

Timeline of Evolution

“Ago” is in millions of years ago
1 cm = 1 million years

Note: the distances are not exactly replicated on the string, there is a little “slop”; and besides, most of these dates are approximate in any case.
The purpose is to provide an overview, a perspective, not learn the specifics!

End of string is origin of earth/moon system (so “time unrolls”)
Total length of labeled string is 46 meters

Source: What is Life?
Lynn Margulis and Dorion Sagan, 1995. Shimon and Shuster.

no	ago	main point	comments
1	4,600	earth origin	Hadaean eon Earth moon system and other planets in solar system formed. Oldest rocks dated from 4,500.
2	4,000	earth crust	Archaean eon begins. Following millennia of out-gassing and volcanism, crust begins to form, assumed first tectonic activity begins. Rocks are dated by radioactivity.
3	3,900	first bacteria	Origin of life (autopoiesis) in the form of bacterial cells. (this implicates both metabolism and reproduction). First kingdom of bacteria known as Monera (they were prokaryotes or non-nucleated)
4	3,600	stromatolites	Evidence of anoxygenic (not using O ₂) communities of bacteria. Microfossils left, evidence of stromatolites ... a species and formation that has persisted from then to now. (seen in Australia)
5	3,500	photosynthetic bacteria	reduced carbon in shales as evidence of widespread photosynthesis in bacteria; oldest direct evidence of tectonic activity
6	3,300	trace O ₂ in atmosphere	... and in sediments
7	3,000	major metabolic pathways	Diversification of bacteria. Probably all major metabolic modes evolved: based on chemical energy, oxidation, photosynthesis.
8	2,500	O ₂ accumulation	Proterozoic eon begins; huge lakes, biogenic bacterial reefs in marine communities; seasonal variation in oxygen accumulation
9	2,200	bacterio-plankton	Widespread prokaryotic plankton in the worlds oceans. Photosynthetic bacteria creating more and more oxygen – which is a corrosive gas, so some species that cannot cope would be disappearing now.
10	2,100	ozone shield	An ozone shield O ₃ forms based on cumulating oxygen. There is both less change through random mutation and greater protection from dangerous UV radiation. Cells can survive closer to the surface and access more light.

11	2,000	mitochondria	Mitochondria, the ancestors of modern complex cells are acquired through ingestion, or “engulfment” enabling a protected environment for the new organelle which can begin to do more. More rapid change becomes possible.
12	1,800	O ₂ rich atmosphere	More oxygen a “poison” (it enables things to oxidize, or burn and rust) There is a large scale transition to aerobic metabolism by those that survive this shift.
13	1,700	eucaryotes	Cells with a nucleus; In other words, cell nuclei have been generated, probably through the engulfment of one bacterium by another. Thus we have cell evolution through symbiosis, and with that the beginnings of speciation as we understand it now.
14	1,600	aerobic life	Diversification of aerobic life, planktonic and benthic organisms develop, possibly through symbiotic acquisition of air breathing mitochondria.
15	1,500	primitive sex, programmed death	The origin of mitosis and meiosis, (different kinds of cell division – growth of a colony and thus multi-cellularity, and separation of gene pairs makes genetic recombination possible in reproduction) This provides a new mechanism for adaptive changes. Programmed death is more of a matter of loss of individual durability as more complex, effective processes take over. I think of death arising from internal changes as a cost of increased complexity.
16	1,400	terrestrial bacterial	Appearance of terrestrial photosynthetic bacteria . . .
17	1,300	seaweeds	Diversification of seaweeds as colonies of photosynthetic cells. What we now call algae have acquired photosynthetic plastids from bacteria
18	1,000	algae diversified	Increased diversity of algae with a cell nucleus.
19	600	egg, sperm, and embryo	After several ice ages followed by diversification; the Animal Kingdom appears: first animals: sponges, coelenterates, arthropods. Inferred origins of egg, sperm, embryo and embryonic stages. These all enable greater flexibility and of course
20	570	Marine animals, plants, fungi	Phanerozoic eon begins; starting with the Paleozoic era; or “the age of marine animals” Trilobites, other hard shelled animals. Appearance of the Plant and Fungal Kingdoms. (note that this follows about 30 million years after the Animal Kingdom – at least as far as current fossil evidence shows)
21	510	Jawless fishes	First jawless fishes
22	500	land colonized	Algae and insects colonize land
23	408	terrestrial plants with seeds	Armored fish, marine invertebrates. Land extensively covered by forests. First appearance of plants with seeds; which enable plants to survive adverse conditions, disseminate, and... this provides a new concentrated food source for other species.
24	360	amphibians	Widespread appearance of fish and amphibian vertebrates; modern-like fishes.

25	300	corals, first reptiles	Mesozoic era; “age of reptiles” begins. Large trees grow in swamps, which has made for the possibility of coal deposits
26	290	reptiles diversify	Inland seas indicated by salt deposits, possibly Gaia hypothesis type control of salinity in oceans. Early dinosaurs & early mammal-like and bird like reptiles, and shrew-like mammals.
27	245	major extinction	Largest known extinction event. The Pangean supercontinent begins to break up and separate according to what we now call continental drift. “Age of Reptiles” begins
28	200	silica in diatoms	This is the source of many white sands as the silica tests accumulate.
29	100	angiosperms, primates	First primates appear along with angiosperms, that is flowering plants. Flowers indicate a relationship between the plants and insects or other animals that pollinate the plants increasing the possibility of species specific spread of pollen to distant plants.
30	66	age of dinosaurs	Prior to the major extinction of dinosaurs, they have diversified and are the major large animals; hence this is the peak of the “Age of Dinosaurs”
31	65	major extinction	With the extinction event that is sometimes attributed to a large meteor hitting the earth, the Cenozoic era, or the “Age of Mammals” begins, with diversification – distinct families and genera. Small primates begin to spread.
32	40	trees with fruit	The existence of fruit implies co-evolution with other animals – The fruit attracts animals which then help to spread the seeds.
33	23	grasslands	Widespread grasslands, and the grazing mammals that used them; again a matter of co-evolution. Grasslands exist where encroaching trees are eaten away.
34	5	hominids	Proconsul, Australopithecus, then Homo
35	0	Cities, now	Major extinction of many other species ... as we modify the earth and co-opt habitats for our own use. What we call “natural resources” are those parts of the world which we want and take for ourselves.
36		future?	Its partly up to us!