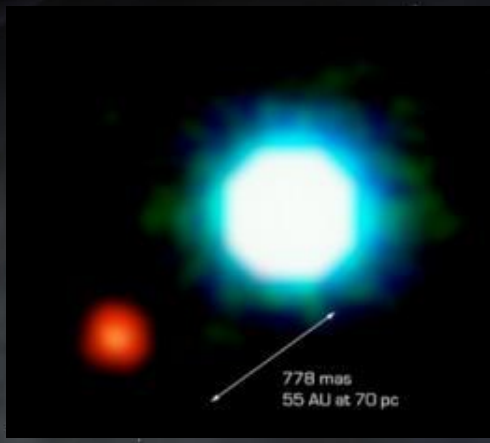
Welcome to Class 14: Europa, Habitability, & Exoplanets

Remember: sit only in the first 10 rows of the room

What are we going to discuss today?



Life might be found in seemingly uninhabitable places

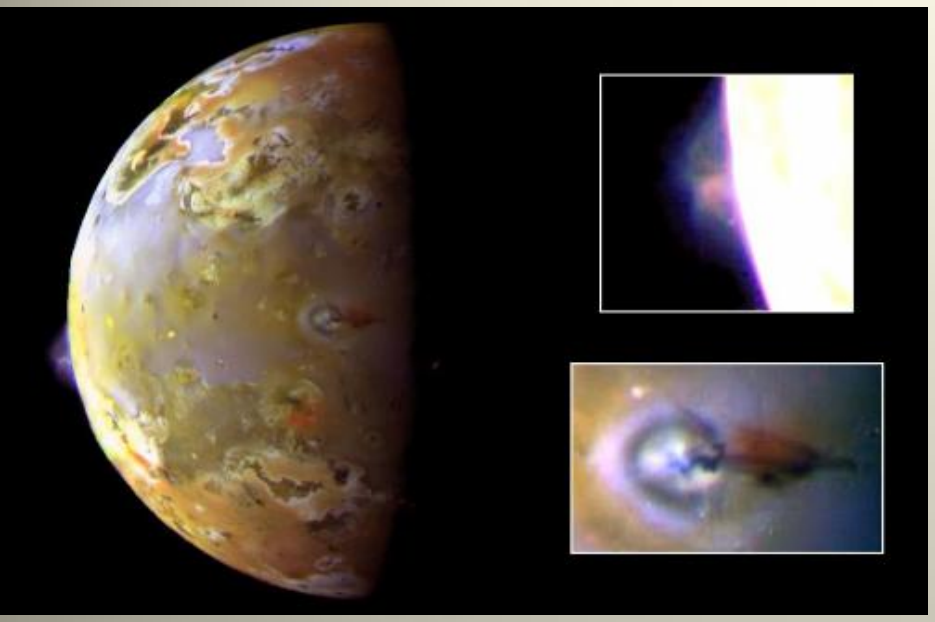
How do we know we've found exoplanets if we can't see them?

PRS: Which is NOT a reasonable way for a planet or moon to retain geological activity?

1. Fusion reactions at its center
2. Fission reactions at its center
3. Latent (left over) heat from formation
4. Tidal heating

Remember to set your channel to 80!

Small moons can be Geologically Active!



Consider: Jupiter's moon Io

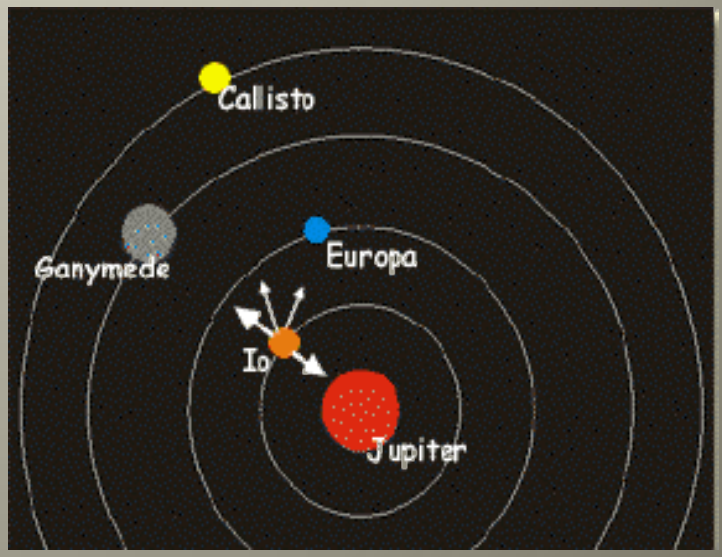
Not a single crater here. The entire surface is smooth and multicolored from various sulfur compounds.

