

Readers familiar with cosmology might find this essay useful as a review. It was written for readers whose education focused on mythological concepts of creation and who would like to understand the evidence-based account of creation. After reading Seeing Reality As It Is, readers should be aware that apperception and the Semmelweis reflex will cause you to reject new information that contradicts your existing beliefs. The new information will just feel wrong. However, feeling is not the same as knowing, and those brain traits exist to keep you alive, not to help you see reality as it is.

The Early Universe

Since we might never know what happened before the Big Bang, if, indeed, anything happened, the story of creation begins about 13.8 billion years ago (plus or minus a few hundred million years) when it is thought that all of the mass and energy of the universe occupied an extraordinarily small volume that began to expand. When it reached the size of our solar system, protons, neutrons, and electrons formed as more fundamental subatomic particles began to cool. By the time the universe was about 1,000 times the size of our solar system, neutrons and protons formed nuclei of hydrogen, helium, deuterium, and lithium. The universe was now about three seconds old. It was too hot to be transparent or to permit newly formed atomic nuclei to capture electrons to form atoms. That would take another 300,000 years. And when the universe had cooled enough to form atoms, over time, they combined under the influence of gravity to form stars.1 When the universe was less than a billion years old, an entire generation of stars had formed and died, and massive galaxies came together.2

      How did atoms such as helium and iron form? When a spinning disk of matter collapses under its own gravity into what will become a star, the intense pressure, and temperature at its core, causing hydrogen to fuse into helium. The process is the same as that of an exploding hydrogen bomb but on an enormous scale. The continuous flow of energy given off by this ongoing hydrogen fusion limits the degree of collapse of the new sun's core. Eventually, when virtually all the sun's hydrogen is converted to helium, the core shrinks until there is sufficient temperature and pressure to fuse helium to create carbon. This process of creating successively heavier atoms continues until iron is formed. Unlike lighter atoms, iron does not give off energy when it fuses; it consumes energy. So nuclear burning stops with iron, and gravity collapses the sun's core.

      Large stars reach the carbon stage more quickly than do small stars. Medium size stars such as our sun (of which we are aware of about 100 billion billion), the iron stage is reached in about 10 billion years. Stars smaller than our sun can burn for very much longer. In stars with a mass about 20 times that of our sun, fusion is more rapid, and iron is formed in about 10 million years. Stars such as our sun gradually brighten as they convert hydrogen into helium. In its infancy, our sun was about 70 percent of its present brightness. Over the next billion years, our sun will increase in brightness by about 10 percent, perhaps enough to vaporize our oceans.3 By about 6.5 billion years from now, the sun's luminosity will about double. At that time, hydrogen at the sun's core will be depleted, but hydrogen in the shell of gas surrounding the core will continue to fuse into helium. This will cause the sun's outer layers to expand, cool, and appear redder. Our sun will have metamorphosed into what is called a "red giant." This phase will take over a billion years, during which the sun will expand to well beyond the orbit of mercury. As helium begins to fuse into carbon in the core, the sun will begin to shrink. It will take about 100 million years to consume the remaining helium in its core. When helium in the core has been consumed, helium in a gas shell surrounding the core will ignite. This consumed helium core surrounded by newly ignited helium gas will be enclosed in a shell of burning hydrogen. As the core contracts, it will draw in the two burning shells. The helium gas shell will experience a series of explosions, which will begin a final brightening and expansion of the sun that will last for about 20 million years. During this phase, the sun will increase its diameter to beyond Earth's present orbit. Although the Earth will have long since lost its biosphere, the enormous loss of mass experienced by the sun during its later years will reduce its capacity to hold Earth in its present tight orbit. It's thought that the resultant increase in the size of Earth's orbit might keep it from being engulfed by the expanding sun. Over the following few million years, the sun's outer layers will dissipate and reveal its smoldering core. Unlike the dense cores of neutron stars formed when larger stars reach the end of their cycle, the sun's core will not collapse beyond the density permitted by electron repulsion of its core atoms. Its smoldering remnant will have become what is called a "white dwarf," perhaps to be orbited by Earth until the next cataclysm.4

