



DO YOU KNOW THAT THERE ARE FUNGI IN THE OCEAN?

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ALEX

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Did you know that fungi, like mushrooms and molds, are super important for our planet? Fungi can form critical relationships with other organisms. For example, many plants rely on fungi to help them grow and thrive. However, fungi are not always friendly and sometimes they can hurt plants by causing disease. Did you also know that there are fungi in the ocean? While you might not be able to see these fungi when you go to the beach (because they can only be seen with a microscope), they are found everywhere in the ocean. Marine fungi are pretty cool, but we do not know a lot about them yet or what roles they play in the ocean. Scientists are starting to learn more about how marine fungi help the ocean and

keep our planet healthy. This article will explore the amazing world of marine fungi!

WAIT—THERE ARE FUNGI LIVING IN THE OCEAN?

What kinds of organisms do you think of when you imagine a beach? You probably think of dolphins, starfish, sea anemones, or maybe even sharks... but did fungi make your list? Marine (ocean) fungi are different from the mushrooms you normally see on land. One of the reasons scientists did not know about marine fungi for so long is that no one has ever seen a marine mushroom! Instead, the fungi in the ocean are microscopic and live “secret” lives.

So far, <1% of marine fungi have been identified, although scientists estimate that there are over 10,000 types of marine fungi living in Earth’s oceans [1]. Some of these fungi are called **obligate marine fungi**, because they have only been found living in the ocean. Many obligate marine fungi have adapted specifically to life in the ocean and some even form important relationships with other organisms, like seaweeds, sponges, corals, and seagrasses. Marine fungi can be found everywhere, from the waves breaking on the beach, down to the hydrothermal vents of the deep seafloor. However, when examining the ocean, scientists have also found fungi that commonly live on land. Scientists are unsure whether these land-based fungi are playing active roles in the ocean, or whether they are just using the ocean to travel to distant lands. Fungi that can survive both on land and in the ocean are called **facultative marine fungi**.

While most marine fungi are microscopic and no marine mushrooms have been observed to date, there is one place where scientists have found macroscopic marine fungi, which means organisms that *can* be seen with the naked eye [2]. These fungi exist in the form of lichens, which are a **symbiosis** between bacteria and fungi. In their symbiosis, these microscopic organisms work together to form the macroscopic lichen. You can see lichens living on rocks along the coastlines. Next time you go to the beach at low tide, look at the rocks and try to find some marine lichens (Figure 1)!

WHAT DO FUNGI NEED TO SURVIVE IN THE OCEAN?

Living in the ocean is not easy. There are several **adaptations** that marine fungi need to be able to survive in the ocean environment. Adaptations are traits that organisms gain to help them survive better in a certain environment. Adaptations needed by marine fungi include high salt tolerance (the ocean is salty!), protection from the sun’s dangerous ultraviolet light, a way to stay alive when food is limited, ways to withstand the high pressure of living in the deep sea, and the ability to spread and reproduce in the ocean ecosystem. The need

OBLIGATE MARINE FUNGI

Fungi that can only live in a marine environment.

FACULTATIVE MARINE FUNGI

Fungi that live in freshwater or on land, but that can also grow and survive in marine environments.

SYMBIOSIS

A close, long-term relationship between two or more organisms.

ADAPTATION

A natural process in which an animal or plant becomes better suited to its environment by gaining new traits that make it more successful.

Figure 1

Coastal marine lichens come in many shapes, colors, and sizes. In some places, you can see them on rocks or cliffs along the beach. They can also be found on rocks under the water, but you will need to wait for a low tide to see them or you will get wet [photos from iNaturalist: © Chris McKee (CC-BY 4.0), Vesa Oikonen (CC0 1.0), Paco Bergson (CC-BY 4.0), Mikko Heikkinen (CC0 1.0), Óscar Sampedro (CC-BY 4.0), and Noa Nieto (CC-BY 4.0)]



Figure 1

for so many adaptations makes facultative marine fungi particularly interesting. To transition from life on land to life in the ocean, these fungi need to be good at a lot of things.

ARE MARINE FUNGI FRIENDS OR FOES?

