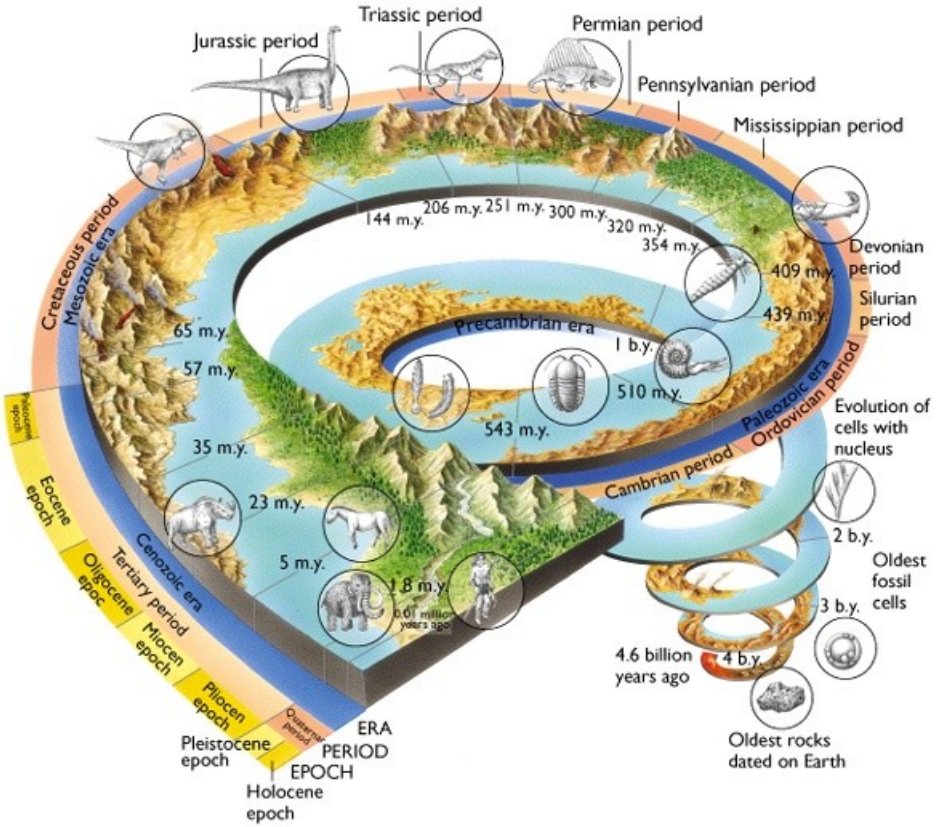
# Life Beyond Earth

- 12-2-2005

# Opening Discussion

- Have you seen anything interesting in the news?
- How could we tell if life was not from Earth? Most people put amino acids. Anything from the list of why we conclude that all life on Earth came from a single source could be used.

# More


Jurassic period
Triassic period
Permian period
Pennsylvanian period
Mississippian period
Devonian period
Silurian period
Ordovician period
Cambrian period
Precambrian era
Paleozoic era
Mesozoic era
Cretaceous period
Cenozoic era
Tertiary period
Eocene epoch
Oligocene epoc
Miocen epoch
Pliocen epoch
Pleistocene epoch
Holocene epoch
ERA
PERIOD
EPOCH
144 m.y.
206 m.y.
251 m.y.
300 m.y.
320 m.y.
354 m.y.
409 m.y.
439 m.y.
1 b.y.
510 m.y.
543 m.y.
65 m.y.
57 m.y.
35 m.y.
23 m.y.
5 m.y.
1.8 m.y.
0.01 million years ago
Evolution of cells with nucleus
2 b.y.
Oldest fossil cells
3 b.y.
4 b.y.
4.6 billion years ago
Oldest rocks dated on Earth

# Drake Equation

- The question of life beyond Earth is one of the primary motivators for the study of astronomy. As some would phrase it, are we alone?
- An equation to estimate the number of extraterrestrial civilizations in our galaxy was devised in the 1960s by Frank Drake.
- $N=R^{*}\times f_{p}\times n_{e}\times f_{l}\times f_{i}\times f_{c}\times L$, $R^{*}$ is the rate of star formation, $f_{p}$ is the fraction with planets, $n_{e}$ is the average number of habitable planets, $f_{l}$ is the fraction that develop life, $f_{i}$ is the fraction that become intelligent, $f_{c}$ is the fraction willing to communicate, L is the expected lifetime of such a civilization.

# Life in our Solar System

- Since Earth is the only planet with life that we know of, we have to base our arguments on small number statistics. After last class though you should have a decent picture of the history of life on Earth.
- The two most likely places that we could find life in our own Solar System beyond the Earth are on Mars and Europa. The warmer, wetter Mars of the past may have supported simple life, but only simple life. The possibility of oceans and active geology on Europa could allow life there as well. It wouldn't even have to be simple life, but a lack of energy source will probably limit it to that.
- Arguments could be made for Ganymede, Callisto, and Titan as well.

