1 5/21/2024 lecture

The history of Mars is split into three eras:

- **Noachian:**
- **Hesperian:**
- **Amazonian:**

Habitable zone: the range of distances from a star at which liquid water could possibly exist on a planet. This changes over time. For example, if life existed on Mars, it would've been only for 500 million years after the formation of the solar system. HOW DOES THIS MAKE SENSE??? I THOUGHT STARS GET BRIGHTER AS THEY AGE?

More massive stars have larger habitable zones, but shorter lifetimes.

Life can exist outside of the habitable zone of a star, so long as there is some source of heat. In fact, having a planet or moon doesn't need to be part of any solar system in order to support life.

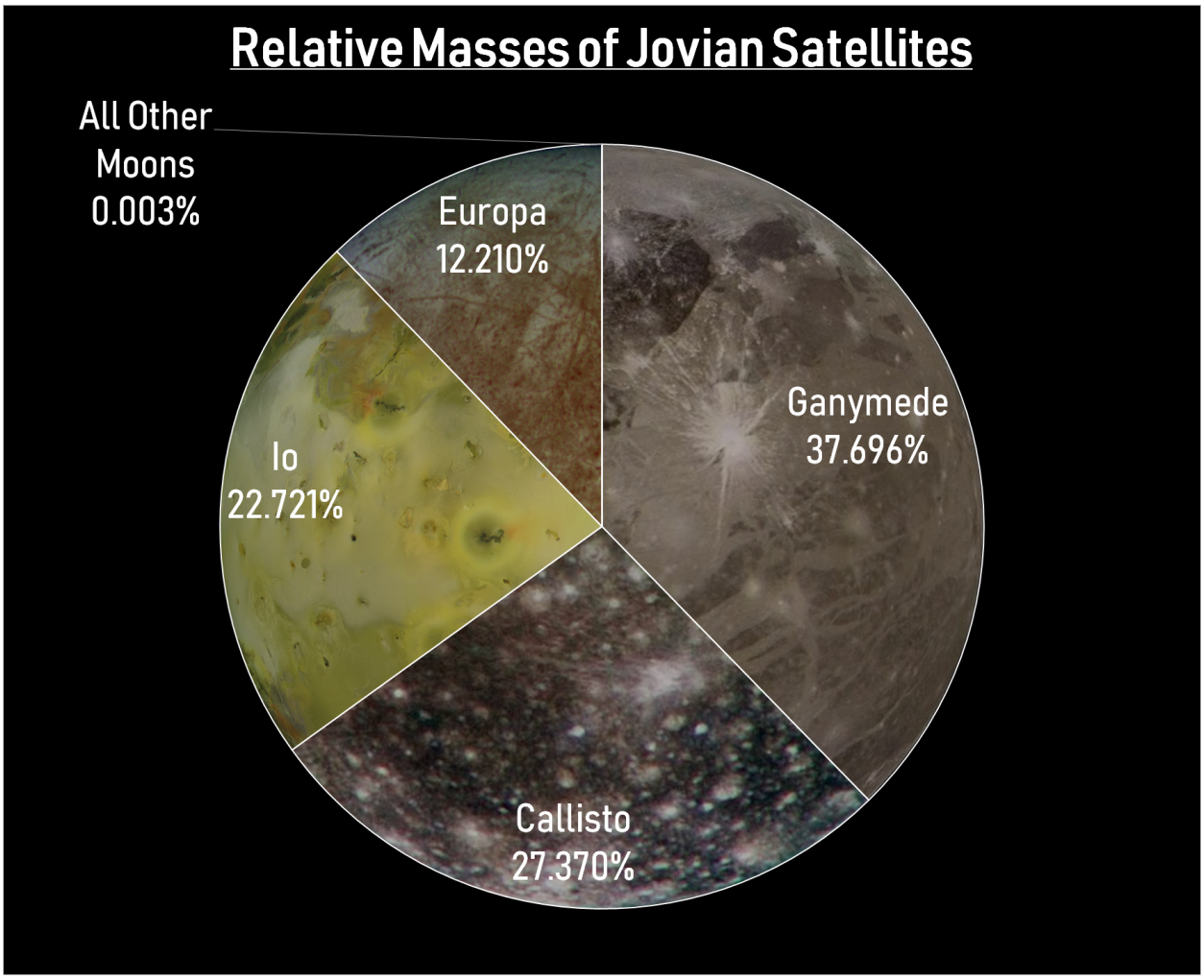
Europa, Enceladus, and other moons of Jovian planets are good candidates for finding life. That's because tidal heating can be a significant source of heat. Tidal heating is especially notable on Io. This is because Io has an eccentric orbit, and it is closer to Jupiter than the other Galilean moons, so when it gets to perihelion, the gravitational field causes spagghetification, and the repeated deformation of Io heats it up via internal friction.

The medium and large moons of Jovian planets are spherical (from self gravity) and orbit in the same direction as their planets, so they likely formed by accretion. A lot of the smaller moons appear to be captured asteroids, since they rotate the other way.

Out of all of Jupiter's satellites, there are 4 moons which account for Europa has an extremely smooth surface. We think the orange spots on Europa could be from organic matter (ADD DESCRIPTION OF THOLIN), but that's just a guess. Studying Europa is hard because the radiation from Jupiter can damage a probe, so we would prefer to do a quick flyby.

There are two reasons we think Europa has a big salty subsurface ocean: we know from measurements of magnetic fields that Europa behaves as a conductor, and the scratch-like patterns (called stress fractures) look like ice, because we know ice is easier to deform than most other kinds of rocks.

The main problems with Europa are the lack of nutrients and the high pressure at the bottom of the oceans.



Ganymede and Callisto are both large and icy and probably have subsurface oceans. Ganymede has a magnetic field, but we don't consider it a major candidate for life because because the pressure in the subsurface oceans would be too high.

Titan is the largest moon of Saturn. The surface has liquid methane and ethane which rain down, and also has enough of an atmosphere that we could fly there. INCLUDE MORE NOTES ABOUT TITAN, AND PICTURES OF THE SURFACE

We have sent a probe to land on the surface of titan and take pictures. There is a liquid lake on Titan, and we have pictures of river-like structures that resemble tributaries (although unfortunately they aren't water rivers). It's very very awesome that we have landed there, taken pictures, and found liquid lakes, but it is very cold (around 70 Kelvin) and doesn't seem to have the right chemicals to support life.

Saturn's moon Enceladus is fairly small, but very interesting because it spews out plumes of warm water containing silica, salts, and phosphorus. The plumes are right above the bluish "tiger stripes" on the surface.

1.1 Water on Venus

On Earth, most of the carbon and water are in the oceans (or somewhere other than the atmosphere). On Venus, those contribute to a very significant greenhouse effect.