The Magic of Reality: How We Know What's Really True Study Guide

The Magic of Reality: How We Know What's Really True by Richard Dawkins

BOOKRAGS

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Plot Summary

The Magic of Reality, written by popular science author and esteemed biologist Richard Dawkins, is an extended essay directed at explaining natural phenomena that occur throughout the known world, and arguing that a scientific understanding is superior to the belief in magic or the supernatural. Each chapter focuses on a different aspect of the world around us. Life, planets, stars, and disasters are all presented to the reader. First, myths are introduced in order to show the reader the ways in which people across the world attempted to explain these things. The author generally brings up interesting facts about these myths, as well as explores their inherent flaws in terms of what they might contribute to the understanding of the universe. Each chapter unfolds in more or less the same sequence, in an argument designed to examine past deficiencies in human beliefs and briefly explain to the reader how these beliefs may have come about in some cases. Once these ideas are presented in the chapter, the author presents what he considers their superior scientific alternatives. After the myths regarding the subject presented by the title heading are introduced, the author proceeds to explain what humans know now about the world, through the use of the scientific method. While many of the subjects that the author approaches are inherently complicated in nature, great efforts are taken to keep the general notion of science as a tool for understanding at play. Thus, the book is an excellent starting point for someone of very little knowledge about concepts such as evolution, the structure of the universe, or the nature of disasters on earth. Each chapter is similarly structured, and the gradual presentation of what scientists have discovered rapidly overcomes the supernatural explanations that once served to provide reasons for things that humans observed in everyday life. Through the work, the author argues that science is superior, not only because it offers better explanations of the world we see around us, but also because by using the scientific method, we come to control more of the world around us, which myths were never capable of doing. The simple approach taken by the author makes this book easily readable by even those totally unfamiliar with established scientific principles, and serves as a strong argument for the scientific understanding of the universe. Simple, yet straightforward and compelling, the book builds on knowledge presented in previous chapters to promote understanding of each separate topic. The work also does a remarkably good job of making simple arguments very powerful, and strongly supports the idea that scientific understanding is superior to the belief in myth or superstition.

The Magic Of Reality

The Magic Of Reality Summary and Analysis

Written by popular science writer and biologist Richard Dawkins, The Magic of Reality is a clear and concise series of essays that explains science's role and significance in the modern world. The argument is that science has continually improved our understanding of the world and replaced many mythologies that never explained the very phenomena they claimed to resolve in the first place. This understanding, argues the author, is even more profound that even the bests myths dreamed up by ancient cultures, and science allows us to continually improve our understanding of the world. The book compares mythologies from across the world, which explain many of the same phenomena in the same way, with the understanding of these same phenomena through the lens of science, making the argument that not only is science a better way to go, but it is also ultimately more magical than anything old storytellers have dreamed up.

What Is Reality? What is Magic?

What Is Reality? What is Magic? Summary and Analysis

The definition of "reality" seems straightforward enough, but is actually obscure in certain situations. Light, for example, can take a long time to travel from star system to star system, so in a sense, what astronomers are looking at isn't "real," but instead happened long ago in the past. Technology will, in the future, allow us to learn more about reality, and while we should keep an open mind about what could exist, we should rely on evidence gathered from scientific study to determine what in fact does exist. Models are useful in determining what is real and what isn't. They come in different forms, but are said to be accurate if the predictions based on them are seen in the real world. Models are constantly being refined in science. A model such as Gregor Mendel's model of heredity, for example, has stood the test of time, but has been improved to become the modern model of DNA, which explains even more about how organisms transmit hereditary information to their offspring. Essentially, we can know a thing is real through three different, but closely related means. We can first know a thing is real if we detect it directly through the senses. We can also detect something real through the use of instruments that rely on these senses. We can also create models of possible realities and test what predictions they make against what actually happens in the world.

Magic, on the other hand, may be divided into three categories: supernatural, stage, and poetic. Supernatural magic is that found in myths. Stage magic is something that appears real, but is not. Poetic magic involves emotional responses to natural beauty. The idea of supernatural magic cannot explain our observations in the universe, and by definition insists that something is going on that we simply cannot understand. A supernatural event is one that people assume cannot be explained, but the scientific method denies that such a mystery is ever really a possibility. Things once said to have supernatural explanations and origins are now commonly understood through science, and it is entirely reasonable to assume that science will continue to progress and explain even more about our universe.