      Why do some stars explode, and where do black holes come from? Stars about 20 times more massive than our sun experience a very different end. When such stars reach the iron stage, gravitation in the star's iron core is so intense that the core collapses. Unlike smaller stars, the mass of iron in the core of large stars is sufficient to compress the nuclei of iron atoms together. Electron repulsion is completely overcome. The collapse takes just a second. If enough material is present to create gravity so intense that light cannot escape, a black hole is formed. If less material is present, a neutron star is formed instead. An explosion following collapse blows the outer stellar material into space and releases the equivalent of all the energy released by our sun in its lifetime. It is as bright as a billion suns. Such an exploding star is called a "type II supernova," and appears as a bright spot in the night sky lasting a few weeks. In 1054 Chinese astronomers observed such a bright spot in the night sky. It was the supernova that produced what we now call the Crab nebula. A more recent supernova was observed in February of 1987.

      How does a supernova explosion create heavy atoms? The shock waves of supernovae create heavier elements such as uranium, lead, gold, and radioactive material, which accounts for the rarity of these heavy atoms. In this way, beginning with hydrogen, stars have manufactured most of the material from which planets are made.5 The initial expansion or Big Bang left the universe a glowing, opaque fireball. As it cooled, stars were speeding away from each other in the expanding universe. Not long after that, large stars began exploding—sending debris in every direction.6 It must have looked like slow motion fireworks. During supernovi, oxygen, nitrogen, and carbon were ejected into space at high speed and collided with slow-moving protons. The collisions formed lithium, beryllium, and boron.

      How are water and other compounds formed? In the gas clouds between stars, conditions are right for the formation of molecules such as hydrogen gas, water, carbon monoxide, ammonia, alkanes (methane series), polycyclic aromatic hydrocarbons (naphthalene), acetylene, and glycine (an amino acid).7 In a 1993 experiment, hydrogen gas and naphthalene were exposed to a 9,400 volts electrical discharge. An infrared spectrum analysis of the yellow-brown residue produced by the discharge revealed a close resemblance to a similar analysis of the Murchison meteorite that fell to Earth in Australia in 1969. It's thought that ionized hydrogen exposed to intense stellar outbursts would create conditions similar to those in the high-voltage experiment. More than 100 chemicals have been detected in interstellar clouds.8 Burning and exploding stars and interstellar synthesis are the primary processes by which hydrogen is converted into the heavier elements and compounds. It's thought that as solar systems formed within galaxies, stellar radiation modified interstellar chemicals to form ethane from acetylene, for example.9,10 Many of the hydrocarbon compounds created by these processes are common building blocks of life as we know it. If autogenesis or self-organizing molecular life required the presence of such compounds, lightning storms in Earth's early atmosphere (simulated in the 1993 experiment) might have produced the required compounds, perhaps making the interstellar contribution unnecessary.

      How do galaxies and solar systems form? The cloud of dust and debris left after a massive star explodes is called a "nebula." In time, matter in nebulae condenses into spinning disks of stars, gas, debris, ice, and dust. Each such spinning disk is a galaxy that can take the shape of a pinwheel or a flat disk with a bulge at its center. It's thought that at least some galaxies have black holes at their centers. A black hole is an object so massive that the velocity needed to escape its gravity exceeds the speed of light, in which case we can't see it directly because light that might emanate from or reflect off it cannot escape its gravity. The disk shape of galaxies is attributed to the spin plane of matter at the center of the disk. Each star in a galaxy is the center of its own spinning disk of matter, which might include planets and rings of debris such as our asteroid belt, all aligned roughly in the spin plane of the star. In turn, each planet could be the center of its own system of moons or rings. Moons, in turn, are capable of capturing and orbiting objects, a fact on which we relied in planning the 1969 moon landing. Even asteroids have been found to have tiny moons.11

      The first galaxies formed about one billion years after the Big Bang and incorporated stellar remnants and interstellar compounds. Recent observations of the cosmos indicate that there are in excess of 100 billion galaxies distributed along the boundaries of spherical voids, like the film on connected soap bubbles.12 The voids measure in the hundreds of millions of light-years across.13

Our galaxy began to form about 10 billion years after the Big Bang, and our star (the sun) is near the outer edge of the galaxy. When we look at the night sky, we see an edge view of hundreds of millions of stars that make up our galaxy. Their number and density appear as a band of white we call the Milky Way. Calculations indicate that there is a black hole of about 4.6 million solar masses at the center of our galaxy. The radiation associated with matter being drawn into such a black hole is thought to be obscured in the visual spectrum by a vast dust cloud between Earth and our galaxy's black hole.

