The Science of Habitable Worlds

LASP Teacher Summit

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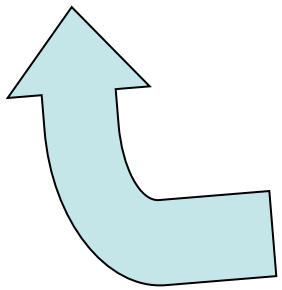
Planetary Habitability

- 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

$$= \boldsymbol{N_{HP} \times f_{life} \times f_{civ} \times f_{now}}$$

N_{HP} = total number of habitable planets in galaxy

f_{life} = fraction of habitable planets with life

f_{civ} = fraction of life-bearing planets with civilization at some time

f_{now} = fraction of civilizations around *now*

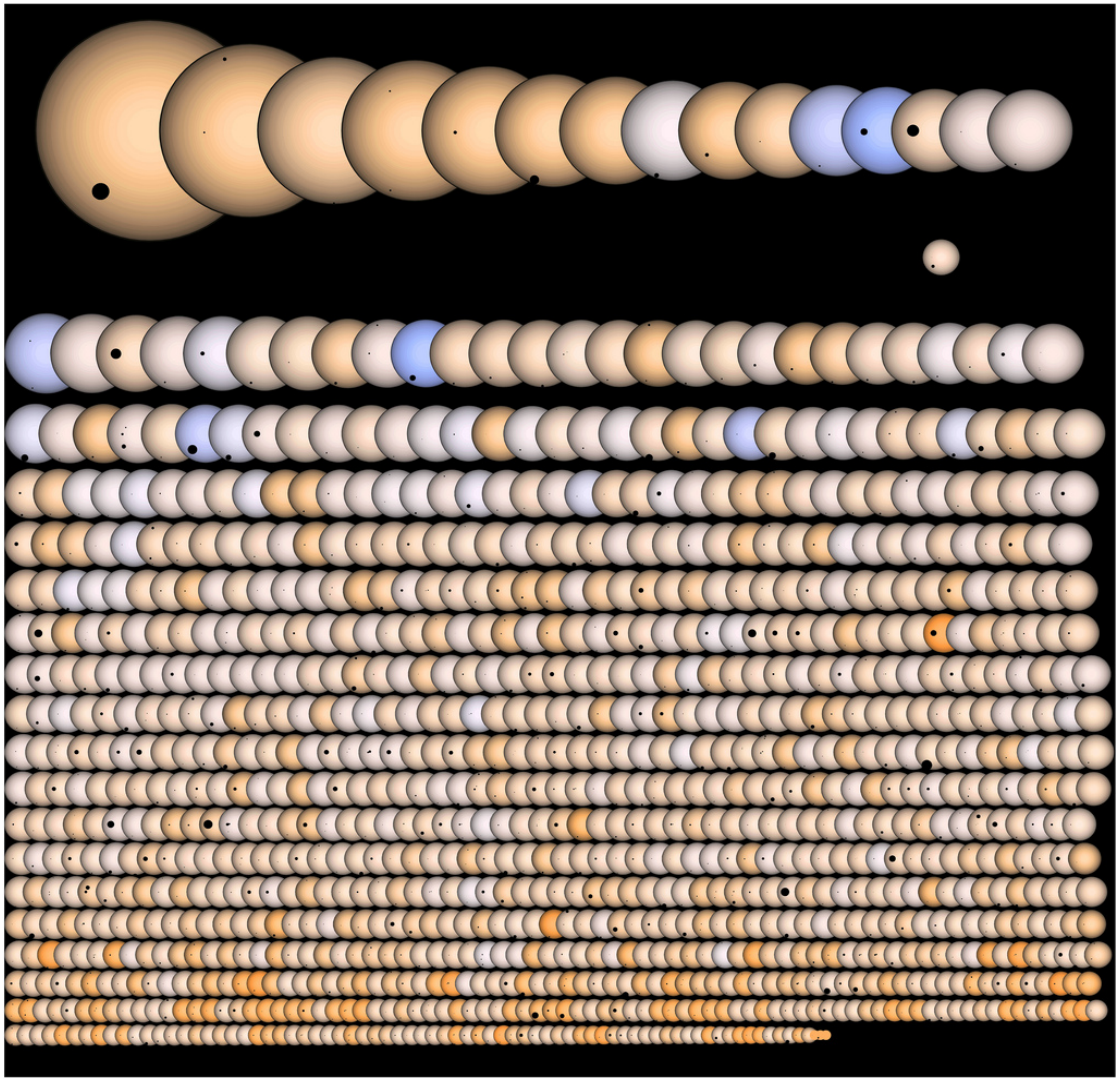
We do not know the values for the Drake equation.

