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# Under Pressure: Investigating the adaptations of deep-sea organisms found on Earth, and how they could be applied to other planets

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**Abstract**

Parts of the deep sea are almost an enigma to us as humans as we've only been able to reach small fractions of it. The high-pressure depths make it very dangerous for humans to encounter this journey but we know that there are organisms that are able to withstand this pressure. In this article, I will be acknowledging a few adaptations of organisms that are able to survive at pressures more than 10,000 psi and applying these to planets found in our solar system that also have high pressures.

**Keywords:** *Biology; Astrobiology; Pressure Adaptations; Deep Sea Creatures; Ocean Worlds; Extra-terrestrial Life*

## Introduction

It is well known that a fraction of the ocean has been explored with only 24.9% of the seafloor having been mapped [1]. The deep sea has an intense environment where sunlight becomes obsolete at 1000 m, making photosynthesis useless and temperatures remaining between -1°C and +4°C [2]. Not only is it an oxygen-deprived environment, but as the depth increases, pressure amounts to a point so high, that a human would be crushed instantaneously if they were to be exposed to it. It is impossible for humans to reach these depths without the assistance of submarines or submersibles. It is reasonable to think that life would not be able survive this harsh climate. However, there are animals, such as sea turtles, sea cucumbers, whales and blobfish that are adapted to the deep sea that can withstand these extreme pressures. In this article, it is discussed whether these adaptations could be applied on other planets in our Solar system, bringing into question whether life can exist outside of Earth.

## Adaptations – Cell membrane

The phospholipid bilayer of the cell membrane is known to adapt to changes in temperature/pressure to protect the contents inside [3]; by either becoming more fluid (a higher number of unsaturated fatty acids) or more uniform (a higher number of saturated fatty acids) as shown in figure 1.

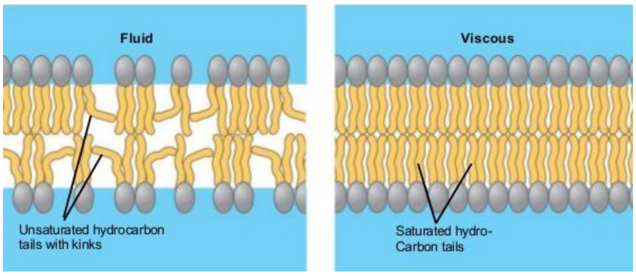


Figure 1 – Pictures a fluid-like (left) and uniform (right) membrane. From the image we can see that an increase in unsaturated hydrocarbon tails can increase the fluidity of the overall structure of the membrane, whereas on the left the membrane becomes more rigid when there are high amounts of saturated fatty acids [3].

A marine bacterium called CNPT-3 was studied, and it was found that the ratio of unsaturated fatty acids to saturated fatty acids nearly doubled when pressure increased from ambient to 69Mpa. This suggests that a key adaptation to survival in the deep blue is having a very fluid cell membrane, so that cells do not burst/become damaged under high pressure [4].

**Adaptations – Respiratory Systems**

A group of animals that can dive to depths of ~3,000 m [5] below sea level, are unusual compared to the bacterium mentioned previously, due to their size and added complexity. The group in question is the 90 species of whales. Whales breathe air just like you and I, they do not possess gills to be able to breathe underwater, therefore they have intricate adaptations to their respiratory and circulatory systems to be able to adapt to the immense change of pressure when they begin a deep dive into the depths of the ocean. Baleen whales in particular have a high amount of elastin in their airways and alveolar, this allows the delicate structures (which hold volumes of air) to be able to stretch and recoil under the influence of high pressure. Additionally, when whales complete a dive, they must do so at a specific rate because outside pressures can increase rapidly (101 kPa every 10 metres). This also causes there to be a pressure gradient between abdominal and thoracic structures and so, the rib cage compresses, allowing for the volume of air in the lungs to be reduced [6].

**Adaptations – Skeletal Structure**

Another species that can withstand these extreme pressures is *Pseudoliparis swirei,* commonly known as the Mariana Snailfish; where it has been observed at ocean depths of 7,415 m [7]. A noticeable trait it possesses is the fact that its skull is not fully fused together, which allows for equalisation of inside and outside pressures, resulting in its structural integrity being maintained [7]. The bones of fish found at this depth are different to those that are found near the surface, where a large portion of their skeletal structure is made up of cartilage, with a reduced bone density also. These two adaptations make the bones less brittle and therefore more likely to sustain against pressure. Interestingly, a gene (*gblap)* that is involved with the calcification process of bones (to bind calcium and hydroxyapatite together), is mutated in these types of fish. The mutation could provide an explanation as to why their bone growth is stunted [8].

**Under pressure**

Earth has an atmospheric pressure of approximately 14.7 psi (pounds per square inch), conversely the deepest parts of the ocean like the Mariana Trench, have a pressure of 15,750 psi – that's around 1,000 times the surface pressure [9]! From the previous subsection, we know that some organisms are able to survive and thrive under this immense pressure – could this open the question of organisms with similar adaptations being able to survive on other planetary bodies?

Titan is a moon of Saturn and has a very similar atmospheric composition to that of Earth's, they also share a similar atmospheric pressure with Titan being larger by 7 psi. It is hypothesised that Titan has thick layers of Type I ice, which would imply there is a high-pressure ocean found beneath it [10]. Therefore, it is not unreasonable to state that there may be organisms underneath this ice that are adapted to this type of pressure, similar to those found on Earth.

Venus has an atmospheric pressure of 1,350 psi. which is obviously considerably larger than Earth's [11]. Neglecting the fact that Venus' atmospheric composition would be undesirable for organisms found on Earth, pressure adaptations that have been previously discussed would be ideal to survive this type of environment. Considering that there have been snailfish recorded at 8000 m (~11,750 psi) below sea level off of the coast of Japan; the adaptations they possess would be useful to survive a pressure that is similar to Venus' [12].

**Conclusion**

Similar to the unexplored parts of the ocean, other planetary bodies raise questions on how organisms could survive there, especially as they are almost unreachable for humans to investigate in detail. In this article, we have compared one extreme factor (high pressure) found in the deep-sea, with oceans/atmosphere's found on other planets in the solar system and discussed whether adaptations to combat high pressure in the ocean could be useful to survive on planets with similar environments.

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