frontiers FOR YOUNG MINDS

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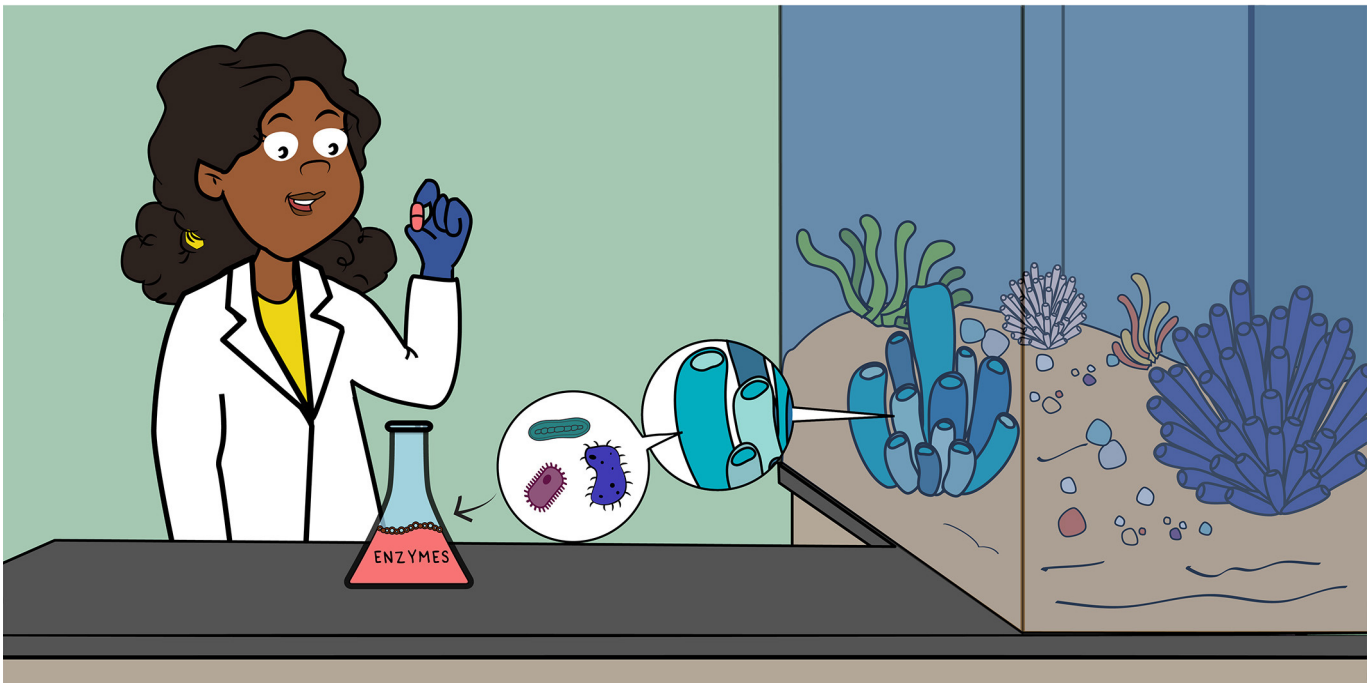

HOW CAN THE MICROORGANISMS LIVING IN MARINE SPONGES HELP US?

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TOTORO

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Enzymes are important molecules that help chemical reactions in living beings happen faster and easier. Did you know that enzymes are present in many products used in our daily lives? Enzymes are present in detergents, in our pets' food and in our own food. Sponges that live in the oceans need help from enzymes, too. Microscopic organisms make their homes on marine sponges, and these microbial partners produce enzymes that help the sponges with nutrient digestion! These useful enzymes can also be used by humans in the food industry, such as in the production of bread and cheese, as well as in detergents and cleaning pollutants. In this article, we will explore the enzymes produced by microorganisms living within marine sponges and describe some ways that these enzymes can be used in industry.