One way marine fungi survive in the ocean is by associating with other organisms, like the symbiosis that forms marine lichens. However, these relationships are complicated and are not always positive. Some marine fungi are **parasites**, meaning they live inside or on other organisms and, like tiny vampires, take nutrients away from that host organism. Parasitic marine fungi play an important role in the ocean by killing other marine microbes, releasing their nutrients into the seawater as food for other organisms [3].

In addition to parasitic fungi, other marine fungi can also cause diseases. For example, a marine fungal **pathogen** called *Fusarium* is killing sea turtles and infecting their eggs. These pathogenic fungi grow in sea turtle nests, covering the surface of the eggs and making chemicals that break down the eggshell. The infected eggs become yellowish-blue and die. The eggs generally become infected through contact with contaminated beach sand. However, scientists have recently seen that pathogenic fungi can be transported from land into the ocean by floating particles of plastic and by contaminated plant parts, such as wood and leaves, that are carried to sea turtle nests by the water and wind [4]. These fungal foes are reducing the numbers of marine turtles that hatch. By working to detect *Fusarium* in the environment, scientists are trying to understand how to prevent turtles from getting fungal infections.

PARASITE

Any organism that lives inside of or attached to another organism which it uses for food, like a vampire, harming the organism it infects.

PATHOGEN

Any organism that can cause a disease or harm the organism it infects.

However, lichens teach us that not all marine fungi are foes—some are friends! Many fungi that live on land have important relationships with plants, but for a long time scientists did not know if marine plants had any fungal friends. Scientists have recently found that some seagrasses form relationships with marine fungi [5, 6]. While the specifics of these friendships are still being researched, the symbiosis looks similar to that of land plants and their fungi, so scientists believe the relationships are likely to help seagrasses thrive.

WHY HAVE I NEVER HEARD OF MARINE FUNGI?

If marine fungi are new to you, do not worry—many scientists have not heard of marine fungi either! Studying these fungi is difficult. First, many marine fungi are microscopic, making them hard to find and study. While scientists have had some success taking ocean samples to the laboratory to try to grow and study marine fungi (Figure 2), these fungi often need very specific food, which can be tricky to make in the lab. How can scientists study something they cannot see or grow?

Figure 2

Scientists can grow some microscopic marine fungi in the lab, like these from seagrasses, by giving them specific food. The fungi grow so much that they become visible to our eyes. Scientists can then study these fungi to learn more about them. However, this process is very tricky, as not all fungi like the same food (photo © Cassie Ettinger).



Figure 2

DNA SEQUENCING

The laboratory process of reading the genetic code in an organism's DNA.

To get around this challenge, scientists are now using **DNA sequencing** to look for marine fungi. This technique can be performed on ocean samples without the need to see or grow the fungus. DNA sequencing tells scientists which specific fungi are found in a certain

place. Scientists can then compare this information to databases that were made from studying the fungi that live on land. However, this technique is still challenging because many marine fungi are newly discovered and do not match these databases. By collaborating and sharing methods and data, scientists can work together to describe marine fungi and bridge gaps in their knowledge of which marine fungi are present and what they might be doing in the ocean.

Another challenge is answering the question of whether facultative marine fungi should be considered true marine fungi. Scientists often find facultative marine fungi in samples collected far away from land [7]. While DNA sequencing has allowed scientists to survey marine fungal diversity in different locations, it cannot tell them what the fungi are doing in these locations, making it hard to know whether facultative marine fungi are truly living in the ocean. Many obligate marine fungi have recently gained the adaptations that allow them to survive in the ocean and they have close relatives that live on land, making it difficult to identify fungi that are actively growing in the ocean from those that are temporary tourists using the ocean to travel to distant lands.

ARE MARINE FUNGI IMPORTANT FOR OUR PLANET?

Even though scientists are still learning about marine fungi, they already know these organisms have crucial roles in the ocean. Some marine fungi can break down dead plants and animals by feeding on them. This process recycles nutrients, like carbon, back into the ocean, making the nutrients available for other marine life. Some fungi can even break down harmful substances like plastic or oil that find their way into the ocean. For example, ocean sites contaminated by oil spills can be cleared up by marine fungi that are effective at breaking down these complex compounds [3, 7]. Although a marine fungi-based solution to clean up plastic pollution has yet to be tried, plastic-eating fungi already exist in the oceans [3]. These fungi will be a great help in solving environmental pollution. Marine fungi also produce fascinating natural products called **secondary metabolites**, which might help fight human diseases. Scientists are researching whether secondary metabolites might be useful as medicines.

