frontiers FOR YOUNG MINDS

BIODIVERSITY
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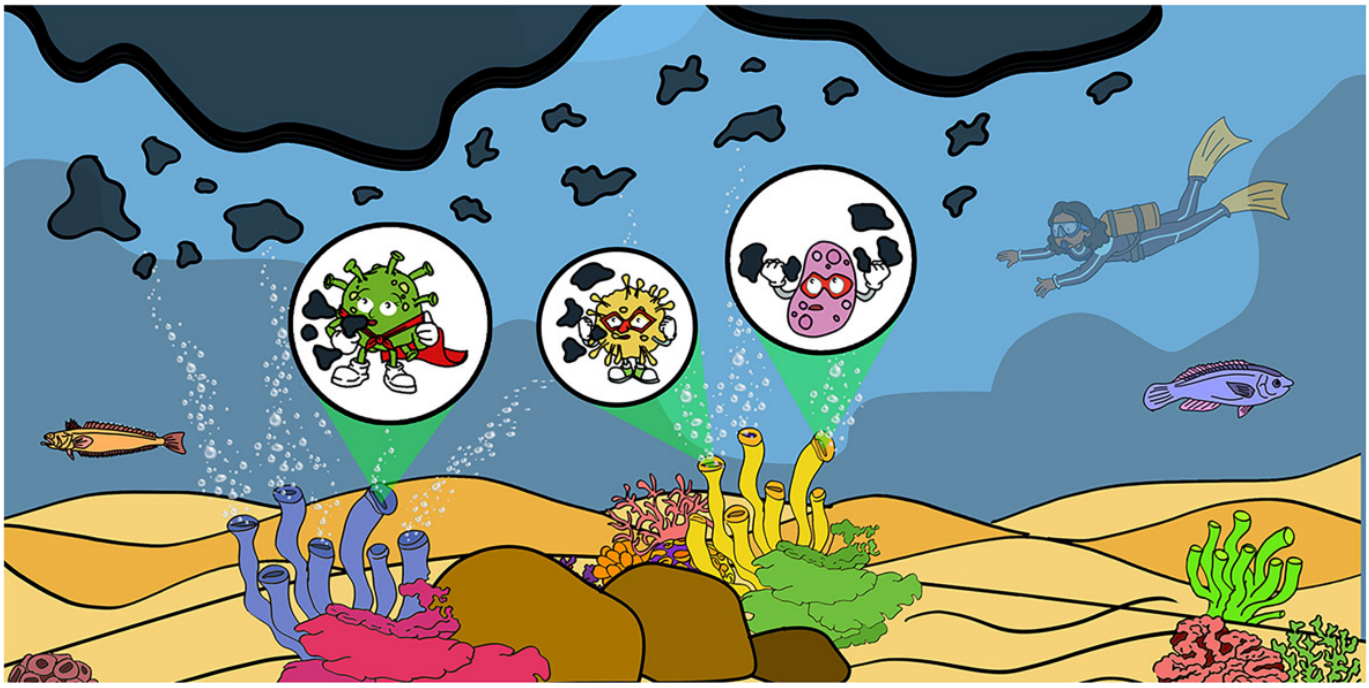

WHY ARE SCIENTISTS INTERESTED IN MARINE SPONGES AND THEIR BACTERIA?

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YOUNG REVIEWER:

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AGE: 16

When you think of sponges, what comes to your mind? Some people might think of bath, kitchen, or makeup sponges. In reality, those objects are all based on ancient living creatures found in aquatic environments, called marine sponges. These animals have bodies full of holes and live attached to a surface. Sadly, marine sponges are at risk of disappearing forever, because of the pollution of the oceans. Scientists discovered that various bacteria live inside sponges. These bacteria produce substances that can help sponges to get stronger and to thrive even in very polluted places. But what is even more interesting is that these substances can be used to improve human health and the health of the environment. Yet, we know little about the potential of this tiny and magnificent world. So, the research must continue!

Figure 1

Bacteria help sponges to survive in their aquatic environments. The bacteria present in the microbiota of sponges produce chemical substances that act like a shield, protecting these animals from predators, toxins, and pathogens.

