SUMMARY

ORIGIN STORY

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Summary of “Origin Story” by David Christian

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A Big History of Everything

Introduction

When we arrive in the universe, we travel from moment to moment with our parents, friends, children, sisters, and even our enemies. Of course, we travel with other lifeforms too, like bacteria and baboons, rocks and oceans, moons and meteors, even slugs and cell phones. But what is the purpose? Where is our place? Where did we begin, where are we heading, and what will the future look like? Today, we can answer these questions better than ever before. With remarkable accuracy, we can determine what lurks billions of light-years from the Earth, as well as what was happening billions of years ago. With today's advancements, it has become easier than ever to figure out the pieces of the jigsaw puzzle of knowledge, allowing us to see the whole picture of the universe. With our large brains, we can build vast maps of the universe and create internal maps of the world.

Today, we have a modern origin story of the universe. Throughout *Origin Story,* author David Christian explains how just about everything came to be: how the universe appeared out of nowhere, and even more amazing, how it generated a rich cavalcade of things, forces, and beings. He explains how stars were forged from atoms of hydrogen and helium, how planets and moons formed from blobs of ice and dust, and how the first living cells evolved in the rich chemical environments of rocky planets. Of course, humans are part of this incredible story as well; in fact, in our short but remarkable history, we have created entirely new forms of complexity, making it appear as if we dominate the change occurring in the world. So if you're ready to learn about the history of everything, then let's dive in.

The Big Bang Was the Beginning of Our History

When it comes to the tale of our origins, we must tell the tale through key transition points called *thresholds*. The thresholds give shape to a complicated narrative of the modern origin story and highlight major turning points - like the emergence of the universe. For the universe to become created, elements had to exist in perfect Goldilocks conditions - that is that environments were not too hot and not too cold, not too thick and not too thin, but just right for the evolution of complexity.

We cannot know what Goldilocks conditions allowed a universe to emerge, but we can get an explanation from novelist Terry Pratchett, who wrote, “The current state of knowledge can be summarized thus: In the beginning, there was nothing, which exploded.” In other words, we know that the universe was created 13.8 billion years ago thanks to the Big Bang, which became the first threshold of our history. While some things cannot be explained, cosmologists do know that before the Big Bang, the universe was smaller than an atom. How small is that? Well, to give you some reference, you can squeeze a million atoms into the dot at the end of this sentence.

With all the energy squashed up inside this tiny atom, it became so inconceivably hot and was forced to expand to release the pressure. In mere seconds, the universe was filled with complex and interesting structures; meanwhile, protons and neutrons joined forced to become nuclei. Just moments later, the universe began to cool, slowing down the turbulent energies. For the next 380,000 years, the universe kept cooling, causing electromagnetic forces to join electrons with neutrons until electrons calmed down enough to fall into orbits around protons. The result? The first atoms.

For the next hundred million years, the universe stayed simple until stars and galaxies began to light up the universe. Free energy, which we call gravity, herded simple forms of matter and provided the Goldilocks conditions for the emergence of stars and galaxies. As gravity pulled atoms together, atoms collided and sped up, raising the temperature. Over time, these atoms created clouds of matter that only grew hotter and denser. At roughly ten million degrees Celsius, protons have so much energy that they can collide violently enough to form helium nuclei. Eventually, a furnace is created that releases colossal amounts of energy. Once lit, the furnace will keep burning as long as there are enough protons to fuse together. The whole new structure will stabilize for millions or billions of years, and thus, a star is born.

But not just one star is born, but billions of stars creating star cities called galaxies that lighten up the darkness of the universe. While the creation of stars was a critical step forward for our universe, the death of these stars was just as important. You see, when a large star dies, the star emits huge amounts of energy and in just a few moments, the explosion sends most elements we find in the period table flying throughout space. As a result, dying stars fertilize and enrich the young universe by creating an environment that would one-day support life.

The Creation of our Solar System

Now that we have seen how violent processes and extreme energies have created galaxies, stars, and new elements, it's time to discuss the creation of our solar system. Simple chemical molecules orbiting young stars created more Goldilocks conditions for the next threshold, creating new astronomical objects: planets, moons, and asteroids. Once the center of our solar system, the sun, was created, a mass of debris consisting of gas, dust, and particles of ice existed; meanwhile, lighter elements like hydrogen and helium were blasted away by the violent bursts of the sun.