Those are active volcanoes! Io is THE MOST GEOLOGICALLY ACTIVE BODY in the solar system! Yet its even *smaller* than Mars (Io and Europa are the size of Earth's Moon).

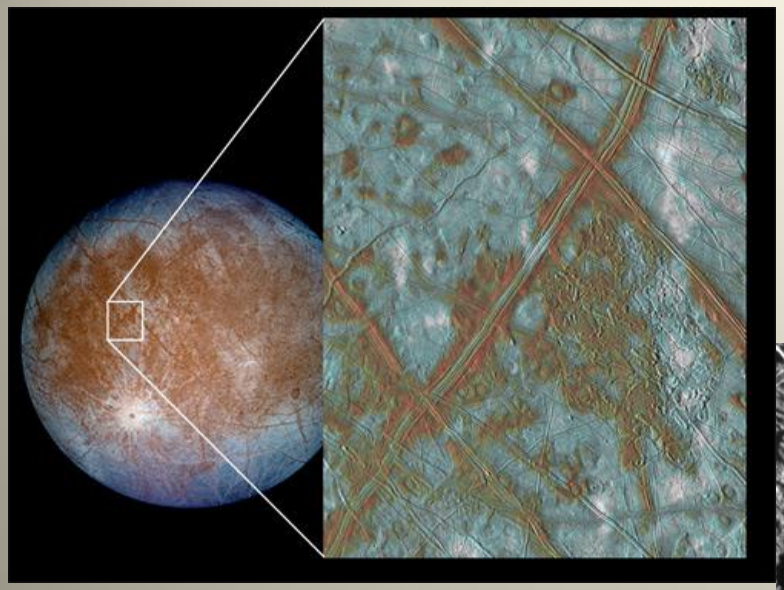
How does this happen?

Tidal heating from Jupiter and the outer three massive moons. Io is being pulled in all directions, and is worked like 'taffy', kneading the moon to remain hot at its center.

But Io is so hot, all of its water has boiled off long ago. In our search for life, we will move one moon further from Jupiter.. To Europa. The `goldilocks' moon

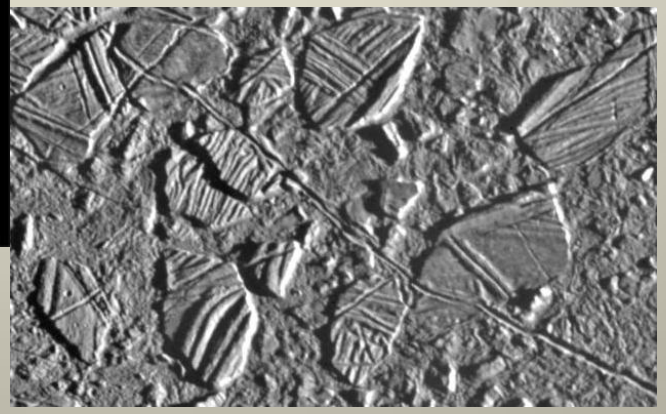


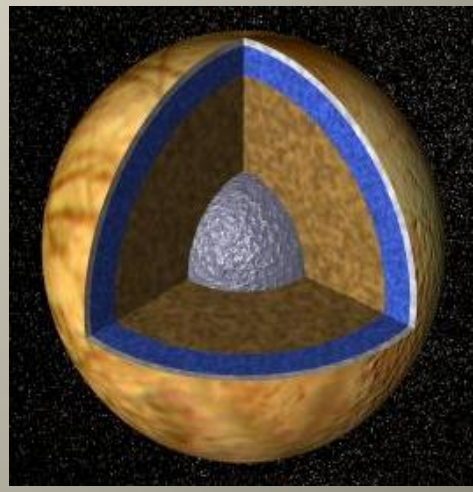
Europa: The largest ocean in the solar system



Its surface is void of craters. Instead, it shows many cracks and iceberg-looking features.

Deep beneath: a solid metal core and rocky mantle.
But above that: ice, slush or possibly liquid water.
On top: a layer of solid water ice with impurities.





Evidence for liquid ocean

1. Lack of impact craters: requires a resurfacing liquid.
2. Chaotic terrain: iceberg-like blocks appear to have been moved.
3. A MAGNETIC FIELD. This requires a conducting fluid: salty ocean.
4. Calculations indicate tidal heating is sufficient to keep this much water liquid.

