hunt, they must also be able to get around on land where they give birth, rest, and evade aquatic predators. They would be more efficient on land if they had legs, and they could probably be better swimmers if they ditched the traits that made them able to scooch around on land. As it is, they must strike a balance between the forces pulling them to either extreme.

While it is true that many mutations are detrimental to an organism and ultimately lost, to say that mutations can only eliminate traits is misguided. DNA dictates how organisms develop, and mutations, which causes changes to DNA, are responsible for the traits that have arisen in the vast array of species on earth. These mutations coded for traits that were chosen against and went extinct, but also for traits that gave individuals an edge over the competition. Given that some 5 million species inhabit the earth, we can point to mutations as the reason for their success. Thus, we can conclude that if no new genetic information occurred all organisms would stagnate, and life as we know it would go extinct.

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Chapter 10: Before Noah's Ark: Considering the validity of the "great flood."

The Biblical story of Noah's ark embodies many different sentiments for many different people. For some, this grand tale elicits hope and inspiration; for others, controversy and skepticism. As of October 2016, believers and skeptics alike can visit Ark Encounter—a theme park with an ark built to match the dimensions passed down from God to Noah in the book of Genesis in the Christian Bible. A $60 admission grants access to the ark and all of its exhibits, including a museum with timelines dating the earth at 6,000 years old, graphics arguing against human-caused climate change, and plans detailing how Noah and his family of seven built the nearly 2 million cubic foot ark[1]. Perhaps the controversy is understandable.

Ark Encounter illustrates one side of the creationist-evolution debate—a philosophical juggernaut that pits belief in a higher power against scientific evidence. Those who support creationism find validity in the grandeur of Noah's ark, for they believe that only a God could empower humans to create such a monstrosity and sail it successfully. Those who support evolution look to Noah's ark as a grand tale full of inconsistencies and blatant scientific flaws. Before debating if and how Noah's ark could have existed, we must first consider the validity of the great flood itself. Many scientists doubt the possibility of a worldwide flood, yet believers claim that it not only happened, but caused an ice age. The pursuit of this truth is no simple task, but modern advancements of technology allow us to further comprehend the possibility of the flood.

Contenders on each side of the Noah's Ark debate rely on their understanding of the age of the earth to explain their support or disbelief of the great flood. Fortunately, scientists have devised numerous ways to scientifically age the earth. One of the most notable ways comes from radiometric dating. Radiometric dating is the process of dating rocks by taking into account the amount of atomic decay that has occurred within the sample over time. Isotopes are radioactive forms of various elements that contain a different percentage of neutral particles than the most common form of the element. Because the isotopes are radioactive, they decay at a constant rate. This is not controversial. For example, the half-life of uranium is about 4.5 billion years[2]. By measuring the ratio of uranium to lead in a sample, scientists can calculate how old the sample is from its half-life.

Other elements are also radioactive and have different half-lives from uranium. Carbon decays into nitrogen with a half-life of 5,730 years, a much shorter half-life than uranium[3]. These different half-lives give scientists different scales for dating objects, like adjusting the magnifying lens on a microscope. Radiometric dating allows them to compare the amount of isotope to the amount of stable element present and therefore use it as a reliable dating technique. In contrast, the Biblical age of the earth is gleaned from ancient texts largely documented by Bronze-age shepherds living in the desert, edited and reedited through time. Therefore, accurately dating historical events from these texts is understandably difficult. Those interested in dating the great flood have proposed a variety of theories about its occurrence. In 1999, Dr. Robert Ballard, the archaeologist who found the Titanic, dredged the floor of the Black Sea and found fossils that indicated an ancient shoreline. Using radiocarbon dating, Ballard found saltwater species ranging in age from 2,800 years to 6,820 years and freshwater species ranging in age from 7,460 years to 15,500 years. These findings support the

idea that the Black Sea was a freshwater lake until flood waters entered from the nearby Mediterranean about 7,000 years ago[4]. This evidence indicates the presence of a monumental shift in salt-levels and animal species in the Black Sea around the time that Noah could have built the ark.

Creationists point to this evidence to support the idea that ocean levels rose as an act of God and inundated the previously freshwater Black Sea during the great flood. Recently, marine geologists have found evidence to suggest that glaciers from an ice age melted around 9,400 years ago and caused Mediterranean waters to rise and flood the Black Sea[5]. Fossil evidence indicates that these floods wiped out 2,000 square kilometers of agricultural land— certainly enough area to have an impact on the anthropology of Europe but not remotely enough to flood the entire world. The evidence for a change in salinity of the Black Sea is not enough to validate the idea that a world-wide flood occurred during that time-frame. In addition, the proposed dates for such an event surpass the proposed age of the earth in the Creationist view.

Creationists who support Noah's Ark tend to propagate the theory that the world is 6,000 years old based on literal readings of biblical accounts. For example, many people make the arguments that the global flood occurred around 2,400 years ago and Noah's Ark carried all of the animals we know today. In addition, they argue that the fossil records indicate a flood and the ice age was a result of such an event. Not surprisingly, scientists disagree with each of these proposed arguments.