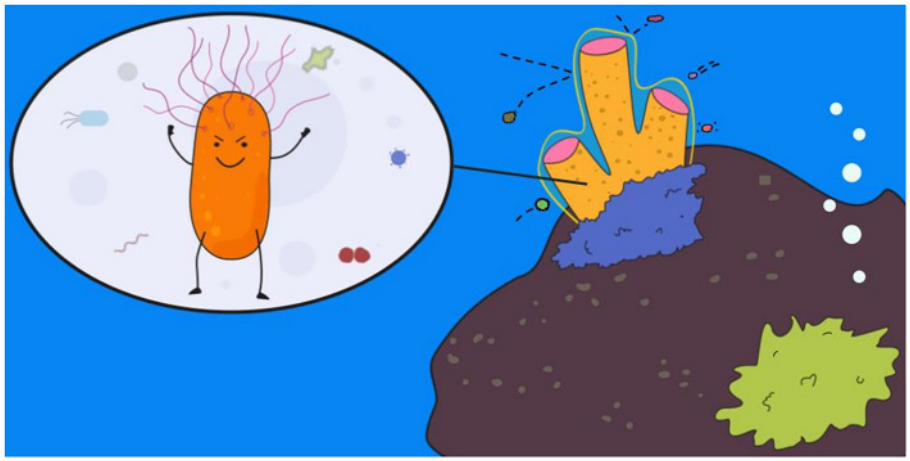

Figure 1

SPONGES AND THEIR BACTERIAL FRIENDS

Marine sponges are some of the oldest animals on Earth—they have been around for more than 600 million years! These animals are invertebrates, which means that they lack a backbone. Many sponges are soft and smooth, but others are hard and rough. The bodies of most sponges are supported by tiny thorn-like structures called spicules. Sponges do not move around; they attach themselves to rocks and reefs. Sponges have developed a special way to feed themselves, even though they cannot move. They get food by filtering out plankton, bacteria, and tiny particles of organic (formerly living) matter that float in the water. Water enters the sponge's body through multiple small openings called pores, and it exits through a larger opening. In addition to filtering large amounts of bacteria out of the water, sponges provide shelter for several other kinds of animals, including algae and shrimp. Because of these functions, marine sponges have enormous ecological importance [1].

Sponges can be found in oceans, lakes, and underwater caves. Their survival in the aquatic environment is highly dependent on a community of microorganisms that lives inside them, called the **microbiota**. These microorganisms, including bacteria, can compose up to 40% of the total mass of the sponge [2]! The sponges' microbiota can protect them from predators, toxins, and disease-causing microorganisms called **pathogens**. The bacteria comprising the microbiota do all of this by producing various substances with special properties (Figure 1). In addition to helping the sponges, these substances may support humans in the fight against human pathogens, and they may be useful in combating environmental pollution caused by oil [1, 2]. This is why the curious relationship between sponges and bacteria inspires scientists all over the world.

MICROBIOTA

A group of microscopic organisms that lives in a close, beneficial relationship with an animal or plant, either inside it or on its surface.

PATHOGEN

A microscopic organism, such as a bacterium, that can cause disease.

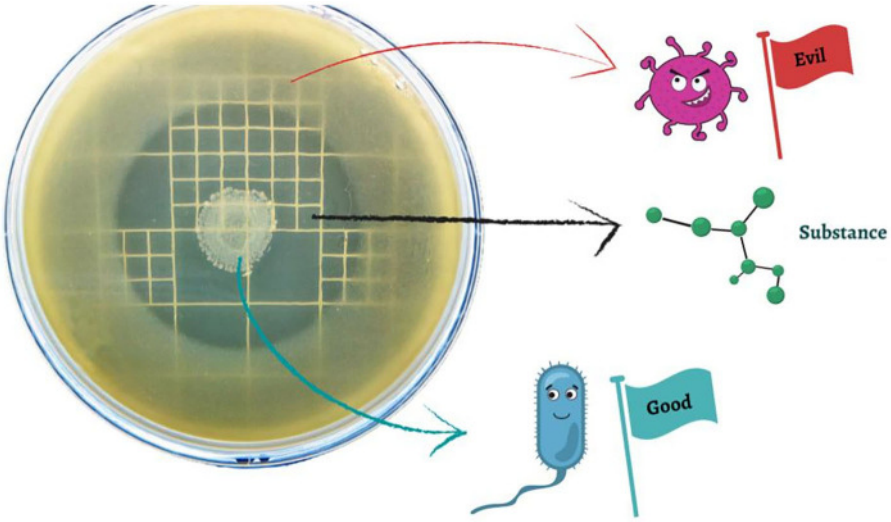

Figure 2

Figure 2

Some substances produced by sponge-associated bacteria can kill pathogens. To test if a sponge bacterium has antibiotic potential, a bacterial pathogen is spread all over a dish containing a growth substance, and the sponge bacteria are placed in the middle. If a halo forms around the sponge bacteria, it means that those bacteria stopped the growth of the pathogen. In the image, you can see the marine sponge bacteria *Bacillus pumilus* in the middle, surrounded by a halo with the human pathogen *Staphylococcus aureus* around it. Therefore, *Bacillus pumilus* isolated from sponges has the potential to kill this pathogen.

