

The geologic timescale is divided into eons, eras, periods, and epochs, with each division representing a significant stage in Earth's history, often marked by major geological and biological events. The names of these periods reflect key characteristics of the life and environment during that time.

Precambrian

The Precambrian is an informal term for the vast span of time that preceded the Cambrian Period, covering about 88% of Earth's history, from its formation around 4.6 billion years ago to the start of the Cambrian Period about 541 million years ago. It's often called the "Age of Early Life." During this time, continents formed, and Earth's atmosphere developed.

Fossils Found:

Due to the soft-bodied nature of most life and the immense age of the rocks, Precambrian fossils are rare. The most common fossils are stromatolites, layered structures created by mats of microorganisms, primarily cyanobacteria. Also found are microfossils of early microorganisms and some of the first simple, soft-bodied multicellular animals, such as those of the Ediacaran biota, which include jellyfish-like creatures and worms.

Cambrian

The Cambrian Period, from about 541 to 485 million years ago, is famous for the Cambrian explosion, a time of rapid diversification when most major animal phyla, or body plans, appeared in the fossil record. This period saw the first widespread appearance of organisms with hard parts like shells and exoskeletons, which fossilize much more easily than soft tissues.

Fossils Found:

The most iconic Cambrian fossils are [trilobites](#), a group of extinct marine arthropods. Other common fossils include early shelled creatures like brachiopods and the reef-building archaeocyathids. Unique fossil deposits like the Burgess Shale in Canada preserve the soft-bodied animals from this period, including the predatory *Anomalocaris* and the bizarre *Hallucigenia*.

Carboniferous

The Carboniferous Period, from about 359 to 299 million years ago, is named for the rich deposits of coal (carbon) that were formed from the dense, swampy forests of this era. The climate was tropical and humid, leading to widespread growth of giant plants. This period is also known for the evolution of the first reptiles and large, flying insects.

Fossils Found:

Abundant fossils from this period include the fossilized remains of vast forests of tree ferns and giant horsetails. Marine fossils are also common, with crinoids (sea lilies), blastoids, and brachiopods dominating the sea floor.

On land, fossils of giant insects like dragonflies with wingspans of up to 28 inches and the first amphibians and reptiles are found.

Jurassic

The Jurassic Period, from about 201 to 145 million years ago, is the middle period of the Mesozoic Era, often referred to as the "Age of Dinosaurs." During this time, the supercontinent Pangaea continued to break apart, leading to new oceans and distinct evolutionary paths for life on different landmasses.



Dinosaur bones preserved by mud on display at the Nevada State Museum 2024. A Hairy Mammoth and an unidentified dinosaur. The bone structure of the dinosaurs is similar to those of the birds that live today which implies that Chucks have survived on Earth for a long, long time. Most of the Dinosaurs were egg laying reptiles.

Fossils Found:

The most famous fossils from this period are those of giant dinosaurs, including herbivores like Apatosaurus and Stegosaurus, and predators like Allosaurus. Marine fossils include various ammonites and large swimming reptiles like ichthyosaurs and plesiosaurs. The first birds, such as Archaeopteryx, also appeared during this period, and their fossils show a combination of reptilian and avian features.

Lucy, the Australopithecus fossil

The famous fossil skeleton of an early human ancestor, a member of the species Australopithecus afarensis, was discovered in 1974 by a team of paleoanthropologists led by Donald Johanson in Ethiopia.

Lewis/Louis Leakey:

While Louis Leakey was a monumental figure in palaeoanthropology and made significant discoveries in East Africa (along with his wife, Mary Leakey), he was not directly involved in the discovery of the "Lucy" fossil. His work, however, was crucial in establishing the theory that human evolution originated in Africa.

Desmond Morris's 1967 book, *The Naked Ape*, and the 1974 discovery of the "Lucy" fossil are significant but distinct milestones in the public understanding of human evolution. They do not directly relate to each other in a historical or scientific sense. Morris wrote his book before the discovery of Lucy. However, they can be seen as two very different approaches to understanding human origins, with Morris's work being a popular, behavioural-centric theory and Lucy representing a hard-data, paleontological discovery that challenged some existing ideas. Morris's work was influential but also highly speculative and has been widely criticized by the scientific community. Many of his theories, particularly those related to the sexual division of labour and the role of male hunting in human evolution, are now considered outdated or incorrect.