Scientists have shown that fossils are organized within the layers of earth's crust. The most ancient organisms are found deeper beneath the surface and the most modern organisms are found near the surface. This occurs because the earth is constantly adding layers to its surface and organisms become petrified. Petrification is a process in which these organisms' organic material is replaced by rock, allowing them to be preserved. The Earth's layers clearly show a timeline of Earth's organisms and can show how life has evolved from invertebrates to modern mammals. If a global flood had occurred some 2,400 years ago, there would be disturbances in the record that are not visible today[6]. If a flood had occurred, organisms living at that time with similar forms would be sorted by how they float in water and not by time, as they are found today. Also, fossilized pollen from distinctly different plants is clearly sorted between layers of rock. If a flood had occurred, pollen would not be sorted in this way because the water would not allow such separation to occur. A global flood would result in all fossils, primitive and advanced, to be in the same layer.

Based on the fossil evidence, it is logical that historical records of a great flood refer to the 2,000 square kilometer flooding of the Black Sea around 7,000 B.C. Given the likelihood that this flood did occur in the Mediterranean region, it is very possible that *if* Noah did build an ark he was under the false pretense that the entire world was flooded because the world as he knew it may have been underwater. Without the ability to see the rest of the world thriving, it is understandable that he believed the whole earth was flooded. Additionally, in the evolution of orally-based traditions, the flood may have grown from 2,000 square kilometers to the entire earth's surface; exaggeration is not likely a recent human invention. The existence of a flood does not necessarily prove the existence of the ark. Furthermore, if the ark did exist, Noah and

his family would have needed some substantial divine intervention to carry out the logistics of God's plan to preserve the species of the earth.

The circumference of Earth at its equator is 24,901 miles. The fastest modern sailboat in the world averaged a speed of 30.8 miles per hour. In this boat, it would take 33.5 days to complete one un-interrupted lap around Earth. When considering Noah's Ark, biblical accounts give no indication that it had a mast to catch wind. Time must have been of the essence for a man and his family that had to travel from continent to continent collecting 14,000 different individual animal species and the different types of food they would need to be able to feed all of them for 300+ days. As the flood waters receded, there was the need to revisit all the continents and return the animals that were characteristic to them. For these reasons, Noah was either ahead of his time in terms of modern engineering and navigation techniques, received divine intervention to make overcoming these logistical obstacles possible, or he never had to build an ark to survive such a world-wide flood.

Debates about the legitimacy of Noah's ark often center on the animals that he and his family collected, cared for, and eventually distributed around the world after the flood. However, Noah's ark would have needed to ensure the longevity of plants and the millions of kinds of bacteria and viruses as well. The idea that Noah preserved "types" or "precursors" of the upwards of 5 million species on earth today is difficult to fathom. Perhaps as a parable, Noah's Ark has stood the test of time, but no competent biologist would support the validity of the story.

To conclude, let us consider the survival of the human race after this great flood. The biblical account of this flood explains that Noah and his seven family members were the only surviving members of the human race, which implies that they repopulated the now more than 7 billion humans on earth in a little over 2,000 years. The biblical idea that eight people began a cycle of reproduction that led to 7 billion people in just over 2,000 years is difficult to imagine on its own, yet a more tangible concept underlies the improbability of this theory: incest. If eight humans, five of whom shared 25-50% of their DNA with each other, were left to repopulate humanity, the likelihood of the occurrence of incest is understandably high. Incest has a detrimental effect on viability of genetic material and it leads to increased health complications. The plausibility of these eight people successfully reproducing and generating a strong foundation for the modern human population seems low. In addition, starting with eight individuals and arriving at seven billion humans in two thousand years is beyond logical comprehension.

The symbolic importance of the Noah's Ark story is undeniable. Unfortunately, the evidence supporting the biblical standpoint is nonexistent. Modern radiometric dating and fossil records provide some of the most convincing evidence against a great flood. Perhaps in Noah's day, large-scale regional flooding engulfed the only portion of the world he had come to know which led to the re-telling of the story of such a flood. Regardless, this story—one as old as biblical time—will certainly continue to provide interesting philosophical, religious, and biological fodder for debate until the time when science is recognized as the authority for understanding earth's history.

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Chapter 11: Did humans and dinosaurs coexist?

Most people have seen, or at least heard of, the movie *Jurassic Park*. It's a science-fiction adventure film that was released in 1993, and showed the most realistic-looking dinosaurs to come to Hollywood's big screens for its time. Not only was the cast and plot of the film great, it depicted a world that fascinated thousands of people; what would happen if the human and dinosaur world collided? Although the film is incredulous in the creation of these dinosaurs, seeing that we would clearly not be at the top of the food chain is a pretty accurate representation of what that world would look like if it were true. Nevertheless, it raises the question of what-if. Is it possible that humans and dinosaurs actually coexisted? Perhaps it is the role media has played in amplifying this fallacy of coexistence that has caused so many to believe it to be true. Regardless of how this falsehood got started, we have substantial evidence to prove that it is indeed just a misconception, and to explain why it's not plausible to think that humans and dinosaurs could have overlapped and coexisted in history.

