The Science of Habitable Worlds
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Planetary Habitability

• The Habitable Zone
• A Deeper Look at Habitability
• Earth: How Habitable Is it?
• Venus: Earth’s Evil Sister?
• Was Mars Habitable?
Necessities for Life

• A nutrient source
• Energy (sunlight, chemical reactions, internal heat)
• Liquid water (or possibly some other liquid)

Hardest to find on other planets
The Drake Equation

Number of civilizations with whom we could potentially communicate

\[ N_{\text{HP}} \times f_{\text{life}} \times f_{\text{civ}} \times f_{\text{now}} \]

\( N_{\text{HP}} = \) total number of habitable planets in galaxy
\( f_{\text{life}} = \) fraction of habitable planets with life
\( f_{\text{civ}} = \) fraction of life-bearing planets with civilization at some time
\( f_{\text{now}} = \) fraction of civilizations around now
We do not know the values for the Drake equation.

\[ N_{HP} : \text{probably billions} \]
\[ f_{\text{life}} : ??? \text{ hard to say (near 0 or near 1)} \]
\[ f_{\text{civ}} : ??? \text{ took 4 billion years on Earth} \]
\[ f_{\text{now}} : ??? \text{ depends on whether civilizations can survive long-term} \]
• Kepler has detected ~70 Earth-sized planet candidates - many more than known previously

• Kepler has also detected ~50 candidates in the ‘Habitable Zone’ of their star (the orbital distance where temperatures should be about right for liquid water and possibly life), compared to ~5 known previously
The Role of Distance from the Sun

Planets Close to the Sun
- Surface is too hot for rain, snow, or ice, so little erosion occurs.
- High atmospheric temperature allows gas to escape more easily.

Planets at Intermediate Distances from the Sun
- Moderate surface temperatures can allow for oceans, rain, snow, and ice, leading to substantial erosion.
- Gravity can more easily hold atmospheric gases.

Planets Far from the Sun
- Low surface temperatures can allow for ice and snow, but not rain or oceans, limiting erosion.
- Atmosphere may exist, but gases can more easily condense to make surface ice.
An Approximation to Planetary Temperatures

This is how they estimate temperatures of extrasolar planets
Figure 24.15 Annotated

Solar System

Mars orbit
Earth orbit
Venus orbit
Mercury orbit
Sun

habitable zone

Star with mass $\frac{1}{2} M_{\text{Sun}}$

Star with mass $\frac{1}{10} M_{\text{Sun}}$

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Could there be life on Europa or other jovian moons?