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Earth

Earth is the third planet from the Sun and the only astronomical object known to harbor life. This is enabled by Earth being an ocean world, the only one in the Solar System sustaining liquid surface water. Almost all of Earth's water is contained in its global ocean, covering 70.8% of Earth's crust. The remaining 29.2% of Earth's crust is land, most of which is located in the form of continental landmasses within Earth's land hemisphere. Most of Earth's land is somewhat humid and covered by vegetation, while large sheets of ice at Earth's polar deserts retain more water than Earth's groundwater, lakes, rivers and atmospheric water combined. Earth's crust consists of slowly moving tectonic plates, which interact to produce mountain ranges, volcanoes, and earthquakes. Earth has a liquid outer core that generates a magnetosphere capable of deflecting most of the destructive solar winds and cosmic radiation.

Earth has a dynamic atmosphere, which sustains Earth's surface conditions and protects it from most meteoroids and UV-light at entry. It has a composition of primarily nitrogen and oxygen. Water vapor is widely present in the atmosphere, forming clouds that cover most of the planet. The water vapor acts as a greenhouse gas and, together with other greenhouse gases in the atmosphere, particularly carbon dioxide (CO_2), creates the conditions for both liquid surface water and water vapor to persist via the capturing of energy from the Sun's light. This process maintains the current average surface temperature of 14.76 °C (58.57 °F), at which water is liquid under normal atmospheric pressure. Differences in the amount of captured energy between geographic regions (as with the equatorial region receiving more sunlight than the polar regions) drive atmospheric and ocean currents, producing a global climate system with different climate regions, and a range of weather phenomena such as precipitation, allowing components such as nitrogen to cycle.

Earth

The Blue Marble, Apollo 17, December 1972

Designations	
Alternative names	The world, the globe, Sol III, Terra, Tellus, Gaia, Mother Earth
Adjectives	Earthly, terrestrial, terran, tellurian
Symbol	⊕ and ♁
Orbital characteristics	
Epoch J2000[n 1]	
Aphelion	152 097 597 km
Perihelion	147 098 450 km[n 2]
Semi-major axis	149 598 023 km[1]
Eccentricity	0.016 7086[1]
Orbital period (sidereal)	365.256 363 004 d[2] (1.000 017 420 96 a_j)
Average orbital speed	29.7827 km/s[3]
Mean anomaly	358.617°
Inclination	7.155° – Sun's equator; 1.578 69° – invariable plane;[4] 0.000 05° – J2000 ecliptic

Earth is rounded into an ellipsoid with a circumference of about 40,000 km. It is the densest planet in the Solar System. Of the four rocky planets, it is the largest and most massive. Earth is about eight light-minutes away from the Sun and orbits it, taking a year (about 365.25 days) to complete one revolution. Earth rotates around its own axis in slightly less than a day (in about 23 hours and 56 minutes). Earth's axis of rotation is tilted with respect to the perpendicular to its orbital plane around the Sun, producing seasons. Earth is orbited by one permanent natural satellite, the Moon, which orbits Earth at 384,400 km (1.28 light seconds) and is roughly a quarter as wide as Earth. The Moon's gravity helps stabilize Earth's axis, causes tides and gradually slows Earth's rotation. Tidal locking has made the Moon always face Earth with the same side.

Earth, like most other bodies in the Solar System, formed 4.5 billion years ago from gas and dust in the early Solar System. During the first billion years of Earth's history, the ocean formed and then life developed within it. Life spread globally and has been altering Earth's atmosphere and surface, leading to the Great Oxidation Event two billion years ago. Humans emerged 300,000 years ago in Africa and have spread across every continent on Earth. Humans depend on Earth's biosphere and natural resources for their survival, but have increasingly impacted the planet's environment. Humanity's current impact on Earth's climate and biosphere is unsustainable, threatening the livelihood of humans and many other forms of life, and causing widespread extinctions.[23]

Etymology

The Modern English word *Earth* developed, via Middle English, from an Old English noun most often spelled *eorðe*.[24] It has cognates in every Germanic language, and their ancestral root has been reconstructed as **erþō*. In its earliest attestation, the word *eorðe* was used to translate the many senses of Latin *terra* and Greek γῆ *gē*: the ground, its soil, dry land, the human world, the surface of the world (including the sea), and the globe itself. As with Roman Terra/Tellūs and Greek

