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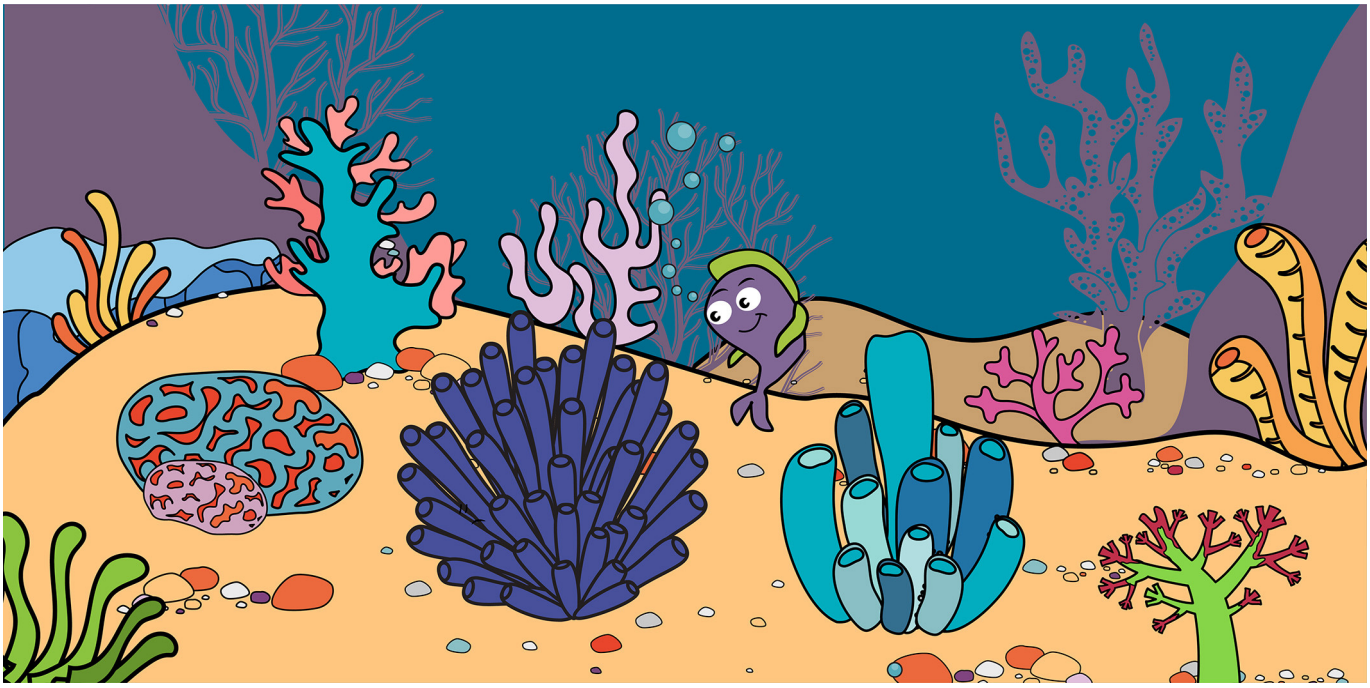

ARE ALL SPONGES SPONGY?

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Sponges are animals that live in oceans, lakes, and rivers. There are close to 10,000 sponge species described by scientists, but far more species await discovery! However, not all sponges look and feel like their kitchen-sink cousins. Over time, sponges have evolved into many sizes and shapes, giving us the huge diversity of sponge species on Earth today. For example, many sponges are rock-hard! These rock sponges use minerals like silica (glass) to build their skeletons—instead of bone like ours. Other sponges have evolved unique ways to eat. Most sponges filter water to get their food, but certain sponges are carnivorous, meaning that they eat meat, including tiny shrimp-like creatures. Sponge species with different body and skeleton shapes and sizes can thrive in very different and unique environments.