N_{HP} : probably billions

f_{life} : ??? hard to say (near 0 or near 1)

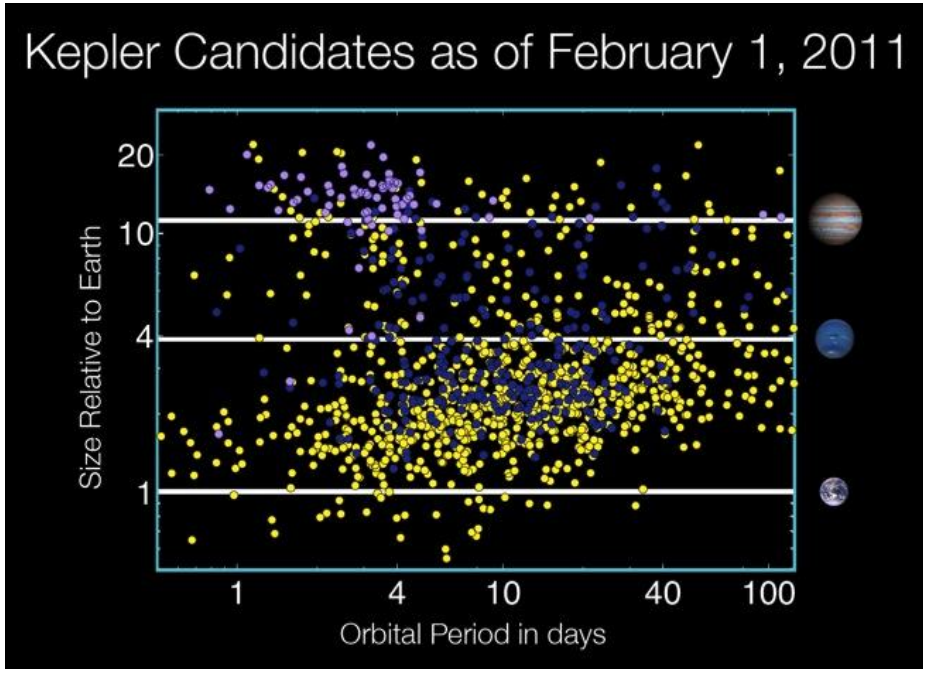
f_{civ} : ??? took 4 billion years on Earth

