Biosphere

- The biosphere is that part of the Earth that contains all of its living organisms. It includes the familiar plants and animals as well as the nearly invisible microorganisms that live in some of the extreme environments on the planet.

- The biosphere is a system of interacting components that exchanges energy, usually in the form of sunlight, and matter, such as carbon, nutrients, and water, with its surroundings.

Ecosystems

- The interactions of biological communities with their physical environments, whether local, regional, or global in scale, define ecosystems.
- Ecosystems are sensitive to imbalance, such as when invasive organisms are introduced.

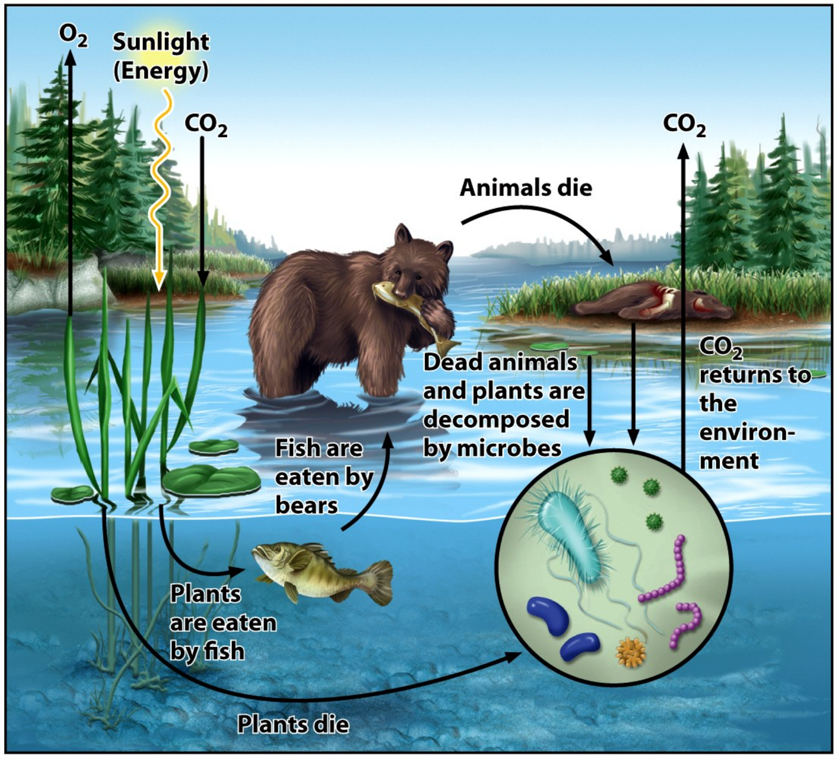

Figure 11.1
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Autotrophs and Heterotrophs

- The organisms of an ecosystem can be divided into producers and consumers according to the way they obtain their food. Producers, or autotrophs, make their own food, while consumers, or heterotrophs, feed directly or indirectly on producers.

TABLE 11.1 ***Organisms as Producers and Consumers***

Type	Energy Source	Carbon Source	Example
Photoautotroph	Sun	CO_2	Cyanobacteria
Photoheterotroph	Sun	Organic compounds	Purple bacteria
Chemoautotroph	Chemicals	CO_2	H, S, Fe bacteria
Chemoheterotroph	Chemicals	Organic compounds	Most bacteria, fungi, and animals, including humans

Metabolism

- Metabolism encompasses all of the processes organisms use to convert the matter and energy they take in to the matter and energy they create and return to the environment.

- Metabolic processes are examples of biogeochemical cycles, or pathways by which chemical elements or compounds move between the biological and geological components of an ecosystem.

Photosynthesis

- Photosynthesis is a particularly familiar metabolic process.