For this reason, the outer planets in our solar system consist mainly of these elements. As you travel closer to the sun, however, rocky planets like Earth, Venus, and Mars consist of elements like oxygen, aluminum, and iron. As matter traveled and collided in orbit, larger objects like meteors emerged. The surrounding debris was light enough to be sucked up by gravity, leading to the formation of planets. Just take a look at Uranus's odd tilt and rotation, and you'll see the evidence of the result of a violent collision with another large body. Our own moon was probably formed from a collision between a young Earth and a Mars-sized protoplanet (an early, pre-planet). The collision sent huge clouds of matter into orbit around Earth, where they likely circled like the rings of Saturn until they came together to form the moon.

It wasn't until 1995 that astronomers identified *exoplanets,* or planets orbiting other stars in our galaxy. Now we understand that most stars have planets, meaning there could be tens of billions of planetary systems of many different types just in our galaxy. Studies over the next few decades will reveal how many of these systems could support life. But what exactly does it take to enable life on a planet? Well, as you may have guessed, life could only sputter into motion thanks to a varied Goldilocks environment of the young Earth. First, our solar system had to be in the right part of the Milky Way galaxy, also known as our galaxy's "habitable zone." Second, the chemistry had to be just right - it couldn't be too hot, too cold, too dry, or too wet. Conditions had to be just right. And in the right conditions, molecules from which life is built can spontaneously emerge.

In 1953, Stanley Miller from the University of Chicago created a laboratory model of early Earth's atmosphere by putting water, ammonia, methane, and hydrogen into a closed system of flasks and tubes. He then heated the mixture and zapped it with electric charges (imagine the equivalent of volcanoes and electrical storms) to provide the activation of energy. Within a few days, Miller found a pinkish sludge of amino acids - simple organic molecules that are the basis for proteins. Today, Miller's basic results stand, even though we know that the early atmosphere was not dominated by methane and hydrogen but by water vapor, carbon dioxide, and nitrogen. Put simply, the emergence of life came from the right combination of temperature and chemicals.

In fact, temperatures aren't only essential for creating life, but also for maintaining life. Luckily, the Earth is prepared to maintain a moderate temperature to avoid extreme temps. For instance, falling rain contains carbon, which will eventually use the map of the earth to find the earth's mantle, where it will be stored for millions of years. If too much carbon dioxide was buried in this way, Earth would freeze. The Earth prevents this from happening by using plate tectonics to spew material, including carbon dioxide, to the surface through volcanoes. Additionally, less carbon dioxide means colder temperatures. If the Earth cools too much, rainfall will dwindle and less carbon dioxide will be buried which will warm things up again. This geological thermostat has been adjusting to the increasing warmth of our sun for over four billion years!

We don't believe this self-regulation to be happening on other planets in our solar system. For instance, Venus's atmosphere contains huge amounts of carbon dioxide, and the planet has likely suffered from a runaway greenhouse effect. As a result, its surface is hot enough to vaporize water and melt lead. Mars, on the other hand, took another turn and cooled so much that most of its water now exists in the form of ice. Neither Mars nor

Venus seems to do plate tectonics, which deprives them of a key component of our planet's thermostat.

With Photosynthesis, the Earth Became the Perfect Environment for the Creation of Life

Life appeared early in the history of planet Earth thanks to the Goldilocks conditions that created simple forms of life. And while it is difficult to identify when life first appeared, the most direct evidence we have today for the earliest life on Earth consists of microscopic fossils found in Western Australia's Pilbara region, which seem to be of bacteria that lived about 3.4 billion years ago. Biologists refer to the first living organism as Luca - "last universal common ancestor." Luca lived earlier than the earliest life-forms and shares many features with modern organisms known as prokaryotes.

Prokaryotes are single-celled organisms whose genetic material is not protected within a nucleus, and today, they are found in two of the three large domains of organisms, Eubacteria and Archaea. These organisms are created in chemically rich volcanic vents on the ocean floor, and these fairly simple creatures were able to create more complex forms of life through the process of photosynthesis. Prokaryotes near the surface of the oceans or on seashores survived through photosynthesis and allowed the amount of life in the early oceans to increase to as much as 10 percent of today's levels.

Through photosynthesis, prokaryotes formed coral-like structures known as stromatolites, which grew into reefs at the edges of continents as billions of organisms accumulated over time. Today, stromatolites still exist in special environments, such as Shark Bay located off the coast of Western Australia. While they are rare today, they first appeared more than 3.5 billion years ago. Just 500 million years later, photosynthesis evolved to produce oxygen, and another 500 million years after that, these levels of atmospheric oxygen increased even more. As a result, oxygen atoms began to form what we now call the ozone layer - the layer that protects the earth's surface from solar ultraviolet radiation. Up until this point, planet Earth had been fairly sterile, but now protected by the ozone layer, algae began to start colonizing the land for the first time.