 Our Star

How did our planets form, and why does Earth continue to be bombarded by meteors and other significant objects as recently as perhaps 13,000 years ago? Our solar system, comprising our star, the Earth, other planets and orbiting material, formed about 4.7 billion years ago from a collapsing cloud of dust, gas, ice, and debris. A simplified description of the process is that as the cloud collapsed in on itself, it began to spin faster and faster, like a skater bringing her arms closer to her body to spin faster. The collapsing cloud was a chaotic affair influenced primarily by gravity, electromagnetism, and inertia.14 German astronomer and mathematician Johannes Kepler (1571‑1630) determined that objects travel around the sun in elliptical orbits. Some objects orbited in nearly circular paths while the orbits of others were acutely elliptical and not necessarily coplanar—a combination that generated collisions of all kinds. In time, random agglomerations of matter attracted and held more and more gas, dust, and debris that came into the vicinity of their orbits. Debris was relentlessly assembled into planets. Some inchoate planets had molten cores, heated in part by nuclear fission. Eventually, the forming planets accumulated enough mass for gravity to crush them into spheres. Some planets were struck by large planetesimals. Such impacts were capable of knocking small, loosely assembled planets to pieces. However, the collective gravity of such a fragmented planet could reassemble the planet in time. Of the material thrown up from such impacts, some would fall back, and some would escape the planet's gravity, never to return. And, if the impact were a glancing blow, a moon could be created from material that neither fell back nor escaped but which was thrust into orbit around the planet. Jupiter, Neptune, Saturn, and Uranus were large enough to capture hydrogen and helium gas in great quantities.

      When the temperature and pressure reached critical levels inside the ball of hydrogen at the center of the sunless system, hydrogen began to fuse into helium and began emitting energy. The sun began to glow and to eject particles (solar wind) that swept orbiting dust beyond the outer reaches of the system. Without obscuring dust, the sun's light revealed a new solar system. During the more than 500 million years this process took to complete, Earth and the other planets settled into a reasonably stable relationship with the sun and each other. However, not all of the smaller orbiting bodies were as stable. Still orbiting the sun is debris that was not captured during the formation of the solar system. Some of it travels in Earth-crossing orbits. We know this debris as asteroids, comets, and meteors. Comets consist chiefly of ammonia, methane, carbon dioxide, and water, and it's thought that an orbiting collection of potential Earth-crossing comets resides beyond the orbit of Neptune to far beyond Pluto. It's possible that sun-orbiting comets exist as far out as 50 times the distance from the Earth to the sun---about a fifth of the distance to Alpha Centauri (the star nearest to our solar system). Comets very far from the sun could have their orbits disturbed by passing stars or other matter, and could enter the inner solar system.15 Military defense systems intended to protect against surprise missile attack regularly recorded upper atmosphere impacts by comets of a few meters in diameter. The impacts average about one per month, and their energy is equivalent to about 1/15th the energy of the Hiroshima bomb.

      Debris between Jupiter and Mars failed to form a planet because Jupiter's gravity was so strong that assembling planetesimals were torn apart. That belt of debris comprises asteroids ranging up to 1,000 kilometers across. Unlike comets, asteroids are typically made of metals such as iron and nickel, silicates similar to stone found on Earth, and carbon. As these asteroids are influenced by the competing gravities of Jupiter and the sun, they collide and form dust and small debris. Given the gravitational interaction of the sun and Earth, it's thought that this dust and debris from an irregular ring close enough to Earth for material to be captured by Earth's gravity.16 The captured dust and small debris (shooting stars) are slowed by our atmosphere and fall harmlessly to Earth.17 It's estimated that from tens of thousands to hundreds of thousands of tons of this matter fall to Earth each year.