In summary, although scientists are still figuring out all the roles marine fungi play, we know that these ocean organisms are just as important as the fungi on land, and that studying them may lead to life- and planet-saving solutions. So, the next time you think about fungi, remember they are not just on land—they live in the ocean, too (Figure 3)!

SECONDARY METABOLITES

Special chemicals made by fungi and bacteria to protect themselves, better survive in a new environment, or compete with others.

Figure 3

Marine fungi can be found everywhere in the ocean. Lichens are the visible (macroscopic) symbiosis between fungi and bacteria found along the coastlines. Other types of fungi are invisible to us (microscopic) and can form relationships with seagrasses and corals. Other marine fungi are harmful pathogens and parasites that can infect and kill sea turtles and other marine organisms.

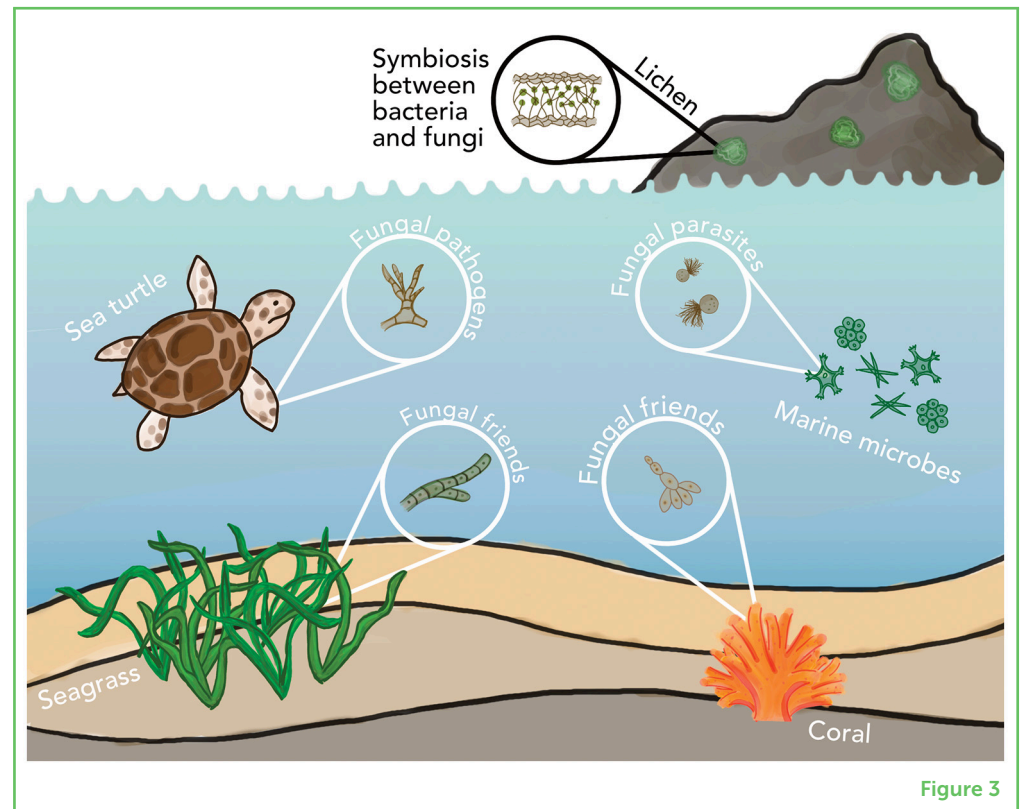


Figure 3

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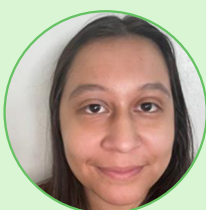
ALEX, AGE: 10

Alex is a primary school student, he is very interested in science and technology, nature, and animal. He love reading. He has a Parrot. He once spent a year in California with his parents, so he is also very interested in both Chinese and American culture.

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