Longitude of ascending node	−11.260 64° – J2000 ecliptic[3]		
Time of perihelion	2023-Jan-04[5]		
Argument of perihelion	114.207 83°[3]		
Satellites	1, the Moon		
Physical characteristics			
Mean radius	6 371.0 km[6]		
Equatorial radius	6 378.137 km[7][8]		
Polar radius	6 356.752 km[9]		
Flattening	1/298.257 222 101 (ETRS89)[10]		
Circumference	40 075.017 km equatorial[8] 40 007.86 km meridional[11][n 3]		
Surface area	510 072 000 km^2[12][n 4] Land: 148 940 000 km^2 Water: 361 132 000 km^2		
Volume	$1.083\,21 \times 10^{12}$ km^3[3]		
Mass	$5.972\,168 \times 10^{24}$ kg[13]		
Mean density	5.513 g/cm^3[3]		
Surface gravity	9.806 65 m/s^2[14] (exactly 1 g_0)		
Moment of inertia factor	0.3307[15]		
Escape velocity	11.186 km/s[3]		
Synodic rotation period	1.0 d (24h 00 m 00s)		
Sidereal rotation period	0.997 269 68 d[16] (23h 56 m 4.100s)		
Equatorial rotation velocity	0.4651 km/s[17]		
Axial tilt	23.439 2811°[2]		
Albedo	0.367 geometric[3] 0.306 Bond[3]		
Temperature	255 K (−18 °C) (blackbody temperature)[18]		
Surface temp. [n 5]	min	mean	max
	−89.2 °C	14.76 °C	56.7 °C
Surface equivalent dose rate	0.274 μSv/h[22]		

Gaia, Earth may have been a personified goddess in Germanic paganism: late Norse mythology included Jörð ("Earth"), a giantess often given as the mother of Thor.[25]

Historically, "Earth" has been written in lowercase. Beginning with the use of Early Middle English, its definite sense as "the globe" was expressed as "the earth". By the era of Early Modern English, capitalization of nouns began to prevail, and *the earth* was also written *the Earth*, particularly when referenced along with other heavenly bodies. More recently, the name is sometimes simply given as *Earth*, by analogy with the names of the other planets, though "earth" and forms with "the earth" remain common.[24] House styles now vary: Oxford spelling recognizes the lowercase form as the more common, with the capitalized form an acceptable variant. Another convention capitalizes "Earth" when appearing as a name, such as a description of the "Earth's atmosphere", but employs the lowercase when it is preceded by "the", such as "the atmosphere of the earth". It almost always appears in lowercase in colloquial expressions such as "what on earth are you doing?"[26]

Absolute magnitude *(H)*	−3.99
Atmosphere	
Surface pressure	101.325 kPa (at sea level)
Composition by volume	78.08% nitrogen (dry air) 20.95% oxygen (dry air) ≤1% water vapor (variable) 0.9340% argon 0.0415% carbon dioxide 0.00182% neon 0.00052% helium 0.00017% methane 0.00011% krypton 0.00006% hydrogen Source:[3]

The name *Terra* /ˈtɛrə/ occasionally is used in scientific writing and especially in science fiction to distinguish humanity's inhabited planet from others,[27] while in poetry *Tellus* /ˈtɛləs/ has been used to denote personification of the Earth.[28] *Terra* is also the name of the planet in some Romance languages, languages that evolved from Latin, like Italian and Portuguese, while in other Romance languages the word gave rise to names with slightly altered spellings, like the Spanish *Tierra* and the French *Terre*. The Latinate form *Gæa* or *Gaea* (English: /ˈdʒiː.ə/) of the Greek poetic name *Gaia* (Γαῖα; Ancient Greek: [gâi̯.a] or [gâj.ja]) is rare, though the alternative spelling *Gaia* has become common due to the Gaia hypothesis, in which case its pronunciation is /ˈɡaɪ.ə/ rather than the more classical English /ˈɡeɪ.ə/.[29]

There are a number of adjectives for the planet Earth. The word "earthly" is derived from "Earth". From the Latin *Terra* comes *terran* /ˈtɛrən/,[30] *terrestrial* /təˈrɛstriəl/,[31] and (via French) *terrene* /təˈriːn/,[32] and from the Latin *Tellus* comes *tellurian* /tɛˈlʊəriən/[33] and *telluric*.[34]