Evolution is a perfect example of something that was once considered supernatural, but is now well-understood by scientists. Small genetic changes in each generation, accumulated over millions of years, readily account for the variety of species we see on Earth today. Small differences from generation to generation may go unnoticed, but over longer time periods may result in profound changes in genetic material and thus, the species population as a whole. Genetic changes that result in environmental advantages for any organism will increase that organism's chance to survive and breed. The incredible truth of this scientific discovery is part of the poetic magic of the universe, and is far greater than anything from supernatural or stage magic, because it is inherently real. This, the author argues, is a compelling reason to pursue scientific

explanations, which have always afforded us greater understanding and a stronger foundation on which to build our knowledge of the universe.

2: Who Was The First Person?

2: Who Was The First Person? Summary and Analysis

Every tribal culture throughout history to present day has a myth about the origins of humankind, and they tend to share many of the same features. They all include gods, which usually appear as giant men or women with magical powers. Some of these myths are still taken seriously today, but none of these myths accurately portray where humans came from.

In reality, there was never a "first" person. There never was, in fact, a first of nearly any species that evolved on Earth. Going back roughly 185 million years ago, for example, humans descended from fish. In the same way, people are born as infants, and die as elderly, but change very little from day to day in terms of their appearance. That is to say, there is very little genetic change from one generation of a species to the next, and each set of offspring still belongs to the same species as its parent.

Evidence for these changes is found in the fossil record. Fossils come from animals that get buried in certain circumstances, essentially becoming stones. There are several types of fossils, and there are even a number of ways to know how old they are, though the ages are always regarded as approximate and not absolute. Even so, the various methods of dating these fossils always agree with one another, and that is a very strong message to scientists that they are on the right track. The idea of gradual change resulting in evolution over vast periods of time is a vital notion to the concept of science, but it is often difficult to grasp, and is often misunderstood completely. Even though the fossil record fizzles out at around four hundred million years ago, we still see that the idea of gradual change is supported strongly everywhere.

We also know that species are closely related to one another when their DNA is similar, and that the closer these DNA patterns match, the more closely related two species are. Both the fossil record and DNA analysis readily demonstrate that all species are related, and that species variation occurred over time. Both of these pieces of knowledge support the other, as well as supporting the modern theory of evolution, and both were arrived at independently of one another, which strongly suggests that biologists' overall view of life and its origins are correct.

3. Why Are There So Many Different Kinds of Animals

3. Why Are There So Many Different Kinds of Animals Summary and Analysis

Many myths try to explain how various animals came into existence, but there are none that attempt to explain why there are so many different species on Earth. There are, after all, roughly two million species that have been identified and named alone. What makes an animal part of a species? Essentially, two animals are said to belong to the same species if they can breed together and produce offspring also capable of breeding. While this is something of an oversimplification, it does serve as a solid guideline for identifying different species across the planet. Different species may be more or less related to one another. Though we (homo sapiens) are the only surviving members of our genus, there is much evidence of other species of humans in the past. Genus' belong to families, families belong to classes. Like trees, a single order can branch out and result in many different species. A similar transformation can be seen in languages. Language changes slightly from generation to generation across the globe. However, languages can also change by taking words and other conventions from separate languages, and this generally does not happen across species.

Animal genes grow different through different periods of time because particular animals get stranded in certain geographical regions. These geographical regions undergo changes, and small differences in genetic material may result in different species over time. Scientists often refer to the genetic material available to a species through the organisms as the "gene pool," even though it is not, strictly speaking, a liquid pool at all, but an abstract idea.

What Are Things Made Of?

What Are Things Made Of? Summary and Analysis

Long ago, many different societies came to the conclusion that everything was composed of different elements: earth, fire, air, and water. One Greek philosopher named Democritus, however, believed that things were made out of atoms—indivisible units of matter that could not be broken down any further. This turns out to be somewhat true, but most of the substances we see around us are compounds—collections of many different kinds of atoms. These compounds are known as "molecules," and may consist of just two atoms, or very many. Diamonds, for example, are crystals of millions of carbon atoms joined together in a single molecule. The atoms in this type of formation are all spaced out in the same way. Most metals are joined together in this way. Other types of matter are liquids and gases. Gases may be compressed, but liquids may not. These different types of matter are known as "phases," and most substances on Earth can be found in any phase, depending on the temperature the substance is currently experiencing. Were we to divide any of these substances into single atoms, they would be too small to see, and if you split the individual atoms, the pieces that come out are no longer the same substance. Even though an atom is never visible, it is observable through enough indirect means that it is recognized as an accurate scientific model, since these models always produce accurate predictions. Atoms are chunks of matter, called nuclei, surrounded by orbiting electrons. The nuclei of these atoms are, in fact, very small, but make up most of the mass of the atom. All atoms are almost completely empty space. The different components of atoms create forces that we perceive as solid. Small particles called photons can pass through certain kinds of matter. Inside the nucleus are very small particles called protons and neutrons. While these particles are very small, they are much larger than electrons, which orbit the nucleus of the atom. Thus, an atom's mass depends almost entirely on how many protons or neutrons there are in the nucleus. Every type of atom has a different number of protons, and both protons and neutrons are made of even smaller particles called quarks. These are very difficult pieces of matter to understand, but that doesn't mean it is impossible to understand, or that humans should stop trying.