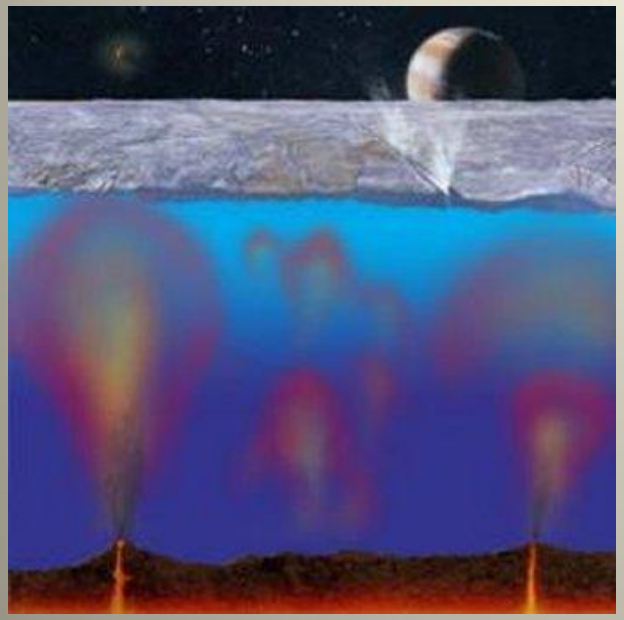
Where there is liquid water, there is the possibility for life

http://www.youtube.com/watch?v=7vAUMS6VtXo

PRS: Which below is not one of the THREE REQUIREMENTS for life?

1. Liquid Water
2. Protection
3. Energy
4. Elements of life

We've got liquid water, but where would Europan life get the needed elements and energy?



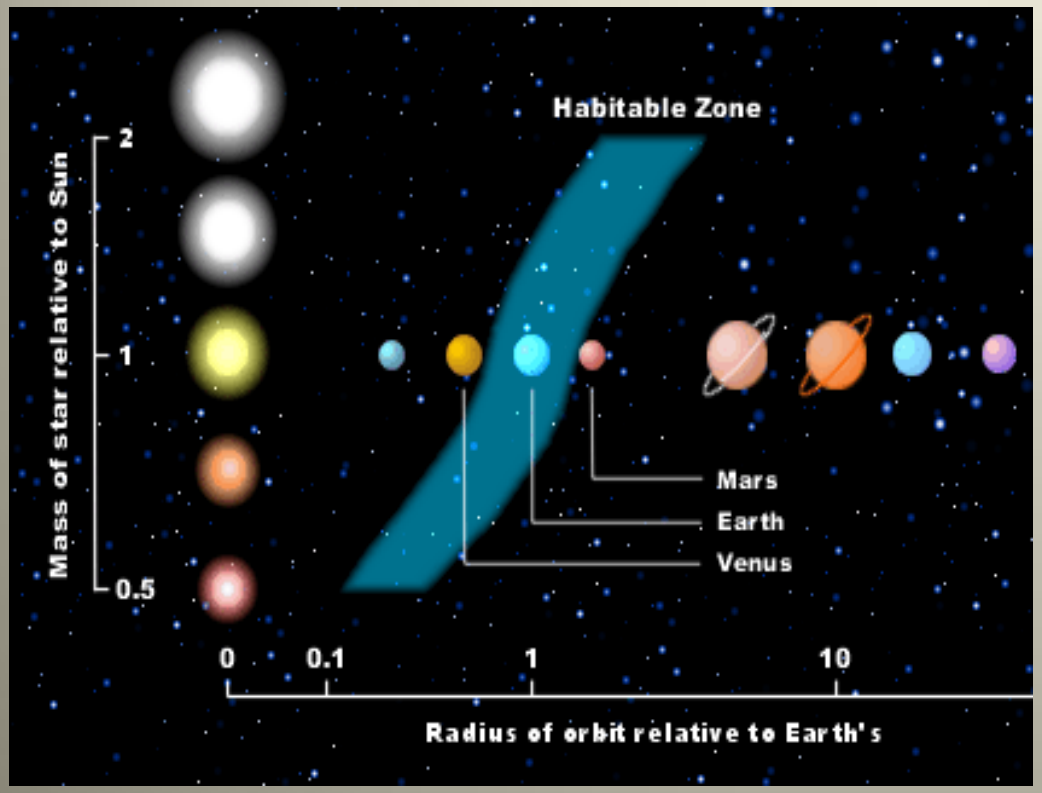
The ocean is heated by a warm, possibly volcanic upper mantle which *may provide* an exhaust of chemicals and elements needed by life.

IF these vents occur they would also provide chemical imbalances in the rock/water boundary, which chemo-autotrophic life might thrive around, just like it does at the base of Earth's oceans around black smokers.

However, be aware, the abundant life we see at the base of OUR oceans is greatly fortified by life above! If black smoker are the ONLY source of energy and organics, then life at the base of Europa will be very, very, very simple and small.