Natural history

Formation

The oldest material found in the Solar System is dated to $4.5682^{+0.0002}_{-0.0004}$ Ga (billion years) ago.[35] By 4.54 ± 0.04 Ga the primordial Earth had formed.[36] The bodies in the Solar System formed and evolved with the Sun. In theory, a solar nebula partitions a volume out of a molecular cloud by gravitational collapse, which begins to spin and flatten into a circumstellar disk, and then the planets grow out of that disk with the Sun. A nebula contains gas, ice grains, and dust (including

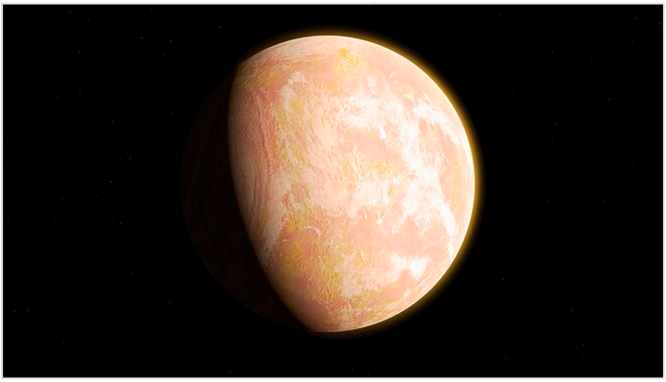

A 2012 artistic impression of the early Solar System's protoplanetary disk from which Earth and other Solar System bodies were formed

primordial nuclides). According to nebular theory, planetesimals formed by accretion, with the primordial Earth being estimated as likely taking anywhere from 70 to 100 million years to form.[37]

Estimates of the age of the Moon range from 4.5 Ga to significantly younger.[38] A leading hypothesis is that it was formed by accretion from material loosed from Earth after a Mars-sized object with about 10% of Earth's mass, named Theia, collided with Earth.[39] It hit Earth with a glancing blow and some of its mass merged with Earth.[40][41] Between approximately 4.1 and 3.8 Ga, numerous asteroid impacts during the Late Heavy Bombardment caused significant changes to the greater surface environment of the Moon and, by inference, to that of Earth.[42]

After formation

Earth's atmosphere and oceans were formed by volcanic activity and outgassing.[43] Water vapor from these sources condensed into the oceans, augmented by water and ice from asteroids, protoplanets, and comets.[44] Sufficient water to fill the oceans may have been on Earth since it formed.[45] In this model, atmospheric greenhouse gases kept the oceans from freezing when the newly forming Sun had only 70% of its current luminosity.[46] By 3.5 Ga, Earth's magnetic field was established, which helped prevent the atmosphere from being stripped away by the solar wind.[47]


Pale orange dot, an artist's impression of Early Earth, featuring its tinted orange methane-rich early atmosphere[48]

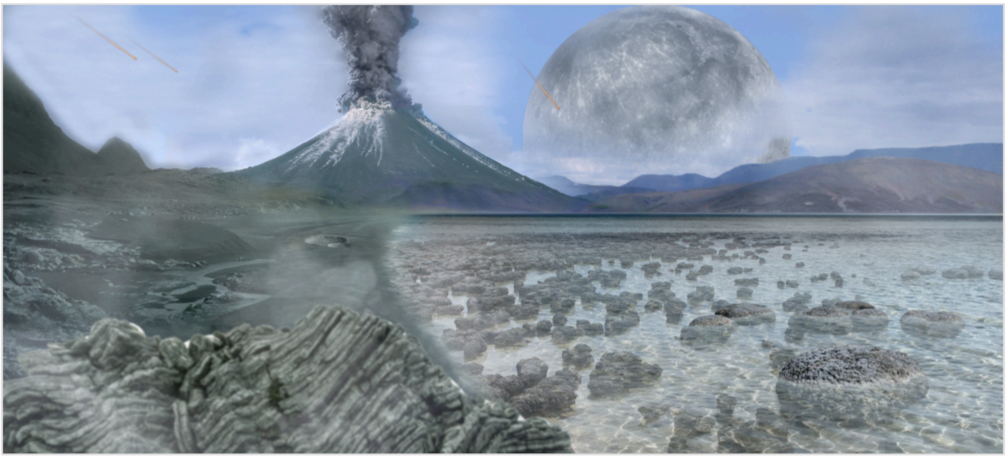
As the molten outer layer of Earth cooled it formed the first solid crust, which is thought to have been mafic in composition. The first continental crust, which was more felsic in composition, formed by the partial melting of this mafic crust.[49] The presence of grains of the mineral zircon of Hadean age in Eoarchean sedimentary rocks suggests that at least some felsic crust existed as early as 4.4 Ga, only 140 Ma after Earth's formation.[50] There are two main models of how this initial small volume of continental crust evolved to reach its current abundance:[51] (1) a relatively steady growth up to the present day,[52] which is supported by the radiometric dating of continental crust globally and (2) an initial rapid growth in the volume of continental crust during the Archean, forming the bulk of the continental crust that now exists,[53][54] which is supported by isotopic evidence from hafnium in zircons and neodymium in sedimentary rocks. The two models and the data that support them can be reconciled by large-scale recycling of the continental crust, particularly during the early stages of Earth's history.[55]