Carbon makes up most life everywhere on Earth. Most types of fuel are also carbon-based. Carbon can make chains hundreds of atoms long, and can be used in the construction of many different molecular structures. Unlike other subjects mentioned in this book, no myths are present anywhere on Earth to explain the origins of matter. In fact, there are hardly any myths that contain knowledge of scientific insight.

5. Why Do We Have Night and Day, Winter and Summer?

5. Why Do We Have Night and Day, Winter and Summer? Summary and Analysis

Both cycles of night and day and the seasons of the year have spawned myths across many cultures. Most events in myths focus on a single occurence that inexplicably repeats itself for eternity. However, just like life and matter, cycles of time can be explained scientifically and in a way that makes more sense. Though the sun appears to cycle around the Earth, it is actually the Earth that travels around the sun, and the Earth also rotates on what is called an axis. The air, and in fact everything on Earth, travels around this same axis, and since everything is traveling at the same speed, we experience it as everything standing still.

Day occurs on whatever half of the Earth is facing the sun. Night occurs on whatever part is facing away from it. Many different animals are active strictly at night, as an adaptation. Animals have similarly adapted to face certain types of weather. Some animals migrate to spend winter in warmer climates, such as birds, who fly south during colder times. Others adapt to grow thicker coats during the winter. Many people think that when the Earth is closer to the Sun, it is summer, and when it is farther away it is winter, but this is incorrect.

In a sense, the Earth orbits the Sun by constantly "falling" over it. What we experience as weight is actually the same effect, known as gravity, which gives weight to all of our mass. The Earth revolves around the sun in an elliptical orbit, just like the other planets do, although the closer a planet is to the Sun, the more circular its orbit appears to be. The Earth is closest to the Sun in January and farthest away in July. The reason that we have seasons is because the Earth spins on an axis that is tilted slightly. The Earth's axis explains why we have winter and summer, and the reason that winter is colder and summer is hotter has to do with the angle at which the Sun's rays hit Earth. During winter, the number of photons that hit Earth from the Sun are greatly reduced.

6. What Is The Sun?

6. What Is The Sun? Summary and Analysis

Myths often behave as though the Sun is male and the moon is female. Cultures across the world worshipped the sun, and believed it was either a God or some other divine object. In reality, the Sun is simply a star very close to Earth in comparison to other stars. Stars are usually very large and produce their own light and heat. Planets, are usually smaller by comparison and reflect light. A star's light and heat is created by the gravitational compression of hydrogen, and planets are known to orbit many stars. When stars run out of hydrogen they generally collapse. There are many different kinds of stars, which all have different masses, densities, and shine in different colors. They also have different "stages" in their lifecycles. When some stars die, they are said to go "supernova," which means that they shed a massive amount of heavier elements out into space.

All planets travel around the sun in the same direction. This is because the entire solar system began as a spinning cloud of supernova dust, so the planets all continued to travel in the same direction as they formed. The reason they all appear to be spinning on the same horizontal level is because this is where the dust was concentrated in the first place.

Asteroids are chunks of this matter that have failed to become planets due to gravitational interference by another object. These asteroids occasionally hit Earth's atmosphere, and even though most of them burn up on impact, some of them manage to survive all the way down to Earth's surface. In fact, an asteroid collision with the Earth is believed to have been what killed off the dinosaurs 65 million years ago.

The Sun is incredibly important to all life on Earth. All of life needs energy, and the Sun supplies this energy. The sunlight is used by plants to create the energy that they need to live and grow. Animals that eat these plants take the energy the plants have already gathered. Animals that eat other animals steal this same energy. This same energy—sunlight—is responsible for the generation of fossil fuels, hydropower, and almost every other source of power on Earth.