# Mars Life

- The Viking probes ran tests on soil samples looking for life. Of 4 tests, 3 said that there might be life in the soil, but the 4$^{th}$ showed there weren't organics so those scoops definitely didn't contain life as we know it.
- More recently scientists found a meteorite named ALH84001 that had features in it that some believed have biological origins. Since that time non-biological explanations have been found and the idea that we are seeing fossils or other evidence of life from Mars has fallen out of favor.

# Life Around Other Stars

- Finding life on planets around other stars is really the ultimate goal. The problem is that we have no chance of actually going to those planets so detection has to come from observations. The actual evidence of life will come from spectra.

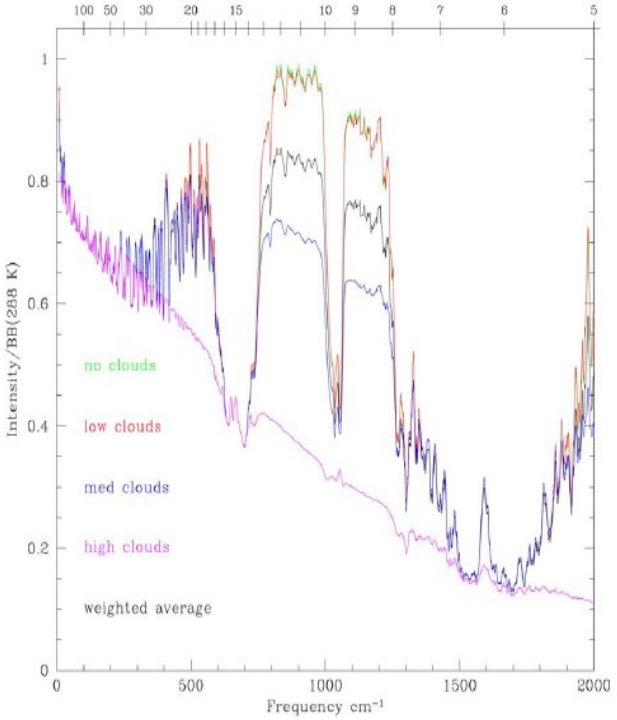
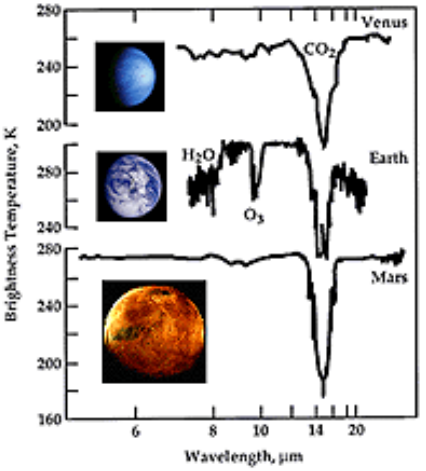
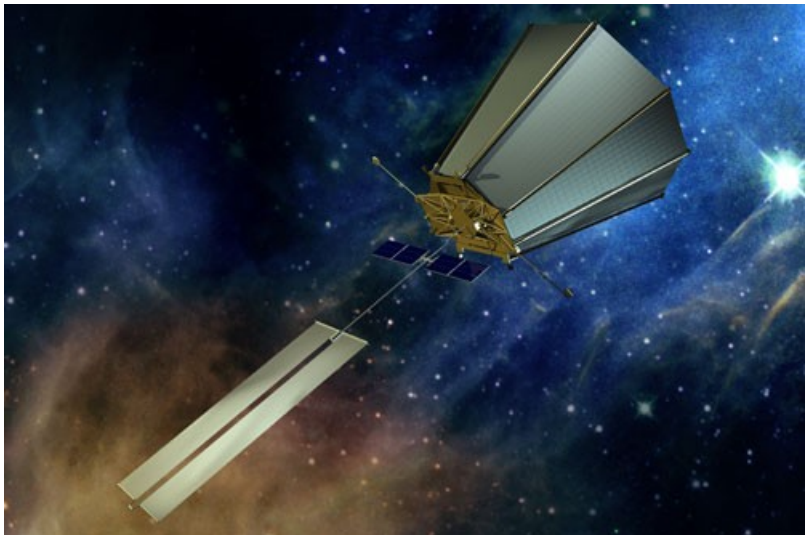