Earth, the Goldilocks planet

Earth lives the perfect distance from our Sun for liquid surface water



If our Sun was BRIGHTER Mars may be in the habitable zone. If our Sun was DIMMER, Venus might be in the habitable zone

Being in the Habitable zone does NOT guarantee a planet/moon is habitable (consider OUR moon)

As a star ages, the habitable zone changes. Stars get brighter with time, then dim at `death'.

Can life exist outside of the habitable zone?

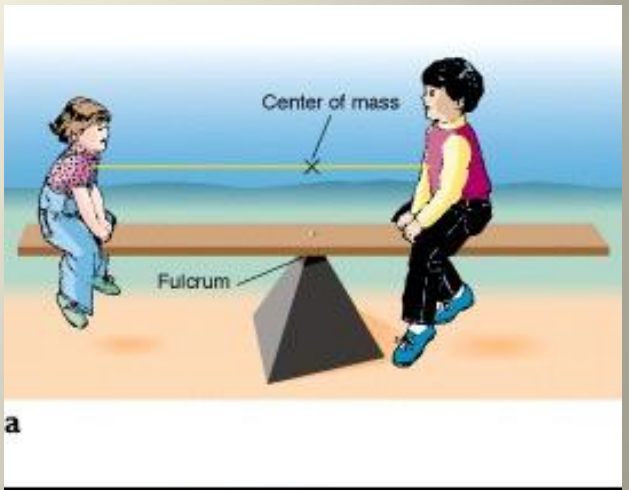
Yes! Or at least we are hoping so: Consider Mars and Europa

PRS: What is an exoplanet?

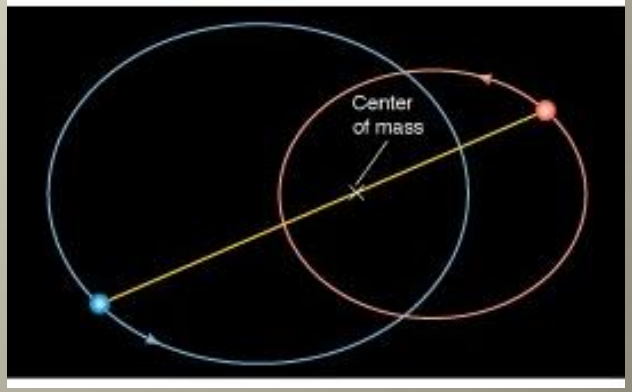
1. A demoted planet (like Pluto).
2. A planet in the outer Solar System.
3. A planet with an exotic atmosphere
4. A planet around another star.

How where exoplanets first identified?

Most planets are too dim to see to see *directly*, but we can see their host stars move. This is called, *indirect* detection.

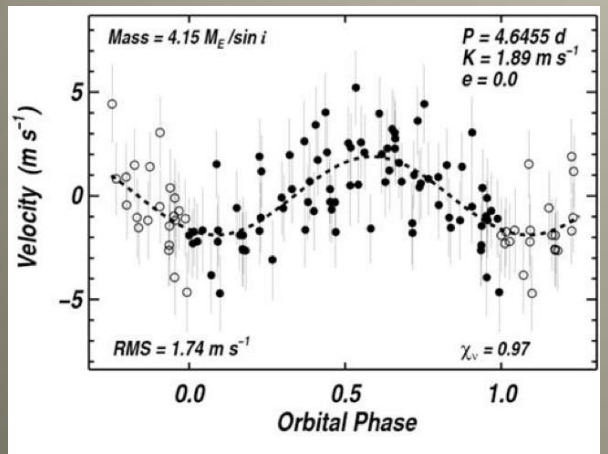


Indirect methods recognize the gravitational influence a massive planet has on their host stars as they orbit the center of mass of the system.



With indirect techniques, there are two main ways to detect an unseen planet.

1) Astrometric: see the host star moving



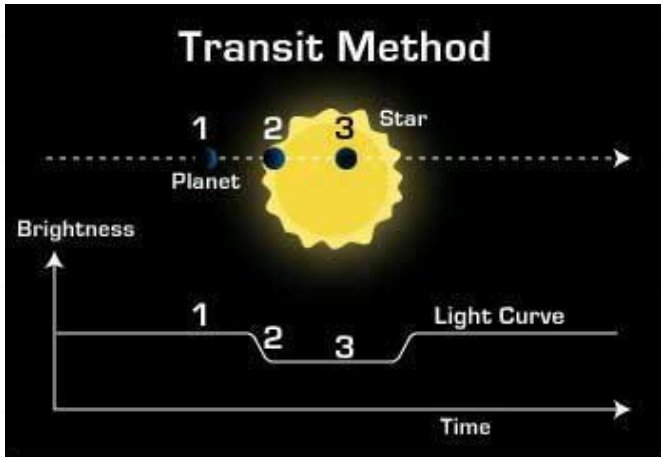
2) Doppler: velocity motions in the host star spectrum

Mostly using spectra to measure Doppler shifts in stars, more than 400 exoplanets have now been discovered orbiting other stars. Some have near Earth size masses.