Lucy in the Sky with Diamonds

The discovery of the fossilized skeleton of *Australopithecus afarensis*, nicknamed "Lucy," was a groundbreaking paleontological find. Her skeleton, dating to about 3.2 million years ago, provided definitive evidence for two crucial aspects of human evolution:

Bipedalism preceded big brains: Lucy's anatomy, particularly her pelvis and leg bones, showed that she walked upright on two legs. However, her skull was small, indicating a brain size no larger than a chimpanzee's. This directly challenged the earlier assumption that the development of a large brain was the first major step in human evolution. Lucy provided a tangible link between ape-like ancestors and later hominins, confirming that bipedalism was a key early adaptation. *The Naked Ape* was published seven years before Lucy was discovered. Morris was writing in a time when the fossil record was much sparser and less complete. His theories were based on comparative ethology and educated speculation, not on the specific fossil evidence that Lucy and other later finds would provide.

The "Lucy" fossil (a 3.2-million-year-old *Australopithecus afarensis*) was discovered in **1974** in Ethiopia by: **Donald Johanson** (an American paleoanthropologist) and **Tom Gray** (his graduate student).

The Beatles Connection: The song and the fossil are linked by a late-night celebration. After finding the skeleton, the team returned to their camp in the Afar region. They were ecstatic and began drinking beer and playing music on a cassette player. The story goes:

1. The Beatles' "**Lucy in the Sky with Diamonds**" was playing loudly and repeatedly on the tape recorder.
2. An expedition member named **Pamela Alderman** suggested, "Why don't we call her Lucy?"
3. The name stuck so well that "Lucy" became the most famous fossil name in history, far overshadowing its scientific catalogue number, **AL 288-1**.

Why the confusion with Louis Leakey?

It's easy to see why the names get crossed:

- **The Era:** Louis Leakey was the "rockstar" of anthropology for decades, and his work made the field famous.
- **The Family:** Louis died in 1972 (two years before Lucy was found), but his wife Mary Leakey and son Richard Leakey were active in the same regions of Africa during that time. In fact, Mary and Richard actually visited Johanson's site to see the fossils shortly before the main Lucy skeleton was uncovered.

Plant Fossils:

Plant fossils are the preserved remains, imprints, or traces of ancient plants. They can be microscopic, like pollen and spores, or macroscopic, such as leaves, roots, stems, and seeds. Fossilization often occurs in fine-grained sediments in environments like river deltas or oxbow lakes, where the plant material is rapidly buried and protected from decay.

Tree fossils:

These are a type of plant fossil, often composed of petrified wood—wood that has turned to stone through a process called permineralization. During this process, minerals from groundwater fill the porous spaces of the wood and gradually replace the organic material while preserving its original structure, including tree rings.

Fern fossils:

These are the preserved remains of ancient ferns, a group of plants that reproduce via spores. Their fossils are often found as intricate impressions of their fronds in sedimentary rock, such as shale and coal. Many of the large ferns from the Carboniferous Period are actually "seed ferns," an extinct group of plants that had fern-like fronds but were true seed plants.

The Earliest Tree

The earliest known tree is *Wattieza*, a genus of cladoxylopsid plants from the Middle Devonian Period, about 390 million years ago. These trees had a hollow trunk and no true leaves, with their branches resembling a cluster of palm fronds. They grew to be 6.5 to 13 feet tall and formed the world's earliest known forests. For a long time, the oldest known tree was thought to be *Archaeopteris*, which lived slightly later in the Devonian period. While it had fern-like leaves, it possessed a modern-looking woody trunk and other characteristics similar to modern seed-bearing trees, making it a crucial evolutionary link between ferns and gymnosperms.

Astronomy

In astronomy, the key signatures of life are molecules in a planet's atmosphere that suggest the presence of biological processes. The primary method for detecting these is spectrography, which the James Webb Space Telescope (JWST) uses to analyse the light passing through an exoplanet's atmosphere.

Biosignatures

A biosignature is any substance or phenomenon that provides evidence of past or present life.

In the context of exoplanet atmospheres, these are gases that are often produced by living organisms and are not easily created by non-biological (abiotic) processes. A compelling biosignature isn't a single gas but a combination of gases that exist in a state of chemical disequilibrium. For example, on Earth, the coexistence of large amounts of oxygen (O₂) and methane (CH₄) is a strong indicator of life because these two gases react with each other and shouldn't exist in high concentrations together without a constant biological source replenishing them.