New continental crust forms as a result of plate tectonics, a process ultimately driven by the continuous loss of heat from Earth's interior. Over the period of hundreds of millions of years, tectonic forces have caused areas of continental crust to group together to form supercontinents that have subsequently broken apart. At approximately 750 Ma, one of the earliest known supercontinents, Rodinia, began to break apart. The continents later recombined to form Pannotia at 600–540 Ma, then finally Pangaea, which also began to break apart at 180 Ma.[56]

The most recent pattern of ice ages began about 40 Ma,[57] and then intensified during the Pleistocene about 3 Ma.[58] High- and middle-latitude regions have since undergone repeated cycles of glaciation and thaw, repeating about every 21,000, 41,000 and 100,000 years.[59] The Last Glacial Period, colloquially called the "last ice age", covered large parts of the continents, to the middle latitudes, in ice and ended about 11,700 years ago.[60]

Origin of life and evolution

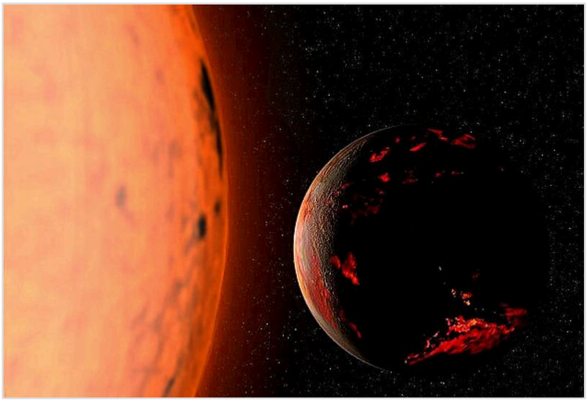
Chemical reactions led to the first self-replicating molecules about four billion years ago. A half billion years later, the last common ancestor of all current life arose.[61] The evolution of photosynthesis allowed the Sun's energy to be harvested directly by life forms. The resultant molecular oxygen (O_2) accumulated in the atmosphere and due to interaction with ultraviolet solar radiation, formed a protective ozone layer (O_3) in the upper atmosphere.[62] The incorporation of smaller cells within larger ones resulted in the development of complex cells called eukaryotes.[63] True multicellular organisms formed as cells within colonies became increasingly specialized. Aided by the absorption of harmful ultraviolet radiation by the ozone layer, life colonized Earth's surface.[64] Among the earliest fossil evidence for life is microbial mat fossils found in 3.48 billion-year-old sandstone in Western Australia,[65] biogenic graphite found in 3.7 billion-year-old metasedimentary rocks in Western Greenland,[66] and remains of biotic material found in 4.1 billion-year-old rocks in Western Australia.[67][68] The earliest direct evidence of life on Earth is contained in 3.45 billion-year-old Australian rocks showing fossils of microorganisms.[69][70]



An artist's impression of the Archean, the eon after Earth's formation, featuring round stromatolites, which are early oxygen-producing forms of life from billions of years ago. After the Late Heavy Bombardment, Earth's crust had cooled, its water-rich barren surface is marked by continents and volcanoes, with the Moon still orbiting Earth half as far as it is today, appearing 2.8 times larger and producing strong tides.[71]