Other ways to detect exoplanets

Doppler shift (velocity) was the most common

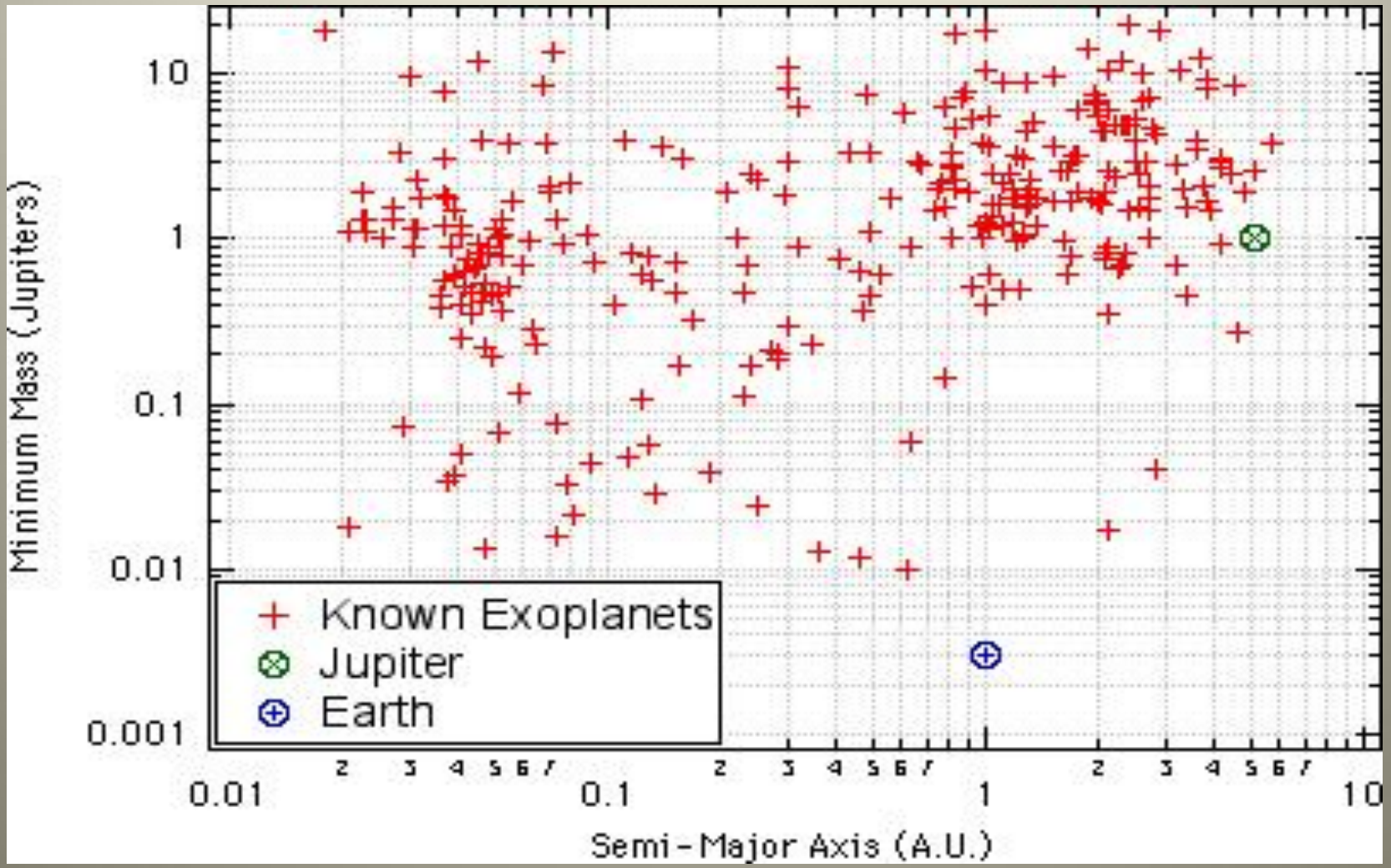
Transits are becoming increasingly more common now because of large sky image surveys



Also used: Gravitational Lensing, *Direct Imaging* and Pulsar Timing

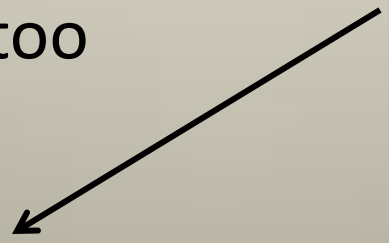
What do these exoplanets look like?