Other potential biosignature gases include:

Ozone (O₃): Formed from oxygen, its presence is a proxy for O₂.

Dimethyl Sulphide (DMS): A gas produced by marine life on Earth, it has been proposed as a robust biosignature for "Hycean" worlds (planets with hydrogen-rich atmospheres and liquid oceans).

Methyl Halides: These gases are produced by various life forms on Earth and are a promising target because they are not known to have significant abiotic sources.

The Role of the James Webb Space Telescope (JWST)

The JWST is a powerful tool for this research because it is designed to conduct infrared astronomy. It uses a technique called transmission spectrography to analyse the atmospheres of transiting exoplanets—planets that pass in front of their host star from our perspective.

How it Works

As starlight passes through the exoplanet's atmosphere, certain gases absorb specific wavelengths of that light. The JWST's instruments, like the Near-Infrared Spectrograph (NIR Spec) and the Mid-Infrared Instrument (MIRI), split this light into a spectrum, which is like a chemical fingerprint.

By analysing the absorption lines in the spectrum, astronomers can identify the chemical composition of the atmosphere.

The JWST's high sensitivity allows it to detect the faint absorption signals of key biosignature gases. However, detecting a single potential biosignature is not definitive proof of life. Further observations and modelling are needed to rule out false positives from abiotic processes and to confirm the existence of a biological source. While the JWST is a revolutionary step, it still has limitations. It is challenging to analyse the atmospheres of small, Earth-sized planets, and long observation times are often required to collect sufficient data. The ultimate goal is to find multiple, converging lines of evidence for life on an exoplanet.

The Launch & Position

The JWST launched on December 25, 2021, aboard an Ariane 5 rocket from Europe's Spaceport in Kourou, French Guiana. It isn't in orbit around Earth like the Hubble Space Telescope. Instead, the JWST is positioned at the second Sun-Earth Lagrange point (L2), which is about 1.5 million kilometres (1 million miles) from Earth. This location is ideal because it allows the telescope to maintain a stable position relative to the Earth and Sun, keeping its sunshield constantly between the two to protect its sensitive instruments from heat and light.

Discoveries

Since becoming operational in July 2022, the JWST has made numerous discoveries, primarily by observing the universe in infrared light. Some of its key findings include:

Early Galaxies:

The telescope has captured images of some of the earliest and most distant galaxies ever observed, providing new insights into the formation and evolution of the universe.