No human and dinosaur fossils have ever been found together, or even in close layers in the fossil records (Hodge 2007). The last of the dinosaurs, excluding ancient birds that are dinosaur descendants, went extinct approximately 65 million years ago, and the earliest human ancestor fossils found have been about 6 million years old (Pickrell 2006). Scientists have found dozens of ways to determine the approximate age of fossils, such as Carbon-14 dating which measures radioactive decay of elements, electron spin resonance by measuring the amount of electrons that become absorbed or trapped in fossils through time, and biochronology that gives a relative chronological order of fossil history in layers of sediment from oldest to youngest (Peppe and Deino 2013). They try to combine multiple forms of dating fossils to determine relative and absolute accuracy. Even if the way fossils are measured is not exact, give or take a couple million years and there is still a gap of over 50 million years in history.

In the Mexican Yucatan Peninsula lies a 13-kilometer-wide rock ridden with iridium. This rock is the remnant of the infamous asteroid that struck the Earth 65 million years ago. As a result of the impact, which initially left a 180-kilometer-wide Chicxulub crater, all non-avian dinosaurs went extinct (Pickrell 2006). Cohabitation between humans and dinosaurs could never have existed regardless of whether or not an asteroid hit the Earth. During the Mesozoic era when dinosaurs dominated the planet, mammals lived in their shadows. The largest mammals at the time were no bigger than the size of an average house cat, and their size is largely related to the dominance dinosaurs displayed over the available niches. The extinction of non-avian dinosaurs not only catalyzed the progression towards humans as we know them today, but it also was the driving force that allowed evolutionary forces to take place. Mammals only began to increase in size after the extinction of non-avian dinosaurs, which ultimately led to the rise of the human lineage approximately 60 million years. The extinction of non-avian dinosaurs was crucial in giving mammals their chance to evolve (Geggel 2015).

In 1984, people found fossilized dinosaur tracks with what looked like giant human footprints in the limestone beds of the Paluxy River in Glen Rose, Texas. Creationists used this finding to argue that there was finally proof of the coexistence of man and dinosaur that contradicted the geological history. However, not long after its discovery, the giant man-like footprints were found to be eroded imprints of the heels and soles of bipedal dinosaurs, most

likely followed by mud backflow from the riverbed that gave it the impression of a giant human footprint. A few people, such as Carl Baugh, Don Patton, and Ian Juby still promote the Paluxy tracks as evidence for coexistence, but neither the "mainstream scientists nor major creationist groups" consider it credible due to the scientific evidence that refuted the Paluxy claim (Kuban 2012). After the Paluxy example, it was established that, once again, no fossil evidence supports the coexistence of dinosaurs and man.

The speculation that dinosaurs and humans coexists comes from the bible, specifically the book of Genesis, and mentions that God created man and land animals on day 6 of creation, and since dinosaurs were land animals, they were created at the same time (Hodge 2007). Creationists, people that share this belief, argue that no human fossils have been found with dinosaur fossils because God wanted to eradicate all evidence of man using the Flood, and all evidence of human fossils have been found post-Flood (Men and Dinosaurs Coexisted n.d.). However, there is no reliable, scientific evidence that supports the belief that they coexisted. The Institute of Christian Research claims that man-made cave drawings, tapestries, and legends of dragons provide evidence that the two survived together (Men and Dinosaurs Coexisted n.d.). This could be considered a worthwhile point due to the fact that such claims have been seen in numerous cultures, but if one looks deeper, other factors explain the dinosaur legend. One explanation is that just like today, ancients were able to dig up fossils that showed massive animals (Natural History of Dragons, n.d.). Like other natural phenomena that could not be explained by primitive science, a grand tale was created to explain the discovery – kind of like Greek Mythology. This has evidence behind it, as traditional Chinese medicine uses "dragon bones" as an ingredient in numerous pharmaceuticals. In reality, these are crushed bones of fossils. In addition to this, living animals that resembled dragons or had dragon-like features also could have given way to the dragon myth in other cultures. For example, a town in Austria used the skull of a "dragon" in the town center as a statue; it is now known to be the skull of an ice age woolly rhinoceros (Natural History of Dragons, n.d.).

Due to the ongoing debate between scientists and creationists, it seems very difficult to believe that *any* major scientist or institution would endorse the flood in support of fossil evidence showing that dinosaurs existed alongside humans. According to the scientific community, humans and dinosaurs did not coexist and lived approximately 60 million years apart, which is supported by fossil, historic, and scientific evidence. A survey done in 2015 that surveyed 1000 people across the United States found that 41% of the American population believes that humans and dinosaurs lived on the planet at the same time (Moore 2015). Surely, there will always be those that chose to follow and believe their religious teachings, but this does show a surprisingly high percentage of people that are unaware of its inaccuracy. There needs to be a better way of educating the general public, especially with speculations that have no scientific evidence.

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Chapter 12: Is evolution a theory in crisis?

