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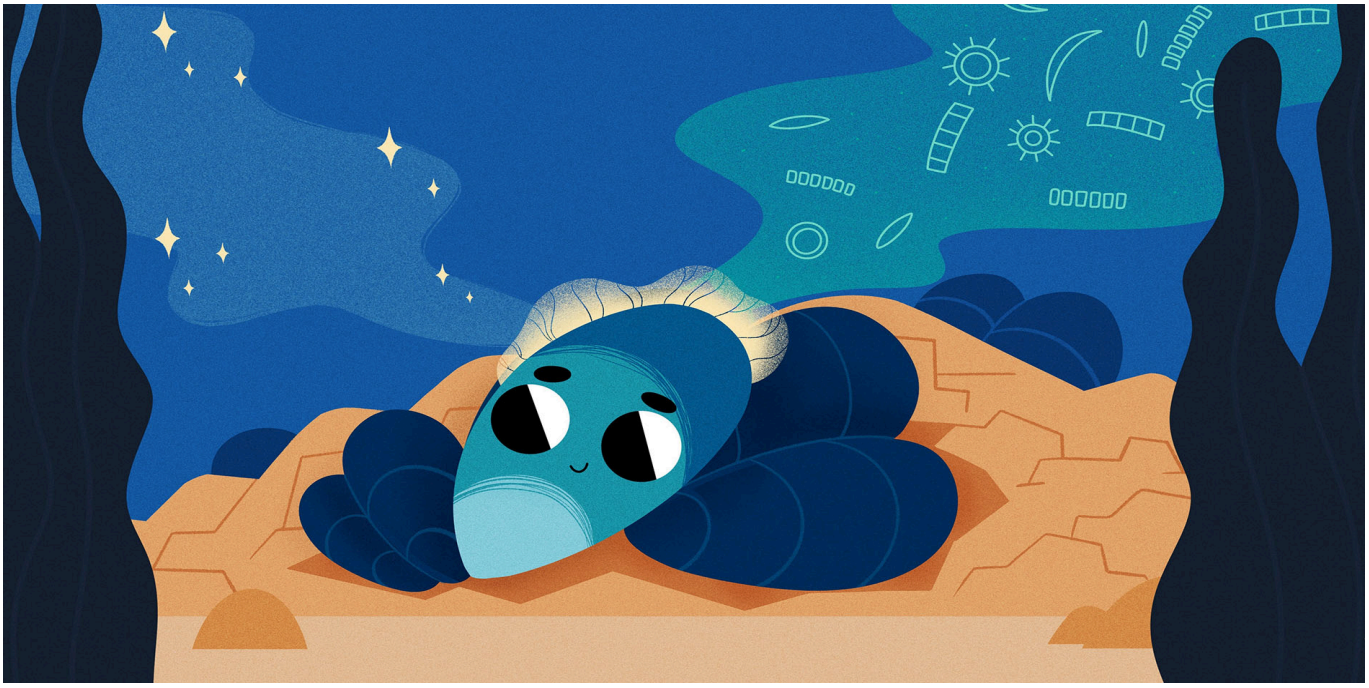

THE IMPORTANCE OF MUSSELS FOR THE PLANET

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YOUNG REVIEWERS:

CHENGKAI

AGE: 11

THE KITE MONTESSORI SCHOOL

AGES: 9–11

XUAN

AGE: 15

ZIQI

AGE: 12

Here is a riddle: it has a soft body, no head, and lives inside two shells, clinging to the rocks in the sea... what kind of animal is it? If you said mussel, you got it! Mussels are constantly working as they filter the seawater in search of food, and filtering makes the water healthier for the other organisms that live there. Along with their role in keeping the environment healthy, mussels are also important for humans—as a source of income for some and a source of food for many. Unfortunately, global warming and human-caused pollution are threatening the lives of mussels and putting the entire ocean environment at risk. There are a few simple things we can all do to protect mussels—but people usually do not take care of things they do not understand, do you agree? So, keep reading to learn about mussels and what you can do to help them!

BIVALVE MOLLUSKS

A group of organisms with soft bodies protected by shells formed from two pieces, called valves. They include mussels and oysters.