      As Jupiter's gravity dislodges asteroids from the asteroid belt, some are drawn toward the sun and inner planets. Within about 10 million years, the orbits of the larger of such asteroids will inevitably intersect the orbits of Mars, Mercury, Venus, Earth, or the sun. Meteor Crater in northern Arizona is 1.2 kilometers in diameter and was formed about 50,000 years ago by a metallic meteor about 30 meters across. Meteors larger than a kilometer across, on average, arrive once every 300,000 years. Such meteors would have energies in excess of 600 thousand Hiroshima bombs. On average, meteors about 10 kilometers across strike the Earth every 100 million years. It's this type of meteor that ended the Cretaceous period and the dinosaurs as well as about 70 percent of Earth's species.18

      In the 20th century, we observed two major impacts. In 1908 a meteor believed to be made up of silicates impacted the Tunguska Valley in Siberia with an energy estimated to be equal to 800 Hiroshima bombs. It was about 60 meters across and did not leave a crater because the silicates were loosely connected fragments that burst apart on impact with the atmosphere. Beneath the impact point, it left an area 50 kilometers across of flattened and burnt trees.19 The second major impact was the Shoemaker-Levy 9 comet collisions with Jupiter that began July 16, 1994. The comet fragments had an estimated combined energy equivalent of 250 million Hiroshima bombs. A less significant recent event occurred when a meteor entered Earth's atmosphere over Russia on February 15, 2013, and exploded in an airburst over Chelyabinsk. The explosion had a total kinetic energy equivalent to approximately 30 Hiroshima bombs.

      Although craters on the moon are numerous, on Earth, the effects of wind and water erosion, sedimentation, volcanism, and plate tectonics eventually destroy evidence of impact craters. To date, the remnants of about 160 impact craters have been found on Earth. For the next crater to be formed is just a matter of time. In 1996, an asteroid measuring between 300 and 500 meters across came within 450,000 kilometers of Earth, the distance that such a comet would travel in less than 6 seconds.20 It's estimated that there are about 2,000 Earth orbit—crossing asteroids larger than one—half mile across.21

      Given the chaotic process by which clouds of matter are converted into solar systems, the arrangement of our sun and planets is clearly one of many possible essentially stable states a collapsing cloud of gas, dust, ice, and debris can achieve. Recent research indicates that other solar systems have evolved different arrangements of suns, planets, moons, comets, and asteroids. Given the nature of solar system formation, stellar debris and interstellar material formed long before our sun ignited are the stuff of which the Earth is made. And inasmuch as our bodies derive from Earth, the dust from which we come and to which we return is the dust of ancient stars.

Our Planet

Why does the Earth have a moon, and why is one day 24 hours long? The Earth began to form about 4.6 billion years ago as an orbiting mass of material larger than things around it. Over time, its increasing gravity attracted matter from farther and farther away. Eventually, it grew to become a small planet. For over a hundred million years, it grew in size as it accreted everything within reach of its gravity or that crossed its path at a relative speed slow enough to permit capture. As Earth collided with planetesimals, perhaps the size of the moon, it was knocked apart only to be brought together and crushed into a sphere by its collective gravity. Under the influence of its gravity, iron, heavy radioactive elements, and other very dense materials sank and formed Earth's core while basalt, granite, and other lighter materials rose to form an outer shell. As radioactive material decayed to more stable forms, its radiation heated Earth's core. Countless meteor and planetesimal impacts on Earth's surface created a layer of molten magma hundreds of kilometers thick. For millions of years, volcanoes poured lava onto the surface and into newly formed impact craters.