No, evolution is not a theory in crisis. Michael Denton, most famously known for his opposition to all things evolution, has played a large role in galvanizing the popular misconception that evolution is a theory in crisis. With two publications "Evolution: A Theory in Crisis" and wait for it … "Evolution: A Theory Still in Crisis", Denton has tried time and time again to convince us that the theory that scientists depend on and have based a multitude of energy and work on is simply a sham. Rather than searching for a nonpartisan peer-reviewed outlet to transmit his message, Denton's work was published by a creationist organization called the Discovery Institute. Phillip Spieth, a famous evolutionary biologist described Denton's books as "inexcusably bad science", but somehow through Denton's work emerged misconceptions that spread like wildfire.

In the world of science, a theory in crisis is something that is considered to be on the brink of obsolescence, a wholesale shift in what scientists think is true, which we know to be untrue of evolution. When something is considered in crisis, it is seen as no longer holding relevance to the conversation; however, the theory of evolution is accepted by the vast majority of scientists and scientific communities. These scientists have made statements against the intelligent design theory and have made strides in advocating the teaching of evolutionary biology in schools, which was also supported by 72 United States Nobel Prize winners (Talk origins archive, 2007).

Like with many other intricate subjects, evolution is a topic that is often debated and discussed among scientists. The fact that scientists debate over the topic of evolution is not validation for Denton or anyone else to conclude that there is disbelief amongst scientists about whether or not evolution has occurred and is responsible for the diversity of life on planet Earth. When scientists debate a topic of evolution they are not debating over whether or not evolution occurred in the first place, but rather debating about the different mechanisms and effects in which evolution displays itself (Berkeley "Misconceptions about evolution"). For example, there was a long enduring controversy over whether most changes at the DNA level were "neutral" or a result of natural selection. We now recognize that the truth is somewhere in the middle. Many DNA substitutions (mutations that have become part of the DNA record) have no functional significance. More specifically, when there is a mutation at a third position of a 3-base codon, it might not change the amino acid because there are several "triplets" that code for the same amino acid. However, in other instances there are changes at the DNA level that have adaptive significance that is clearly attributable to natural selection. Though the two groups of scientists have differences both "selectionists" and "neutralists" agree 100% that evolution does occurs, they were debating the "how".

Evolution is a theory that is rich in complexity. Notions of the theory of evolution have existed as far back as with the ancient Greeks (Bardell 1994). Today the theory of evolution is a well-established and accredited contribution to the world of science. Saying that many scientists now refuse to "believe" in it is a fallacy. One cannot "believe" in evolution because it is not a belief. Comparing evolution to something that people choose to believe in is mistaking evolution for faith. Religion according to dictionary.com is defined as "a set of beliefs", something that one chooses to accept as true regardless of the amount of evidence. Substantial amounts of evidence in the form of fossil records, phylogenetic trees, DNA comparisons, comparative morphology,

intermediate fossils, index fossils, etc. all reveal the role that evolution has played on this Earth, thus indicating its validity.

Some confusion may stem from a misunderstanding of what a theory actually is. Because of how the word is used in day-to-day conversation many might believe theories to be less credible than that of scientific laws and facts; however, they are actually higher up on the "hierarchy of science" (Not Just a Theory 2008). Scientific theories are a summation of laws and facts combined. Imagine a brick house, compiled of hundreds of tiny brick pieces. Each brick plays an intricate role in the overall foundation of the brick house, and just as the bricks go to support the overall structure of the house, laws work to build up the foundation of a theory (Kampf 2016). Just as Newton's laws of physics go to explain the theory of gravity, laws go to support theories.

Another issue some might raise with the validity of Evolution is it's "lack of proof". People cannot understand how something that has been verified with numerous amounts of evidence everyday can still remain a theory and not a fact, and that is because in science theories are not something that can be proven, just invalidated. This idea of non-absolute proof in science stems from the notion of undetermination of theory by evidence (Stanford 2013). The idea of undetermination is that universe is so vast and complex that we have no way of concluding anything without some degree of uncertainty. And we will not have that certitude until we have explored all over space and time to gain the assurance that there lies no contradictions in the whole of the universe (Engel 2014).

If the facts that prove the scientific theory of evolution were to be proven wrong through new discoveries, then the theory of evolution could also be proven wrong! However, the more that is discovered through science, the more support there is for the theory of evolution. If alternatively, evidence was gathered that showed that evolution does not occur, scientists would formulate new hypotheses to explain the new observations. But this has not happened. Principles including natural selection, genetics, anatomy, behavior, heritability, fitness, environmental change, and many others are used to create the overlying idea that evolution is responsible for all surviving and extinct species to have ever existed. Over 95% of scientists accept evolution and have for decades; that is hardly the hallmark of "an unproven thought" (Hafiz 2014).