ANTIBIOTIC

A medicine capable of killing or stopping the growth of bacteria. Antibiotics are used to treat bacterial infections.

ANTIBIOTIC RESISTANCE

When microorganisms develop some mechanisms to evade the drugs designed to kill them.

SUBSTANCES THAT FIGHT BAD MICROORGANISMS

Sometimes, bacterial pathogens can invade our bodies and make us sick. When this happens, doctors usually prescribe medicines called **antibiotics**, which are used to kill bacterial pathogens and cure the disease. However, if antibiotics are used improperly or too often, bacteria find ways to overcome them and survive, developing what is called **antibiotic resistance**. Some bacteria, known as superbugs, can even be resistant to multiple antibiotics. When pathogens become antibiotic resistant, antibiotics lose their effectiveness and become useless. Superbugs are a rising concern worldwide, representing a serious threat to human health. The search for new antibiotics that can kill those resistant pathogens is of great importance [3].

But what role do marine sponges play in this scenario? Well, some sponge-associated bacteria act as a shield for the sponge. These bacteria produce antibiotics that kill pathogens that could injure the sponge. Maybe the bacteria that live within sponges can also help us fight antibiotic-resistant bacteria! First, scientists need to do experiments to find out if these antimicrobial substances are safe for humans and effective against human pathogens. After a bunch of experiments and hard work, these substances could become new antibiotics that could be used in patients (Figure 2).

HOW DO BACTERIA HELP TO TREAT CONTAMINATED PLACES?

With the help of their microbiota, sponges can survive in contaminated places. Since these animals cannot move and they must filter their food out of the water, toxic substances present in the water, like oil, can be taken up and retained in a sponge's body, affecting its health and

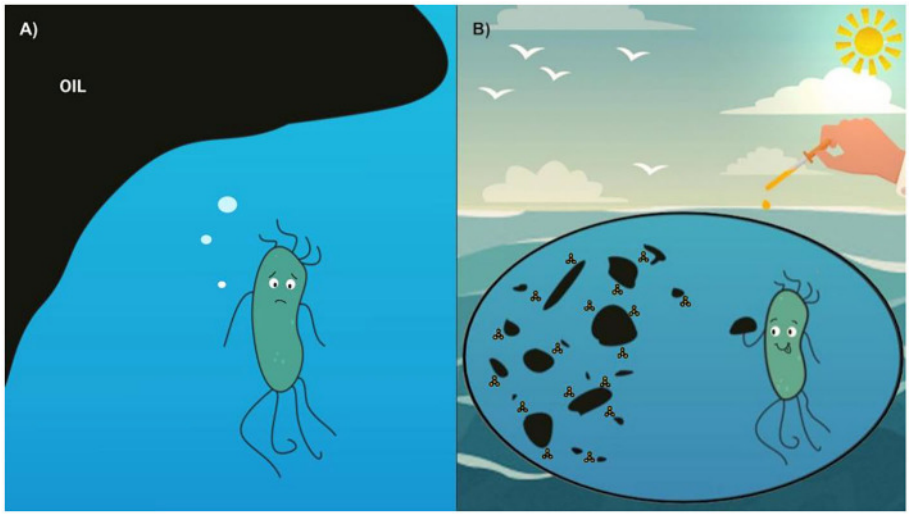

Figure 3

What role do biosurfactants play in bioremediation? **(A)** Petroleum does not mix with water, so when it is spilled in the ocean, it forms gigantic drops. Although there are a lot of bacteria living in the ocean that are capable of degrading petroleum, they cannot reach it because those drops do not mix with water. **(B)** Biosurfactants cause petroleum to be "broken" into smaller pieces that can mix with the water and spread out. This helps bacteria to break down the petroleum and clean the water, in a process called bioremediation.

BIOSURFACTANT

A substance that is released by microorganisms and is capable of mixing oil with water.

even causing death. But how does the microbiota help sponges survive in contaminated places? To preserve the sponge, microbiota bacteria can produce substances called **biosurfactants**, which can transform toxic substances like oil into non-toxic ones. Some biosurfactants enable the bacteria that make them to use oil as a food source, which eliminates the oil from the sponge and helps the sponge to survive in oil-contaminated environments [4].