During the Neoproterozoic, 1000 to 539 Ma, much of Earth might have been covered in ice. This hypothesis has been termed "Snowball Earth", and it is of particular interest because it preceded the Cambrian explosion, when multicellular life forms significantly increased in complexity.[72][73] Following the Cambrian explosion, 535 Ma, there have been at least five major mass extinctions and many minor ones.[74] Apart from the proposed current Holocene extinction event, the most recent was 66 Ma, when an asteroid impact triggered the extinction of non-avian dinosaurs and other large reptiles, but largely spared small animals such as insects, mammals, lizards and birds. Mammalian life has diversified over the past 66 Mys, and several million years ago, an African ape species gained the ability to stand upright.[75][76] This facilitated tool use and encouraged communication that provided the nutrition and stimulation needed for a larger brain, which led to the evolution of humans. The development of agriculture, and then civilization, led to humans having an influence on Earth and the nature and quantity of other life forms that continues to this day.[77]

Future



Conjectured illustration of the scorched Earth after the Sun has entered the red giant phase, about 5–7 billion years from now

Earth's expected long-term future is tied to that of the Sun. Over the next 1.1 billion years, solar luminosity will increase by 10%, and over the next 3.5 billion years by 40%.[78] Earth's increasing surface temperature will accelerate the inorganic carbon cycle, possibly reducing CO_2 concentration to levels lethally low for current plants (10 ppm for C4 photosynthesis) in approximately 100–900 million years.[79][80] A lack of vegetation would result in the loss of oxygen in the atmosphere, making current animal life impossible.[81] Due to the increased luminosity, Earth's mean temperature may reach 100 °C (212 °F) in 1.5 billion years, and all ocean water will evaporate and be lost to space, which may trigger a runaway greenhouse effect, within an estimated 1.6 to 3 billion years.[82] Even if the Sun were stable, a fraction of the water in the modern oceans will descend to the mantle, due to reduced steam venting from mid-ocean ridges.[82][83]

The Sun will evolve to become a red giant in about 5 billion years. Models predict that the Sun will expand to roughly 1 AU (150 million km; 93 million mi), about 250 times its present radius.[78][84] Earth's fate is less clear. As a red giant, the Sun will lose roughly 30% of its mass, so, without tidal effects, Earth will move to an orbit 1.7 AU (250 million km; 160 million mi) from the Sun when the star reaches its maximum radius, otherwise, with tidal effects, it may enter the Sun's atmosphere and be vaporized.[78]

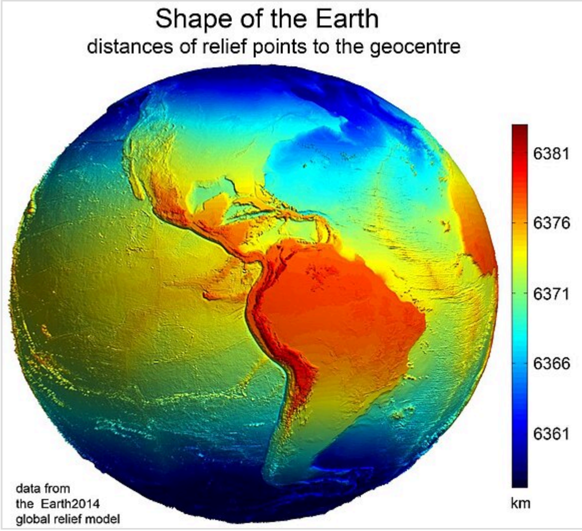
Physical characteristics

Size and shape

Earth has a rounded shape, through hydrostatic equilibrium,[85] with an average diameter of 12,742 kilometres (7,918 mi), making it the fifth largest planetary sized and largest terrestrial object of the Solar System.[86]

Due to Earth's rotation it has the shape of an ellipsoid, bulging at its Equator; its diameter is 43 kilometres (27 mi) longer there than at its poles.[87][88] Earth's shape furthermore has local topographic variations. Though the largest local variations, like the Mariana Trench (10,925 metres or 35,843 feet below local sea level),[89] only shortens Earth's average radius by 0.17% and Mount

Everest (8,848 metres or 29,029 feet above local sea level) lengthens it by only 0.14%.[n 6][91] Since Earth's surface is farthest out from Earth's center of mass at its equatorial bulge, the summit of the volcano Chimborazo in Ecuador (6,384.4 km or 3,967.1 mi) is its farthest point out.[92][93] Parallel to the rigid land topography the Ocean exhibits a more dynamic topography.[94]



Earth's western hemisphere showing topography relative to Earth's center instead of to mean sea level, as in common topographic maps