7. What Is A Rainbow?

7. What Is A Rainbow? Summary and Analysis

Rainbows are also the subjects of Myths across the world. They are usually treated like physical objects in these myths, often being portrayed as bridges or roads, or at the very least rainbows are portrayed as places with a physical location. However, these colorful sights are simply illusions. If you try to move towards a rainbow, it will appear to move farther away, and eventually fade altogether. Additionally, a rainbow is actually a full circle that cannot be seen completely because the illusion is often "blocked" by the ground. The colors present in a rainbow are created through a process similar to what happens when light strikes a prism. When light strikes a prism, particles known as photons pass through the prism, and it is separated into different wavelengths. This was proven by Isaac Newton in a series of experiments. Rainbows are caused by a similar process that happens inside raindrops. Any one observer can only see one particular spectrum of light at a given height and distance, and so it appears as though a colorful half-circle is glowing somewhere in the distance. Light itself is actually a variety of photons of different wavelengths, and each wavelength is represented in the human visual field by a different color, ranging through red, orange, yellow, green, blue, and purple. We perceive different wavelengths as different colors of light. We can only see a small fraction of these wavelengths, but that small fraction is the entire spectrum of visible light able to be seen by humans. In order to see a rainbow, one must be facing away from the sun. The sun will hit each drop of rain you see in front of you, and the light from the sun will break down into different wavelengths. Each wavelength deflects at a different angle, so the viewer will perceive each color at a slightly different height, resulting in a stripe of red, orange, yellow, green, blue, and purple.

8. When And How Did Everything Begin?

8. When And How Did Everything Begin? Summary and Analysis

Again, the myths concerning the origins of the world are greatly varied across cultures. Most of these myths assume that something was alive before the universe was created. Scientifically speaking, there were two competing models of the universe during the twentieth century. One, known as Steady State Theory, is now known to be wrong. The Big Bang Theory instead insists that the universe began at a definite moment. It is also possible that there is more than one universe. Our sun is one star in a galaxy of billions of stars, known as the Milky Way Galaxy. We have observed many, many galaxies throughout the universe. We can also learn a lot about stars through the use of spectroscopes, instruments that break down light from stars in a way similar to prisms. In fact, this method has been used to establish that galaxies far away from us are moving away from us. Light waves travel somewhat like other waves with which scientists are familiar. They also are affected by the Doppler effect, which is also what causes sound waves to appear to be of higher frequency when their source is moving towards us, and lower when it is moving away from us. In the case of light waves, they are "redshifted" when their source moves away from us, and "blueshifted" when moving towards us. From this observation, it has been discovered that other galaxies are moving away from us, and the farther away a galaxy is from us, the farther away it moves. Astronomers have been able to trace this motion back through time, and have used it to discover that the universe is 13 to 14 billion years old.

9. Are We Alone?

9. Are We Alone? Summary and Analysis

There are no known myths about life on other planets. This, in and of itself, is indicative of a larger problem with myths, namely that they do not describe phenomena that do not concern primitive cultures. There have been countless myths about strange and magical creatures, such as genies, vampires, or fairies, but these creatures always live on Earth, or at least a culture's conception of it. With the rapid technological advancement of the 1950s, stories about aliens became hugely popular, often amongst people already fond of science fiction stories. Psychologists have studied people who claim to have memories of alien abductions, and these memories often turn out not to be memories at all, but instead are a combination of different memories and perceptions all combined out of the order in which they occurred to produce what is known as a false memory. A very common cause of a person believing that they have been abducted is known as sleep paralysis. When asleep, the brain paralyzes the body so that it cannot move while it dreams, and sometimes, when a person wakes up, that paralysis continues. This experience can be fearful and even lead to hallucinations. In centuries before, incidents of sleep paralysis were often explained by demonic visitations. This century, they are explained by visits of alien creatures.

While it is entirely certain that intelligent aliens have not visited the Earth, there is still a very wide and active debate about the possibility of life on other planets. In fact, scientists take this debate very seriously, and have managed to break down the stages of what needs to be learned about the universe before we can determine if it possesses life elsewhere than on the Earth. First, scientists need to know the number of planets that exist outside of our solar system. They do this through a variety of methods, involving ultra-sensitive telescopes. It turns out, through these processes, that the majority of stars scanned for planets do in fact possess them, but only a small number of stars relative to the size of the galaxy have been sampled.

Additionally, water has to exist on a planet, and it must be within a certain distance of the star that it orbits. This distance is known as the "Goldilocks Zone," in which water will neither freeze nor boil so that it can support life. The size of a planet, or rather, its mass, will also greatly affect the chances for life to occur on a planet, since too great a gravitational force would not allow larger creatures to evolve.

If life were to be discovered on another planet, there are good reasons to believe that it will look a great deal like life on Earth. This is because the adaptations on Earth are so varied and comprehensive, there aren't many other ways for creatures to evolve in a way that would be adaptive to an environment which could support life in the first place.