To understand how biosurfactants work, first we need to talk about surfactants in general. You may have observed that oil and water do not mix. So how can the grease on dishes be removed? Simple! We use detergents. Detergents have surfactants as an ingredient. Surfactants are molecules that can mix oil with water. Biosurfactants are natural surfactants produced by living things, including microorganisms.

In addition to protecting the health of marine sponges, maybe biosurfactants from sponge bacteria could be used by scientists to clean up the petroleum often found in natural environments. Petroleum is an important oil used as fuel for ships, planes, and vehicles. This oil leaks into the water very frequently and causes severe damage to marine ecosystems. Humans have developed various technologies to decontaminate those waters, but unfortunately these processes take too much time.

But there is hope! Some bacteria in petroleum-contaminated waters can break down petroleum, but only at a very slow pace. That is because petroleum does not mix with water, so the microorganisms cannot reach it to break it down. Scientists discovered that if they put some biosurfactant from bacteria in oil-contaminated waters, the process of oil breakdown becomes faster (Figure 3). Biosurfactants help to spread the petroleum out in the water, making it more available for microbes. To do this, researchers take

a little piece of a marine sponge and isolate the bacteria from it. They then cultivate these bacteria and purify the biosurfactant that they produce. When they have enough biosurfactant, scientists can use it to help contaminated environments recover from pollution. Processes like this one, which use microorganisms to reduce or remove substances that contaminate the environment, are called **bioremediation**. Biosurfactants have several advantages over other surfactants, including low toxicity and the ability to be naturally broken down by microorganisms in the water.

BIOREMEDIATION

Any process that uses microorganisms or their substances produced to recovery the natural environment previously contaminated.

POWERFUL, BUT NOT INVINCIBLE: MARINE SPONGES IN DANGER

As you have seen, thanks to their microbiota, sponges are a precious source of new substances that have the potential to be extremely important for human health and the health of our oceans. These substances help sponges to be very strong and give them the ability to survive in polluted places. However, these magnificent animals are in danger! Some water environments have become so polluted that it is impossible for sponges to thrive. Also, these animals are vulnerable to stress caused by human activities and climate change. Many species of sponges are still unknown. Unfortunately, they are at risk of disappearing forever, before they are even identified.

The relationship between sponges and their bacteria is an example of mutual trust. It also shows that collaboration is essential in nature. Now it is up to us to learn from this wise animal and work together with each other and with nature to preserve the environment. That is the only way we can continue to experience the many fascinating discoveries that nature holds, and the many benefits they may bring to humanity in the future.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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I am a high school student specializing in science. I have a keen interest in biology and conservation and am planning to study environmental sciences when I go to university, with an emphasis in wildlife. I have been a vegetarian since I was 7 years old to protest against animal cruelty and protect our planet. I also love art and expressing my creativity through different artistic activities.

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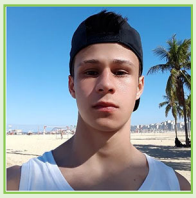

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I am a graduate student in biotechnology at the Universidade Federal do Rio de Janeiro (UFRJ). Currently, I work with bacteria isolated from marine sponges, searching for powerful biosurfactants that can protect environments from pollution or that can be used by industries for creating innovative products. I have always been in love with nature, especially with the ocean and its aquatic animals. In my studies, I found out that the world of microorganisms is much more interesting and complex than I thought. That is why I study the charming microorganisms present in the microbiota of sponges. †orcid.org/0000-0002-6076-1624

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I am an undergraduate student in biological science and biotechnology at the Universidade Federal do Rio de Janeiro (UFRJ), where I am an intern at the Molecular and Marine Bacteriology Laboratory. The ocean has a unique ecosystem and biodiversity; we cannot even imagine the varied and incredible forms of life

that exist in it. Unfortunately, it is little explored, including the marine sponges and their microbiota. In the laboratory, I work with bacteria taken from marine sponges to find their potential benefits for the environment or human health. †orcid.org/0000-0003-3834-1284

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I graduated in biology from the Universidade do Grande Rio (2016) and completed a master's degree in microbiology from the Universidade Federal do Rio de Janeiro (2019), where I worked on antimicrobial and biosurfactant activity from sponge-associated bacteria. I have not stopped since then! I am currently a doctoral student and have explored the genome of *Bacillus* bacteria associated with sponges from the coast of Rio de Janeiro, Brazil. I also enjoy swimming, watching Japanese animations, and reading books. †orcid.org/0000-0003-3922-1233

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