This oxygen buildup led to a new atmosphere which became a profound shock to living organisms because, for most of them, oxygen was poisonous. Therefore, rising oxygen levels caused what biologist Lynn Margulis called an “oxygen holocaust.” Organisms like prokaryotes retreated to the deep ocean while oxygen continued to lower the temperature of the Earth, causing the planet to be covered in ice for a hundred million years. While this could’ve proven to be detrimental to the planet, Earth thankfully has a geological thermostat driven by plate tectonics, which gave rise to organisms known as eukaryotes - organisms that could suck the oxygen out of the air, which helped raise the temperature of the Earth.

Eukaryotes didn’t just help stabilize global temperatures, but they also marked a biological revolution that would eventually allow the evolution of large organisms, like you and me. Up until this point, living organisms were single-celled prokaryotes who simply copied themselves. Eukaryotes, however, mixed their genetic material with a “partner.” In other words, eukaryotes had sex. The result was a new twist to evolution, allowing slight but random genetic variations that were guaranteed for every generation. As a result, evolution was able to speed up significantly, which prepared the planet for a much more exciting time: the era of big life.

The Rise and Fall of the Era of Big Life

With more Goldilocks conditions, photosynthesis continued to give Earth the boost of energy it needed to allow single-celled organisms to evolve into complex, multi-celled begins. Over three billion years, there was enough time for big life to evolve and transform the planet. Large plants ground rocks into soils, turning the dusty, rock surface of the Earth into lush and exotic gardens, forest, and savannas. Additionally, multicellular organisms evolved, causing the ocean to transform with strange new creatures, like shrimps, seahorses, octopi, and blue whales.

But it wasn’t just the oceans that were changing, animals were now faced with the problem of gravity, requiring rigid materials and internal plumbing systems to move liquids throughout their bodies. Animals developed organs, like hearts, skeletons, eyes, wings, and claws to survive the changing atmosphere on Earth. Slowly, evolution allowed life to become more intelligent through something we call natural selection. Mammals, for instance, illustrate a powerful evolutionary trend that allows them to elaborately process information. They collect information, process it, and act on it to help them survive. The antelope that wants to hug lions, for example, won’t be around long enough to pass its genes to any offspring.

But evolution isn’t the only thing that allowed mammals to thrive, it was also a lucky break for them that a giant asteroid crashed into Earth - effectively causing the extinction of dinosaurs. Just 65 million years ago, everything changed in just a matter of hours. When the asteroid hit, it was moving at thirty kilometers a second (or one hundred thousand kilometers an hour) and took just seconds to fly through the Earth’s atmosphere and land in the Yucatán Peninsula of modern Mexico. In just seconds, the asteroid generated dust clouds so big they blocked the sun for months. Tsunamis formed a wall of water that crashed on the shores of the Gulf of Mexico and killed fish and dinosaurs hundreds of kilometers away. Within weeks, the blocked sunlight created a nuclear winter and nitric acid rained from the sky, killing most of the organisms it touched.

Big species were hit the hardest, they needed more energy, were less numerous and reproduced more slowly than smaller creatures. This is why the large dinosaurs perished and why smaller organisms like birds and rodentlike mammals survived and evolved; in fact, one of these organisms would become our ancestors.

Humans Evolved From Primates Leading to the Invention of Language

The appearance of humans in our origin story is a *big deal*. As a whole, humans are an extremely young species, having arrived just six million years ago on a planet that is 13.8 billion years old. Despite our short existence, we have drastically evolved from our primate ancestors. For example, humans today walk on two legs, which is very different from knuckle-walking primates like chimps and gorillas. For this to happen, the body required rearrangements of the back, the hips, and even the braincase. With narrower hips, childbearing became more difficult and dangerous, which meant the earliest humans likely gave birth to infants not yet capable of surviving on their own. As a result, babies required more parenting and sociability.

Early humans continued to evolve, and just two million years ago the species classified as *Homo erectus* were larger, had bigger brains, made more sophisticated stone tools, and learned to manage and control fire. This allowed them to cook their food, allowing them to tap into a huge new source of energy. Cooking reduced the time they spent chewing and digesting their food, resulting in the shrinking of the gut and providing more energy to the brain. But perhaps the biggest evolutionary difference between modern and early humans is language.