To measure the local variation of Earth's topography, geodesy employs an idealized Earth producing a shape called a geoid. Such a geoid shape is gained if the ocean is idealized, covering Earth completely and without any perturbations such as tides and winds. The result is a smooth but gravitational irregular geoid surface, providing a mean sea level (MSL) as a reference level for topographic measurements.[95]

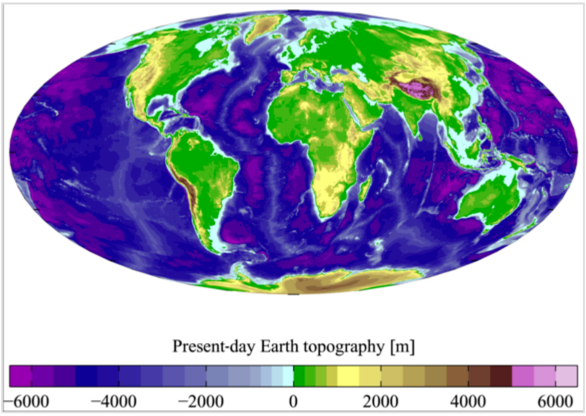
Surface

Earth's surface is the boundary between the atmosphere, and the solid Earth and oceans. Defined in this way, it has an area of about 510 million km^2 (197 million sq mi).[12] Earth can be divided into two hemispheres: by latitude into the polar Northern and Southern hemispheres; or by longitude into the continental Eastern and Western hemispheres.


A composite image of Earth, with its different types of surface discernible: Earth's surface dominating Ocean (blue), Africa with lush (green) to dry (brown) land and Earth's polar ice in the form of Antarctic sea ice (grey) covering the Antarctic or Southern Ocean and the Antarctic ice sheet (white) covering Antarctica.

Most of Earth's surface is ocean water: 70.8% or 361 million km^2 (139 million sq mi).[96] This vast pool of salty water is often called the *world ocean*,[97][98] and makes Earth with its dynamic hydrosphere a water world[99][100] or ocean world.[101][102] Indeed, in Earth's early history the ocean may have covered Earth completely.[103] The world ocean is commonly divided into the Pacific Ocean, Atlantic Ocean, Indian Ocean, Antarctic or Southern Ocean, and Arctic Ocean, from largest to smallest. The ocean covers Earth's oceanic crust, with the shelf seas covering the shelves of the continental crust to a lesser extent. The oceanic crust forms large oceanic basins with features like abyssal plains, seamounts, submarine volcanoes,[87] oceanic trenches, submarine canyons, oceanic plateaus, and a globe-spanning mid-ocean ridge system.[104] At Earth's polar regions, the ocean surface is covered by seasonally variable amounts of sea ice that often connects with polar land, permafrost and ice sheets, forming polar ice caps.

Earth's land covers 29.2%, or 149 million km^2 (58 million sq mi) of Earth's surface. The land surface includes many islands around the globe, but most of the land surface is taken by the four continental landmasses, which are (in descending order): Africa-Eurasia, America (landmass), Antarctica, and Australia (landmass).[105][106][107] These landmasses are further broken down and grouped into the continents. The terrain of the land surface varies greatly and consists of mountains, deserts, plains, plateaus, and other landforms. The elevation of the land surface varies from a low point of −418 m (−1,371 ft) at the Dead Sea, to a maximum altitude of 8,848 m (29,029 ft) at the top of Mount Everest. The mean height of land above sea level is about 797 m (2,615 ft).[108]



Relief of Earth's crust

Land can be covered by surface water, snow, ice, artificial structures or vegetation. Most of Earth's land hosts vegetation,[109] but considerable amounts of land are ice sheets (10%,[110] not including the equally large area of land under permafrost)[111] or deserts (33%)[112]

The pedosphere is the outermost layer of Earth's land surface and is composed of soil and subject to soil formation processes. Soil is crucial for land to be arable. Earth's total arable land is 10.7% of the land surface, with 1.3% being permanent cropland.[113][114] Earth has an estimated 16.7 million km² (6.4 million sq mi) of cropland and 33.5 million km² (12.9 million sq mi) of pastureland.[115]