f_{now} : ??? depends on whether civilizations can survive long-term

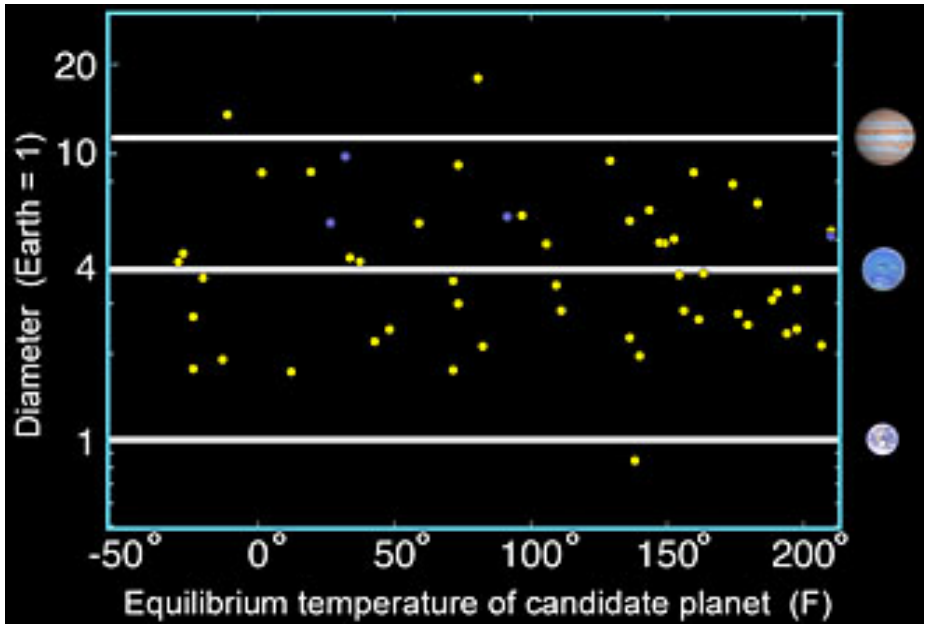


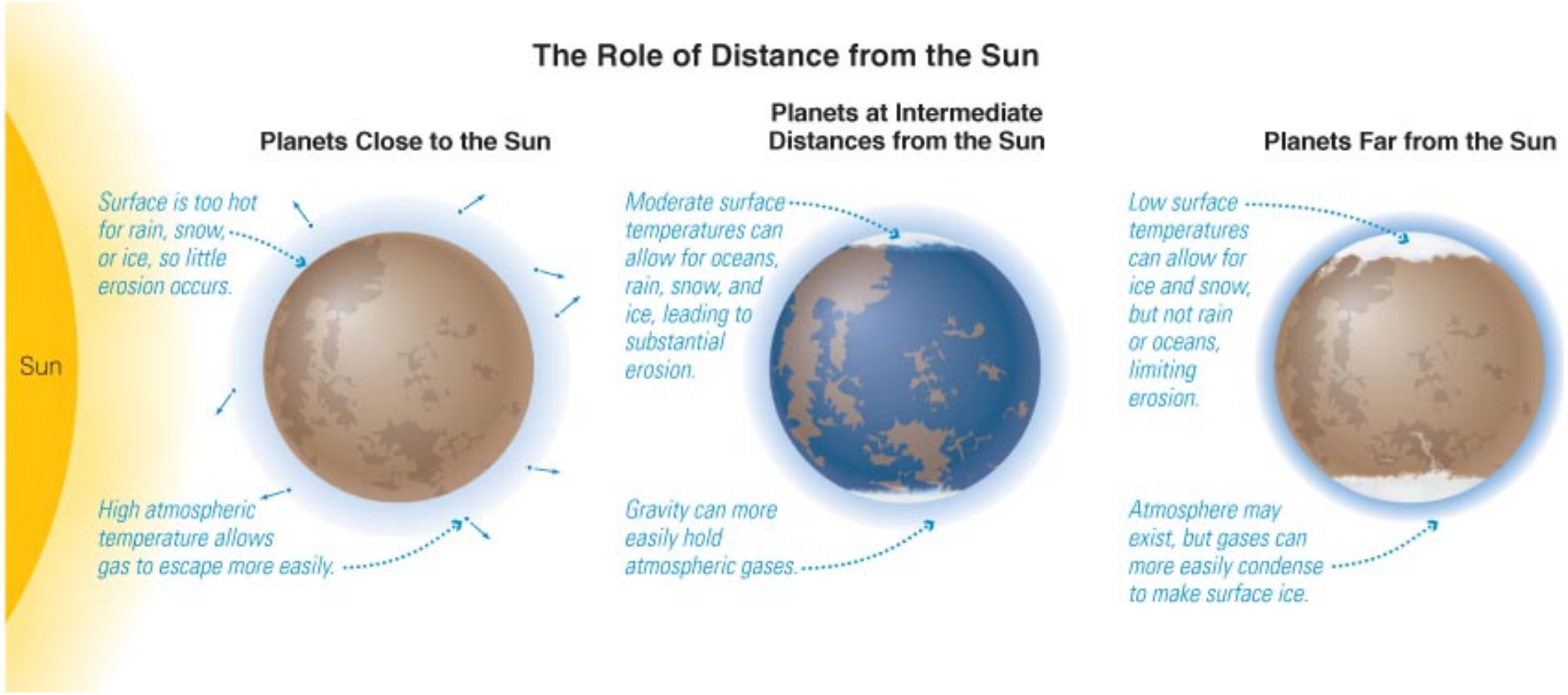
- Kepler has detected ~70 Earth-sized planet candidates - many more than known previously

