**Paleontology**

**Paleontology**, also spelled **palaeontology** or **palæontology**, is the scientific study of life that existed prior to, and sometimes including, the start of the [Holocene](https://en.wikipedia.org/wiki/Holocene) [epoch](https://en.wikipedia.org/wiki/Epoch_(geology)) (roughly 11,700 years before present). It includes the study of [fossils](https://en.wikipedia.org/wiki/Fossil) to classify [organisms](https://en.wikipedia.org/wiki/Organism) and study their [interactions](https://en.wikipedia.org/wiki/Biological_interaction) with each other and their environments (their [paleoecology](https://en.wikipedia.org/wiki/Paleoecology" \o "Paleoecology)). Paleontological observations have been documented as far back as the 5th century BC. The science became established in the 18th century as a result of [Georges Cuvier](https://en.wikipedia.org/wiki/Georges_Cuvier)'s work on [comparative anatomy](https://en.wikipedia.org/wiki/Comparative_anatomy), and developed rapidly in the 19th century. The term itself originates from [Greek](https://en.wikipedia.org/wiki/Ancient_language) παλαιός (*'palaios'*, "old, ancient"), ὄν (*'on'*, ([gen.](https://en.wikipedia.org/wiki/Genitive) *'ontos'*), "being, creature"), and λόγος (*'logos'*, "speech, thought, study").

Paleontology lies on the border between [biology](https://en.wikipedia.org/wiki/Biology) and [geology](https://en.wikipedia.org/wiki/Geology), but differs from [archaeology](https://en.wikipedia.org/wiki/Archaeology) in that it excludes the study of [anatomically modern humans](https://en.wikipedia.org/wiki/Anatomically_modern_human). It now uses techniques drawn from a wide range of sciences, including [biochemistry](https://en.wikipedia.org/wiki/Biochemistry), [mathematics](https://en.wikipedia.org/wiki/Mathematic), and engineering. Use of all these techniques has enabled paleontologists to discover much of the [evolutionary history of life](https://en.wikipedia.org/wiki/Evolutionary_history_of_life), almost all the way back to when Earth became capable of supporting life, nearly 4 billion years ago.[[2]](https://en.wikipedia.org/wiki/Paleontology#cite_note-3)As knowledge has increased, paleontology has developed specialised sub-divisions, some of which focus on different types of fossil organisms while others study [ecology](https://en.wikipedia.org/wiki/Paleoecology) and environmental history, such as [ancient climates](https://en.wikipedia.org/wiki/Paleoclimatology).

Body fossils and [trace fossils](https://en.wikipedia.org/wiki/Trace_fossil) are the principal types of evidence about ancient life, and [geochemical](https://en.wikipedia.org/wiki/Geochemistry) evidence has helped to decipher the evolution of life before there were organisms large enough to leave body fossils. Estimating the dates of these remains is essential but difficult: sometimes adjacent rock layers allow [radiometric dating](https://en.wikipedia.org/wiki/Radiometric_dating), which provides [absolute dates](https://en.wikipedia.org/wiki/Absolute_dating) that are accurate to within 0.5%, but more often paleontologists have to rely on relative dating by solving the "[jigsaw puzzles](https://en.wikipedia.org/wiki/Jigsaw_puzzle)" of [biostratigraphy](https://en.wikipedia.org/wiki/Biostratigraphy" \o "Biostratigraphy) (arrangement of rock layers from youngest to oldest). Classifying ancient organisms is also difficult, as many do not fit well into the [Linnaean taxonomy](https://en.wikipedia.org/wiki/Linnaean_taxonomy)classifying living organisms, and paleontologists more often use [cladistics](https://en.wikipedia.org/wiki/Cladistics" \o "Cladistics) to draw up evolutionary "family trees". The final quarter of the 20th century saw the development of [molecular phylogenetics](https://en.wikipedia.org/wiki/Molecular_phylogenetics), which investigates how closely organisms are related by measuring the similarity of the [DNA](https://en.wikipedia.org/wiki/DNA) in their [genomes](https://en.wikipedia.org/wiki/Genome). Molecular phylogenetics has also been used to estimate the dates when species diverged, but there is controversy about the reliability of the [molecular clock](https://en.wikipedia.org/wiki/Molecular_clock) on which such estimates depend.

**Subdivisions:**

As knowledge has increased, paleontology has developed specialized subdivisions. [Vertebrate paleontology](https://en.wikipedia.org/wiki/Vertebrate_paleontology) concentrates on fossils from the earliest fish to the immediate ancestors of modern [mammals](https://en.wikipedia.org/wiki/Mammal). [Invertebrate paleontology](https://en.wikipedia.org/wiki/Invertebrate_paleontology) deals with fossils such as [molluscs](https://en.wikipedia.org/wiki/Mollusc" \o "Mollusc), [arthropods](https://en.wikipedia.org/wiki/Arthropod), [annelid](https://en.wikipedia.org/wiki/Annelid) worms and [echinoderms](https://en.wikipedia.org/wiki/Echinoderm). [Paleobotany](https://en.wikipedia.org/wiki/Paleobotany) studies fossil [plants](https://en.wikipedia.org/wiki/Embryophyte), [algae](https://en.wikipedia.org/wiki/Algae), and fungi. [Palynology](https://en.wikipedia.org/wiki/Palynology" \o "Palynology), the study of [pollen](https://en.wikipedia.org/wiki/Pollen) and [spores](https://en.wikipedia.org/wiki/Spores) produced by land plants and [protists](https://en.wikipedia.org/wiki/Protist" \o "Protist), straddles paleontology and [botany](https://en.wikipedia.org/wiki/Botany), as it deals with both living and fossil organisms. [Micropaleontology](https://en.wikipedia.org/wiki/Micropaleontology) deals with microscopic fossil organisms of all kinds.