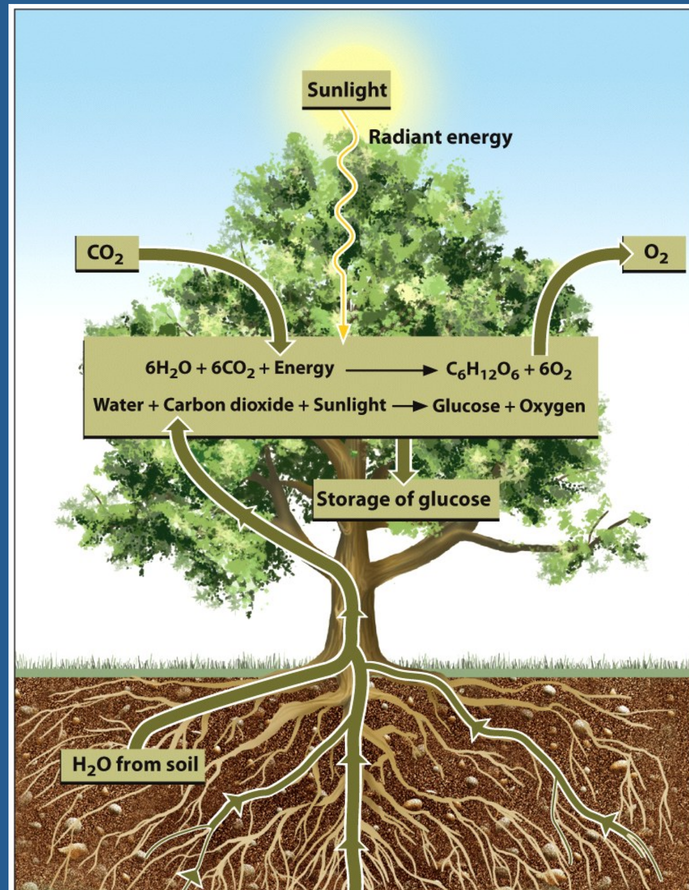

Figure 11.3
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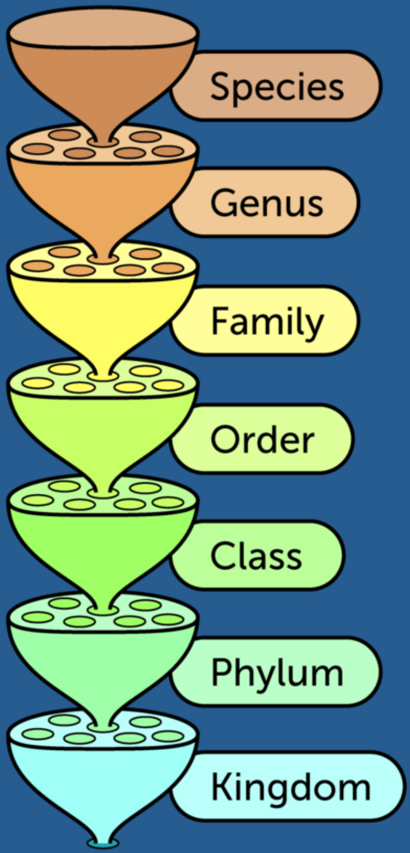
Respiration

- Respiration, by which organisms use oxygen to release the energy stored in carbohydrates, is another key metabolic process.
- Many organisms consume O_2 from the atmosphere to metabolize carbohydrates, releasing CO_2 and H_2O. Other organisms, such as microorganisms that live in anaerobic environments where O_2 is absent, break down oxygen-containing compounds dissolved in water, such as SO_4^{2-}, to obtain O_2, and release gases such as H_2, H_2S, and CH_4.