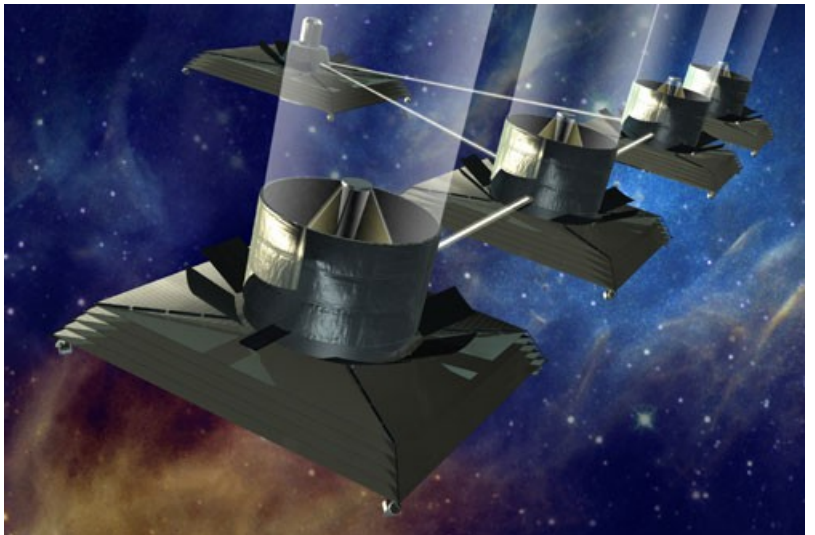

Figure 1. Normalized Infrared Thermal Emission Spectral Models of the Earth



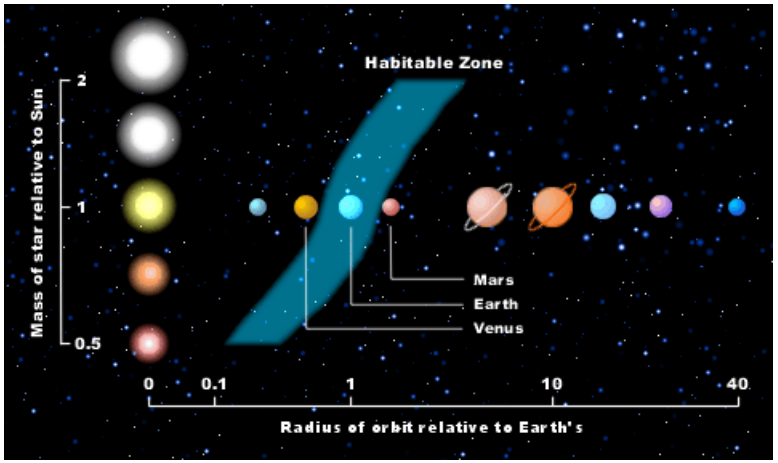
# Terrestrial Planet Finder

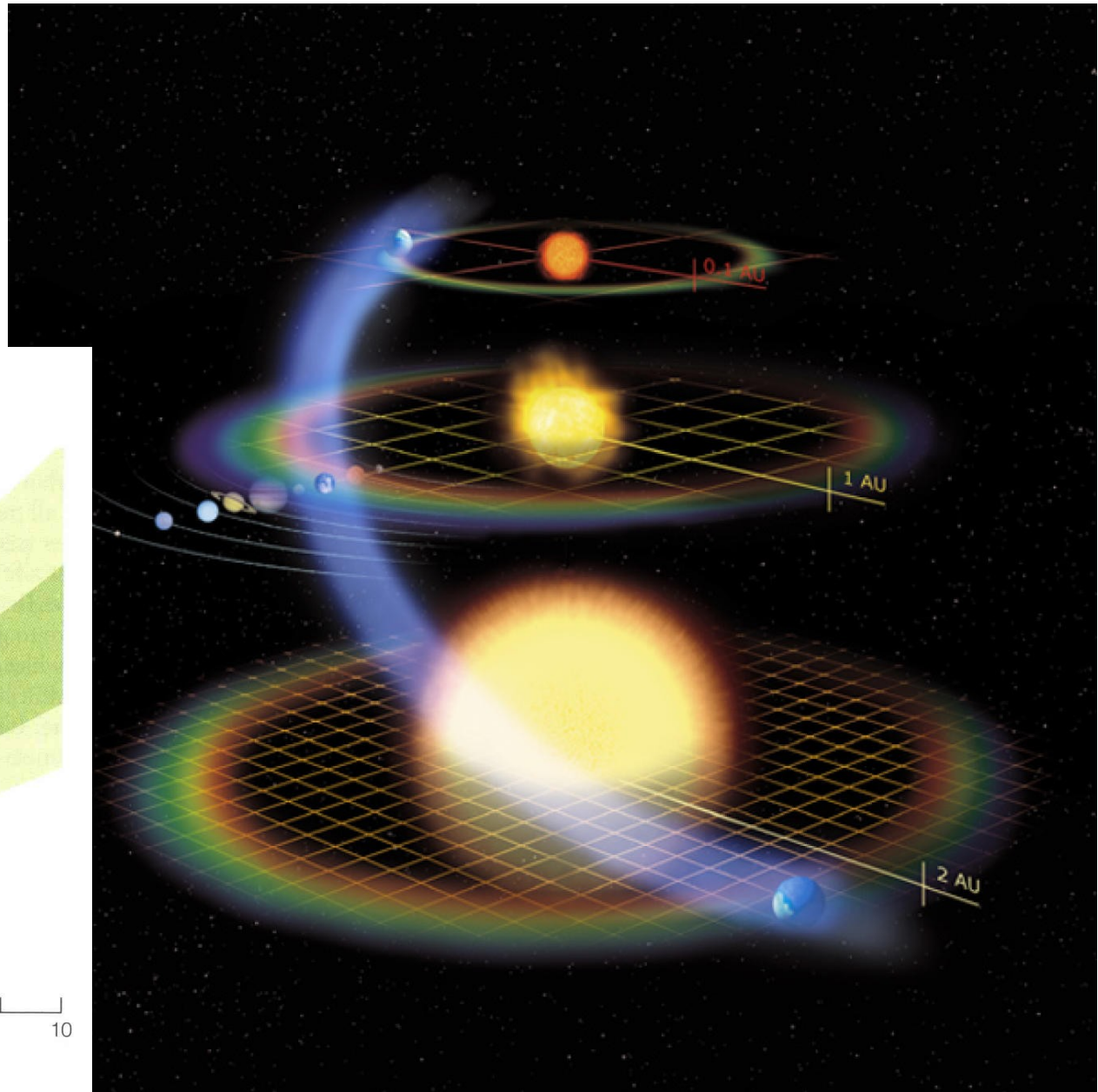
- The TPF mission will put a large optical interferometer into space that will be able to image terrestrial planet, all be it at very low resolutions.
- The two parts of TPF are a visible coronagraph (2014) and an IR interferometer (2020).