Instead of focusing on individual organisms, [paleoecology](https://en.wikipedia.org/wiki/Paleoecology" \o "Paleoecology) examines the interactions between different ancient organisms, such as their [food chains](https://en.wikipedia.org/wiki/Food_chain), and the two-way interactions with their environments. For example, the development of [oxygenic photosynthesis](https://en.wikipedia.org/wiki/Oxygen#Photosynthesis_and_respiration) by bacteria caused the [oxygenation of the atmosphere](https://en.wikipedia.org/wiki/Oxygen#Build-up_in_the_atmosphere) and hugely increased the productivity and diversity of [ecosystems](https://en.wikipedia.org/wiki/Ecosystem). Together, these led to the evolution of complex [eukaryotic](https://en.wikipedia.org/wiki/Eukaryotic) cells, from which all [multicellular](https://en.wikipedia.org/wiki/Multicellular) organisms are built.

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[Paleoclimatology](https://en.wikipedia.org/wiki/Paleoclimatology), although sometimes treated as part of paleoecology, focuses more on the history of Earth's climate and the mechanisms that have changed it[[29]](https://en.wikipedia.org/wiki/Paleontology#cite_note-30) – which have sometimes included [evolutionary](https://en.wikipedia.org/wiki/Evolution) developments, for example the rapid expansion of land plants in the [Devonian](https://en.wikipedia.org/wiki/Devonian) period removed more [carbon dioxide](https://en.wikipedia.org/wiki/Carbon_dioxide) from the atmosphere, reducing the [greenhouse effect](https://en.wikipedia.org/wiki/Greenhouse_effect) and thus helping to cause an [ice age](https://en.wikipedia.org/wiki/Ice_age) in the [Carboniferous](https://en.wikipedia.org/wiki/Carboniferous) period.

[Biostratigraphy](https://en.wikipedia.org/wiki/Biostratigraphy), the use of fossils to work out the chronological order in which rocks were formed, is useful to both paleontologists and geologists. [Biogeography](https://en.wikipedia.org/wiki/Biogeography) studies the spatial distribution of organisms, and is also linked to geology, which explains how Earth's geography has changed over time

**Sources of evidence;**

**Body fossils**:

Fossils of organisms' bodies are usually the most informative type of evidence. The most common types are wood, bones, and shells. Fossilisation is a rare event, and most fossils are destroyed by [erosion](https://en.wikipedia.org/wiki/Erosion) or [metamorphism](https://en.wikipedia.org/wiki/Metamorphism) before they can be observed. Hence the fossil record is very incomplete, increasingly so further back in time. Despite this, it is often adequate to illustrate the broader patterns of life's history. There are also biases in the fossil record: different environments are more favorable to the preservation of different types of organism or parts of organisms. Further, only the parts of organisms that were already [mineralised](https://en.wikipedia.org/wiki/Mineralisation_(biology)" \o "Mineralisation (biology)) are usually preserved, such as the shells of molluscs. Since most animal species are soft-bodied, they decay before they can become fossilised. As a result, although there are 30-plus [phyla](https://en.wikipedia.org/wiki/Phylum) of living animals, two-thirds have never been found as fossils.

**Trace fossils**::

[Trace fossils](https://en.wikipedia.org/wiki/Trace_fossil) consist mainly of tracks and burrows, but also include [coprolites](https://en.wikipedia.org/wiki/Coprolite) (fossil [feces](https://en.wikipedia.org/wiki/Feces)) and marks left by feeding. Trace fossils are particularly significant because they represent a data source that is not limited to animals with easily fossilised hard parts, and they reflect organisms' behaviours. Also many traces date from significantly earlier than the body fossils of animals that are thought to have been capable of making them. Whilst exact assignment of trace fossils to their makers is generally impossible, traces may for example provide the earliest physical evidence of the appearance of moderately complex animals (comparable to [earthworms](https://en.wikipedia.org/wiki/Earthworm)).

**Geochemical observations** :

Geochemical observations may help to deduce the global level of biological activity at a certain period, or the affinity of certain fossils. For example, geochemical features of rocks may reveal when life first arose on Earth, and may provide evidence of the presence of [eukaryotic](https://en.wikipedia.org/wiki/Eukaryotic) cells, the type from which all [multicellular](https://en.wikipedia.org/wiki/Multicellular" \o "Multicellular) organisms are built. Analyses of [carbon](https://en.wikipedia.org/wiki/Carbon) [isotope ratios](https://en.wikipedia.org/wiki/Isotope_analysis) may help to explain major transitions such as the [Permian–Triassic extinction event](https://en.wikipedia.org/wiki/Permian%E2%80%93Triassic_extinction_event).[[15]](https://en.wikipedia.org/wiki/Paleontology#cite_note-Twitchett-16)