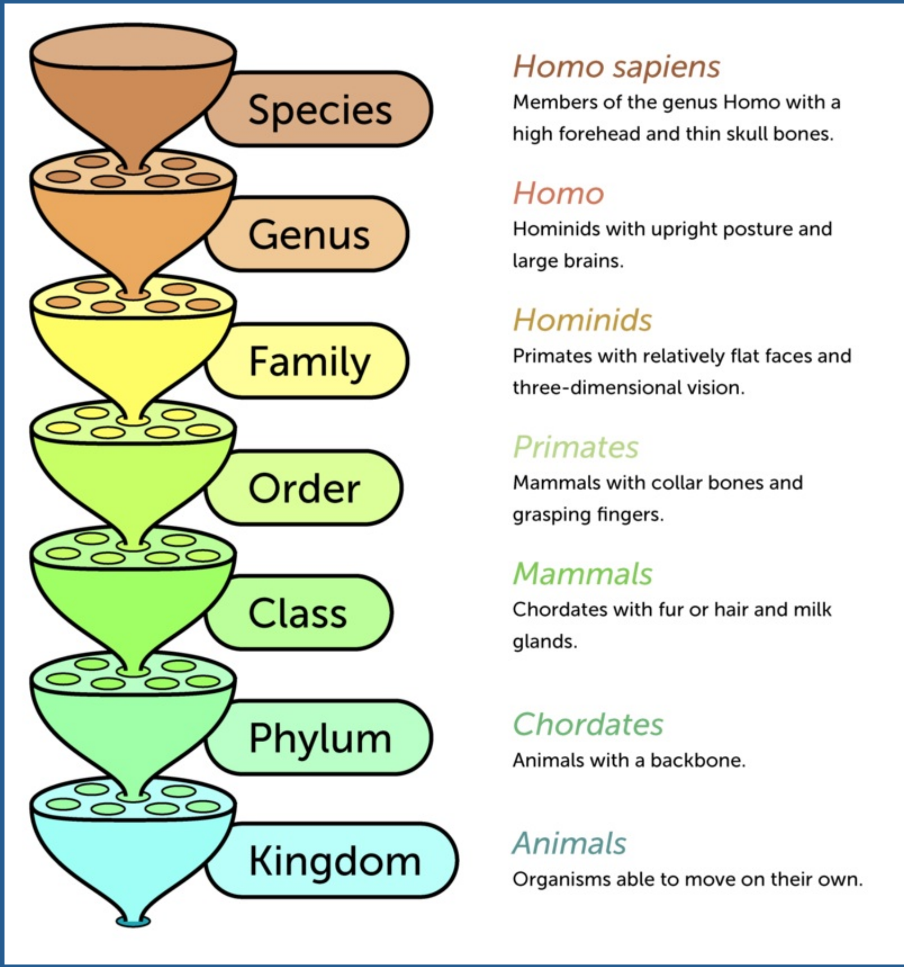
Linnaean Classification of Organisms

- In 1735, Swedish botanist Carl Linnaeus developed a classification, or taxonomy, of organisms based on shared characteristics rather than shared evolutionary history.

- His organization grouped organisms into a system of taxonomic ranks, from kingdom through species.



Humans: An Example of Linnaean Classification



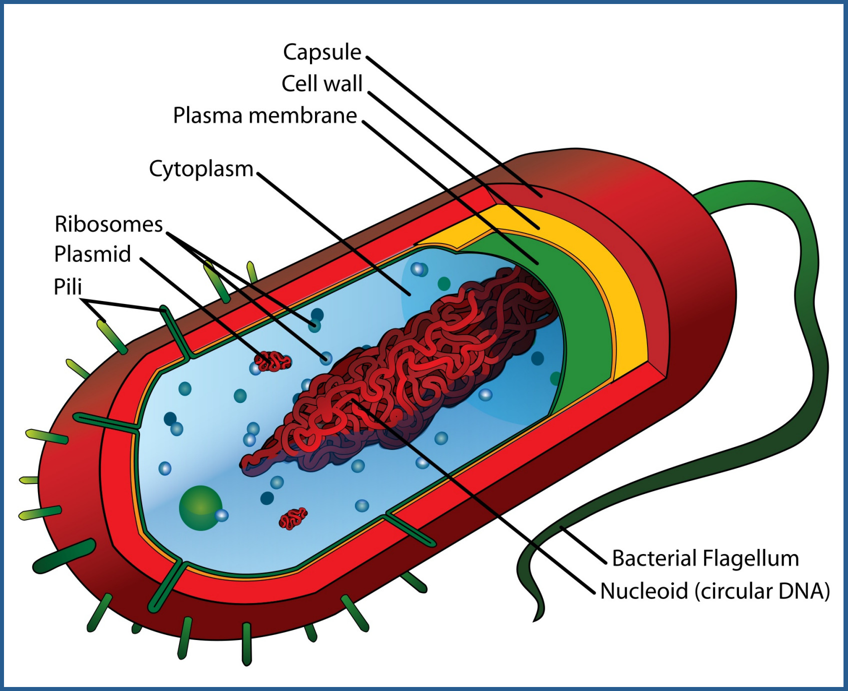
Prokaryota and Eukaryota

- Two hundred years after Linnaeus, a two-empire classification system based on cellular structure was proposed to divide prokaryotes from eukaryotes.

Linnaeus 1735[14]	Haeckel 1866[15]	Chatton 1925[16]	Copeland 1938[17]	Whittaker 1969[18]	Woese et al. 1990[19]	Cavalier-Smith 1998[13]
2 kingdoms	3 kingdoms	2 empires	4 kingdoms	5 kingdoms	3 domains	6 kingdoms
(not treated)	Protista	Prokaryota	Monera	Monera	Bacteria	Bacteria
					Archaea	
		Eukaryota	Protoctista	Protista	Eukarya	Protozoa
						Chromista
Vegetabilia	Plantae		Plantae	Plantae		Plantae
				Fungi		Fungi
Animalia	Animalia		Animalia	Animalia		Animalia