Figure 1

(A) Male and female mussels have a difference that help us to tell them apart, for example, males of *Perna perna* specie (known as the brown mussel) have a white mantle while in females it is orange. In both sexes, gills are responsible for water filtration, respiration and digestion. The foot is small and it helps with tiny movements. The byssus helps to fix the mussel in one place. The adductor muscle assists in the opening and closing of the shell along with other muscle ligaments associated with them. **(B)** The gills separate the animal's food (in circle) from the water and release filtered water and food debris back into the water, along with feces (poop). (Images created on Canva by William Moraes and Helena Souza).

MICROALGAE

Small plants that live in water.

FILTER FEEDERS

Animals that eat by filtering the water to remove particles of food.

PHOTOSYNTHESIS

Process carried out by plants to produce energy from sunlight, water, and carbon dioxide.

NUTRITIOUS MUSSELS

Have you ever eaten mussels? Mussels belong to a group or organisms called **bivalve mollusks**. The word "mollusk" means soft, a very specific body characteristic, and "bivalve" means it has two valves, also known as shells (Figure 1). Bivalve mollusks include other edible creatures like oysters and scallops. Mussels are tender, tasty, and nutritious (Figure 2)! They are rich in protein, nutrients that keep our muscles healthy, and they are a good source of vitamins including D and B_{12}, as well as minerals including iron, phosphorus, and calcium. In addition, they have the types of fats that are considered healthy [1]. Some researchers also argue that mussels could help to reduce hunger in the world [1]. As the world's population increases, more and more food is required to feed everyone, and producing all this food uses up fresh water and costs a lot of money, particularly for animal feed and medicines. The costs of growing mussels are lower, since mussels feed on nutrients from the environment and they do not need fresh water.

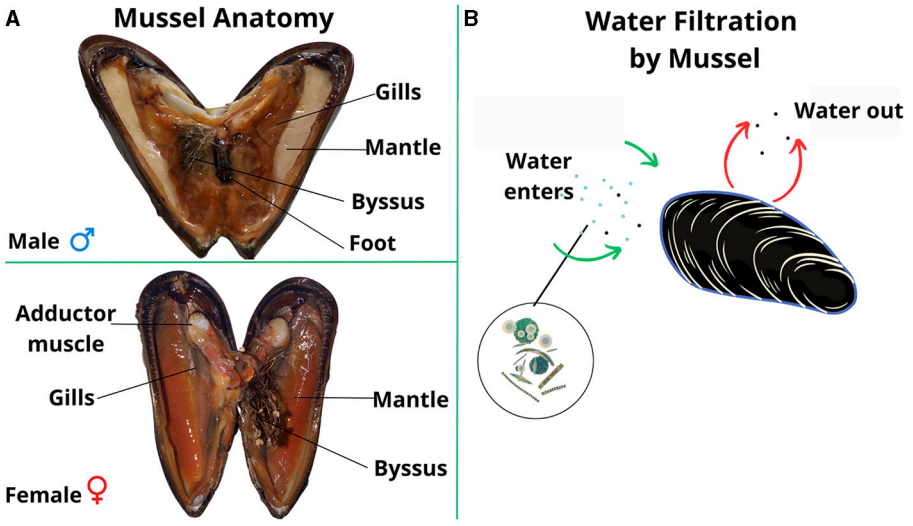

Figure 1

MUSSEL ENVIRONMENTALLY FRIENDLY AND ECONOMICALLY IMPORTANT

Mussels feed on very small plants called **microalgae**, which are present in seawater. As they feed they filter the water, which helps to clean out any substances suspended in it. **Filter feeders** like mussels help sunlight to penetrate deeper into the water. This is important for organisms that perform **photosynthesis**, which produces the oxygen needed to keep the water healthy for other organisms. Mussels are also a very important food for fish, birds, starfish, octopuses, and many other animals (Figure 2). Mussels live attached to the rocks, through a very thin, strong structure called the **byssus**. Many mussels can grow

Figure 2

Mussels have many benefits, both to humans and the environment. **(A)** They are a healthy food source, with many nutrients; **(B)** they are an income source for many families and marine farmers; **(C)** they are used in environmental health studies; **(D)** they can be used in several new technologies; **(E)** they are important food for many other ocean organisms; **(F)** they may be able to reduce world hunger and **(G)** they are an environmentally friendly food source (Image created on Canva by Helena Souza).