Perhaps an indication of the vigorous nature of modern evolutionary biology is the degree to which it has integrated other fields. One prime example is medicine. Much of modern medical research is predicated on the fact that disease organisms, bacteria and viruses for example, evolve rapidly in response to not only the human immune system, but the drugs we use to treat them. For example, when *Penicillin* was discovered in London in September of 1928, by the bacteriologist, Dr. Alexander Fleming, it immediately became the go-to antibiotic, and transformed the medical profession. Today, most bacteria have evolved resistance, and we had to switch to other antibiotics. Like penicillin, each new antibiotic has an early phase where it is extremely effective, but in time, bacteria evolve resistance and new antibiotics are required. Perhaps one of the most vivid demonstrations of how bacteria evolve resistance to drugs can be seen in the video produced by Harvard Medical school: https://www.youtube.com/watch?v=plVk4NVIUh8. There is no clearer demonstration of the dependence of modern medicine on understanding and incorporating evolutionary thinking.

Another indication that evolutionary theory is not in crisis is that nearly every university has faculty who specialize in research on evolution and teach courses in evolution. There are

over 500 scientific journals that publish papers about evolution, all in support. Many books have been written about the evidence in support of evolution. Hundreds of Masters and Ph.D. theses are completed annually about evolutionary topics. There are many scientific societies dedicated to advancing our understanding of how evolution works (not whether it occurs). For example, in North America the Society for the Study of Evolution, formed in 1947 (http://www.evolutionsociety.org/index.php?module=content&type=user&func=view&pid=40, hosts annual meetings (for the last 15 meetings see: http://www.evolutionsociety.org/index.php?module=content&type=user&func=view&pid=10), and one can download the abstracts from presentations and get a flavor for the rich depth and breadth of contemporary evolutionary research. All of this evidence should make it clear that evolution is not a theory in crisis. In contrast, it is a robust and active field of scientific discovery enjoying extreme success. Thus, it is important to recognize that Denton and others, are using misinformation to create a public perception that suits them.

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Chapter 13: Transitional fossils: finding the missing links

Coming in at 6-feet-tall, completely covered in long, wiry hair, and encapsulated in ice, the "Minnesota Iceman" was a sideshow exhibit that popped-up in malls and state fairs in the United States and Canada in the 1960's. This prehistoric popsicle owes his claim to fame to Frank Hansen, a Minnesota native and bona fide caveman caretaker. Spurring rumors that the missing-link may no longer be missing, the Minnesota Iceman attracted much attention from cryptozoologists and mainstream scientists alike. But was the Minnesota Iceman really the missing link, a Sasquatch, or merely a sideshow gaff?

A common misconception about evolution is that evolutionists cannot point to any transitional fossils -- fossils that show the intermediate states between an ancestral form and that of its descendants (Berkley.edu). Any ill-conceived perceptions regarding evolution and lack of transitional fossils are likely the byproduct of the slang term, "missing-link". An ambiguous term, it has been sensationalized by popular media and even used by creationists as an argument against evolution. However, this term is misleading, as it takes an otherwise complex idea and simplifies it by suggesting the existence of a single, undiscovered (missing) fossil (link) being needed to confirm transition between one kind of organism and another. This is simply untrue.

In fact, although the number of transitional fossils that make up a portion of the fossil record could be in the hundreds or even thousands, the exact count is unclear as the fossil record is incomplete. The probability of any organism dying and being fossilized is extremely small, hence finding fossils is a pretty amazing event in itself. Plus, most fossils are of common organisms, as you'd expect, and if evolutionary change happens quickly and in small populations of relatively rare organisms, the chances of the intermediates being fossilized are even more remote. Thus, lack of intermediates in the fossil record is not due to a lack of species transition. Rather, they are the direct result of just how rare fossils are.

Transitional fossils are indeed key evidence of evolution, and they exist. They are unique organisms that share common body and skeletal features found in two distinct groups of animals, one old and ancestral, the other a descendant with derived and novel traits. However, it does not follow that to be counted as a transitional form, an organism has 50% of the characteristics of both the ancestor and descendent. Transitional forms often have a much more imbalanced distribution of features; but, they are still transitional.

One of the most notable transitions took place over 55 million years ago, when terrestrial mammals became adapted to hunt in the ocean and evolved into whales. Not only did ancestors of modern whales once have legs and feet, paleontologists have speculated that whales' ancestors were likely mammals of the order artiodactyl -- deer- or pig-like scavengers that lived near the sea. A key observation supporting this hypothesis is the existence of the double pulley ankle bone that is present in the hind legs of both ancient whales and modern artiodactyls. The transition from land-loving mammal to water-living whales took millions of years. Once joked about, the existence of walking whales proved true when, in 1902 a team of geologists stumbled upon a prehistoric graveyard in Egypt's Western Desert. Covered in a dusting of sand, the 50-foot-long skeletal remains of 37-million-year-old whales with feet were discovered.

Now known as the 'Valley of the Whales', the Wadi al-Hitan desert was once a shallow, tropical sea, evidence of which is seen in the fossilized remains of sea dwelling creatures, as well as fossilized mangroves and seagrass. But most impressive are the hundreds of nearly perfectly preserved remains of ancient *Basilosaurus* and *Dorudon* whales with hind leg bones and pelvises still intact. In other words, these are transitional fossils at their finest. The ancient whales found in Wadi al-Hitan are merely one example of a transitional organism, albeit an important one at that. There are hundreds of more examples of fossils that provide evidence of transition in organisms and surely more to be discovered.