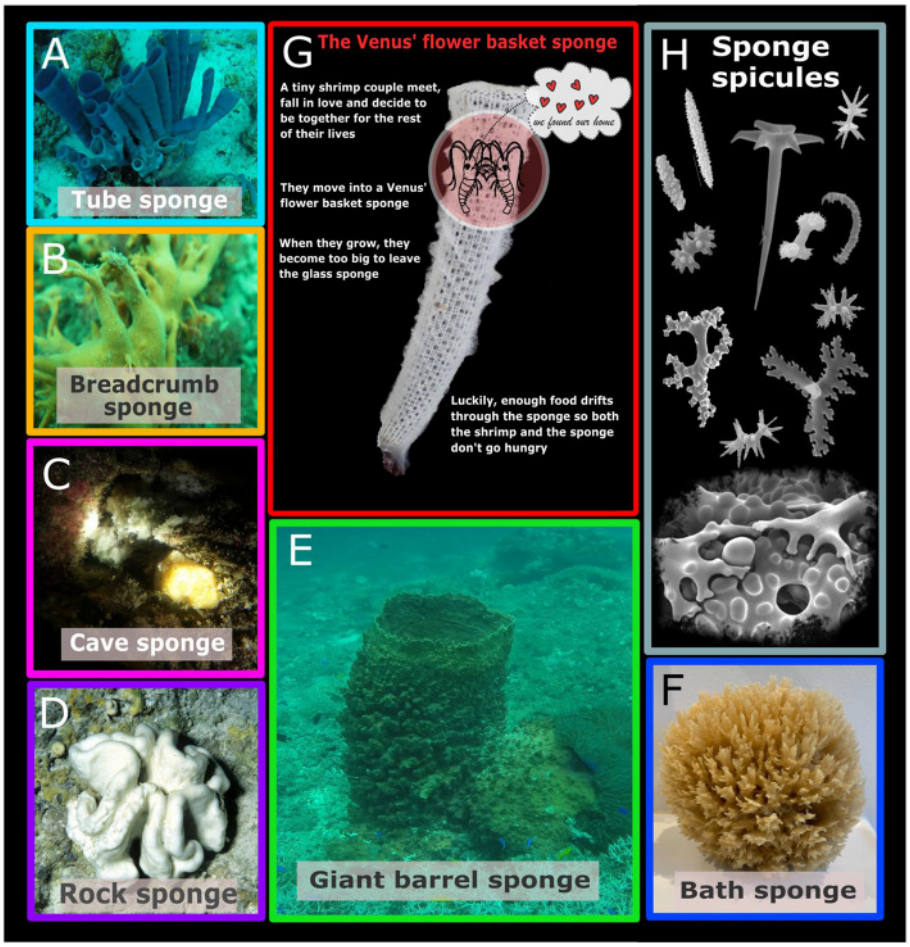

Figure 1

(A–F) Examples of various-shaped sponges and their common names. **(G)** The Venus' flower basket sponge provides a home for tiny shrimps. **(H)** Spicules are microscopic structures, made of silica (glass) or calcium carbonate (similar to limestone), that make up a sponge's body. Notice the many unique shapes of the spicules.

WHAT IS A SPONGE?

Have you ever looked closely at a living sponge? Although they may look more like plants or fungi, sponges are actually animals. Sponges live in waters all around the world, from the deep seas of the Arctic and Antarctic to the shallow and warm tropical seas, as well as in rivers, streams, ponds, and lakes [1]. Adult sponges do not move around—they are fixed to the bottom of the seafloor, on rocks, or on other sandy or hard underwater surfaces (Figure 1).

Unlike humans, sponges do not have stomachs, organs, backbones, or blood. Still, they are multicellular animals, which means that they are made up of many cells that work together, like in the human body. If you put a sponge in a blender, the cells can recognize each other afterwards and reform into tiny sponges! Sponges are the only animals that can rebuild themselves if they are torn apart!

Sponges have many different sizes and shapes. They can be huge and round, or make thin crusts on rocks, or even look like vases or cups (Figures 1A–F). Larger sponges can also serve as homes for other animals like fishes, turtles, and shrimps (Figure 1G).

The sponge body is made of holes and channels through which water is pumped and filtered to obtain particles of food. Because they filter the water, sponges are called **filter feeders** [2]. Some sponges can filter up to 50,000 times their own volume in a day. This would be like an average-sized person drinking 3,500 l (or 925 gallons) of water in a day! Due to this water flow through their bodies, sponges are very important in marine ecosystems.

