

Earth Systems and Cycles

Earth evolution:

Condensation and formation (4.56 Ga); initial cooling and differentiation into core, mantle, crust, atmosphere, oceans (4.4 Ga); lithosphere solidification and earliest continental crust (4 Ga).

Since 4 Ga, **plate tectonics** shapes the surface - constructive and destructive plate boundaries

Volcanism provided **atmosphere** and **hydrosphere** to the Earth

Earth's gravitation allowed capture of water vapor, nitrogen, sulfur, carbon dioxide gases (no free oxygen until photosynthesis)

Biosphere: sum of all materials involving organisms

Carbon dioxide and water gases in atmosphere contribute to greenhouse effect; note that the moon is below freezing with greenhouse gases, but Venus has 'runaway' greenhouse (no surface water)

Oldest fossil life (bacteria): 3.5 Ga - maybe 4 Ga

Photosynthesis: generation of carbohydrates using sunlight, yields **free oxygen**

Oxygen migrating to the stratosphere forms ozone, which can block UV radiation, and allow life on land; significant amounts possibly from 3.5 Ga; more likely, 2 to 1.5 Ga

Geochemical cycles—maintain steady state of chemical balance

Climate change/mass extinctions:

may result from many causes, including superplumes, bolide impacts or nearby novae radiation

Superplume at **Permian-Triassic boundary** (Siberian flood basalts): dust may have led to climate cooling (90% marine species, 70% land vertebrates wiped out)

K/T boundary: almost certainly bolide impact triggering global cooling (hit at Yucatan); evidence in Ir anomalies, etc.

Self-induced climate change: **greenhouse gases**