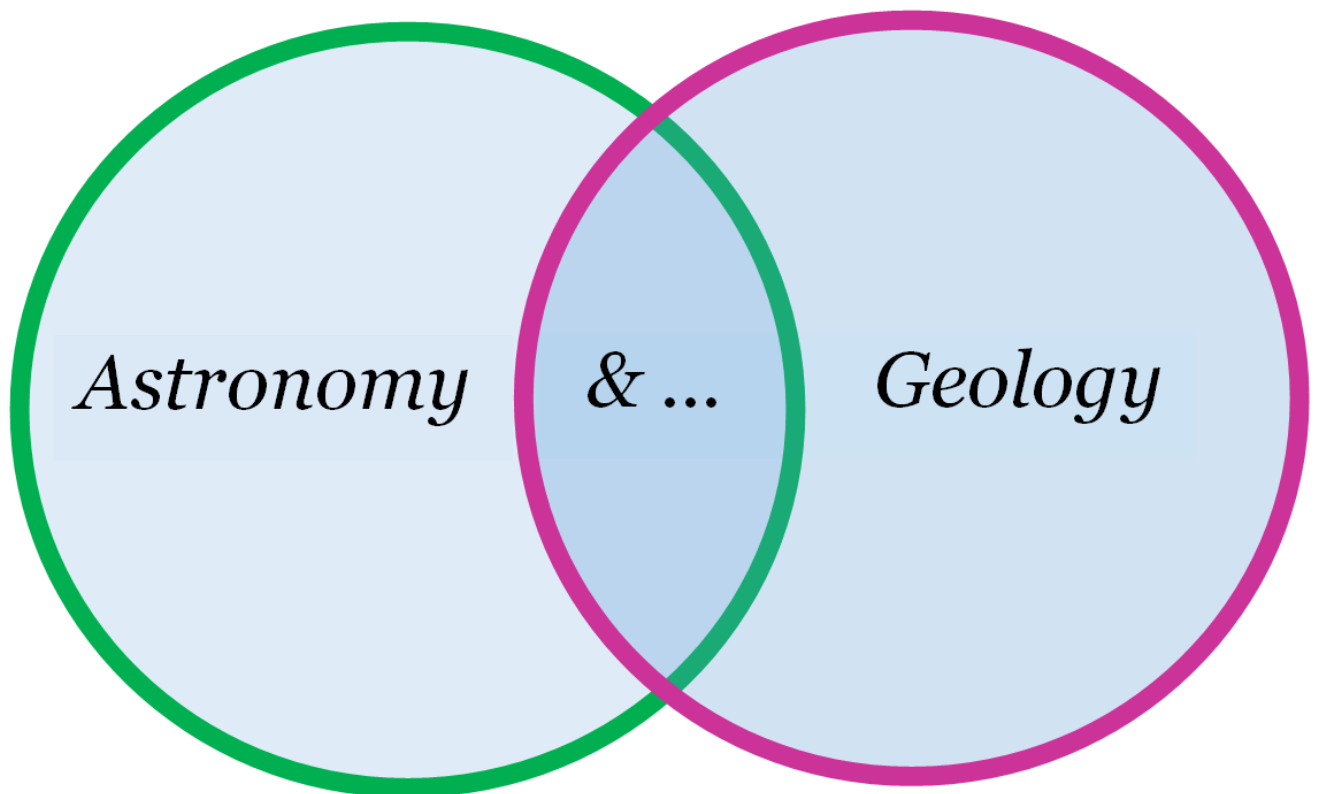
This is the beginning of the intersection of the intersection of Astronomy and Geology. A set of newly acquired knowledge known as **Planetary Science**.

Exoplanet Atmospheres:

The JWST has performed detailed analyses of the atmospheres of exoplanets, detecting molecules like water vapour, methane, and carbon dioxide. This data is crucial for assessing the potential habitability of planets outside our solar system.

Star and Planet Formation:

It has provided unprecedented views of stellar nurseries and protoplanetary disks, revealing new details about how stars and planetary systems are born.



The Universe's Expansion:

By observing distant supernovae, the JWST is helping scientists to refine measurements of the universe's expansion rate, which could help resolve the "Hubble tension" — a discrepancy between different methods of measuring this rate.

The James Webb Space Telescope (JWST) has made a number of significant discoveries about our solar system's planets, particularly Mars. However, it can't observe Earth, Venus, or Mercury directly due to its position and instrumentation.

Mars ●

JWST's observations of Mars have provided detailed insights into its atmosphere and surface. Using its sensitive instruments, the telescope has captured images and spectra of the Red Planet, helping scientists to better understand its weather, dust storms, and seasonal changes.

Atmospheric Composition:

JWST's spectrographs have confirmed the presence of carbon dioxide, water, and carbon monoxide in Mars's atmosphere. This data helps to analyse the planet's atmospheric chemistry and how it interacts with the surface.

Thermal and Surface Features:

The telescope's infrared capabilities have created detailed thermal maps of Mars, showing temperature variations across its surface. Observations have revealed features like the Hellas Basin, which appears as a darker, cooler spot due to atmospheric pressure changes. The images also show surface features like craters and volcanic rock, providing new perspectives on the planet's geology.

Earth, Venus, and Mercury 🌍

JWST is specifically designed to observe faint, distant infrared light from the early universe. To do this, it needs to be kept extremely cold and shielded from bright, hot sources.

Orbital Position:

The telescope orbits at the Sun-Earth Lagrange Point 2 (L2), which keeps the Sun, Earth, and Moon behind it. This position provides an ideal view of deep space, but it means that to look at the inner solar system planets (Mercury, Venus, and Earth), JWST would have to turn and face the Sun.

Risk of Damage:

Turning toward the Sun would expose JWST's sensitive instruments to intense heat and light, which could cause irreversible damage and end the mission. Therefore, to protect the telescope and ensure its primary mission, it cannot be used to observe these inner planets.