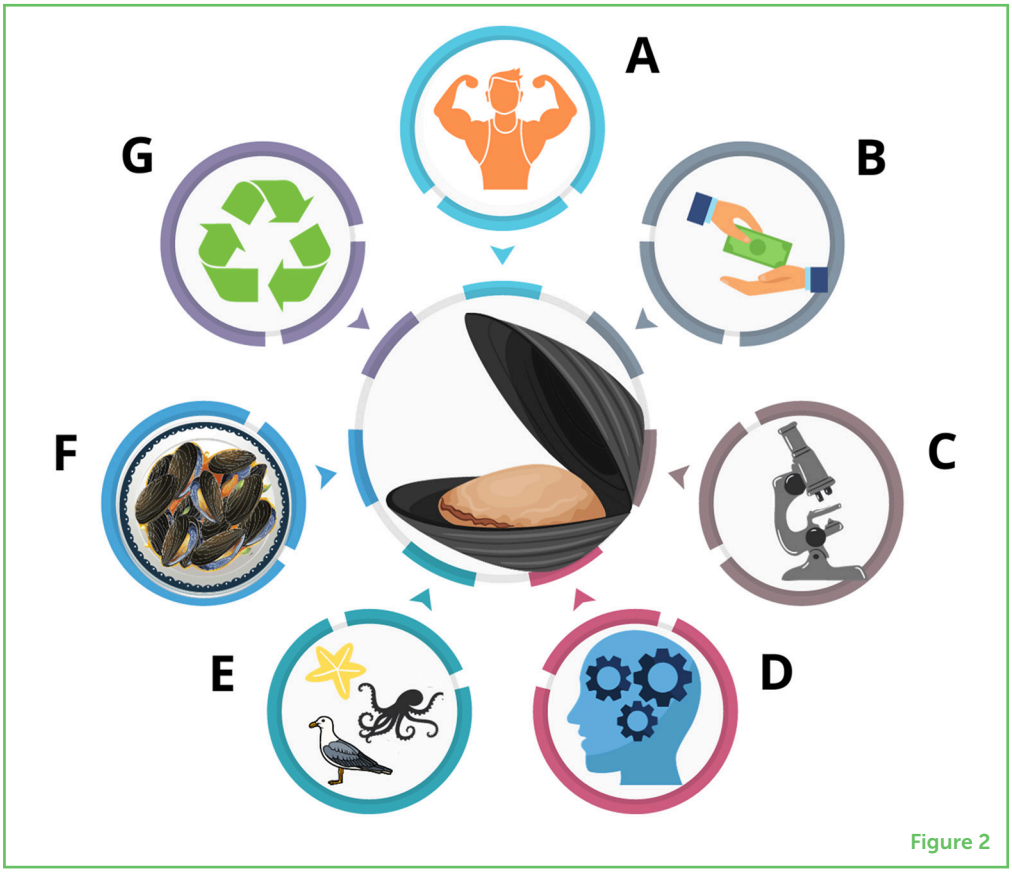

Figure 2

BYSSUS

Thread-like structures used by mussels to attach to rocks or other objects in the water.

close together, creating an environment for other species to live in (Figure 2).

Mussels can teach us a lot! The byssus is composed of materials that, although very thin, can attach the mussels to a surface so firmly that not even the ocean currents and waves can remove them. Based on the properties of the byssus, some researchers are conducting tests to develop medical materials such as surgical glues, which can be used to help wounds heal [2]. Mussel shells have also been studied to assess their usefulness in drug production [3] and pet food.

Because they are filter feeders and remain in the same place for a long time, mussels can accumulate contaminants from the environment, so studying them can help researchers understand the health of the environment (Figure 2).

Mussels are very important for many families that live close to the sea and make a living by selling them—either as food or as art made from mussel shells (Figure 2). Mussels can be taken directly from the natural banks where they grow, or they can be grown in marine (ocean) farms. Marine farms are a good option for growing mussels because there are no feed costs, since mussels feed on microalgae in seawater, and no electricity is needed. No medicines are needed to treat mussels grown in marine farms, so this saves money, too [1]. Marine farms also use

very little fresh water, do not generate much waste, and have very low CO_2 emissions.

GLOBAL WARMING IS A THREAT TO MUSSELS

Although mussels help us in many ways, we are not helping them in return. Today, the results of human activities threaten mussels in several ways (Figure 3), including the effects of global warming.