FILTER FEEDERS

Are animals that feet on food particles from the water. Examples are sponges, baleen whales and sharks.

How do sponges filter so much water? Within their tissue, they have chambers that are lined with special cells that have tail-like appendages called **flagella**. These tails all wiggle around together to create a water current through the sponge body. This current makes the water flow through the sponge and provides the sponge with food and oxygen. This explains why most sponges are full of tubes and holes: they allow the water to flow around inside the sponge [2].

FLAGELLA

Wildly whipping tail structures keeping the water moving inside the sponge body.

WHAT MAKES A SPONGE SPONGY OR ROCK-LIKE?

Some sponge species have lots of tiny, hard parts called **spicules** that assemble into a skeleton and make their bodies stiff. Spicules are made of either calcium carbonate (similar to limestone) or silicon dioxide (quartz/glass), and they come in a dizzying variety of shapes and sizes (Figure 1H). A single sponge can contain several different types of spicules [2]. Spicules are what make some species "spongy" and others "rock-like." Sponges without spicules are generally the most squishy and spongy, like our bath sponge (Figure 1F). Although most modern kitchen and bath sponges are made of plastic, sponges without spicules, like the Mediterranean bath sponge *Spongia officinalis*, have been used by humans for thousands of years as cleaning tools, among other uses. These are the species that kitchen sponges try to mimic. Other sponges have evolved dense skeletons packed with hard spicules. Some of these spicules can form an interlocked network that makes the sponge hard as a rock, and they are unsurprisingly known as rock sponges (Figure 1D) [3]. These spicules are very strong, but they can still be bent, and light can pass through them. This combination of properties makes spicules very interesting to both materials scientists and biologists.

SPICULES

A tiny structure made up of minerals that serves as a piece of the skeleton of sponges and other marine or freshwater animals.

Sponges can look very similar when we hold them in our hands, so scientists called **taxonomists** need to look closely for unique characteristics to tell species apart from one another. Spicules play a very important role in this process because they are unique and can be used to identify different species. Spicules can even be used to identify totally new species of sponges. There are over 9,350 known sponge species in the world. Each of these species has either a distinctive set of spicules or, if the sponge is soft, no spicules at all [3].

TAXONOMISTS

A scientist who groups organisms into categories and studies the relationships between various types of organisms.

Figure 2

A series of images taken over time, showing a small carnivorous sponge (1–3 cm in length) in an aquarium. The sponge catches two tiny shrimps with its hook-like spicules. Although the "arms" are large enough to be seen with the naked eye, the spicules that line the arms are so small that they can only be seen under a microscope (Image credit: J. Vacelet).

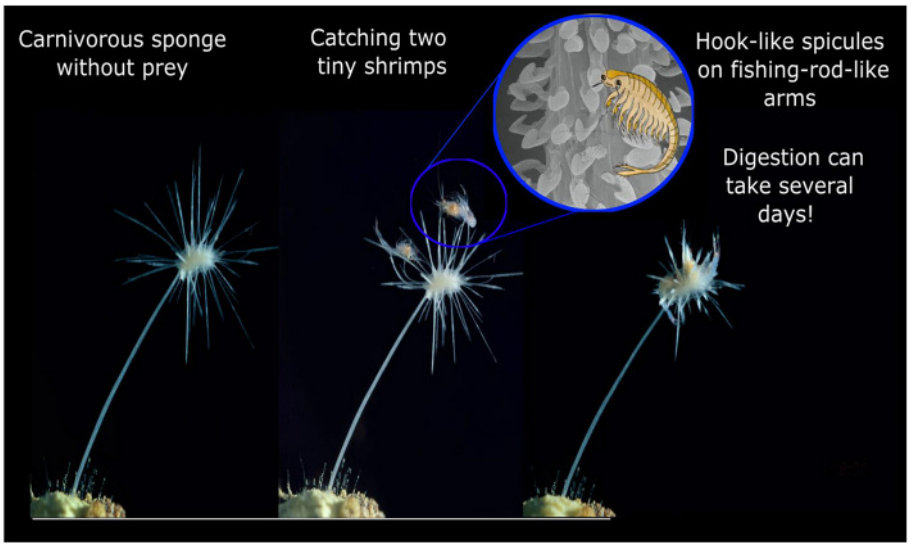

Figure 2

THE CURIOUS CASE OF CARNIVOROUS SPONGES

In addition to making some sponge species rock-like, evolution has also driven other changes in sponges over many millions of years. Although most sponges are filter feeders, certain species have developed techniques to eat larger prey, such as larvae and crabs (Figure 2). These are called **carnivorous** sponges, meaning that they eat meat. Carnivorous sponges have lost the ability to filter food from the water.