Another fascinating and especially well documented case of a series of intermediate fossils involves horses (see http://www.amnh.org/exhibitions/horse/the-evolution-of-horses/). Beginning about 55 million years ago, horses began a tremendous evolutionary run. The fossil record shows massive changes in size and shape, as horses responded to changes in the environment of North America. One of the best documented cases of horse evolution can be seen at the University of Nebraska's Ashfall site, located in northeastern Nebraska. In 1971, Dr. Michael Voorhies discovered a site where hundreds of animals had been buried by ash that came from a volcanic eruption to the west in Idaho about 10 million years ago. The eruption was

Photograph of transitional whale skeleton on top of desert at Wadi al-Hitan in Egypt.
http://assets.atlasobscura.com/media/W1siZiIsInVwbG9hZHMvcGxhY2VfaW1hZ2VzL2VkMzEzOTA0MjBiMmNiZmZiNTcyZDAwZGZlM2EwMjM1N2FkNWVjOTEuanBnIl0sWyJwIiwidGh1bWIiLCJ4MzkwPiJdLFsicCIsImNvbnZlcnQiLCItcXVhbGl0eSA5MSAtYXV0by1vcmllbnQiXV0/ed31390420b2cbffb572d00dfe3a02357ad5ec91.jpg

estimated to be 100 times more powerful than the recent eruption of Mount St. Helens. At the Ashfall site was a waterhole, where lots of animals congregated. While the ash blew like snow,

it accumulated in low spots like the waterhole, reaching a depth of eight feet, trapping a variety of animals including our transitional horses.

Incidentally, work at the site is ongoing and open to visitors in the summer (http://www.nebraskastudies.org/0200/frameset_reset.html?http://www.nebraskastudies.org/0200/stories/0201_0105.html). From the "Rhino Barn" visitors can watch as scientists and interns continue to uncover the animals, including the herd of 100 or more rhinos that perished at the waterhole long ago.

Back to horses. Fourteen million years ago, Nebraska was a subtropical jungle. As the climate cooled, Nebraska became a savanna. When the area was a jungle, horses had three toes – two on each side of a central toe, that helped with traction. As time progressed and the climate dried, horses became single-toed. Fossils at Ashfall and other places clearly establish the transitions in foot and toe structures (among other things like stature) between these forms and others.

Photo from http://www.smithsonianmag.com/evotourism/evolution-world-tour-ashfall-fossil-beds-nebraska-6171451/?page=2of three-toed horses Cormohipparion occidentale.

However, unlike the remains of the horses and whales, the Minnesota Iceman is nothing more than a hairy hoax on ice. After vanishing from the public eye in the late 1960's, the Minnesota Iceman resurfaced over 40 years later, when in 2013 he was auctioned off on eBay under a listing describing him as "a one of a kind hoax that was fabricated by a mid-20th century showman [Frank Hansen]". Museum owner, Steve Busti purchased the Iceman for a whopping $20,000, and the sideshow exhibit now resides among other strange objects at the Museum of Weird in Austin, Texas.

So, although speculations surrounding the Minnesota Iceman have cooled down (pun intended), there is no shortage of transitional fossils that support the basic predictions of evolution. Evidence that, for example, shows whales did once roam the earth on four legs. So, although some may still want to debate the legitimacy of evolution, thanks to a little hard work and a lot of curiosity, I guess you could say scientists have a leg up on the competition. Interested people can consult the Wikipedia page that lists numerous transitional fossils, which despite the odds, are actually quite numerous: https://en.wikipedia.org/wiki/List_of_transitional_fossils#Evolution_of_the_horse.

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Chapter 14: A really big hole: origin of the Grand Canyon

"*When you took your children to the Grand Canyon, and stood on the edge of the Grand Canyon, dad, did you teach them the true message of the Grand Canyon?*" Ken Ham, Director Creation Science Foundation

Indeed, creationists and scientists alike seek the truth. The ways of arriving at the truth, however, are rather different. Creationists accept the Christian Bible as a historical document, which is the true and inerrant word of God. There can be no evidence that overturns what is said in the Bible. Scientists take a different approach. Rather than faith in a document written 3000 years ago by Bronze-age sheepherders, scientists demand observable, verifiable evidence, with hypotheses that are tested, and ideas that are changed in the face of new evidence. In the case of the Grand Canyon, these two approaches come into direct conflict.

There are many sites on this Earth that are worthy of being on a bucket list. For example, the Blue Hole in Belize, Ha Long Bay in Vietnam, the Tibetan Plateau in China and the Door to Hell in Turkmenistan. Aside from being geological wonders of this planet, the only thing these sites have in common is the fact that exactly none of them are located in the United States. But American geology connoisseurs need not travel far to observe a masterpiece. The U.S. is flooded with monumental formations that can only be constructed through the powers of nature. Niagara Falls in New York, Mammoth Cave in Kentucky, Monument Valley in Utah and Yosemite Valley in California are a few treasures in our own backyard. However, there is one area in the United States that epitomizes nature's ability to leave visitors speechless: The Grand Canyon.