- 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

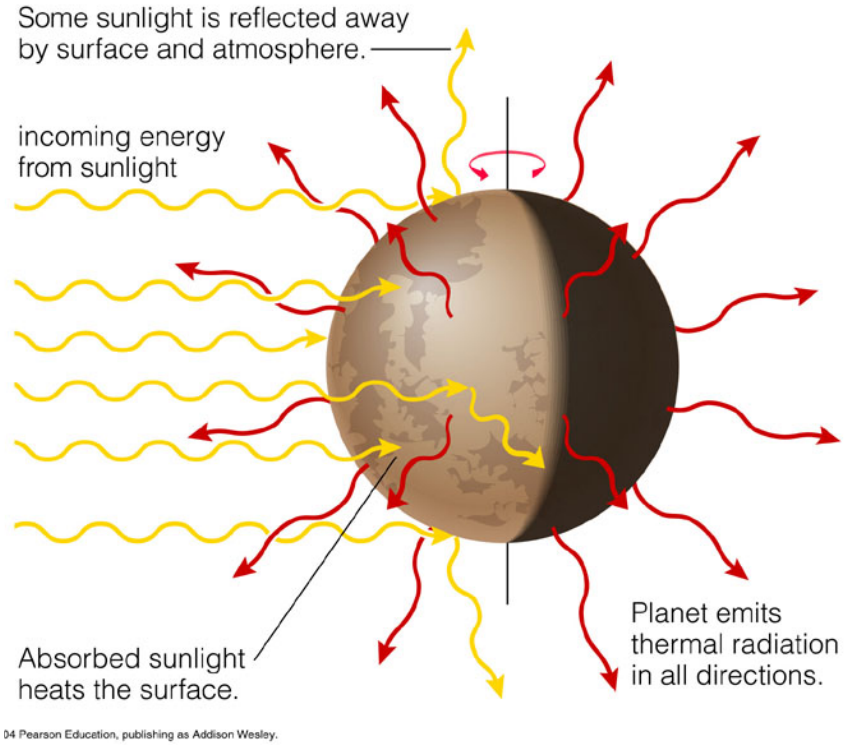


Kepler Candidates in the Habitable Zone




The Role of Distance from the Sun
Planets Close to the Sun
Planets at Intermediate Distances from the Sun
Planets Far from the Sun
Sun
Surface is too hot for rain, snow, or ice, so little erosion occurs.
High atmospheric temperature allows gas to escape more easily.
Moderate surface temperatures can allow for oceans, rain, snow, and ice, leading to substantial erosion.
Gravity can more easily hold atmospheric gases.
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