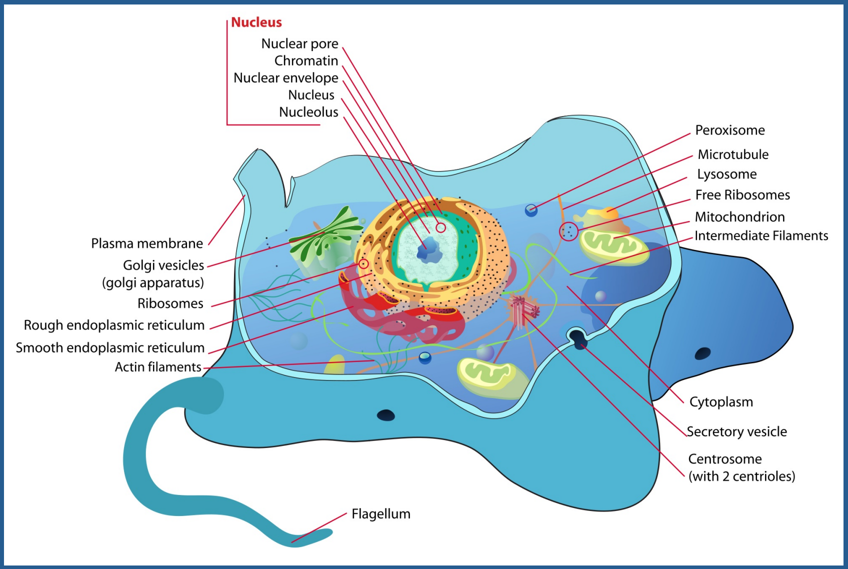
Prokaryotes

- Prokaryotes are organisms whose cells lack a nucleus, mitochondria, or other membrane-bound organelles.
- Genetic material is contained within a single fiber.
- Respiration and photosynthesis occur through a complex cell wall.



Eukaryotes

- Eukaryotes are organisms whose cells contain complex structures enclosed within membranes.
- Genetic material is contained within many fibers in the nucleus.
- Respiration and photosynthesis by small, specialized organs inside a simple cell wall.



Bacteria, Archaea, and Eukarya

- In 1990, a three-domain classification system was proposed to separate the Prokaryota into Bacteria and Archaea because of major differences in the structure and genetics between the two groups.

Linnaeus 1735[14]	Haeckel 1866[15]	Chatton 1925[16]	Copeland 1938[17]	Whittaker 1969[18]	Woese et al. 1990[19]	Cavalier-Smith 1998[13]
2 kingdoms	3 kingdoms	2 empires	4 kingdoms	5 kingdoms	3 domains	6 kingdoms
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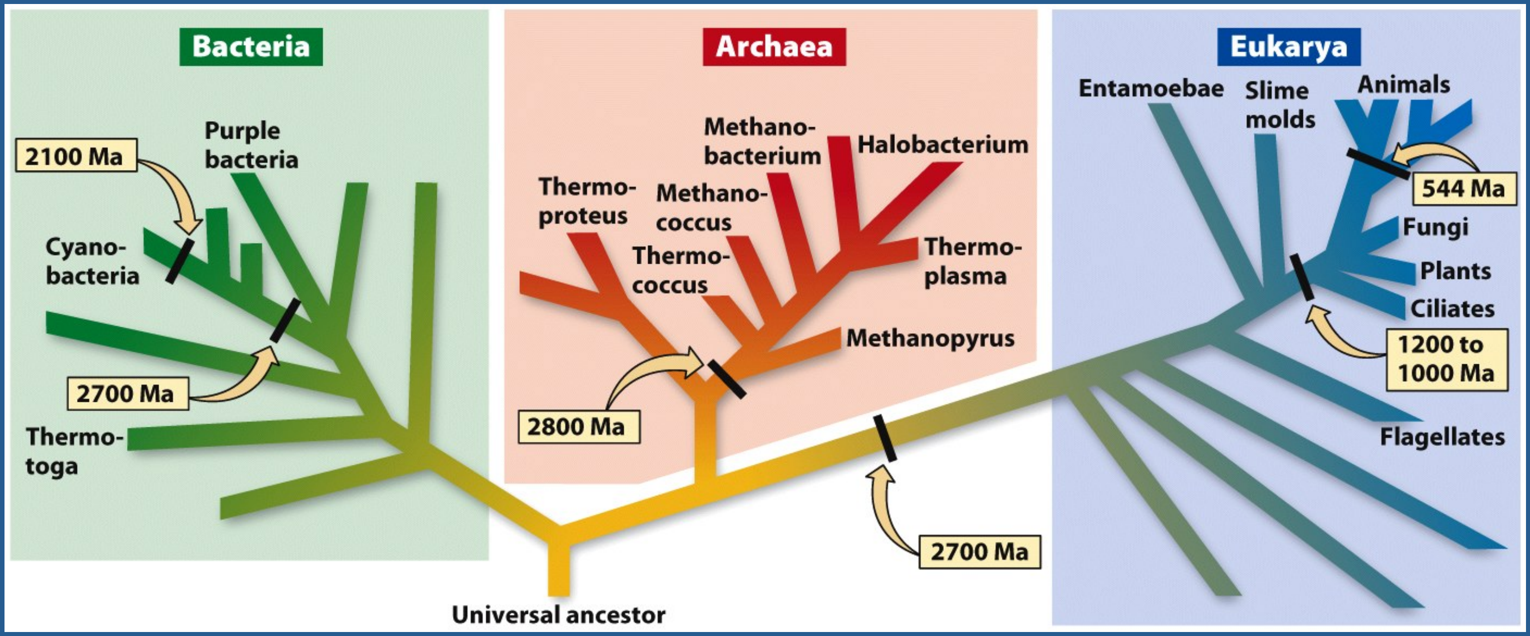
						Chromista
Vegetabilia	Plantae		Plantae	Plantae		Plantae
				Fungi		Fungi
Animalia	Animalia		Animalia	Animalia		Animalia

