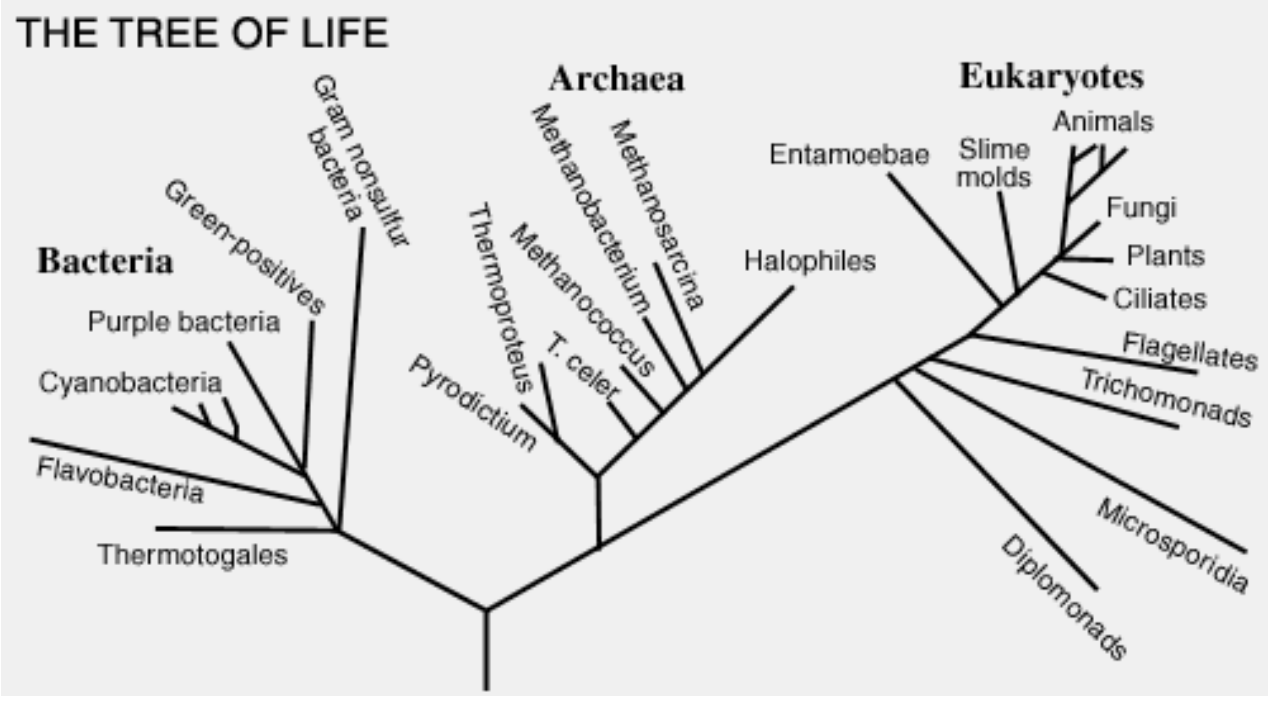
The Tree of Life

The history of life has not unspooled as a simple line. As Darwin proposed, it has grown like a tree over time, as new species have branched off from old ones. Most of those branches have been pruned by extinction, but not before they gave rise to life as we see it around us on Earth today.

Scientists have been drawing and redrawing the tree of life for decades. At first they could only compare different species by looking at their anatomy, such as the sutures of skulls and the twists of wombs. But this method failed when scientists tried to step back and look at life on its broadest scale. You can compare elm leaves to the leaves of maples or pines, but there are no leaves on humans to compare them with. Fortunately, elms and humans are both based on DNA. By sequencing snippets of genetic material from hundreds of species, ranging from frogs to yeast to cyanobacteria, scientists over the past 25 years have assembled the tree of life. The latest version appears below.



This tree is not an icon, but a scientific hypothesis. It offers the simplest interpretation of the genetic sequences that scientists have studied, how genes have mutated from one form to another. As new species are discovered and new genes are sequenced, the simplest interpretation may demand that some of the branches be rearranged. But despite a surge of new data, this tree has retained its basic structure, which suggests that it is fundamentally sound.

This tree is a strange thing to behold. In the late nineteenth century, evolutionary biologists drew the tree of life as if it were a mighty oak, with branches coming off a main trunk. The simplest organisms

such as bacteria sprouted near its base, and humanity was placed at its very crown, the pinnacle of evolution. But instead of a single shaft of evolution ever ascending, scientists now see life splayed out into an unruly thicket.

The tree is split into three main branches. our own, the eukaryotes, includes plants, fungi, and animals, as well as single-celled protozoa, such as amoebae that live in the forest soil and the oceans, and parasites that cause diseases like malaria, dysentery, and giardia. Eukaryotes all have a distinct sort of cell. They keep most of their DNA balled up in their nucleus, and their cells contain many other compartments where new proteins are built and energy is generated.

Biologists once thought that all of the species that were not eukaryotes fell into a single group, known as prokaryotes. After all, they all seem to look the same. Their DNA, for instance, floats loose inside their membranes, not coiled in a nucleus. But the genes tell another story. Bacteria form their own branch, while there is a third major branch on the tree of life that is more closely related to us than to bacteria. First identified in the 1970s by University of Illinois biologist Carl Woese, these organisms may look like bacteria, but they have cellular machinery that is radically different. Woese named these microbes archaea, meaning "first," for the branch on which they appear.

Another great surprise of the new tree of life is just what a small space we multicellular eukaryotes take up in the story of evolution. It's almost impossible to make out the difference between ourselves and the elm trees. And meanwhile the diversity within the bacteria, archaea, and single-celled eukaryotes turns out to be stunning. Microbiologists are continually dredging up new species, new families, even new kingdoms of microbes, which have colonized the deepest reaches of Earth's crust, the boiling water of hot springs, and the acid-drenched warmth of the human gut. Most of the diversity of life, not to mention the sheer physical mass, is microbial.

The base of the tree of life represents the last common ancestor of all life on Earth today. All living species share certain things in common. All of them, for example, carry their genetic information as DNA and use RNA to turn them into proteins. The simplest explanation for these universal properties is that all living species inherited them from a common ancestor.