

3) Synchronous rotation is when an object rotates exactly once around its axis during every orbit (rotation period=orbital period). This means that moons with synchronous rotation always keep the same face pointed towards their planet. This is common with jovian moons because tidal friction is responsible for slowing a moon's rotation down until it is locked into a synchronous rotation. The jovian planets are very massive and their moons tend to have close orbits, both of which cause higher gravity and stronger tidal forces.

4) Tidal heating is a source of internal heating created by tidal friction. When the gravity pulling on one side of an object is significantly larger than on the other side, it causes the object to stretch. If the object is rotating then the direction in which the object is stretched changes with time. This means that along a given axis the object is periodically stretching and relaxing, which causes friction that builds up heat.

Tidal heating is particularly important for satellites with eccentric orbits because of synchronous rotation. If the moon always shows the same face to the planet then the axis along which it gets stretched never changes. However, if the moon has an eccentric orbit then the distance from the planet changes, which changes the strength of the gravity and thus the amount of stretch changes periodically. A moon with an elliptical orbit will have small tidal bulges when it is far from its planet and large tidal bulges when it is near, thereby producing friction and tidal heating even with synchronous rotation.

Normally tidal forces would cause a moon to move away from its planet over time, until it is no longer receiving much tidal heating. However, if the moon gets locked into orbital resonance with other moons then it is forced to maintain a close orbit for the billions of years necessary for life. Orbital resonance is when two or more moons achieve orbits in which they periodically line up, and in which their gravitational tug-of-war reaches a happy medium in which it maintains the current orbit rather than changing it.

Within our solar system, Io is the moon most affected by tidal heating because it is the closest moon to Jupiter, has a highly eccentric orbit, and is locked into orbital resonance with Europa and Ganymede. This causes so much internal heat that Io erupts almost constantly and is the most volcanically active body in our solar system.

6) Energy on Europa could come from several different sources. First, of course, is the energy from deep sea vents caused by tidal heating. This energy would be the same as what drives the black smoker ecosystems here on Earth. Photosynthesis is also possible, even though Europa is much farther from the Sun than the Earth and the sunlight would be 25 times dimmer. While sunlight could not penetrate very far into the ice, it could possibly provide energy to life living in pockets of water near the surface.

This energy might filter down as organisms move between the crust and the ocean below. Although such dim sunlight would not be able to supply energy to a large ecosystem. Another possible source of energy on the surface could come from high energy particles and ultraviolet sunlight hitting the surface ice and breaking up molecules producing small quantities of other molecules. These then could be used in energy-producing reactions, should the icy crust get cycled into the ocean on a regular basis. Finally, potassium from the rocks could get dissolved in the ocean. Potassium radioactively decays and produces both hydrogen and oxygen molecules which could facilitate chemical reactions that might support a small biomass.

Overall, even if all of these energy sources were combined, they would not produce anywhere near as much power as the Earth is accustomed to getting from the Sun. This means that if life did form on Europa, only a small amount could be supported and it is likely that only very simple organisms would develop.

9) Titan is the only body in the solar system other than Earth to have known lakes of a liquid on its surface. However, as Titan is typically about -180 C, the liquid is methane instead of water. The atmosphere of Titan is thicker than the Earth's, and is composed mostly of nitrogen (like the Earth) but without any oxygen. The atmosphere also has a thick hydrocarbon haze, made up mostly of organic molecules, which would provide an abundant source of material for life. Overall, the prospects for "life as we know it" on Titan are slim, but there is a chance for simple life using a different liquid medium.

- 26) B
- 27) C
- 28) B
- 30) C