10. What Is An Earthquake?

10. What Is An Earthquake? Summary and Analysis

Earthquakes can be a very frightening event in a person's life, so it is no surprise that they are a common source of legend and myth. A large portion of the settled world is vulnerable to severe earthquakes, and they commonly feature in news around the world. This turns out to have always been the case, for just as the origin of man and animals has many different myths associated with it, so do earthquakes. Earthquakes are a result of plate techtonics. Continents across the Earth actually move very slowly. Millions of years ago the continents were in very different places. North America and Europe were pushed up against one another, and below them South America and Africa shared a physical land border. These continents move very slowly apart from one another, or towards one another in some cases. The land masses drifted apart due to sea-floor spreading. These motions are caused by convection currents deep under the Earth's surface. Convection is brought about by a heat that causes motion, since it is hot enough that even rock partially melts that deep under the Earth's crust. In fact, the substance far enough below the Earth's crust consists of superheated liquid rock and metals, and it is the turbulence from this extremely hot interior that ultimately causes the continental plates on the Earth's crust to drift as they do. Plates slide away from other plates, which creates larger sea-floors. Plates can also be pushed up under other plates. This process is known as subduction, which creates mountains, and often creates volcanoes as well as Earthquakes. The best example of friction between two plates causing earthquakes is at the San Andreas fault line in California, where the Pacific and North American plates are both moving northwest. The Pacific plate is moving faster, and constant earthquakes are a result of this motion.

11. Why Do Bad Things Happen?

11. Why Do Bad Things Happen? Summary and Analysis

It seems unfair to many of us that bad things happen to good people. Myths have developed across the world to explain tragedies like death and disease. It was once thought by Hippocrates that earthquakes were a large cause of disease. Many other superstitious theories involving sickness are still taken seriously by people today. In reality, the question of why bad things happen to good people does not make sense to ask. There is a popular idea that everything happens for a "reason" or "purpose," which is utter nonsense. We also believe in things like the Law of Averages, but tend to misapply their logic. The universe doesn't have any sort of conscious mind, and things simply happen because they happen. The entire range of living creatures on Earth is designed to survive in a certain way, and nearly all forms of life compete continuously with one another. Since our ancestors were probably hunted all of the time, it makes sense for us to adopt a paranoid view of the world, and this is most likely responsible for the way we attribute disasters to some form of larger purpose.

Illnesses work similar to the way many predators do, and there is no logical reason to believe they strike good or bad people any more than they strike ordinary people. They are generally parasitic bacteria, viruses, or fungi. Our bodies' immune system usually fights these diseases off. The immune system identifies and fights off foreign agents in the body. It can fail in certain ways, and even attack things that are not dangerous, resulting in allergic reactions. Cancer is a group of our own cells that have mutated and become parasitic. Tumors sometimes spread to other parts of the body, becoming malignant. The immune system has trouble recognizing these cancer cells as dangerous, since they are actually our own cells.

12. What Is a Miracle?

12. What Is a Miracle? Summary and Analysis

Most of what are called miracles are garbled accounts of something that happened after generations of retellings. We tend to exaggerate coincidences and pass these stories along to others. These myths about miracles tend to make good stories and get further added to or embellished as time passes. This means that a story about a frightful encounter with a small shadow can eventually wind up being a story about spirits or monsters. These stories are often very thrilling to tell, and this causes them to get added to even more as time goes on. When, then, is it reasonable for us to believe in a miracle? Philosopher David Hume came up with a good measure for believing if an account of a miracle is true or not. He says one should determine whether or not believing it is more difficult than believing the story was made up. For example, if someone tells you that they saw a miracle, you must determine whether it is more likely that they simply made the story up, or whether the miracle actually occurred. Many tales of miracles turn out to be harmless pranks, but others can be very dangerous, as the Salem witch trials were. In these witch trials, many innocent people wound up dead because the courts accepted children's testimony about acts of witchcraft as true.

We should not accept magical or supernatural explanations for anything, but rather continue to search for explanations that can be verified through the scientific method. Today's unexplained events wind up becoming tomorrow's technology and understanding.

Characters

Gregor Mendel

Gregor Mendel was a monk who, through the use of plant-life, discovered the principles of heredity. Mendel used pea stalks in his observations and recorded certain characteristics, such as height and color. Through careful observation of a large amount of these plants, he was able to determine that the plants appeared to pass on their characteristics to their offspring. For example, tall peas crossbred with other tall peas produced new plants of similar height. He was also able to determine that characteristics like color had "dominant" and "recessive" traits. Plants, and indeed, most life in general, carry two sets of chromosomes, and in some cases only one of these traits is displayed. In the case of the color of the pea-stalks, a plant may carry both a "green" and a "yellow" color gene, from either of its parents, but since "green" is dominant, the plant would only show the characteristics of greenness, even though the plant itself carried both types of hereditary information. This appearance, Mendel called the "phenotype," whereas he termed the actual information carried by the plant its "genotype." Mendel had no knowledge of genetics, and this information would not become known until many years after his death; nonetheless, his observations were confirmed and supported by findings from other sources, and his initial discoveries were further explained by naturalist Charles Darwin and the later discovery of the DNA molecule.