CARNIVOROUS

If an animal feeds on other animals tissues, meaning eating its meat, it is called a carnivorous animal.

Most carnivorous sponges live in the deep-sea at depths of more than 4,000 m (13,123 feet). In some regions, these sponges are the most common animals, surviving the cold, dark, crushing pressures of the deep ocean. Scientists think that eating meat is a tactic certain sponges use to survive when other ways of finding food do not work. A similar strategy is used by some plants, like the Venus fly trap, which evolved carnivory to live in food-poor habitats.

Carnivorous sponges generally have long fishing-rod-like "arms" lined with hook-like spicules that are used to capture prey. The spicules work like hook-and-loop fasteners, like Velcro or the seeds that get stuck to you when you walk outside. Prey animals caught in these hooks are slowly digested by the sponge. Sponges catch their food slowly, and it can take them several days to digest their catch.

It is not clear when this unique feeding mechanism evolved, but scientists think that carnivorous sponges have been on Earth for at least 60 million years, meaning that they appeared just after the dinosaur age ended. Since then, at least 150 sponge species have evolved to be carnivorous to survive in extreme, food-poor environments such as the deep sea [4].

Figure 3

(A) Example of a fossil exploration site near Albufeira in the South of Portugal, where loose rock sponge spicules were found within white rocks. **(B)** Bodies of preserved fossil sponges of various shapes and ages. **(C)** A nearly whole fossil rock sponge skeleton, after treatment with acid to remove the stony part around the skeleton.

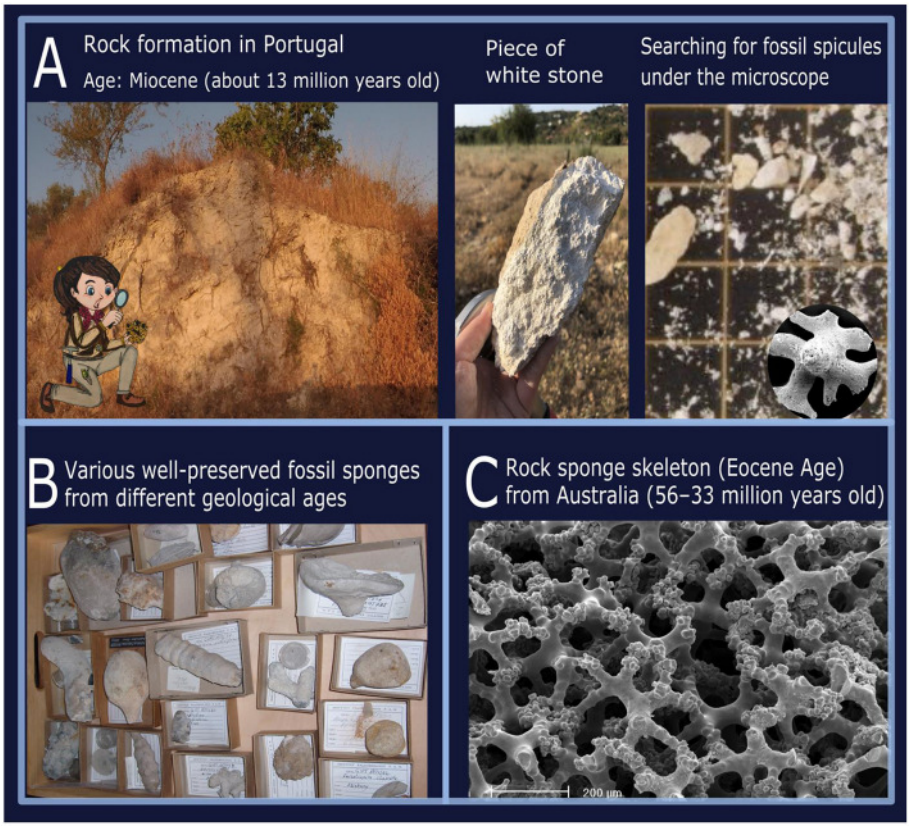

Figure 3

SPONGES HAVE BEEN ON EARTH FOR MORE THAN 550 MILLION YEARS!