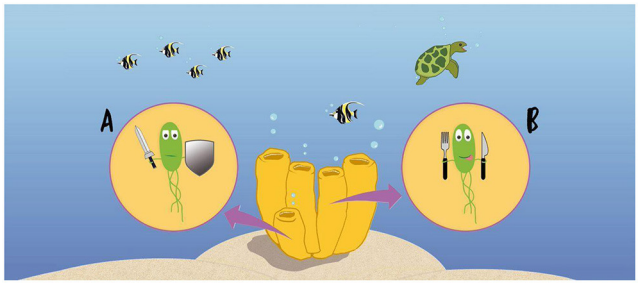

Figure 1

Sponge-microorganism friendship. **(A)** Bacterial partners can help the sponge defend itself against competitor animals, such as fishes and turtles. **(B)** As a "thank-you," the sponge provides a nutritional "banquet" for its microscopic partners.

A FEW FACTS ABOUT SPONGES

When you hear the word "sponge," what comes to your mind? Probably the sponge you use for dishwashing or the one you use while bathing, right? These are artificial sponges, made of synthetic materials. In the past, we used sponges from the ocean, called marine sponges, for these common tasks.

Marine sponges are **invertebrate** animals, meaning that they do not have a spine or skull. Some sponges live fixed to the ocean sediment or to the surfaces of rocks and never move during their lifetimes. Sponges can be of different shapes, sizes, and colors [1]. These animals can inhabit the deep sea, where there is little to no light, or they can live in shallower regions that are more exposed to sunlight.

INVERTEBRATE

Animals that are characterized by the absence of a spine and skull. Marine sponges and octopuses are examples of invertebrate animals.

Did you know that sponges feed by **filtration**? Instead of mouths, they have small holes called pores spread over their bodies. These holes allow water to enter, move to the inside of the sponge, and then exit through an opening in the top of the sponge. As the water travels through their bodies, the sponges absorb oxygen and other nutrients dissolved in the water.

FILTRATION

Process of obtaining oxygen and nutrients through the entry of seawater that circulates through the sponge body and exits through the upper opening.

DO SPONGES LIVE ALONE?

While a sponge may appear to be living alone attached to its rock or the ocean bottom, it is not alone! Invisible to the naked eye, microscopic organisms live inside sponges. These microorganisms include bacteria, archaea, fungi, and viruses, and they perform important jobs for the sponges, including helping them with nutrient digestion and producing vitamins that are crucial for the sponges' diets. The microorganisms also release defensive substances that protect sponges against natural predators, competitors, and harmful microorganisms (Figure 1A) [1].

What do the sponges' microscopic buddies receive in exchange for this help? It has been estimated that a 1 kg sponge can filter up to 24,000 liters of water per day! Because of this large volume of water, sponges accumulate more nutrients in their bodies than they need.

This plentiful food helps the microorganisms within the sponges to produce their helpful substances (Figure 1B).

WHAT ARE ENZYMES?

ENZYMES

Special proteins that make chemical reactions happen faster.

Did you know that microorganisms, plants, and people all have something in common? They all produce substances called **enzymes**. Enzymes are special molecules that make chemical reactions happen faster. The job of some enzymes is to break down large molecules into smaller pieces. The enzymes produced by the microorganisms living inside sponges are what allow these microorganisms to perform their helpful activities, like breaking down large nutrients into vitamins and other substances that the sponges can easily absorb!

Scientists have discovered that the enzymes produced by sponge microorganisms not only benefit the sponges—they can be extremely helpful to humans, too! Humans have found many uses for these microbial enzymes. Microbial enzymes have some advantages over plant and animal enzymes. First, microorganisms produce enzymes in large quantities, and it does not take much time or space to grow microorganisms in the lab. Also, enzymes from microorganisms can be active and stable under harsh conditions. Finally, microbial enzymes are not toxic to humans [2].

HOW ARE ENZYMES USED?

The use of microbial enzymes in industrial processes has received increasing attention over the past few years. This is because using these enzymes can reduce waste and cause less damage to the environment.