Lying in the state of Arizona, this 277-mile-long and 18-mile-wide canyon dives just over 6,000 feet deep into the Earth. The views from the canyon rim are nothing short of spectacular, and for those venturing to the canyon floor to the Colorado River, the view upwards is equally exhilarating. But how, exactly, did this geological wonder form? Like many arguments in the evolutionary world, there are two sides: one from a creationist standpoint and the other from an evolutionary standpoint (Zimmermann, 2013).

The infamous tale of Noah's Ark has reared many points of discussion for evolutionists and creationists alike. The idea is that Noah needed an ark to escape (with a few other people and representative animals) a global flash flood, and according to creationist Dr. John Osgood, "Biblical data places the flood at 2304 BC." It is this flood, for which Noah was preparing for over 2,000 years ago, that creationist think was responsible for the formation of the Grand Canyon. Unfortunately, scientific evidence renders this conceptualization completely inaccurate. We explore why in this essay.

Creationists believe that after the great flood, two lakes near the Grand Canyon overflowed from the mass amount of residual water. Excess water violently spilled over and instantly eroded weak nearby areas. According to the Bible, this is a perfectly plausible event. The book of Genesis tells readers that the flood occurred over the entire surface of the Earth and, therefore, evidence of spill ways should be visible. Such spill ways could impart a powerful scouring force on the earth's surface and create canyons in their path. Creationists promote this as the process by which the Grand Canyon was formed and they believe it would have done so quickly, given the global scale of the flood and the likely enormous volume of water that would

have moved over the earth's surface from these lakes. They even claim that fossils of marine organisms are downstream of the canyon, showing that it was scoured by ocean water. However, it has been known for a century that the central U.S. was the site of an inland ocean, thereby erasing this attempt to salvage the flood as the cause of the Grand Canyon.

Contrary to the creationist viewpoint comes a more logical science-based explanation.

Through a collision between two tectonic plates below the Earth's surface came the birth of what is known today as the Rocky Mountains. Upon formation of these mountains came an abundance of snowfall in the area. Though not the tallest, the Rocky Mountains are among the longest mountain ranges in the world. The vast nature of these mountains leads to a large collection of snowfall. Come warmer times, the snow quickly melts and only has one way to travel: down. This melting, mountain run-off collected into a large river we now call the Colorado River, a river spanning 1,450 miles from Colorado to Mexico. It is, in fact, the Colorado River that created the Grand Canyon (Zimmermann, 2013).

But let's explore further the geological explanation for the existence of the Grand Canyon, arguably the world's foremost wonder created by erosion.

In the beginning, after uplift of the Rocky Mountains, water and wind were responsible for the initial formation of the canyon. The high abundance of water descending from mountains tops, either as a result of annual rainfall or melting of glaciers during glacial advances, acted as a freight train carrying mass amounts of large rock and sediment down the mountain side. Over time, this constant transportation of materials carved an unbiased groove, or channel, through the land. Once the channel was formed, it captured newly released water and sediments, thus widening and deepening the channel.

The geology of the canyon itself provides clues to its origin and subsequent history. The canyon walls consist of horizontal layers of various kinds of rock. Through relative and absolute age-determining methods, the majority of the highest layers of rock (those nearest to the surface) date back approximately 250 million years, relatively young compared to much lower layers dating back approximately 1.84 billion years (Mathis and Bowman, 2007). This approximation is the appropriate time frame for erosion to have worked its magic. There is simply no way that a flood could have yielded a canyon this deep and wide. But, how did the canyon become so wide?

Water from sources other than the Colorado River also contributed to the size of the Grand Canyon. As the canyon became deeper and deeper, more tributaries and streams poured into the forming river, destined for the growing canyon. Over time, as cycles of dry times and powerful storms occurred, wind and water erosion, once again, carved out masses of land only to be washed down the Colorado. A common misconception is that the canyon got its width from flooding of the Colorado. Although, to some extent, that may be true, the majority of widening is due other forms of erosion.

The ideas behind creationists' theories are not difficult to convey or understand and, therefore, gain popularity among the misinformed. It is true that flowing water is a powerful

force of nature. However, the truth of the Grand Canyon lies within the methods of science, which continue to provide evidence of an ever-evolving Earth, and a Grand Canyon that is millions of years older than that attributed to Noah and his Ark. An overwhelming majority of creationists have no training or knowledge of geology, putting all opinions and interpretations of the Christian Bible at odds with all scientific data and theories. And the misconceptions about the Grand Canyon are perpetuated by people such as Ken Hamm, who has a college degree and runs a creationist website called Answers in Genesis. Hamm believes that the earth is 6,000 years old, a view that most biologically literate Christians find unacceptable. In fact, believing that the Grand Canyon was created a few thousand years ago is, in fact, an embarrassment to those scientists who have studied geological processes. Thus, the creationist belief about the formation of the Grand Canyon falls in the category of a parable and not science.

