A brief history of life on Earth.

Life is a process; therefore studying the history of life is very important in order to understand life existing today. We will revisit history of life on Earth several times during the course

Origin of life. *When* and *how* life first appeared on Earth? The question is still unanswered. We can only hypothesize.

How? We will speak about the modern theories later in the course.

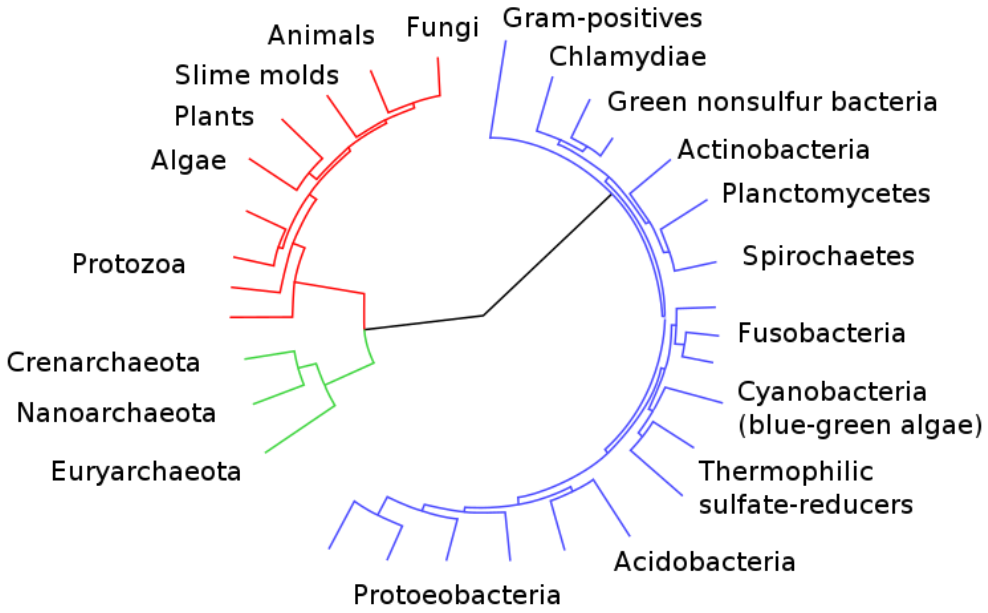
When? Some scientists think that life on Earth could have first appeared as early as 4.28 billion years ago, soon after ocean formation 4.41 billion years ago, and not long after the formation of the Earth 4.54 billion years ago. The earliest undisputed evidence of life on Earth dates from at least 3.5 billion years ago.

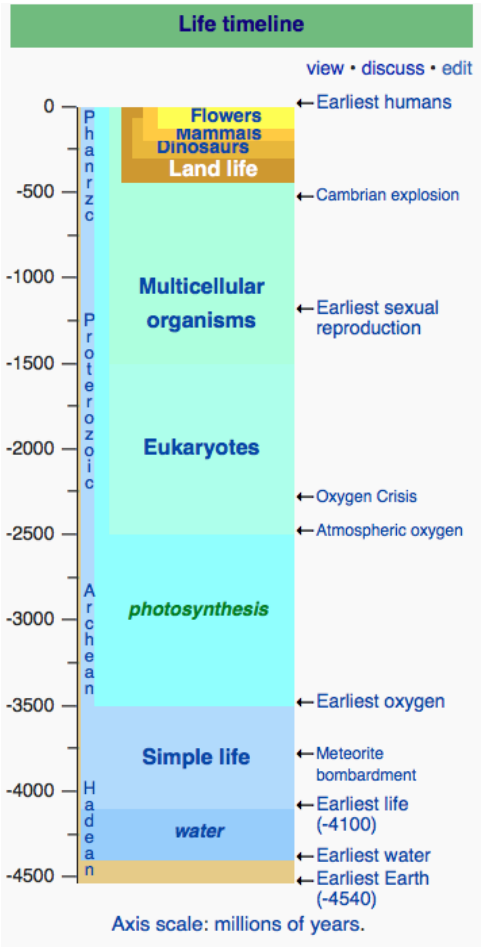
Stromatolites - rock-like structures formed by bacteria.

Modern stromatolites

Strelley Pool Australian Archaean Stromatolites – 3.43 billion years old

LUCA. The genetic code is universal. This fact indicates that all modern life evolved from a common ancestor. Scientists in 2016 reported identifying a set of 355 genes believed to be present in the **last universal common ancestor** (LUCA) of all living organisms. LUCA should not be assumed to be the first living organism on Earth. The LUCA is estimated to have lived some 3.5 to 3.8 billion years ago (sometime in the Paleoarchean era). The composition of the LUCA is not directly accessible as a fossil, but can be studied by comparing the genomes of its descendents, organisms living today.





Before photosynthesis evolved, Earth's atmosphere had no free oxygen (O_2). Photosynthetic prokaryotic organisms that produced O_2 as a waste product lived long before the first build-up of free oxygen in the atmosphere, perhaps as early as 3.5 billion years ago.

The Great Oxygenation Event was the biologically induced appearance of dioxygen (O_2) in Earth's atmosphere. Although geological, isotopic, and chemical evidence suggest that this major environmental change happened around 2.45 billion years ago.