AMYLASE

Amylase is an enzyme that is capable of breaking starch into smaller bits. This enzyme is also present in the saliva of humans, where it starts the process of digestion.

Did you know that enzymes are used to create many of the products we encounter in our daily lives? For example, they are used in the production of animal food, medicines, detergents, and paper [3]. **Amylase** is one type of enzyme that is frequently used in industry, because it can break down starch, which is a large, complex sugar, into smaller, more useable bits. In bread baking, amylase helps the dough to rise, which creates bread that is easier to chew and that lasts longer on our kitchen shelves [2].

LIPASE

Lipase is an enzyme which function is to turn the fat in smaller molecules. This enzyme plays essential roles in digestion of lipids in living organisms.

Lipase is another interesting enzyme. It works by breaking down fat molecules called lipids. Some factories just throw away lipids, which are hard to break down or wash off. Lipase can help to clean up these oily pollutants [2]. In the food industry, lipase digests the fat in cheese, which can make some cheeses more delicious and help them to keep their nice aromas and tasty flavors longer.

Figure 2

Scientists find promising enzymes produced by the microorganisms living in marine sponges. They must decide what the enzymes would be best used for, as microbial enzymes can help with manufacturing detergents, production of cheeses, and much more!

There has only been a small amount of research done on enzymes that come from the microorganisms living in marine sponges. The microbial enzymes that have been studied so far are potentially very useful. They have been isolated from sponges living in some of the most extreme marine environments (Figure 2) [3].

In 2017, a new enzyme called **esterase** was discovered, which is produced by a bacterium living in a sponge 760 m deep [4]! This enzyme is active in the presence of high amounts of salt, relatively high pH (8–10) and at low temperatures (4–20°C). How could we use this enzyme? Esterase could be used to make detergents that are good for washing things in cold water. These "cold detergents" are ideal for removing stains like blood and sweat.

ESTERASE

Esterase is an enzyme that helps break down smaller and simpler fat molecules.

In 2018, a new enzyme called a **protease** was identified in the **archaea** *Halococcus* [5]. Isolated from an Indian sponge, *Halococcus* is known to love salt. The protease breaks down proteins into smaller pieces, and it was found to have its greatest activity when it was in a solution three times saltier than seawater! Surprisingly, the protease was most active at 70–80°C, so this incredible enzyme could be ideal for processes that depend on high temperatures [5]. In the leather industry, this protease could remove the hair from animal hides, decreasing the use of toxic chemicals that are normally released into the environment. In the baking industry, this protease also could help to make low-gluten flour for people who need to eat a gluten-free diet [5].

PROTEASE

Protease is an enzyme that speeds up the reaction of breaking proteins in smaller pieces and it is present in plants, human beings and microorganisms.

ARCHAEA

Microorganisms that live in extreme habitats, including thermal cracks at 100°C and the digestive tracts of cows.

CONCLUSION

So now you know that marine sponges are invertebrate animals and do not live alone. Microscopic partners live inside sponges, with mutual collaboration between them. Furthermore, these microorganisms have adapted to the marine environment, developing unique molecule-breaking capabilities. Therefore, marine microbial enzymes are adapted to extreme conditions such as high or low temperatures, high pressures, high salinity, and a wide pH range. These characteristics mean that enzymes can be used to make certain industrial processes greener and cheaper. Despite these great qualities, there is still not

much research being done on these enzymes [2]. Enzymes produced by microorganisms that live in sponges must be studied in more detail, so that the most important uses can be identified for the benefit of man and the planet!

