If alien life exists, what might we predict about their biology?

The possibility of alien life has been a source of great fascination since the early 20th century, inspiring countless sci-fi films, games and books. The search for extraterrestrial life continues, and perhaps most notably, the investigation by the Mars rover *Curiosity* has found compelling evidence that there were lakes and rivers present in the past, as well as preserved organic molecules within the soil (Vasavada, 2022), suggesting there could have been life on Mars thousands of years ago.

We will consider astrobiology, including determining habitable environments and reflecting on origins of life, to 'invent' an alien, then explaining the biology behind its adaptations.

Our first assumption is that liquid water is necessary for life due to its beneficial properties, such as solvation, high specific heat capacity, adhesiveness and cohesiveness. Liquid water has been found on Mars, and on the icy moons of our Solar System (Camprubí et al., 2019), so is not as scarce as often believed.

The second assumption is the necessity of an energy source for life to develop, as energy is required for all key life processes that we know of. This can come from different forms, such as a star, or hydrothermal vents as for deep-sea marine ecosystems. It is interesting that one of the predominant theories on abiogenesis, the origin of life, involves hydrothermal vents and extremophile archaea, single-celled organisms able to tolerate extreme conditions (Dodd et al., 2017).

The third assumption is the presence of oxygen –the large shift in the evolution of life was from self-sustenance to the ability to use oxygen, producing 16-18 times more ATP per molecule of glucose than anaerobic respiration. For our organism to be multicellular, it ultimately relies on the presence of oxygen due to respiration's energy yield being much greater than energy demands. Consequently, this energy can then be allocated towards growth and replication, so can greatly increase in size. For our organism, it is large and multicellular because of the numerous benefits of a higher metabolism.

Our organism – the Siliconisaur

Our digital drawing of the Siliconisaur

The siliconisaur is a filter-feeding primary consumer found on Mars, located in an ecosystem around Olympus Mons, the solar system's largest volcano. There are many extremophile archaea present here, their main food-source. Being silicon-based, it also collects dust from sandstorms for biomass, allowing it to grow larger.

The volcano provides thermal energy, which is utilised by the thermophilic archaea as producers. Furthermore, its existence is from when Mars had a denser atmosphere and had more water on its surface (Jakosky, 2019). With these assumptions in place, we are able to meet our requirements for life.

Silicon-based compounds for life

For Earth, Carbon is the basis of organic compounds, making the backbone of the requirements for life. However, in our theory of alien life, we predict that silicon would form similar compounds, with both elements having four valence shell electrons and thus interacting similarly with other atoms regarding the number of bonds formed and bond length.

Carbon, hydrogen, nitrogen and silicon are the only 4 elements with higher abundance in the early rows of the periodic table, narrowing down the selection of a different atom to provide the basis for life. To reduce options further, it is almost essential that the element can form two or more bonds, eliminating hydrogen. While oxygen, nitrogen and silicon have a weaker bond strength than carbon, the importance of maintaining a strong scaffold of a molecule that remains unchanged during many reactions still stands. Consequently, nitrogen is then also ruled out, as its bond strength is almost half of carbon's. The main issue of silicon compounds is the instability; silicon has a greater atomic radius and increased shielding than carbon so forms weaker bonds, and consequently is more reactive and unstable than the carbon alternative. To counteract this, we propose that the habitat of the siliconisaur is much denser with stronger gravity, as the current findings of the existence of silicon analogs to carbon compounds have limited testing, with only distinct temperatures and pressures being replicated in these experiments, and never replicating an entirely different planetary habitat.

The origin of 'handedness' of carbon compounds, where amino acids are considered left-hand and carbohydrates right-hand, is predicted to have originated from silicon: the formation of the first carbon compounds came from a pool which had a silicon surface. Therefore, even on Earth, whilst silicon is not the building block for life, it is believed that it had a part in determining the structures of organic compounds. The fact that silicon was involved in the origins of life makes it plausible that in a different habitat, silicon could form the backbone itself.

Resistance to heat

To survive the high temperatures of its habitat, the siliconisaur has developed a unique adaptation. Inspired by the *Chrysomallon squamiferum,* a snail with an iron sulphide outer shell and scales, our alien has a hard iron shell. This helps to deflect heat energy away from its sensitive tissue, alongside acting as a physical barrier to severe erosion from sandstorms.

The armoured shell of C. Squamiferum (credit: owlcation.com)

This iron also originates from the sandstorms which are rich in iron oxides as the surface of Mars is covered in rust. With its mouth of thousands of threadlike teeth for catching iron oxides, silicon oxides and other mineral ions, the siliconisaur benefits from the hazardous sandstorms.

Metabolism with ATP synthase

When it comes to aliens, we often think of robotic voices and clunky movement, and in fact, aliens may be machine-like. All forms of life ultimately require a form of metabolism for self-sustenance. One of the highest energy yielding processes is respiration, where during chemiosmosis the rotation of an enzyme causes the phosphorylation of ADP. The mechanism of this enzyme, ATP synthase, is surprisingly identical to the mechanism of a turbine to generate electricity, as ATP synthase itself is a motor, with a proton turbine attached to a molecular machine, and converts energy stored in a proton gradient into chemical energy (Kopeski, 2012).

The siliconisaur can utilise energy from the sandstorms it is exposed to, in replace of energy from the electrochemical gradient as in respiration. This is done via giant motor structures on its surface, especially on the hair-like projections within the mouth, as these will be most exposed to wind and sandstorm particle, and upon rotation, they convert kinetic energy into chemical energy via forming further bonds with silicon. This transformation permits the siliconisaur to store energy.

Conclusion

While coming up with prerequisites for alien life that expand past the basis of the Earth's, we decided on the existence of siliconisaur by giving it several attributes that would explain how it would be best suited to the extreme environment of Mars. Although the existence of alien life continues to be disputed, scientists continue testing for the spontaneous generation of life, and it is becoming clearer that life would be derived in a similar way to that of the Earth's. The siliconisaur is no agile animal, rather, more of a crystalline lump, but is still highly adapted to our established conditions. Abiogenesis remains key in the understanding of alien life, and therefore establishing its prerequisites permitted us to come up with an organism with its characteristics drawn from this; thus, the siliconisaur was born.

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