      Computer simulations indicate that a mass larger than Mars might have collided at a shallow angle with the Earth's mantle about 4.5 billion years ago. The collision would have ejected material both into space and into Earth orbit. By the time gravity resettled the debris, Earth had acquired a moon. The impact was apparently slightly off-center, resulting in the moon's orbital plane being about 5 degrees different from the Earth's. Were the orbital planes exactly the same we would have solar and lunar eclipses each month at the new moon and the full moon. When the moon first formed, its distance from Earth was about half what it is today, resulting in much greater lunar tides than we experience today. Although our present lunar month is about 29.5 days, the first lunar month was considerably shorter. Fossil records of tidal activity contained in "tidal rhythmites" formed about 1 billion years ago indicate that the Earth rotated about 30 percent more rapidly, completing a day in just over 18 hours and a year in 481 days. As the moon interacts with Earth's rotating gravitational field, Earth's rotational speed is slowing while the moon's orbital velocity and diameter increase. In other words, the distance from Earth to the moon is increasing and Earth days are getting longer.22

      Why does Earth have mountains, oceans, a magnetic field, and an atmosphere? About 4.4 billion years ago, Earth began to retain its atmosphere. Churning molten material in Earth's core produces a magnetic field around the Earth strong enough to move compass needles, shape charged particles from the sun into the Arora Borealis, and to prevent gases in Earth's atmosphere from being blown away. By about 4.2 billion years ago, Earth reached its present diameter of about 8,000 miles. The core is about 4,000 miles in diameter and is made up of iron and nickel. Heat from the core creates convection currents in the less dense mantle between the core and Earth's crust. Typically no more than about 20 miles thick, all but the lightest crust material is churned under by the slowly roiling mantle. Continents are made of low-density material that floats on and is driven by the slowly moving mantle convection below. We perceive this motion as continental drift. The continental crustal material is too light to be drawn into the churning mantle and can preserve some of the Earth's oldest rocks. When mantle currents stretch and shear continents, they form rift valleys and fault zones. When continents collide without one continental plate slipping beneath the other, mountain chains form, as the light crustal material has nowhere to go but up. When one plate slips beneath another as they are driven together, crustal rock melts from heat generated as the plates scrape past each other. Upwellings of molten rock at these plate boundaries break the surface as volcanoes. What we call the Pacific ring of fire are volcanoes around the Pacific plate. These forces, together with erosion from wind and water, have destroyed most of Earth's earliest rocks. However, some Australian zircons date back about 4.3 billion years. There are a few theories regarding the source of water in Earth's oceans. One is that it was delivered to Earth by water-containing comets. Another is that hydrogen and oxygen contained in Earth's mantle rock combined when the rock was melted by volcanic, tectonic, and other means.

      It's thought that the early atmosphere formed when the iron/nickel core coalesced and volcanic activity vented gasses from the interior to Earth's surface. It is estimated that this process could have produced over 80 percent of our atmosphere within about one million years. The earliest known atmospheric composition was nitrogen, hydrogen, carbon dioxide, water vapor, sulfur dioxide, hydrochloric acid, methane, and ammonia. Atmospheric oxygen, primarily a byproduct of photosynthesis, would not begin to appear in significant quantities until about 2.5 billion years ago and would take about 600 million years to reach present levels. In time, comet and asteroid impacts diminished on an Earth thick with clouds in an orange sky. Although the sun's energy output was perhaps 25 percent less than it is today, some believe that greenhouse gases in the early atmosphere (methane, ammonia, and carbon dioxide) trapped solar radiation to a greater degree than does our atmosphere today. As the sun's energy output increased over the ensuing billion years, Earth's surface temperature did not rise proportionately because heat-trapping greenhouse gasses gradually diminished.23

      As Earth continued to cool, complex molecules delivered to Earth by comets and asteroids were no longer destroyed by intense heat. Some theorize that single-celled microorganisms might have incubated on other planets and could have arrived on Earth if impacts on other life-supporting planets ejected organism-containing fragments (tektites) that ultimately reached Earth. Such organisms would have been released into the oceans and atmosphere. In any event, compounds formed in space by natural stellar processes would have been available to begin combining on a sterile Earth. Such compounds would have interacted in storms, churning oceans, and waters heated by geothermal activity. Without oxygen, the atmosphere had not formed the ozone layer that today filters out the sun's ultraviolet radiation. This is pivotal to the evolution of life because ultraviolet radiation damages DNA. However, while ultraviolet radiation could reach Earth's surface, it could not penetrate water. After some nine billion years of evolving since the Big Bang, the universe had produced one of perhaps countless planets with primordial chemistry that was ready to support self-organizing and self-replicating molecules.

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Creation According to Science

Endnotes

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