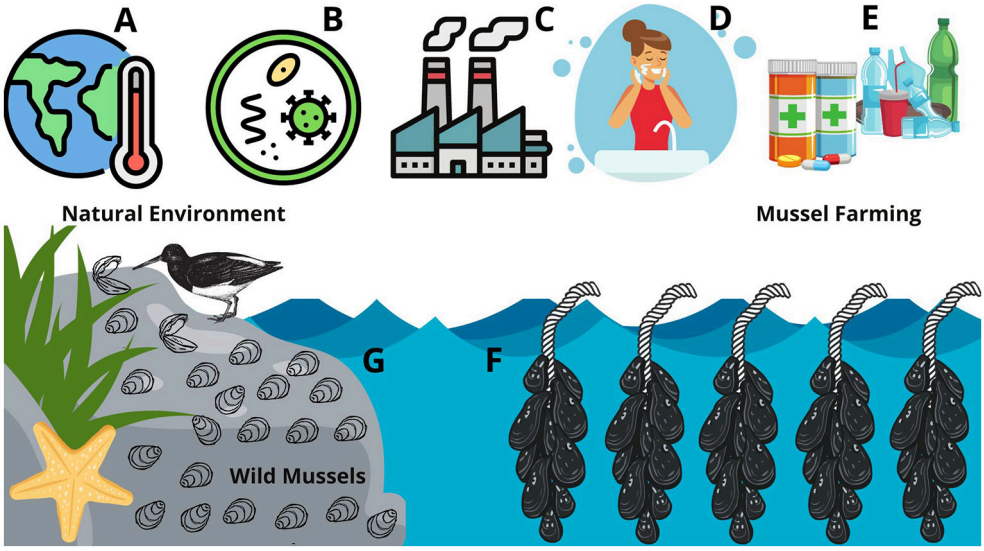

Figure 3

Threats to our mussel friends include **(A)** global warming, which can increase water temperature and cause death; **(B)** untreated sewage pollution that can cause diseases and deaths of many species; **(C)** chemical pollution by industries; and **(D, E)** contamination by emerging pollutants from our daily lives, such as personal care products, medicines, and plastics; **(G)** These threats harm the survival of animals that feed on mussels, like starfish and birds. **(F, G)** Both wild mussels and those grown by humans are threatened (Image created on Canva by Helena Souza).

Global warming is the term used for the increasing temperature of our planet. Many researchers believe that humans are responsible for global warming because we emit greenhouse gases from burning fuels and from certain industries. Wildfires are increasing due to climate change, and they also release greenhouse gases. Recently, many mollusks have been dying due to the overheating of ocean water. When large numbers of these animals die, the bad smell can also attract disease-transmitting insects, which makes the problem even worse.

POLLUTION CAN HARM MUSSELS

If the water coming through sewers from homes and industries is not treated properly, it can contain an excess of nutrients such as phosphorus and nitrogen. If this water makes its way into rivers, ponds, and seas, it can speed up the growth of algae and other aquatic plants because the nutrients feed them. Overgrowth of algae turns the water into a greenish, cloudy broth. With so many algae, sunlight can no longer penetrate into the water to help photosynthetic organisms produce oxygen. Without oxygen, all the organisms in the water can

die [1]. Some algae can also release poisonous substances, called **phycotoxins**, which do not harm mussels but can cause poisoning in humans that eat them. Symptoms include nausea, vomiting, paralysis, and even death. To verify if mussels are contaminated, authorities must examine the water for the presence of phycotoxins and ban the capture of animals when phycotoxin levels are high.

PHYCOTOXINS

Toxic chemicals produced by algae.

In addition, untreated sewer water can contain dangerous bacteria present in human feces (poop). These bacteria can be bad for the health of mussels and the people who consume contaminated mussels.

Certain metals, such as lead, have been discovered in high concentrations in mussels [4]. Eating too much lead-containing seafood can cause lead to accumulate in the body, leading to problems with the nervous system and even death. Mercury, another metal that has been found in mussels and other seafood, can also cause nervous system problems if too much is eaten. In pregnant women, mercury can also interfere with the proper development of their unborn babies.

EMERGING POLLUTANTS HAVE UNKNOWN DANGERS

Emerging pollutants are fairly new contaminants, for which we do not fully understand the environmental impacts. For example, tiny particles of plastic—or microplastics—have gotten a lot of attention in recent years plastics reach the oceans due to improper disposal of bottles, bags, cups, and other objects. Once in the ocean, plastic objects are broken down into small pieces due to the action of waves, and the resulting microplastics can be taken up by organisms like mussels—and then eaten by humans and other animals that eat the mussels. Studies have already found microplastics in humans [5].

Chemicals that come from plastics have also been found in mussels and, although the harm to humans is still unknown, it is suspected that these chemicals can damage the reproductive systems of animals and humans [6].