High Mass (all more massive than Earth) and near their host star.



PRS: Why do you suppose we've not found exoplanets with orbital periods greater than 20 years?

1. None exist.
2. Our measurements don't go back far enough.
3. These planets are too small to detect.
4. We have found exoplanets with 20 year orbital periods.



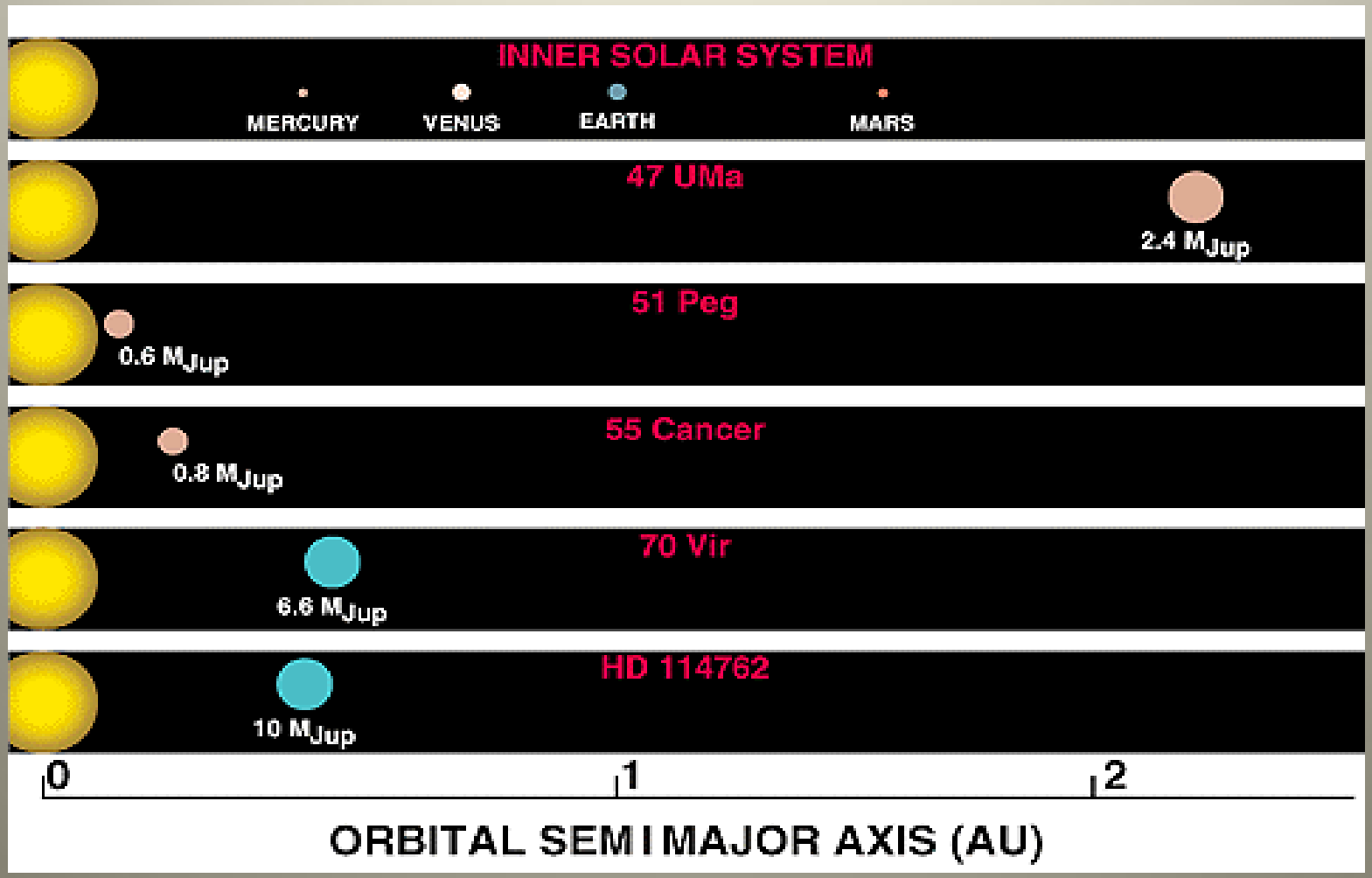
In actuality, direct imaging has found planets with orbits greater than 20 years. The traditional method of using Doppler technique, however, would never have completely studied the orbit for such objects yet.

PRS: Why do you suppose we've not found exoplanets with masses as small as the Earth?

1. None exist.
2. Our measurements are not sensitive enough.
3. We have found exoplanets with masses as small as Earth.

What do these solar systems look like?

There is something very wrong with these solar systems!
Why would 'Gas/Ice Giants' form where Terrestrial Planets form?