The intersection of astronomy and geology

The intersection of astronomy and geology is a vibrant interdisciplinary field is also commonly known as Planetary Geology (or Astrogeology).

While traditional geology focuses on the Earth, and astronomy focuses on the stars and the universe at large, this intersection applies geological principles to celestial bodies like planets, moons, asteroids, and comets.

1. Core Disciplines of the Intersection

The overlap creates several specialized fields that use astronomical data to answer geological questions:

Planetary Geomorphology:

Studying the surface features of other worlds—such as the massive volcanoes on Mars (like Olympus Mons) or the methane lakes on Saturn's moon, Titan.

Cosmochemistry:

Analysing the chemical composition of matter in the universe to understand how planets formed from the early solar nebula.

Planetary Geophysics:

Using physics to study the internal structures of planets, such as the liquid iron cores of terrestrial planets or the "ice" mantles of Uranus and Neptune.

Impact Cratering:

A process unique to the intersection, where astronomical objects (asteroids/comets) create geological structures on a planet's surface.

2. How the Two Fields Work Together

The relationship is a "two-way street" where each discipline provides essential tools for the other: Astronomy Helps Geology; Geology Helps Astronomy;

Telescopes and probes:

Provide the "field site" photos of distant surfaces.

Geologists provide the "ground truth" to interpret what those photos actually mean.

Samples

Astronomy identifies meteorites and tracks their origin in space.

Geology analyses these rocks in labs to determine the age and history of the Solar System.

Evolution

Provides the orbital context (gravity, radiation) that affects a planet.
internal heat or plate tectonics changes its atmosphere over eons.

Explains how a planet's

3. Real-World Applications

The Search for Life (Astrobiology):

Geologists look for "biosignatures" in rocks (like those being collected by the Perseverance rover on Mars), while astronomers identify which star systems have "habitable zones" where those rocks might exist.

Exoplanet Characterization:

As astronomers discover thousands of planets around other stars, they rely on geological models to predict if those planets are rocky like Earth or gaseous like Jupiter.

Galactic Influence on Earth:

Recent research suggests that as our Solar System passes through the Milky Way's spiral arms, increased comet impacts may have triggered major geological shifts or extinction events on Earth.

4. Key Figures

The field was largely pioneered by Eugene Shoemaker, a geologist who dreamed of going to the Moon. He realized that the craters on the Moon were not volcanic (as many astronomers thought) but were caused by impacts—a discovery that forever linked the two fields. Eugene Shoemaker is the only person whose ashes have been buried on the Moon, a tribute to his role in merging geology with space exploration.

Shoemaker-Levy 9 (SL9)

Was a comet that provided the world with its first-ever direct observation of a collision between two solar system objects. The comet was named after its three discoverers, who spotted it on a photographic plate in March 1993. It was the ninth short-period comet they found together, hence the "9" in its official name. The team consisted of:

- **Eugene Shoemaker:** A pioneer in planetary science and the founder of the field of astrogeology.
- **Carolyn Shoemaker:** Eugene's wife and a prolific astronomer who, at one point, held the record for discovering the most comets by an individual.
- **David H. Levy:** A Canadian astronomer and science writer famous for his passion for comet hunting.

The Breakup

In July 1992, the comet passed too close to Jupiter and was torn apart by the planet's massive tidal forces. It transformed from a single body into a "string of pearls"—a fragment chain stretching about **1.1 million kilometres** long.

The Impact (July 1994)

Over the course of six days in July 1994, more than 20 fragments slammed into Jupiter's southern hemisphere at speeds of approximately **60 km/s**.

- **The Scars:** The impacts created giant dark soot clouds in Jupiter's atmosphere. Some of these "bruises" were larger than Earth and remained visible for months.
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- **The Energy:** The largest fragment (Fragment G) exploded with a force equivalent to **6 million megatons of TNT**—roughly 600 times the world's entire nuclear arsenal at the time.

Why It Mattered

- **Atmospheric Probe:**

The collisions acted like a natural experiment, allowing scientists to study the composition of Jupiter's deeper atmospheric layers.

- **Planetary Defence:**

It served as a massive wake-up call regarding the potential threat of comet and asteroid impacts on Earth.

- **Water Discovery:**

Analysis of the impact sites confirmed the presence of water in Jupiter's stratosphere, likely delivered by the comet itself.