ANTIBIOTICS

Medicines used to treat diseases caused by bacteria.

HORMONES

Chemicals produced by the body's glands that have many functions, including growth and sexual development.

Other emerging pollutants, including medicines like **antibiotics** and **hormones**, have also been found in mussels [7]. Incorrect disposal of medicines in sinks or toilets is concerning because the effects of these substances can be severe. For example, antibiotics in water can cause the bacteria naturally found in the environment to become antibiotic resistant. This means that humans and other animals could develop bacterial infections that are very difficult to treat or that might not even be curable at all with current antibiotics. Studies on hormones are just beginning, but researchers believe that hormones consumed in food can unbalance the functioning of the body, possibly causing diseases of the reproductive system, including infertility.

HELPING MUSSELS: KNOWLEDGE IS KEY!

Are you worried about the threats to the lives of mussels, and the consequences for the lives of all of us? Do you know how you can help? It is easy! Avoid using plastics, and do not throw old medicines out in the garbage—dispose of them properly. And most importantly, talk to your parents and friends about what you have learned here. By doing these simple things, you will contribute to the health of the ocean environment, which is so necessary for the life of the planet. Speaking of which, we are in Ocean Decade (2021–2030)! This period was established by several countries of the world as a time to focus on taking care of the marine environment. You have already taken the first step toward contributing, by learning about mussels!

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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.

YOUNG REVIEWERS

CHENGKAI, AGE: 11
My name is Chengkai, I am the only child in my family, and I am 5th grade. I like to look at maps and I like to draw them. I attend live math meetings. I speak Chinese, English, and a bit of Arabic. I have two bikes, but no pets. I play violin, basketball and badminton. I learned swimming last summer and I am the only one who can swim in my family. I am proud of myself.

THE KITE MONTESSORI SCHOOL, AGES: 9–11
The Kite Montessori School in Sopot and Gdynia educates for a promising future and sustainability through great connections with well-prepared teachers and experience-based learning. We live in Northern Poland alongside the Baltic Sea. Our children love outdoor activities and visiting the seaside. We take responsibility for our environment and strive to be sea advocates. Ola, Bogdan, Janek, Mikołaj, Stasiu, and Florek contributed the most to the review of this article.

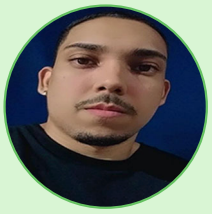
XUAN, AGE: 15
I am a secondary student who is very interested in the sciences, with a particular focus on the life sciences and chemistry. I like to go outdoors, and observing plants and animals has always been fascinating to me.

ZIQI, AGE: 12
I am an aspiring scientist and I love animals!

AUTHORS

HELENA DE OLIVEIRA SOUZA
Hello! I loved science classes in school, so I studied biology at the Federal University of Rio de Janeiro and received a master's degree in environmental sciences and conservation. Currently, I am a Ph.D. student in environmental sciences at the State University of Rio de Janeiro. I am studying the effects of environmental pollution on mussels that we consume. Nature brings me happiness, and this is one of my motivations to study and help take care of the environment. *helenabiolog@gmail.com

VANESSA DE MAGALHÃES FERREIRA
I am an oceanographer and university professor. I work with marine farms, both in the production of aquatic organisms as food for humans and in taking care of their health. In my university, I work in what is called "extension" by educating the public about the science of mariculture—especially young people and children. I also develop environmental education activities. I have a special interest in working with young people of various educational levels.



WILLIAM DOS SANTOS MORAES
I am an oceanographer, and I graduated from the State University of Rio de Janeiro. Currently, I am a master's in oceanography at the State University of Rio de Janeiro. I am studying the effects of microplastic pollution on mussels in Guanabara Bay. I like to study human impacts and share my knowledge with others, so that we can somehow help reduce these impacts and protect the environment.

MARCOS ANTÔNIO DOS SANTOS FERNANDEZ
I am oceanographer with a master's in geosciences and a Ph.D. in inorganic analytical chemistry. Currently, I am an associate professor of oceanography at the State University of Rio de Janeiro. My research interests are chemical oceanography and marine ecotoxicology and geochemistry. I have been working mainly with contaminants present in ship paint and heavy metals. In the last years, my group developed ways to monitor the environment using animals, but without killing them, and also invented new equipment for underwater studies. I began diving by age 15, and I love marine the diversity and beauty of organisms.