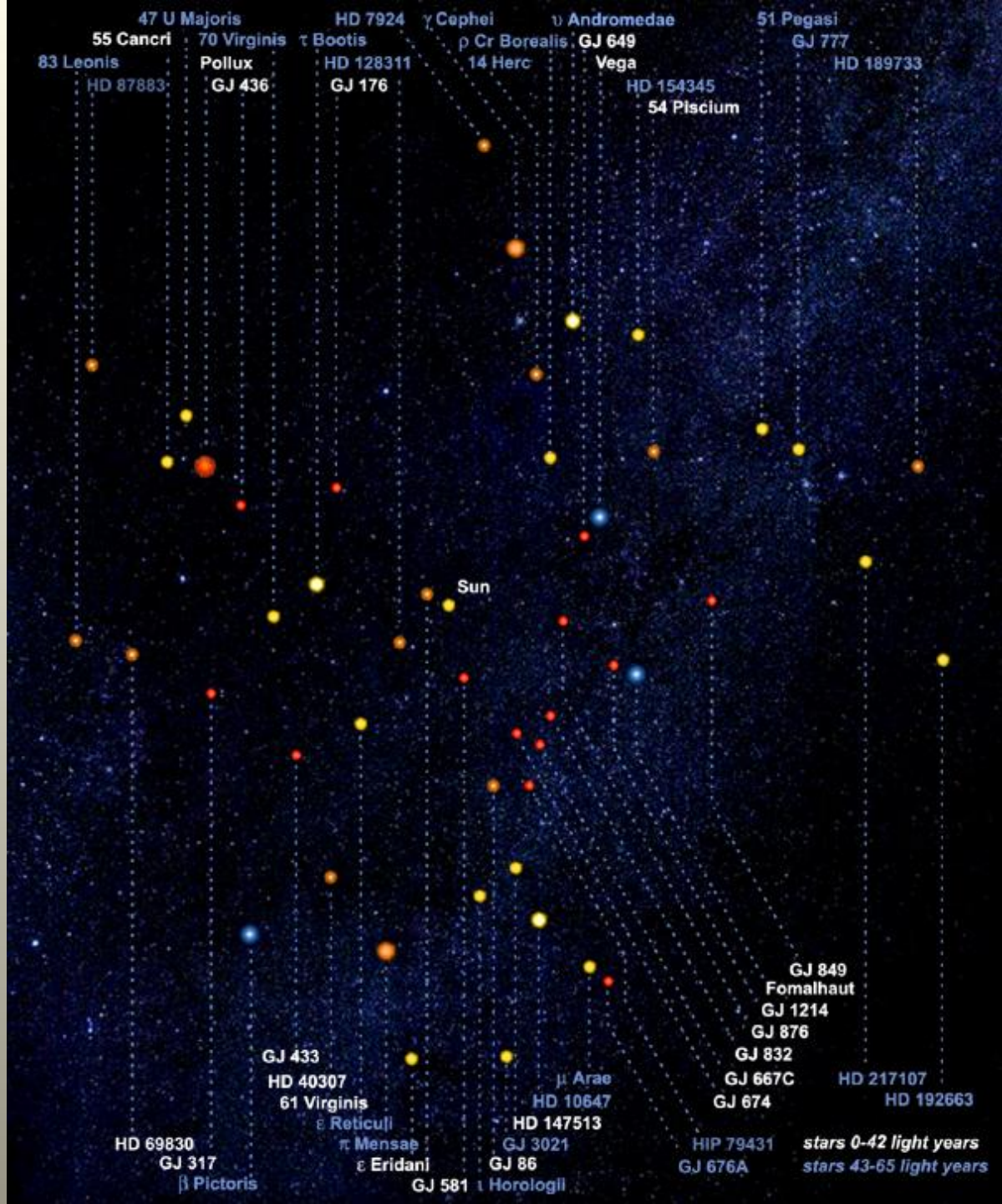
Where are these exoplanets?

Most are within 100 light years of us.

Most are orbiting stars like our Sun.

Most likely have terrestrial planets

Might there be life on planets in any of these solar systems?



PRS: How do you think NASA intends to detect life on a distant exoplanet?