Modern Classification of Organisms

- Modern classification systems generally group organisms based purely on inferred evolutionary relatedness, ignoring morphological similarity.



Microorganisms

- Single-celled organisms, including bacteria, archaea, some fungi, some algae, and most protists, are known as microorganisms, or microbes.
- Microorganisms are the most abundant and genetically diverse group of organisms on Earth. Their genetic diversity is so great that the differences among groups of microorganisms are much greater than the differences between plants and animals, including humans.
- Their genetic diversity has allowed them to colonize, adapt to, and thrive in environments that would be lethal to most other organisms.

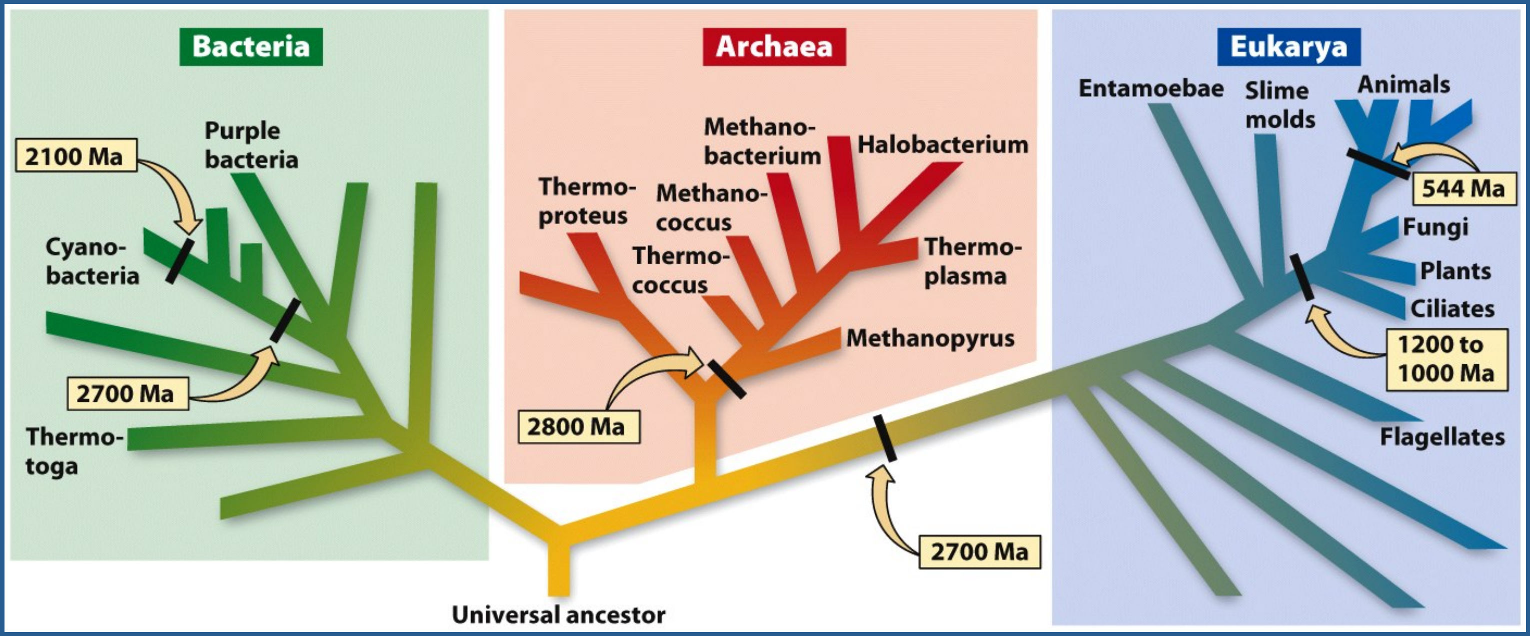
Extremophiles

TABLE 11.3 ***Characteristics of Extremophiles***

Type	Tolerance	Environment	Example
Halophile	High salinity	Playa lakes Marine evaporites	Great Salt Lake, Utah
Acidophile	High acidity	Mine drainage Water near volcanoes	Rio Tinto, Spain
Thermophile	High temperature	Hot springs Mid-ocean ridge vents	Yellowstone National Park
Anaerobe	No oxygen	Pores of wet sediments Groundwater Microbial mats Mid-ocean ridge vents	Cape Cod Bay sediments

Bacteria, Archaea, and Eukarya

- The Bacteria and Archaea appear to have evolved first; all of their descendants have remained single-celled microorganisms. The Eukarya, thought to be the youngest branch of the universal tree of life, evolved into larger, multicellular organisms.