While many animals can communicate, communication among early animals was incredibly limited. For example, birds and baboons can warn others in their group of the approach of predators. Even chimpanzees can acquire and use a vocabulary of one or two hundred words, but their vocabularies are small and they don’t use syntax or grammar. Their linguistic ability never seems to exceed that of a two or three-year-old human. Linguistic enhancements allowed humans to share information with precision and clarity, allowing knowledge to accumulate from generation to generation through a mechanism called *collective learning*.

Collective learning is a driver of change because it allows for instantaneous exchanges of information, giving humans access to increasing power over their surroundings. As humans learned to better use their resources, the population grew significantly. Italian demographer Massimo Livi-Bacci estimates that 30,000 years ago, there may have been 500,000 humans and that 10,000 years ago, there may have been five or six million. This suggests that human populations increased about twelve times in the last 20,000 years, which also suggests that total human energy consumption also increased about twelve times.

Early humans at this point lived all over the globe in small communities. They enjoyed storytelling, relaxing, dancing, painting, and even had the luxury of a varied diet. Of course, this would all lead to the next threshold in our origin story: farming.

The Invention of Farming Allowed for More Resources and Energy

Now that the population was growing at an alarming rate, the communities of early humans began to turn to farming and agriculture to feed the growing number of mouths. Villages began to grow and acquire new roles as they settled along trade routes and religious sites. For example, let's take a look at Natufians - "affluent foragers" who lived in the Fertile Crescent east of the Mediterranean. Initially, these communities of people were foragers; however, many of the places they settled quickly evolved into towns with growing needs for resources.

As populations grew, the Natufians had to extract more resources from the land, this meant they needed to groom the land more carefully and eventually take up some form of farming. Of course, humans were initially reluctant to become farmers. After all, farming is hard work. When we look at the bones of Natufian women, we can see clear evidence of wear from long hours of rocking back and forth on their knees as they ground grain. Additionally, the bones of early farmers show signs of stress associated with intensive labor required for plowing, harvesting crops, felling trees, and building fences.

Over time, however, the necessity for farming continued and farming eventually began to change human life. But farming didn't just give farmers food, wood, and fibers. It also gave them indirect access to new flows of energy. For example, a human can deliver at most about 75 watts of energy, while a horse or ox can deliver up to ten times as much. All that extra energy could now be used to plow the land more deeply or to increase the production of plants and animals that had other uses besides food, like flax and cotton. Or they could plant trees and use the wood to build homes, farms, barns, and fences, or burn it to cook their food and warm their homes.

Thanks to all this newfound energy, human life began to drastically change. Now that people were *pastoral nomads* and traveled from place to place, they carried with them more than just goods and people. They also carried ideas, technologies, and even diseases through the Silk Roads of Afro-Eurasia. Communities could now work together and share ideas and resources. For example, in modern-day Iraq, there was so little rainfall that they needed to divert water from the Tigris and Euphrates rivers to successfully farm. At first, farmers used simple ditches they dug themselves. Eventually, communities collaborated to build and maintain an elaborate system of canals and dikes to create regions suitable for irrigation farming.

As the productivity of farming improved, farmers began to generate a surplus in food, goods, and even people. Now that fewer hands were needed for farming, people had more time on their hands for other activities - like making and selling pots. For instance, there is evidence of pottery workshops dating as far back as 6,000 years ago. As a result, surpluses and populations continued to grow and people began to specialize in tasks and take up professions, including kings, courtiers, priests, tax collectors, and silver workers.

All of these advancements led to the building of roads to enable trade, like the Royal Road that connected Persia to the Mediterranean. The road was built in the fifth century BC and was 2,700 km long, taking travelers just seven days to travel between the two areas, a huge improvement from the previous travel time of 90 days. Humans were quickly becoming more accustomed to the exchanging of goods and ideas, a practice that would one day shape the way we live today.

The Discovery of Fossil Fuels Accelerated Human Advancements

In 1492, Christopher Columbus became one of the first men to cross the Atlantic ocean. It was European navigators like Columbus who began to link up the major world zones, allowing humanity to make giant leaps forward as goods and ideas traveled all over the world more rapidly than ever before. New information provided the intellectual bricks and mortar for new types of knowledge. For example, when Isaac Newton developed his laws of gravity, he had access to comparisons of how pendulums swung in Paris, the Americas, and Africa. No previous generation of scientists could have tested their ideas so thoroughly or widely.