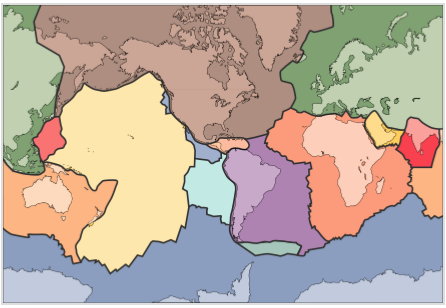
The land surface and the ocean floor form the top of Earth's crust, which together with parts of the upper mantle form Earth's lithosphere. Earth's crust may be divided into oceanic and continental crust. Beneath the ocean-floor sediments, the oceanic crust is predominantly basaltic, while the continental crust may include lower density materials such as granite, sediments and metamorphic rocks.[116] Nearly 75% of the continental surfaces are covered by sedimentary rocks, although they form about 5% of the mass of the crust.[117]

Earth's surface topography comprises both the topography of the ocean surface, and the shape of Earth's land surface. The submarine terrain of the ocean floor has an average bathymetric depth of 4 km, and is as varied as the terrain above sea level. Earth's surface is continually being shaped by internal plate tectonic processes including earthquakes and volcanism; by weathering and erosion driven by ice, water, wind and temperature; and by biological processes including the growth and decomposition of biomass into soil.[118][119]

Tectonic plates

Earth's mechanically rigid outer layer of Earth's crust and upper mantle, the lithosphere, is divided into tectonic plates. These plates are rigid segments that move relative to each other at one of three boundaries types: at convergent boundaries, two plates come together; at divergent boundaries, two plates are pulled apart; and at transform boundaries, two plates slide past one another laterally. Along these plate boundaries, earthquakes, volcanic activity, mountain-building, and oceanic trench formation can occur.[121] The tectonic plates ride on top of the asthenosphere, the solid but less-viscous part of the upper mantle that can flow and move along with the plates.[122]

As the tectonic plates migrate, oceanic crust is subducted under the leading edges of the plates at convergent boundaries. At the same time, the upwelling of mantle material at divergent boundaries creates mid-ocean ridges. The combination of these processes recycles the oceanic crust back into the mantle. Due to this recycling, most of the ocean floor is less than 100 Ma old. The oldest oceanic crust is located in the Western Pacific and is estimated to be 200 Ma old.[123][124] By comparison, the oldest dated continental crust is 4,030 Ma,[125] although zircons have been found preserved as clasts within Eoarchean sedimentary rocks that give ages up to 4,400 Ma, indicating that at least some continental crust existed at that time.[50]



Earth's major plates, which are:[120]
- Pacific Plate
- African Plate[n 7]
- North American Plate
- Eurasian Plate
- Antarctic Plate
- Indo-Australian Plate
- South American Plate

The seven major plates are the Pacific, North American, Eurasian, African, Antarctic, Indo-Australian, and South American. Other notable plates include the Arabian Plate, the Caribbean Plate, the Nazca Plate off the west coast of South America and the Scotia Plate in the southern Atlantic Ocean. The Australian Plate fused with the Indian Plate between 50 and 55 Ma. The fastest-moving plates are the oceanic plates, with the Cocos Plate advancing at a rate of 75 mm/a (3.0 in/year)[126] and the Pacific Plate moving 52–69 mm/a (2.0–2.7 in/year). At the other extreme, the slowest-moving plate is the South American Plate, progressing at a typical rate of 10.6 mm/a (0.42 in/year).[127]

Internal structure

Earth's interior, like that of the other terrestrial planets, is divided into layers by their chemical or physical (rheological) properties. The outer layer is a chemically distinct silicate solid crust, which is underlain by a highly viscous solid mantle. The crust is separated from the mantle by the Mohorovičić discontinuity.[130] The thickness of the crust varies from about 6 kilometres (3.7 mi) under the oceans to 30–50 km (19–31 mi) for the continents. The crust and the cold, rigid, top of the upper mantle are collectively known as the lithosphere, which is divided into independently moving tectonic plates.[131]

Geologic layers of Earth[128]

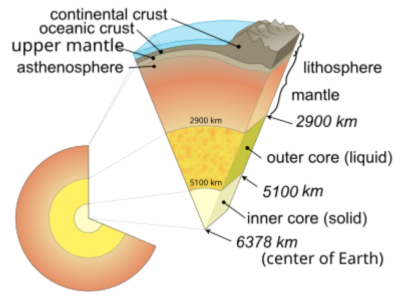


Illustration of Earth's cutaway, not to scale

Depth[129] (km)	Component layer name	Density (g/cm^3)
0–60	Lithosphere[n 8]	—
0–35	Crust[n 9]	2.2–2.9
35–660	Upper mantle	3.4–4.4
660–2890	Lower mantle	3.4–5.6
100–700	Asthenosphere	—
2890–5100	Outer core	9.9–12.2
5100–6378	Inner core	12.8–13.1