Microbial Mats

- Microbial mats are layered microbial communities commonly found in tidal flats, hypersaline lagoons, and hot springs. They often consist of a layer of photoautotrophic cyanobacteria overlying a layer of either chemoautotrophic or chemoheterotrophic microorganisms.

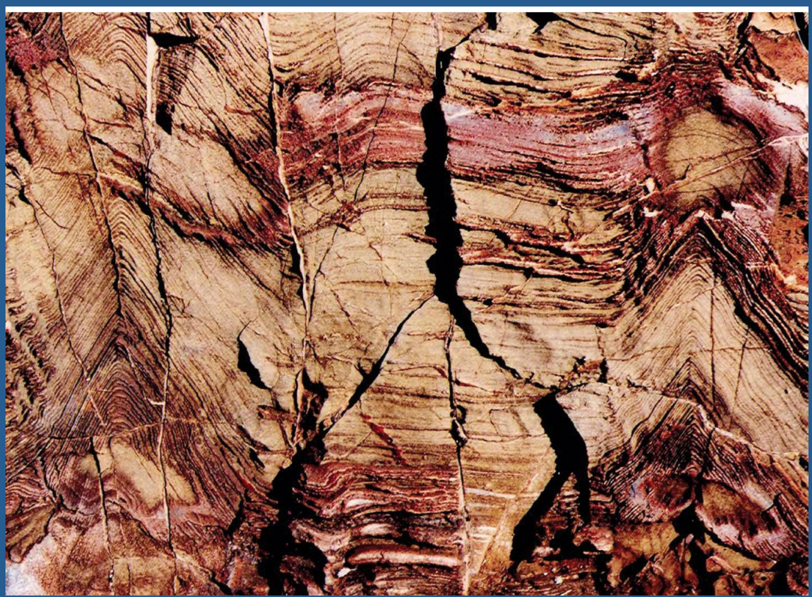
- Microbial mats were more widespread in the geologic past than they are today. They are one of the most common features preserved in Precambrian sedimentary rocks formed in aquatic environments.

Stromatolites

- Stromatolites are rocks believed to have been formed from ancient microbial mats.
- They range in shape from flat sheets to dome-shaped structures.
- Most stromatolites are distinctively thinly layered internally, as shown by a cross section of a living modern stromatolite from Shark Bay, Australia.

Stromatolites

- The oldest stromatolites appear to be 3.4 Ga in age but there are numerous examples of younger stromatolites around the world.



Warrawoona Fm. (3.4 Ga), Western Australia

Hoyt Fm. (490 Ma), Saratoga Springs, New York

Stromatolites

- Most ancient stromatolites likely formed when sediment was trapped and bound by microorganisms on the surface of microbial mats, as at Shark Bay, but some stromatolites may have been formed by mineral precipitation either indirectly controlled by microorganisms or due to oversaturation of the surrounding water.