As a result, humans were learning at a faster rate, leading to the mega-innovation of fossil fuels. The fossil-fuels revolution gave humans access to flows of energy much greater than those provided by farming. England was one of the first countries in the world to feel the power of fossil fuels, and English manufacturers and households began switching over to coal, instead of wood, to heat their homes, and by 1700, coal was producing 50% of English energy. However, Londoners soon began to complain about the city's foul air and as the demand for coal increased, coal miners had to dig deeper mines, which soon filled up with water.

England called for inventors to help solve this technological problem, and by the 1770s, an engineer named James Watt solved them by improving the steam engine. The James Watt steam engine gave a taste of energy flows so vast that it would go on to transform human societies in as little as two centuries. Steam engines allowed coal miners to access deeper mines, allowing them to extract 55 times more coal between the years of 1800 and 1900.

With all this cheap energy, inventors began to experiment and invest in new technologies, such as electricity. In the 1820s, Michael Faraday discovered that you could generate an electrical current by moving a metal coil inside an electric field, and by the 1860s, electricity generation became possible. Life was soon transformed as lightbulbs entered home and factory life by turning night into day, and cities, highways, and ports began to light up at night. But electricity didn't stop there, it continued to revolutionize communication. And by 1837, the invention of the telegraph allowed communication to occur at the speed of light. Soon, telephones and radio made it possible to transmit real conversations almost instantaneously over huge distances.

The Era of Humans

In the twentieth century, humans began to transform our surroundings, our societies, and even ourselves without much intention. This is why many scholars today argue that planet Earth has entered a new geological age, the Anthropocene epoch, or the “era of humans.” In the second half of the twentieth century, the first global superpowers, the United States and the Soviet Union, emerged after the bloodbath of the world wars. And in the decades following World War II, the world witnessed the most remarkable spurt of economic growth in human history.

All of this growth has led to technological and political transformations that have radically changed the human lifestyle. In fact, modern humans live in ways that would likely baffle, confuse, and possibly terrify our ancestors. In the past, activities such as plowing, sowing, harvesting, milking cattle, rearing children, and even cooking dominated the lives of most people for thousands of years. Today, farmers are entrepreneurs who earn wages and work on industrial farms that specialize in a few crops, some of them even genetically engineered! Additionally, most people no longer live in villages, but in towns and cities - environments that are almost entirely shaped by human activity.

While there are many benefits to the Anthropocene era, there are many downsides as well. Economic progress has led to vast inequality, which can be seen through the slave trade that remained quite respectable until as late as the eighteenth century. And as our lifestyles have changed, our traditional attitudes toward families have changed too. Today, rearing children has become more expensive, so urban families have fewer children, and fertility rates are beginning to fall. The Anthropocene era has impacted more than just our lifestyles, however, it has also impacted our environment.

Human activity is changing the distribution and number of living organisms, altering the chemistry of the oceans and the atmosphere, rearranging landscapes and rivers, and unbalancing the ancient chemical cycles that circulate various gases, like nitrogen and oxygen, through the biosphere. In fact, current scientific models predict that within a few decades, as greenhouse-gas emissions create a warmer world, sea levels will rise, drowning many coastal cities and creating unpredictable and extreme weather patterns that will make agriculture more difficult.

So what will happen to Earth? Well, the next hundred years are really important as we are currently managing an entire biosphere, and our future depends on how well we do it. How can we treat the biosphere more gently? How resilient is it? Well, The Stockholm Resilience Centre has identified "planetary boundaries" - limits humanity cannot cross without seriously endangering our future. Two of the most critical boundaries for a sustainable planet are climate change and biodiversity. Unfortunately, researchers suggest that we have crossed critical boundaries in our impacts on flows of phosphorous and nitrogen, and we are close to the boundaries in our use of land, particularly forests.

So how can we create a sustainable world? Can we create a world that allows us to self-regulate similar to how earth self regulates? Well, the Paris climate accord has provided a clear scientific understanding of humans' impact on the planet. But there is still not yet a strong global consensus, and many remain convinced that the warning lights are caused by bad science. Additionally, few have the luxury of thinking on the grand scale needed to seriously imagine the near future. But achieving a sustainable world is the ultimate goal. After all, it would mean that human societies could be around for thousands, perhaps hundreds of thousands, years to come. And during that time, what other thresholds could we cross?

Final Summary

The origin story of humanity and the Earth is a tale of increasing complexity. Over the past billions of years, complex matter has allowed stars, life, humans, and even modern life to emerge from a universe that began from the size of a single atom. And while it took time for life to become sustainable, the past few hundred years have seen a rapid increase in development and advancement. As a result, society has rapidly accelerated, allowing us to live in a society with so much complexity that we have the power to influence the future of mankind and the earth.