The increased production of oxygen set Earth's original atmosphere off balance. Free oxygen is toxic to obligate anaerobic organisms, and the rising concentrations may have destroyed most such organisms at the time. Cyanobacteria were therefore responsible for one of the most significant mass extinctions in Earth's history. Besides marine cyanobacteria, there is also evidence of cyanobacteria on land.

A eukaryote is any organism whose cells have a cell nucleus and other organelles enclosed within membranes. Eukaryotes belong to the taxon Eukarya or Eukaryota. The defining feature that sets eukaryotic cells apart from prokaryotic cells (Bacteria and Archaea) is that they have membrane-bound organelles, especially the nucleus, which contains the genetic material and is enclosed by the nuclear envelope. The presence of a nucleus gives eukaryotes their name, which comes from the Greek εὖ (eu, "well" or "true") and κάρυον (karyon, "nut" or "kernel"). Eukaryotic cells also contain other membrane-bound organelles such as mitochondria and the Golgi apparatus. In addition, plants and algae contain chloroplasts. Eukaryotic organisms may be unicellular or multicellular. Only eukaryotes form multicellular organisms consisting of many kinds of tissue made up of different cell types.

Eukaryotes can reproduce both asexually through mitosis and sexually through meiosis and gamete fusion. In mitosis, one cell divides to produce two genetically identical cells. In meiosis, DNA replication is followed by two rounds of cell division to produce four haploid daughter cells. These act as sex cells (gametes). Each gamete has just one set of chromosomes, each a unique mix of the corresponding pair of parental chromosomes resulting from genetic recombination during meiosis.

Multicellular organisms are organisms that consist of more than one cell, in contrast to unicellular organisms.

All species of animals, land plants and most fungi are multicellular.

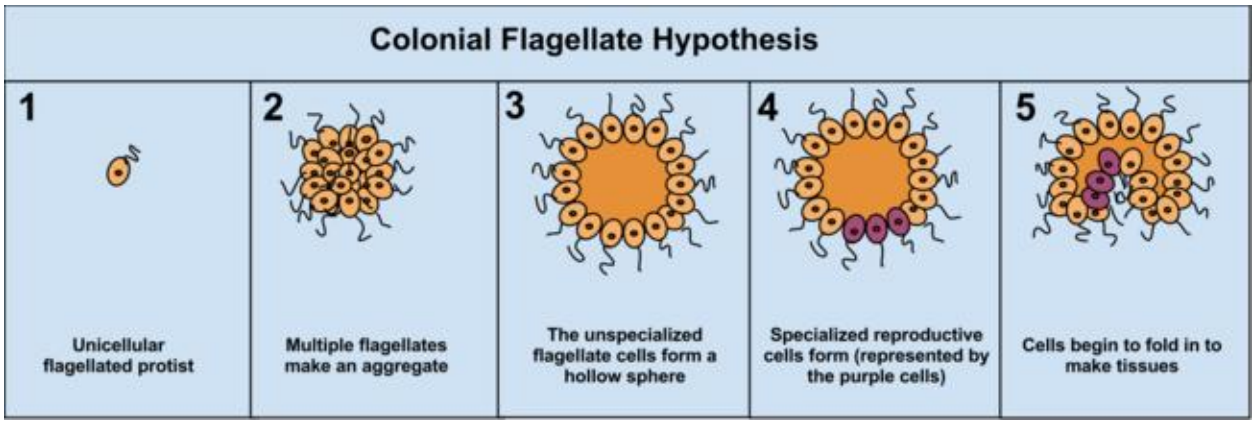
Multicellular organisms arise in various different ways, for example by cell division or by aggregation of many single cells. Colonial organisms are the result of many identical individuals joining together to form a colony.

Multicellularity has evolved independently at least 46 times, including in some prokaryotes. Animals have evolved a considerable diversity of cell types in a multicellular body (100–150 different cell types), compared with 10–20 in plants and fungi.

The colonial theory

The Colonial Theory of Haeckel, 1874, proposes that the symbiosis of many organisms of the same species (unlike the symbiotic theory, which suggests the symbiosis of different species) led to a multicellular organism. At least some, it is presumed land-evolved, multicellularity occurs by cells separating and then rejoining (e.g. cellular slime molds) whereas for the majority of multicellular types (those that evolved within aquatic environments), multicellularity occurs as a consequence of cells failing to separate following division. The mechanism of this latter colony formation can be as simple as

incomplete cytokinesis, though multicellularity is also typically considered to involve cellular differentiation.



The advantage of the Colonial Theory hypothesis is that it has been seen to occur independently in 16 different protozoan phyla. For instance, during food shortages the amoeba Dictyostelium groups together in a colony that moves as one to a new location. Some of these amoeba then slightly differentiate from each other. However, it can often be hard to separate colonial protozoans from true multicellular organisms, as the two concepts are not distinct; colonial protozoans have been dubbed "pluricellular" rather than "multicellular".

Cancer

Multicellular organisms, especially long-living animals, face the challenge of cancer, which occurs when cells fail to regulate their growth within the normal program of development. Changes in tissue morphology can be observed during this process. Cancer in animals (metazoans) has often been described as a loss of multicellularity. There is a discussion about the possibility of existence of cancer in other multicellular organisms or even in protozoa. For example, plant galls have been characterized as tumors but some authors argue that plants do not develop cancer.