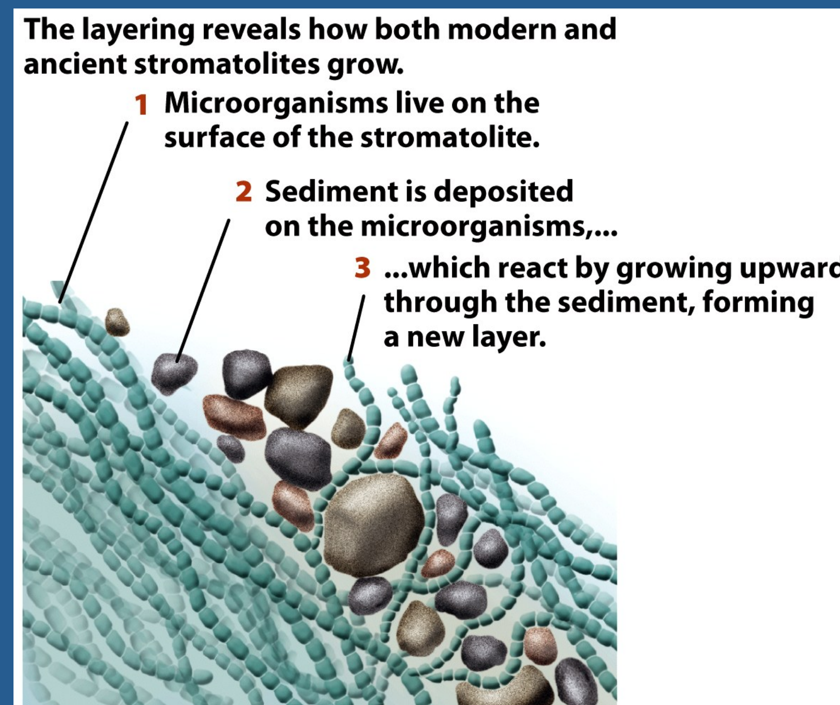


Figure 11.11d
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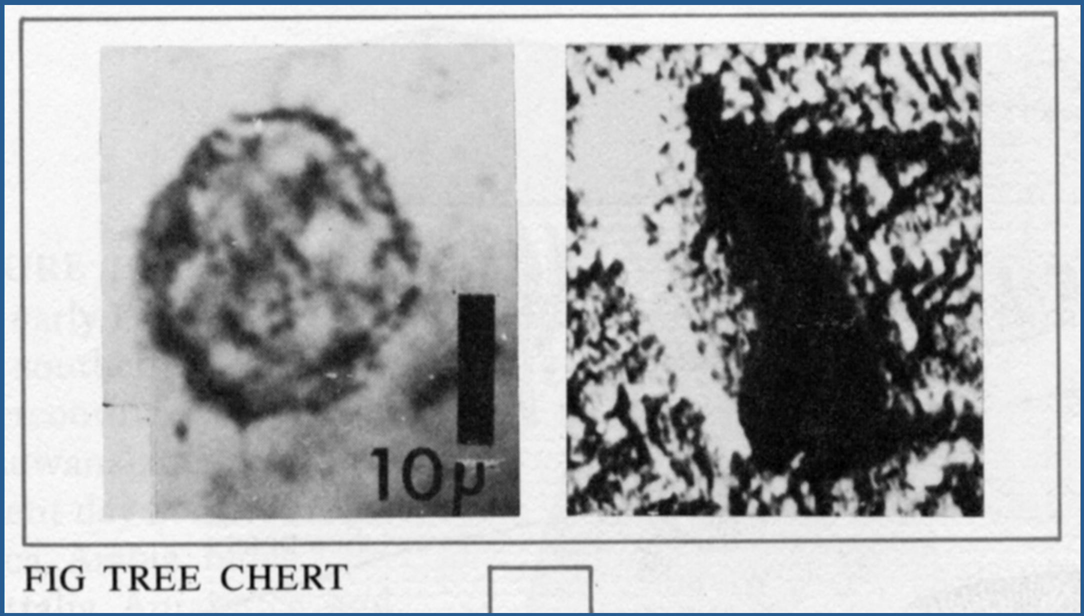
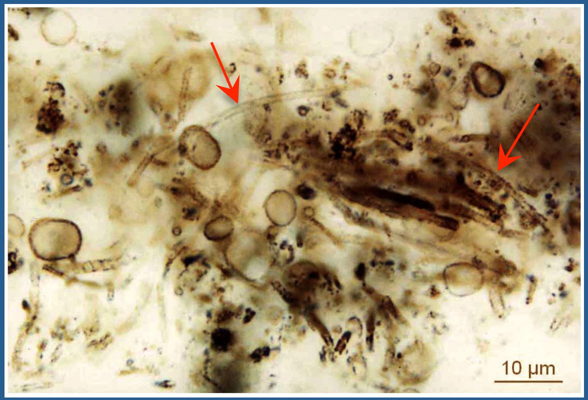
Oldest Microfossils

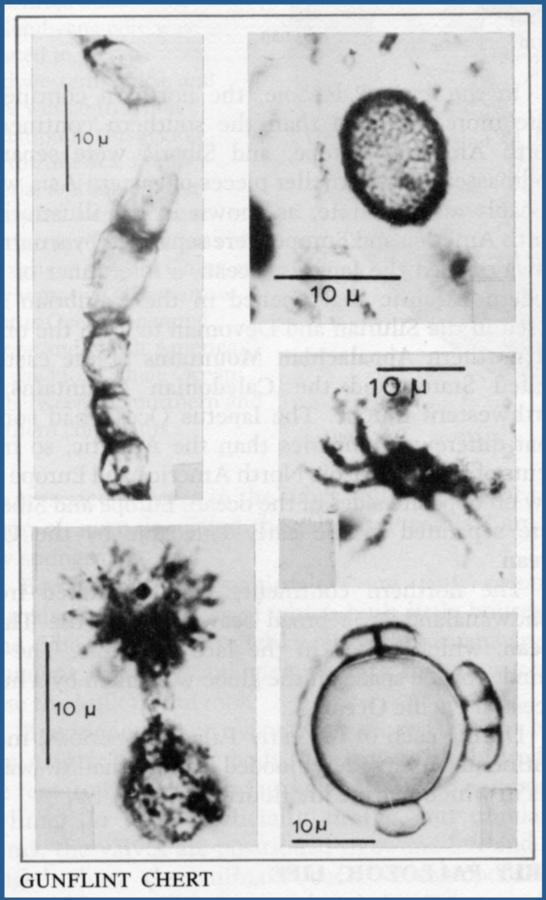
- Among the oldest known microfossils are non-colonial unicellular bacteria-like fossils found in the 3.2 Ga Fig Tree Chert of South Africa.