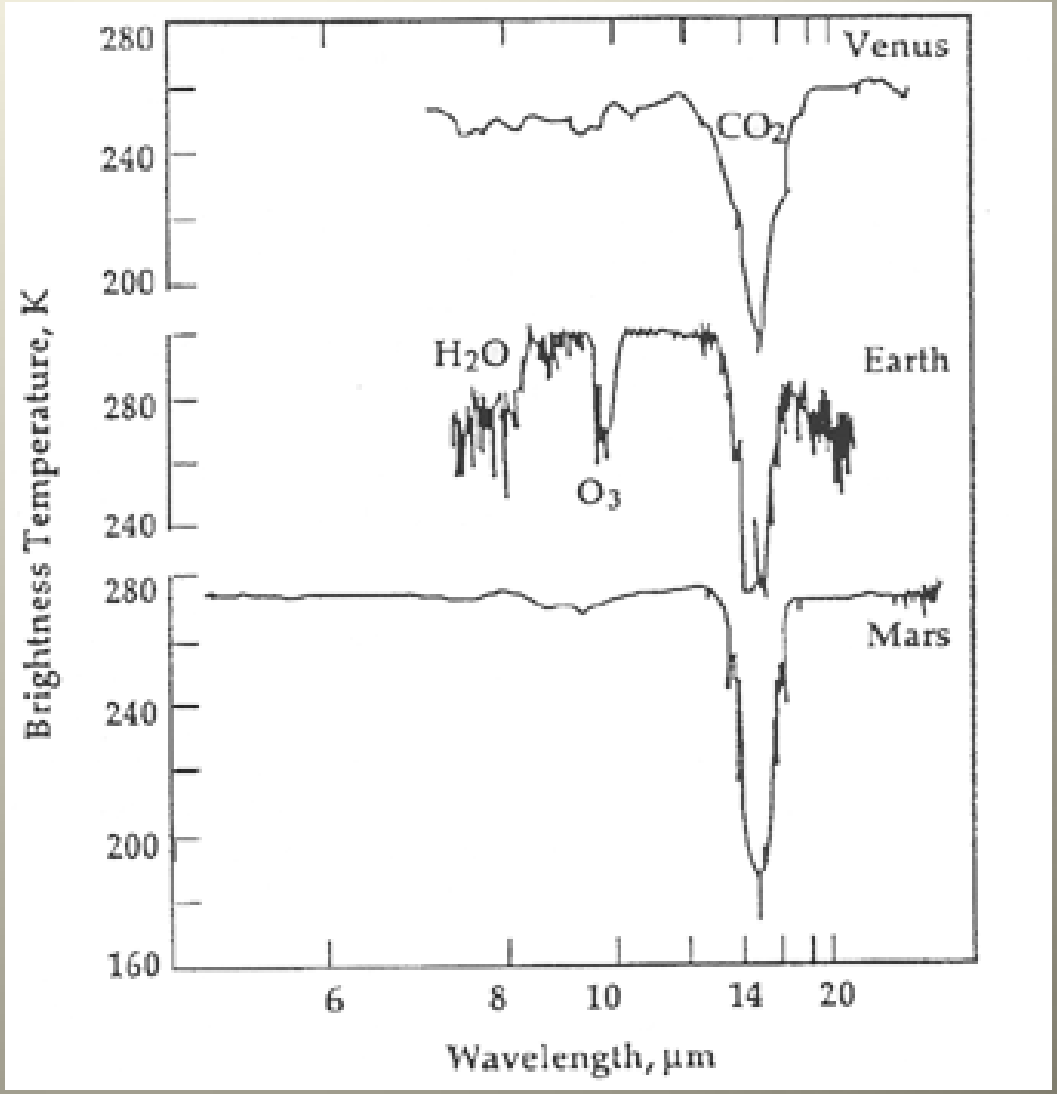
1. Image the surface to look for life
2. Send an orbiter and lander to bring back samples.
3. Take spectra of its atmosphere
4. Look for water in an image of its surface.

Water (H_2O) and Ozone (O_3)

NASA intends to put powerful telescopes in space which can obtain enough light from the planet (and not the star).

If we detect absorption of water and ozone in the planet atmosphere, we will know it has life.

If we don't detect it, there might still be life.



Put all your materials on the floor and place your PRS clicker in front of you.

Please: use just one clicker for yourself.

Take care that others can not view your selection

1. Which of the three requirements for life is only marginally met on Europa?

1. Liquid water
2. Source of Energy
3. Source of Elements

2. The definition of a star's habitable zone applies only to moons or planets that are ..

1. like Earth
2. not too close
3. not too far
4. All of the above.

3. How might life exist outside a stars habitable zone?

1. It has significant liquid water
2. It has a source of elements
3. It has a significant source of energy
4. All of the above are met.

4. Which below is not an indirect method for identifying exoplanets?

1. Gravitational lensing
2. Transits
3. Doppler technique
4. Astrometric technique
5. All are indirect methods

5. Most exoplanets found thus far are …

1. Short period, high mass
2. Short period, low mass
3. Long period, low mass
4. Long period, high mass

For Class 15 (last class!)

- Read assigned textbook pages, guided by the reading questions.
- Attempt answering the learning objectives after reading the textbook.