

Question 4

In the past thirteen months, NASA has successfully landed spacecraft on the planet Mars and on Titan, one of the moons of Saturn. One of the goals of each mission was to look for evidence of water. Different evidence of the past or present existence of water was found on both Mars and Titan. Neither Mars nor Titan has oxygen-containing atmosphere.

a) Scientists are not concerned with the absence of oxygen in the atmosphere, but instead view water as a sign of the possible existence of microbial life. Given what we know about the history of life on Earth, why is water regarded as a much more important sign of possible life than oxygen?

The evidence found on the surface of Mars is consistent with a number of scenarios. One is that the surface of the planet once contained oceans, rivers, and lakes. However, currently the atmosphere on Mars is too thin to allow these bodies of water to remain on the surface.

b) Assume that these bodies of water once contained living organisms. Provide two alternative hypotheses for how a planet might move from having a thick atmosphere over the surface with bodies of water containing living organisms to having a thin atmosphere over the dry surface with no detectable living organisms.

NASA scientists describe Titan as an extraordinary world where Earth-like geophysical processes operate on exotic materials in very alien conditions. Instead of liquid water, there is liquid methane (temperature on Titan is sub -170°C); instead of silicate rocks, there is frozen water ice; instead of dirt, there are hydrocarbon particles; and instead of lava, Titan's volcanoes spew very cold ice.

c) We have no idea what life on Titan might look like. However, if we are to find a living organism on Titan, it will have the following three properties:

d) Assume that life is found on Titan and that these organisms live in an environment where energy is freely available from abiotic sources. If in the future, the energy from abiotic sources becomes limiting, what feature would be common in the organisms that would survive and thrive during such a transition? Why?

Question 4 Solution

In the past thirteen months, NASA has successfully landed spacecraft on the planet Mars and on Titan, one of the moons of Saturn. One of the goals of each mission was to look for evidence of water. Different evidence of the past or present existence of water was found on both Mars and Titan. Neither Mars nor Titan has oxygen-containing atmosphere.

a) Scientists are not concerned with the absence of oxygen in the atmosphere, but instead view water as a sign of the possible existence of microbial life. Given what we know about the history of life on Earth, why is water regarded as a much more important sign of possible life than oxygen?

Water forms hydrogen bonds, and can form those with other molecules. These hydrogen bonds can be used as part of molecule stabilization or reaction mechanism. In addition, if some useful compound is being produced abiotically or is excreted as part of some organism's life cycle, the compound would diffuse throughout the body of water. This diffusion would ensure that primitive organisms would receive all the available nutrients from the environment. On the other hand, we know that oxygen only appeared on Earth as a waste product of photosynthesis II, so it was not essential to development of life on Earth, although it was key in increasing its diversity and complexity.

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b) Assume that these bodies of water once contained living organisms. Provide two alternative hypotheses for how a planet might move from having a thick atmosphere over the surface with bodies of water containing living organisms to having a thin atmosphere over the dry surface with no detectable living organisms.

(1) Some external development caused the atmosphere to become thin. The thin atmosphere then caused the change in the environment that caused the bodies of water to dry up and the organisms to disappear from the surface.

(2) Organisms on the surface developed some form of metabolism that resulted in a waste product that escaped into the atmosphere and caused it to become thin. The thin atmosphere then caused the change in the environment that caused the bodies of water to dry up and the organisms to disappear from the surface.

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c) We have no idea what life on Titan might look like. However, if we are to find a living organism on Titan, it will have the following three properties:
metabolism, controlled/regulated growth, reproduction.

d) Assume that life is found on Titan and that these organisms live in an environment where energy is freely available from abiotic sources. If in the future, the energy from abiotic sources becomes limiting, what feature would be common in the organisms that would survive and thrive

through such a transition? Why?

If energy from abiotic sources become limiting, organisms that can produce their own energy would have selective advantage, since they could grow and replicate regardless of the abundance of abiotic energy in the environment. Such organisms, then, would survive and thrive through a transition to the environment with limited sources of energy from abiotic sources.