Oldest Microfossils

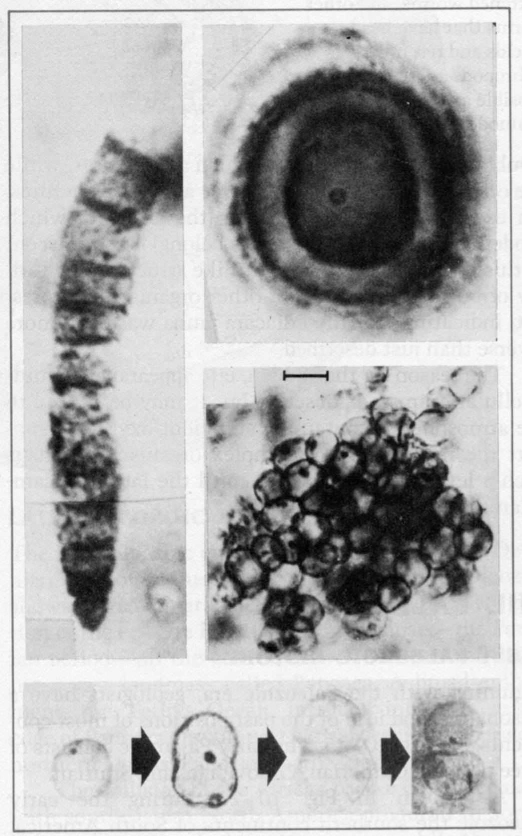
- The 2.1 Ga Gunflint Chert of western Ontario preserves not only bacteria and cyanobacteria but also organisms believed to be ammonia-consuming and some that resemble green algae and fungus-like organisms.





Oldest Microfossils

- The 850 Ma Bitter Springs Chert of central Australia preserves some thirty species of microorganisms, including cyanobacteria, freshwater green algae, and an assortment of possible fungi, dinoflagellates, and heterotrophic bacteria.

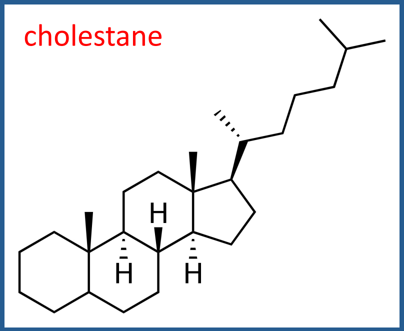


Green algae undergoing cell division
BITTERSPRINGS CHERT

Molecular Fossils and Eukarya

- Form and size alone are not enough to allow us to deduce the function of microorganisms, so microfossils are ultimately limited in the information they can provide.

- Molecular fossils, or chemofossils, are very stable organic compounds that remain after an organism breaks down following its death. One such compound, cholestane, made only by Eukarya, has been identified in 2.7 Ga rocks from Western Australia.



Oxygenation of Earth's Atmosphere

- The oxygenation of Earth's atmosphere appears to have occurred in two main stages, separated by more than a billion years.

- Oxygen produced by cyanobacteria through photosynthesis began to rise about 2.7 Ga and reached an initial plateau about 2.1 to 1.8 Ga, when the first eukaryotic fossils, a type of algae, appeared in the geologic record. The relatively large size of these organisms is thought to be a consequence of the increase in oxygen.

- Atmospheric oxygen levels then rose dramatically about 580 Ma, almost to their modern level, possibly due to the increased burial of organic carbon by sedimentation.

Ediacaran Fauna

- The Ediacaran fauna, first identified in the Ediacara Hills of South Australia but found in several locations worldwide, are soft-bodied multicellular organisms of uncertain affinity that range in age from 585-542 Ma.

Dickinsonia (South Australia)

Pteridinium (Namibia)

Cambrian Evolutionary Radiation

- Every major animal phylum that exists on Earth today, as well as a few more that have since become extinct, appeared within less than 10 million years during the early Cambrian evolutionary radiation, also called the Cambrian explosion.