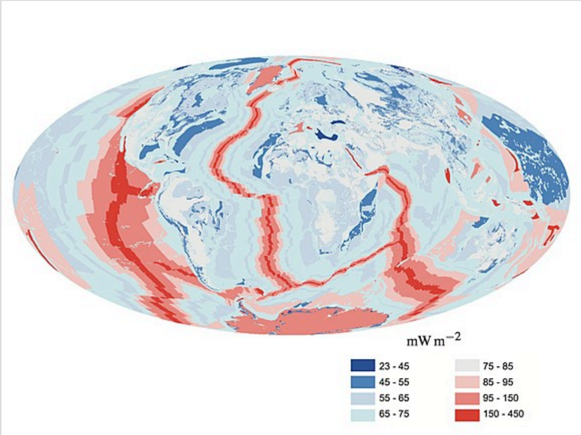
Beneath the lithosphere is the asthenosphere, a relatively low-viscosity layer on which the lithosphere rides. Important changes in crystal structure within the mantle occur at 410 and 660 km (250 and 410 mi) below the surface, spanning a transition zone that separates the upper and lower mantle. Beneath the mantle, an extremely low viscosity liquid outer core lies above a solid inner core.[132] Earth's inner core may be rotating at a slightly higher angular velocity than the remainder of the planet, advancing by 0.1–0.5° per year, although both somewhat higher and much lower rates have also been proposed.[133] The radius of the inner core is about one-fifth of that of Earth. The density increases with depth. Among the Solar System's planetary-sized objects, Earth is the object with the highest density.

Chemical composition

Earth's mass is approximately 5.97×10^{24} kg (5.970 Yg). It is composed mostly of iron (32.1% by mass), oxygen (30.1%), silicon (15.1%), magnesium (13.9%), sulfur (2.9%), nickel (1.8%), calcium (1.5%), and aluminium (1.4%), with the remaining 1.2% consisting of trace amounts of other elements. Due to gravitational separation, the core is primarily composed of the denser elements: iron (88.8%), with smaller amounts of nickel (5.8%), sulfur (4.5%), and less than 1% trace elements.[134][49] The most common rock constituents of the crust are oxides. Over 99% of the crust is composed of various oxides of eleven elements, principally oxides containing silicon (the silicate minerals), aluminium, iron, calcium, magnesium, potassium, or sodium.[135][134]

Internal heat

The major heat-producing isotopes within Earth are potassium-40, uranium-238, and thorium-232.[136] At the center, the temperature may be up to 6,000 °C (10,830 °F),[137] and the pressure could reach 360 GPa (52 million psi).[138] Because much of the heat is provided by radioactive decay, scientists postulate that early in Earth's history, before isotopes with short half-lives were depleted, Earth's heat production was much higher. At approximately 3 Gyr, twice the present-day heat would have been produced, increasing the rates of mantle convection and plate tectonics, and allowing the production of uncommon igneous rocks such as komatiites that are rarely formed today.[139][140]



A map of heat flow from Earth's interior to the surface of Earth's crust, mostly along the oceanic ridges

The mean heat loss from Earth is 87 mW m^{-2}, for a global heat loss of 4.42×10^{13} W.[141] A portion of the core's thermal energy is transported toward the crust by mantle plumes, a form of convection consisting of upwellings of higher-temperature rock. These plumes can produce hotspots and flood basalts.[142] More of the heat in Earth is lost through plate tectonics, by mantle upwelling associated with mid-ocean ridges. The final major mode of heat loss is through conduction through the lithosphere, the majority of which occurs under the oceans.[143]

Gravitational field

The gravity of Earth is the acceleration that is imparted to objects due to the distribution of mass within Earth. Near Earth's surface, gravitational acceleration is approximately 9.8 m/s^2 (32 ft/s^2). Local differences in topography, geology, and deeper tectonic structure cause local and broad regional differences in Earth's gravitational field, known as gravity anomalies.[144]

Magnetic field