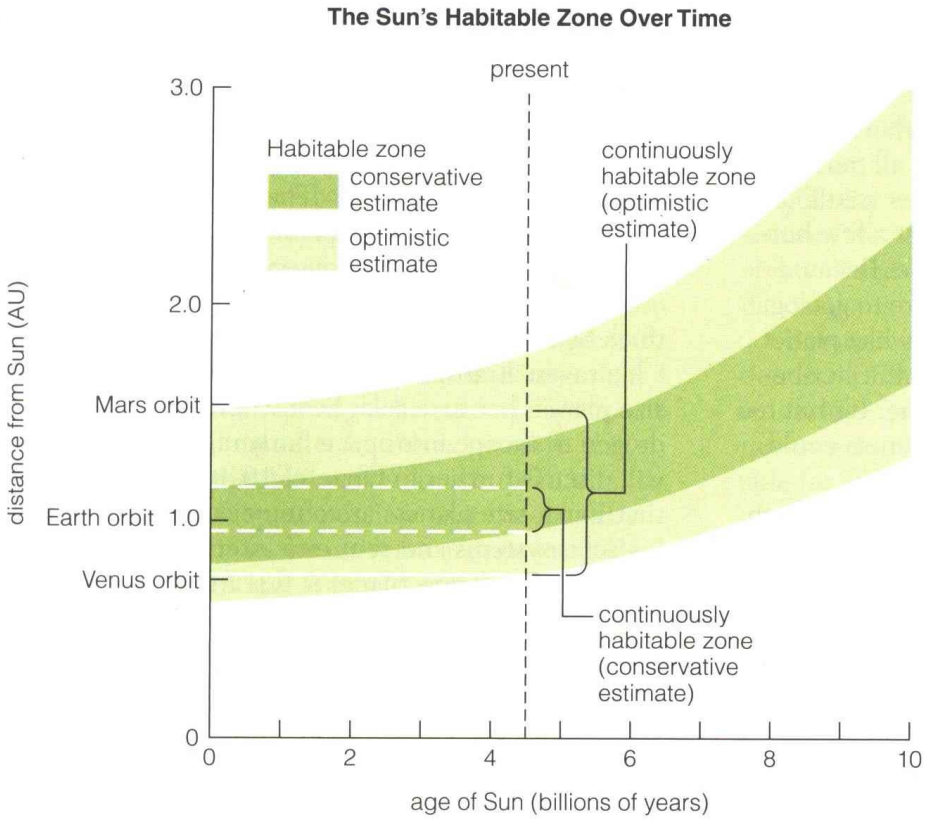




# Habitable Zones



# Rare Earth

- Going back to the Drake equation, we only have good values for a for of the terms. Most are rather up in the air. There are a number of scientists who argue that the Earth will turn out to be rare in having advanced life. They typically argue that simple life will be very common, but that a lot had to go right to get advanced lifeforms.
- Questions surround the abundance of heavy elements, impacts, and stable climate on terrestrial planets outside of our solar system.

# Minute Essay