Charles Darwin

Charles Darwin was a naturalist who, through a great deal of careful observation, developed the theory of evolution. While on a sea-voyage aboard the HMS Beagle, Darwin carefully recorded his observations of the natural wildlife, particularly species of birds he encountered on a series of islands that were close to one another. The extraordinary amount of information Darwin was able to record allowed him to see that these birds all had particular adaptations that allowed them to survive on the different islands. For example, beak size and shape was a common difference amongst these birds, and the difference in beak sizes and shapes typically had to do directly with the means by which a bird on a given island could gather food for itself and its young. Upon more examination, Darwin came to the conclusion that these birds had once been the same species, but differentiated when individual animals became separated from one another on the separate islands. As different environmental challenges were faced on each of the islands, the birds developed traits to help them cope with these challenges over the generations. This process was called selective adaptation by Charles Darwin, and was an advancement of Mendel's theory of hereditary traits. It was additionally later supported even more by the discovery of the DNA molecule, which provided a clear scientific explanation as to how these traits were modified and passed on.

JJ Thompson

JJ Thompson was a British physicist responsible for improving the mass spectrometer and allowing more careful observation of atomic and subatomic particles. This work demonstrated that even though atoms were the smallest pieces of what we generally consider basic matter, these pieces themselves are all reducible to even smaller pieces.

Ernest Rutherford

Ernest Rutherford was a physicist responsible for the most successful model of the atom, which includes protons and neutrons inside the center of the atom, and electrons in orbit around the "nucleus" of the atom.

Neils Bohr

Neils Bohr is a physicist responsible for very successful models of subatomic interactions.

Arthur C. Clark

Arthur C. Clark is a science fiction author responsible for coining the phrase, "Any sufficiently advanced technology is indistinguishable from magic."

Isaac Newton

Isaac Newton was a physicist responsible for the modern theory of gravity.

Alfred Wegener

Alfred Wegener was a geologist responsible for advancing the theory of continental drift. His theories were initially mocked, but evidence for his case mounted throughout the years until the theory of plate techtonics was established as scientific fact.

David Hume

David Hume was a British philosopher who came up with a robust test for miracles. He posed this question to anyone who heard or otherwise encountered evidence of a miraculous event: is it easier to believe in the miracle itself, or some other explanation of that miracle. According to Hume, it was always easier to believe that some other explanation was the true nature of the miracle, as opposed to a sudden suspense in the laws of physics.

Objects/Places

Gods

Gods are typically giant humans with magical powers. They are often the focus of myths.

Fossils

Fossils are solidified pieces of animals, often from millions of years ago.

Species

A species is a certain type of animal.

Genus

A genus is a group of species.

Family

A family is a group of genuses.

Order

An order is a group of families.

Class

A class in a group of orders.

Gene

A Gene is a piece of genetic material that carries hereditary information.

Atoms

Atoms compose the smallest pieces of matter that can be elements.

Elements

Elements are the smallest single bits of substances we are able to see. Single elements combine to form molecules.

Molecules

Molecules are various configurations of different atoms and elements.

Nucleus

The center of an atom is the nucleus.

Protons

Protons are positively charged particles inside an atom's nucleus.

Neutrons

Neutrons are uncharged particles inside a nucleus.

Electrons

Electrons are very small negatively charged particles that orbit an atom's nucleus.

Axis

The axis is an invisible line through the center of the Earth around which the rest of the Earth spins.

Asteroids

Asteroids are chunks of matter prevented from becoming planets by a large gravitational force.

Photons

Photons are particles that humans can perceive as light.

Spectroscopes

Spectroscopes are scientific tools that allow us to determine many different qualities of surrounding stars.

Continent

A continent is a mass of land that floats across the Earth's surface at a very slow rate.

Themes

The Scientific Method

This book focuses on the things that we have learned from the scientific method. The author borrows important and solidly established facts from all sorts of different sciences, ranging from biology to optical sciences to cosmology. These observations are all used to demonstrate the idea that science is by far a better tool for understanding the universe, because science, unlike mythology or the belief in magic, allows humankind to predict events and control our environment. Whenever humans engage in experiments or observations grounded in the scientific method, we gain a greater understanding of the world, and things that were once explained by myths (which, further argues the author, never actually explained anything in the first place) suddenly have a more powerful and coherent explanation. These discoveries are carefully related to one another. This fact is demonstrated to the reader through the progression of chapters that proceed in such a related fashion, combining discoveries in biology and physics to explain where life comes from, for example. In this fashion, the book consistently demonstrates the superiority of the scientific method in terms of making sense of the things we see around us, since it presents us with a world where various observations agree with one another on a consistent basis.