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Chapter 15: Did Darwin renounce evolution on his deathbed?

Did Charles Darwin renounce evolution and reclaim his Christian beliefs on his deathbed? Stories claiming this to be true began to arise just months after Darwin's death in April of 1882 (Moore 1994). The most notable of these stories came from a Lady Hope who insisted that in the late months of 1881 she visited a bedridden Darwin at Down House where they held discussions of creation and evolution. It was then that, according to Lady Hope, Darwin proclaimed he had fallen back into the faith that was planted in him as a child, renouncing his scientific theories (Morris, 2006).

There are many reasons to believe that this story was fabricated, at least in part, by Lady Hope to discredit Darwin's controversial claims on evolution. The strongest proponent against Lady Hope come directly from the family of Darwin, specifically his son Sir Francis Darwin and his daughter, Henrietta. In his book The Darwin Legend (1994), James Moore documents more than 20 years of investigation into the life of Charles Darwin. Moore's book tells us that Sir Francis wrote to Thomas Huxley, evolutionist and passionate defender of Darwin, in February of 1887 claiming that Lady Hope's story and others were 'false without any kind of foundation.' Francis again affirmed in 1917 that he had no reason to think his father "ever altered his agnostic point of view" (Moore, 1994). Henrietta wrote in the London evangelical weekly, The Christian, in 1922 "I was present at his deathbed. Lady Hope was not present during his last illness, or any illness… He never recanted any of his scientific views, either then or earlier… The whole story has no foundation whatever."

Further evidence to suggest that Darwin maintained his belief of evolution comes from Darwin himself. On November 23rd, 1880, a gentleman named FA McDermott sent a letter to Charles Darwin with the topic being specifically Darwin's belief in the new testament. McDermott asks "My reason to writing to you therefore is to ask you to give me a Yes or No answer to the question Do you believe in the New Testament?" (Barry, 2015) Darwin's written response, also from November, 1880, was direct stating "I am sorry to have to inform you that I do not believe in the Bible as a divine revelation & therefore not in Jesus Christ as the son of God" (Barry, 2015). It's difficult to assume that Darwin would have completely flip-flopped his beliefs just one year before Lady Hope's visit.

Some claims have been made, even by Henrietta, that Lady Hope never existed and couldn't have been told these things by Charles. There's no doubt now that Lady Hope was real. She was born Elizabeth Reid Cotton in 1842, married admiral Sir James Hope who died four years later, remarried once after, and by the age of 67 was widowed a second time and left with little money to fend for herself (Taylor, 2005). It was then that Lady Hope created her story which would give rise to countless others making the same claim. Darwin personally invited Lady Hope to his home in (most likely) September of 1881 (Moore, 1994). It's most widely thought that she was invited to appease Darwin's wife, Emma, a devout Christian who worried about Darwin's salvation. Lady Hope wrote in the Boston Examiner in 1915 that when she brought up the topic of evolution 'his fingers twitched nervously and he said that as a young man he had some foolish ideas'. She went on to claim that he asked her to arrange a prayer meeting in the courtyard, further pushing the idea that he no longer believed his own claims on evolution (Taylor, 2005). Her story was published 34 years after the incident occurred. What reason would Lady Hope have had to keep the story of such a transcending event to herself for 34 years before sharing?! Another reason to believe that the story was fabricated as a method of creating

personal popularity or worth within the church as she lived out her final years alone and with little money.

While Lady Hope's story doesn't directly claim that Darwin had some type of holy epiphany, the way she constructed her story left many open ends and suggestions about Darwin's final days. Moore writes in his book that these stories of 'holy fabrication' are just attempts to beautify Darwin's story for/towards Christianity. Russell Grigg notes in Creation magazine (1995) that for most of Emma Darwin's married life she was "deeply pained" by Charles's stance on religion, and if anyone would have wanted to corroborate Lady Hope's claims it would have been her; she never did.

While all known facts point to the opposite, let's say that Darwin did revert to the faith-driven nature of his youth. What affect does that truly have on the argument of evolution vs creation? Nearly every scientist who has deciphered a scientific theory in their lifetime never recanted their beliefs or their science. Why would Darwin have? When considering the Bible and other scriptures it's made clear that there is a severe price to be paid for denying one's faith. When at the end of his life, even if Darwin truly did accept his Christian beliefs and deny evolution, the personal pay-off would have therefore be extremely great. Claiming a spot in the Heaven creationists have always preached about would be a much more worthwhile prize than spending the last days of your life preaching the theory of evolution; the negative of believing and being wrong with have meant nothing at that point. Say, however, a scientist with no conflicting belief such as Albert Einstein was on his deathbed and decided suddenly to renounce his theory of relativity. Would that have somehow made his theory wrong? Would we then question the proven facts and laws that have shown his theory to be true? The answer is obviously, no. Even if Charles Darwin changed his mind, no matter the reason, it does not and will not change any of the scientifically investigated and proven facts that currently prove the theory of evolution to be an undeniable truth.

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