$$E_{in} = \frac{F_{sun\,@\,Earth}(1 - \text{reflectivity})\pi R^2}{d^2}$$

$$E_{out} = 4\pi R^2 \sigma T^4$$

$$T_{eff} = 280K\sqrt[4]{\frac{1 - \text{reflectivity}}{\text{d}^2}}$$

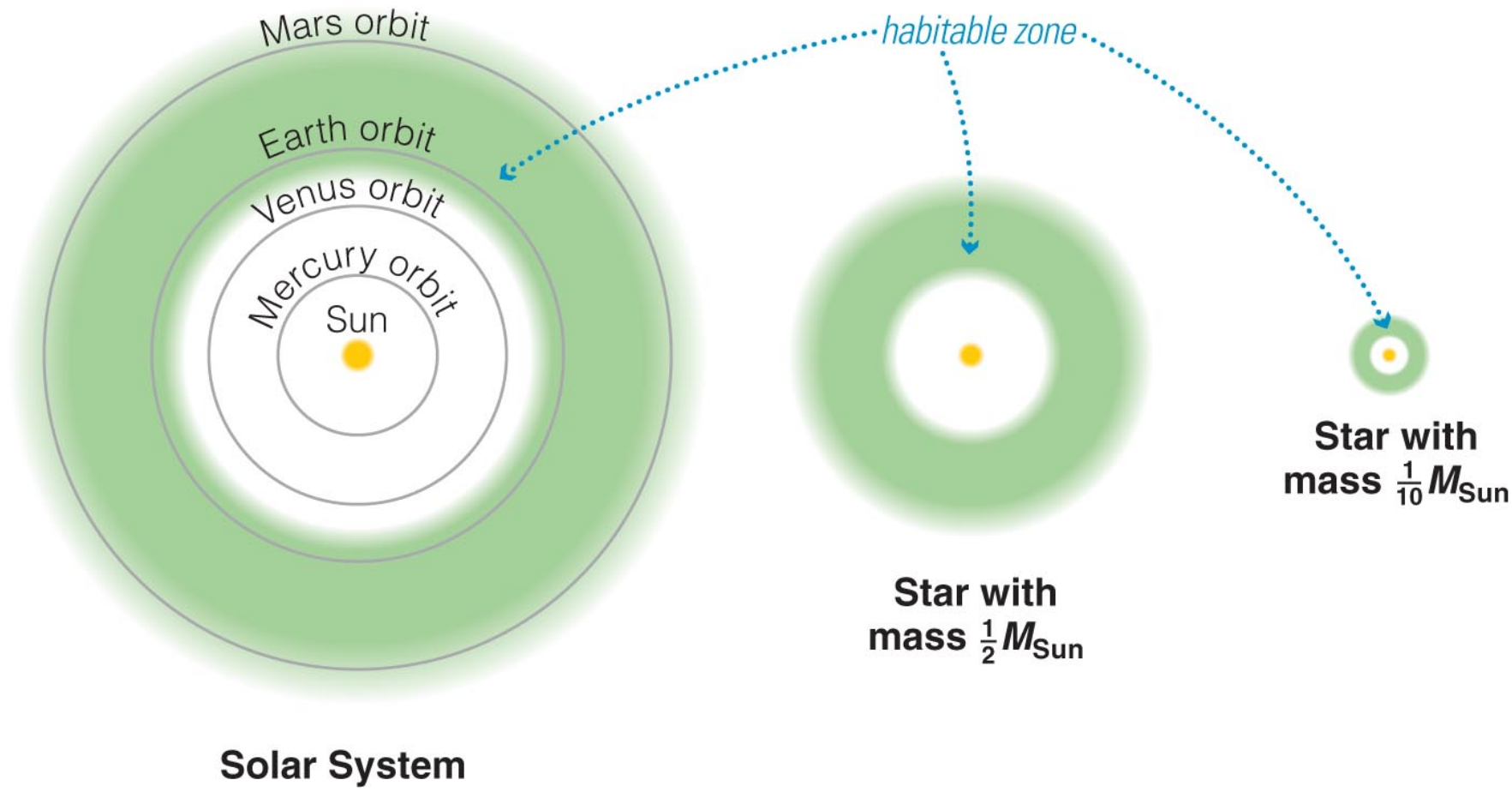
$R \equiv$ planet's radius

$T_{eff} \equiv$ "Effective Temperature"

$d \equiv$ planet's distance from sun in AU

This is how they estimate temperatures of extrasolar planets

Figure 24.15 Annotated



Could there be life on Europa or other jovian moons?