It is likely that sponges were the first animals that evolved on Earth. However, not all sponge groups have survived since then. Some species went extinct, while others adapted (like the carnivorous sponges) to survive harsh climatic conditions such as decreased oxygen in the water and increased temperatures caused by global warming. To date, Earth has experienced five big extinction events, and one of the biggest occurred 250 million years ago, before the dinosaurs even existed. This extinction is known as The Great Dying. During The Great Dying, 90% of all ocean life went extinct. It was a harsh time for sponges, and only a handful of species survived. One of the surviving groups was the rock sponges.

PALEONTOLOGISTS

A scientist who studies fossils and the history of life on Earth.

Paleontologists that work with fossils know that rock sponges made it through The Great Dying because scientists have found the skeletal remains of these sponges from the Cambrian Period (about 550 million years ago) onwards throughout the Earth's history. In the fossil record, the skeletons of rock sponges remain largely whole and can be used to identify rock sponges even after millions of years (Figure 3). This is very unique among sponges. Most other "spongier" sponges that have only a few loose spicules or no spicules at all are less preserved in

FOSSIL RECORD

Remains of animals and plants that lived in the past (fossils) and their placement in the rock formation (record).

the **fossil record** because they do not have a formed skeleton. This means that even if paleontologists do find the spicules of these softer sponges, it is much more difficult to identify the species—a bit like finding just a little finger bone instead of a whole skeleton [5].

CONCLUSIONS

The species of sponges that we humans use and are most familiar with are just a few examples of the numerous diverse groups of sponges that exist in nature. Sponges have adapted to lots of different habitats and environmental changes over hundreds of millions of years. These adaptations helped them outlive not only the dinosaurs, but also many other plant and animal species.

Although sponges have various body shapes, colors, and spicule shapes, they still are some of the simplest animals that exist. Nevertheless, from the fossil record, we know that sponges were quite abundant in the past and they are still plentiful today. Like many other animals, sponges are affected by human activities. This means that sponges can be harmed by climate change, pollution, and over-fishing. As we take steps to protect our oceans from these man-made threats, we should be sure to remember the sponges and include these ancient and fascinating animals in our conservation plans.

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Juniper is a horse lover, avid reader, and an amazing skier. She also loves mountain biking and camping, and her favorite subject is science.

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Astrid is a marine biologist with a background in biology and paleontology. Currently, she is a postdoc at the Southern University of Denmark. Her research goal is to better understand how sponges adapt and survive extreme events, such as low oxygen conditions, and how sponge biodiversity has changed over evolutionary time. She has over 10 years' experience working with sponges and she uses genomics and traditional taxonomy in her research. She has discovered and named several deep-sea rock sponges and she is a passionate scientific illustrator. Astrid loves all sorts of outdoor activities including fossil hunting and diving. *schuster@biology.sdu.dk

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Brian is a marine biologist currently working as a postdoc at the University of Southern Denmark. Although he is originally from inland Texas, he has a lifelong love of the ocean and SCUBA diving. His current research includes figuring out how certain sponges can survive for months at a time without oxygen. Throughout his career, he has been interested in how sponges respond to stress, with the overarching goal of understanding how sponges respond to manmade changes in the ocean. When he is not diving and annoying sponges, Brian enjoys many other outdoor activities, including rock climbing and kitesurfing.

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Allison is a systematic biologist who has studied various organisms, including slime molds and tree ferns, as well as larger systems like mountains. She is currently the director of the Gothenburg Global Biodiversity Center in Gothenburg, Sweden, and she is interested in understanding the impact people have on nature, and how we can adjust our lifestyles to make sure that biodiversity thrives now and into the future. She loves being out in nature, both on land where she hunts for edible fungi in the forests, and in the sea, which she explores with the help of SCUBA diving gear.