The Inadequacy Of Myth

Though the author deals with the subject as briefly as possible at the beginning of each chapter, many of the myths that are explored within the book receive scathing reviews, by virtue of their content. The author never makes the argument that science is perfect, but instead makes the argument that it is vastly superior to mythology, which it manages to replace as it gathers facts and understanding about the universe. In most cases, argues the author, myths make good stories, but fail to explain what they are supposed to explain in the first place. Many myths depend on a single event that repeats itself, for example, but no explanation for why the event should repeat itself more than once is provided. In other cases, myths claim to explain something while getting facts completely wrong in the first place. Additionally, the author notes that no cultures anywhere have myths explaining things like matter or gravity. This is a scathing demonstration of how inadequate myths actually are. The implicit reasoning is as follows: if myths are supposedly accounts of why things are a certain way, they ought to contain pieces of information that at least point to a basis in reality, like references to atoms, or the fact that the Sun is a star we are much closer to. Instead, in myths, the sun is typically some kind of divine being, and things like atoms are never referred to at all.

Reality is Beyond Magic

A somewhat finer yet no less crucial point the author is attempting to make here is that not only does science provide us with answers that allow us to understand and predict the world that surrounds us, but this understanding is far superior by virtue of its "poetic magic." At the beginning of the book, reality is separated from the supernatural, and magic is divided into three categories. The author defines "supernatural magic" as a belief in gods that can mysteriously change their surroundings and create things like people and places at will. "Stage magic" is defined as an act or object that appears to defy an understanding of the way things work, but is actually deceptive or misleading in some way. "Poetic magic," on the other hand, is a separate experience, which consists of awe and wonder at the contents of the natural world. This third type of magic is part of reality, and science increases it, since the truths behind what causes phenomena are always far more profound and wondrous than the myths that are replaced by them. By first exploring the oversimplified and entirely misleading world of ancient myths, and then contrasting them sharply with science grounded in evidence and observation, the author is readily demonstrating that myths are simply stories, and that science is more than that precisely because it is real, and continues to empower mankind in a way that myths do not.

Style

Perspective

This book is written from the perspective of a well-respected and accomplished biological scientist. Richard Dawkins is the author of many books of similar nature to this one, and his arguments range in complexity, but are always presented in a compelling fashion. The author believes that science is a powerful tool for understanding and for changing the world in which we live, and through his many presentations of the various creation myths, believes that these stories offer little to us in terms of understanding the truth about the nature of the universe. That being said, it is reasonable to suggest that the author is heavily biased in terms of his beliefs in the strength of science versus the weaknesses of myths, and does, in fact, appear to poke fun at many of these myths often. However, his knowledge as a biologist does lend him credibility in terms of his defense of science, since he is readily familiar with concepts such as heredity and evolution. His familiarity with these subjects takes his arguments very far, and lends them a clarity that would otherwise not exist, and in fact in the chapters where he describes biological ideas, he is by far at his strongest. His other chapters still present scientific ideas solidly and straightforwardly, but the examples lack many of the strong analogies that he develops in chapters on biology.

Tone

The tone of the book is generally of a playful nature. The author commonly pokes fun at ancient myths by understating the defenciencies they possess, and sometimes takes the joke farther, appearing dismissive towards these myths, and, in some places, holding them in outright contempt. Though one could make the argument that myths are far more complex than merely being stories that someone made up thousands of years ago, this is not the purpose of the book. The author states in several places that these myths make good stories, and one could make a faint assertion that Dawkins enjoys myths on that level, and might even acknowledge that earlier civilizations may have had good reasons for believing as they did, he never makes such arguments outright, since his main point is to illustrate the "poetic magic" he asserts is inherent in scientific study. He argues that this poetic magic is far superior to belief in the supernatural, and when he explains these scientific studies or ideas, his tone is straightforward and colloquial whenever it is possible. The book is absent of virtually all technical jargon, except when Dawkins makes very brief references to complex physical or biological concepts, and even then, the author quickly reverts to explaining his points in a straightforward manner.

Structure

The book is divided into twelve chapters. Each chapter poses a question, and proceeds to answer it two ways. First, the author samples myths, which generally exist about any of the principles he is explaining. While he presents these myths, he points out their deficiencies, and at times even remarks on which myths he enjoys over the others. In some cases, he presents cases from history where superstition or belief in the supernatural resulted in unfortunate incidents, or even, as in the case of the Salem witch trials, tragedies. After the myths have been explored, the author generally moves on to a discussion of the concept through the lens of science. Ideas are usually built on from chapter to chapter, so that the idea of hereditary traits is introduced before genes are. This progressive establishment of scientific understanding for the reader simplifies the arguments presented by the author, and usually follows the course of history for a certain science. This history of scientific progress is critical to the author's argument, and serves implicitly as a counterpoint to mythology and the supernatural. Myths, argues the author, often become more fantastic with time, and in showing in each chapter the ways in which science modifies and improves its own theories to accommodate new information, the author strengthens his argument simply by the way in which he has chosen to structure it.