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REFERENCES

1. Santos-Gandelman, J. F., Giambiagi-de Marval, M., Oelemann, W. M. R., and Laport, M. S. 2014. Biotechnological potential of sponge-associated bacteria. *Curr. Pharm. Biotechnol*. 15:143–55. doi: 10.2174/138920101566614 0711115033
2. Singh, R. S., Singh, T., and Pandey, A. 2019. Microbial enzymes–an overview. *Adv. Enzyme Technol*. 2019:1–40. doi: 10.1016/B978-0-444-64114-4.00001-7
3. de Oliveira, B. F. R., Carr, C. M., Dobson, A. D. W., and Laport, M. S. 2020. Harnessing the sponge microbiome for industrial biocatalysts. *Appl. Microbiol. Biotechnol.* 104:8131–54. doi: 10.1007/s00253-020-10817-3
4. Borchert, E., Selvin, J., Kiran, S. G., Jackson, S. A., O'Gara, F., Dobson, A. D. W., et al. 2017. A novel cold active esterase from a deep sea sponge *Stelletta normani* metagenomic library. *Front. Mar. Sci.* 4:287. doi: 10.3389/fmars.2017.00287
5. Gaonkar, S. K., and Furtado, I. J. 2020. Characterization of extracellular protease from the haloarcheon *Halococcus sp.* strain GUGFAWS-3 (MF425611). *Curr. Microbiol.* 77:1024–34. doi: 10. 1007/s00284-020-01896-6
6. de Oliveira, B. F. R., Carr, C. M., Dobson, A. D. W., and Laport, M. S. 2020. Harnessing the sponge microbiome for industrial biocatalysts. *Appl. Microbiol. Biotechnol.* 104:8131–54. doi: 10.1007/s00253-020-10817-3

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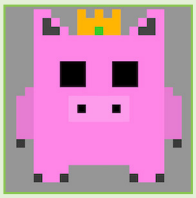
YOUNG REVIEWER



TOTORO, AGE: 12

Hi! I like to get creative and work on cool projects. Sometimes, I do a bit of experimentation or some DIY. When I do science, it makes me feel more creative, and I hope you do too. So, you could also get your brain working, enjoy and be creative!

AUTHORS

BEATRIZ DE CARVALHO RIBEIRO

I have been a bachelor's degree student in biological sciences (microbiology and immunology) at the Universidade Federal do Rio de Janeiro (UFRJ) since 2019. I have always admired the microscopic world and the marine environment. I found a laboratory that brought all these fascinations together, and today I am part of the Molecular and Marine Bacteriology Laboratory at UFRJ. My current line of research is on enzymes produced by bacteria associated with marine sponges and how these enzymes can be used in industries.

ISABELLE RODRIGUES LOPES

Since I was a child, I have always liked nature and science. In 2017, I started studying microbiology and immunology at the Universidade Federal do Rio de Janeiro (UFRJ), and I am part of the Molecular and Marine Bacteriology Laboratory. I research the incredible world of marine sponges and their associated bacteria, more specifically the enzymes they produce and their industrial and biotechnological applications. I intend to discover new enzymes that help the world in some way!

BRUNO FRANCESCO RODRIGUES DE OLIVEIRA

I just completed my Ph.D. in microbiology at the Universidade Federal do Rio de Janeiro (UFRJ), with a part-time stay at the University College Cork (2020). My fascination with marine microbiology started while I was finishing my master's degree. I was astonished by the infinity of biologically active substances to be discovered in the microbial life of oceanic ecosystems. From then on, I have dedicated myself to understanding the tiny fellows thriving in incredible marine sponges, and how we can harness their genomes to find new, useful industrial enzymes. *bfroliveira@id.uff.br

MARINELLA SILVA LAPORT

I obtained a bachelor's degree in biomedicine (1996) at the Universidade Federal do Estado do Rio de Janeiro, and a Ph.D. degree (2003) at the Universidade Federal do Rio de Janeiro (UFRJ). I did postdoctoral studies at the FioCruz (2004) and at the Université Libre de Bruxelles (2012–2014). I have been an associate professor at the UFRJ since 2004. Currently, I develop and coordinate research activities in the Molecular and Marine Bacteriology Laboratory at the UFRJ. My research focuses on symbioses of microorganisms with sponges and the exploration of microbial metabolic diversity for biotechnological purposes.