Quotes

"Indeed, to claim a supernatural explanation of something is not to explain it at all and, even worse, to rule out its possibility of its ever being explained. Why do I say that? Because anything 'supernatural' must by definition be beyond the reach of a natural explanation." Chap. 1, p. 14

"Stories are fun, and we all love repeating them. But when we hear a colourful story, whether it is an ancient myth or a modern 'urban legend' whizzing around the internet, it is also worth stopping to ask whether it—or any part of it—is true." Chap. 2, p. 25

"Adam's task of naming all the animals was a tough one—tougher than the ancient Hebrews could possibly have realized. It's been estimated that about 2 million species have so far been given scientific names, and even these are just a small fraction of the number of species yet to be named." Chap. 3, p. 38

"A lump of iron is made of lots of tiny crystals packed together, each crystal consisting of millions of iron atoms, spaced out 'on parade' like the carbon atoms in a diamond crystal. Lead, aluminium, gold, copper—all are made of crystals of their different kinds of atoms." Chap. 4, p. 52

"Whenever things change rhythmically with great precision, scientists suspect that either something is swinging like a pendulum, or something is rotating: going round and round. In the case of our daily and seasonal rhythms, it's the second." Chap. 5, p. 66

"The Aztecs believed that they had to sacrifice human victims to appease the sun god, otherwise he would not rise in the east each morning. Apparently it didn't occur to them to try the experiment of not making sacrifices, to see whether the sun might, just possibly, rise anyway." Chap. 6, p. 79

"First, if you try to approach the rainbow, no matter how fast you run, you'll never get there: the rainbow will run away from you until it fades away altogether. You can't catch it. But it isn't really running away because it isn't really in a particular place at all, ever. It's an illusion—but a fascinating illusion, and understanding it leads on to all sorts of interesting things, some of which we'll come to in the next chapter." Chap. 7, p. 96

"Some scientists will tell you that time itself began in the big bang, and we should no more ask what happened before the big bang than we should ask what is north of the North Pole. You don't understand that? Nor do I." Chap. 8, p. 103

"At the time a bright comet called Hale-Bopp was prominent in the sky and the cult believed—because their spiritual leader told them so—that an alien spacecraft was accompanying the comet on its journey. They bought a telescope to observe it, but then sent it back to the shop because it 'didn't work'. How did they know it didn't work? Because they couldn't see the spacecraft through it!" Chap. 9, p. 114

"Come to think of it, did you ever notice, when looking at a modern map, that the eastern side of South America looks suspiciously like the western side of Africa, as though they 'wanted' to fit together, like pieces in a jigsaw puzzle?" Chap. 10, p. 131

"It is hard to resist this feeling that, somehow, there ought to be a kind of natural justice. Good things should happen to good people. Bad things, if they must happen at all, should only happen to bad people." Chap. 11, p. 138

"If a rumour is old enough, it starts to be called a 'tradition' instead, and then people believe it all the more. This is rather odd, because you might think they would realize that older rumours have had more time to get distorted than younger rumours that are close in time to the alleged events themselves." Chap. 12, p. 154

Topics for Discussion

What, according to the author, is "real"? Why does reality become difficult to understand in some cases? What steps or process does the author argue should be taken to establish reality?

What, according to the author, would our ancestors look like at about 186 million years ago? How did they go from what they used to be to what they are now?

Name two ways that a single species can become two separate species, according to the author. Which appears to be the most common way this occurs?

Are atoms really the smallest pieces of matter? Briefly outline the general structure of an atom. What happens to atoms when they connect to other atoms?

Why is it winter in some places on Earth when it is closest to the sun, according to the author? Where do the ends of Earth's axis lie on its surface?

Briefly explain, from the argument of the author, how the planets came to form in our solar system, and why they are all revolving on the same horizontal plane.

Why, according to the author, are we unable to ever actually catch up to a rainbow?

How are scientists able to see other galaxies, and what have they learned as a result of doing so?

What are the facts scientists look at when determining how likely it will be to find life on other planets?

What happens when continents drift away from one another? What happens when they drift towards each other?

Why do diseases infect people? Why, according to the author, is it reasonable for us to have a somewhat paranoid view of the universe in this respect?

Briefly restate Hume's miracle test in your own words. Does this sound like a reasonable process to undergo in order to determine whether or not a miracle actually happened?