

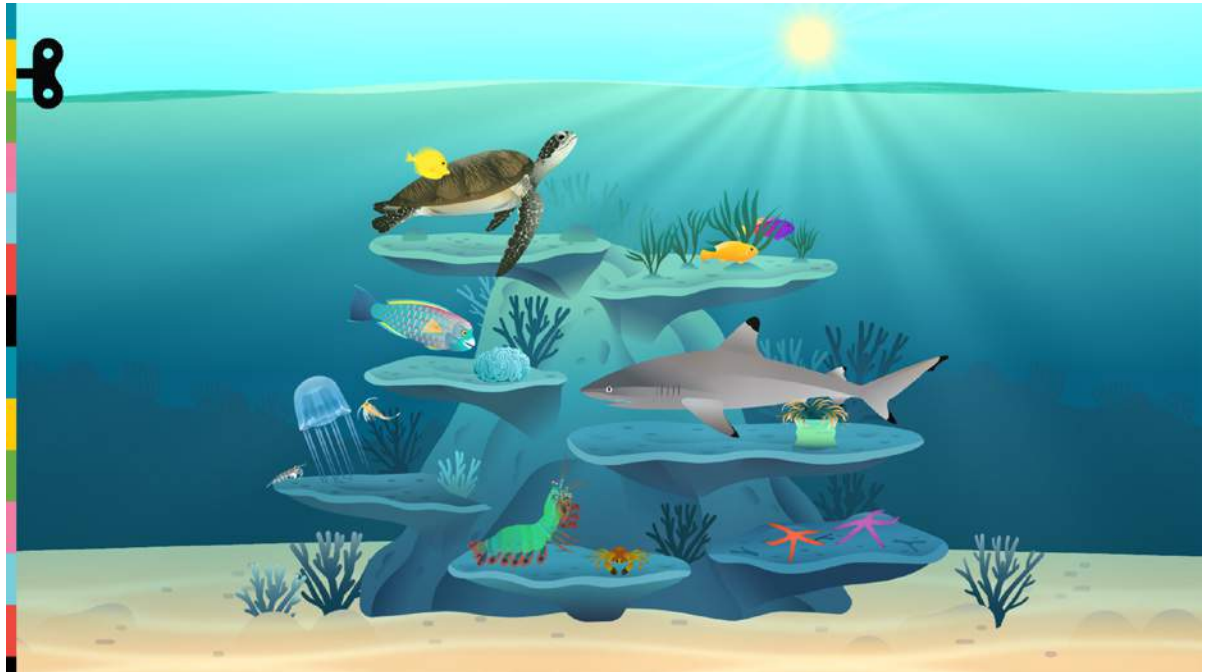


CORAL REEF

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Coral Reef by Tinybop



IN THE APP

As you play *Coral Reef* by Tinybop, you'll explore how some organisms live together and depend on each other in an Indo-Pacific coral reef. Pay attention to what animals eat and how they eat it. Consider how different living things get energy from food. Is the organism a producer, consumer, or decomposer?

A coral reef is an underwater **ecosystem**. It's home to thousands of plant and animal species, to living and nonliving things, that all depend on each other. Nonliving things include the air, water, sunlight, soil, and minerals that animals, plants, bacteria, and other living things need to survive.

The Indo-Pacific reef is home to over 700 species of coral and 3,000 kinds of reef fishes. This rich **biodiversity**, the variety of life in an ecosystem, ensures that all living things in an ecosystem have food and can survive. Every living and nonliving thing in an ecosystem is connected. If one is lost or harmed, it can affect the health of the entire ecosystem.

Food is essential to all life. In addition to nutrients, food is packed with stored energy. Living things use **energy** released from food to do everything: to breathe, move, grow, and reproduce. All living things must constantly replenish their energy reserves to survive and thrive. But not all living things get energy from the same sources.

Different types of organisms get energy from different types of sources:

- **Producers**, like plants and algae, get energy from the sun and use it to produce their own food.
- Most animals are **consumers**, which means they get energy by eating other living things. **Carnivores** only eat the meat of other animals. **Herbivores** only eat plants, algae, and fungi. **Omnivores** have the broadest diets, eating a combination of plants, animals, and other living things.
- **Decomposers**, which include fungi and bacteria, get energy by breaking down waste and dead organisms and ingesting what they need.

There is a constant flow of energy within every ecosystem: from the sun, to producers, to consumers, to decomposers. Anytime an animal eats a plant or another animal, or consumes any other source of nutrients, a small amount of energy is transferred as food. When energy is transferred linearly across a single path of living things, from one living thing to another, a **food chain** forms. An entire network of interconnected food chains within an ecosystem is called a **food web**.



DID YOU KNOW

Coral is made up of thousands of individual coral polyps, a type of tiny animal called a cnidarian. Sea anemones and jellyfish are also cnidarians.

Australia's Great Barrier Reef, the world's largest coral reef — at 1,400 miles in length, it can be seen from outer space — began with a single polyp. A polyp attaches to a rock and clones itself over and over again. Eventually thousands of identical polyps form. As polyps grow, they release a type of rock called calcium carbonate. This hardens into a limestone skeleton. Over time, the limestone builds up, providing ample hiding spaces for small fish, invertebrates like crabs and shrimp, and other animals.

Turning energy from the sun into food



IN THE APP

Drag seeds to plant seagrass.



Seagrass is a type of plant that grows in the ocean. Like plants on land, seagrasses have roots, stems, and leaves. They flower and produce seeds, too.

Seagrass is an important part of coral reef ecosystems, providing not only food but also shelter to other living things. Fish and small invertebrates, like crabs, hide from predators in seagrass beds and lay their eggs on it. Seagrass is also the base of ocean food pyramids. It is a **producer**. Like other plants, seagrasses capture light energy from the sun and transform it into chemical energy through photosynthesis.

All energy in an ecosystem starts with the sun. During **photosynthesis**, plants capture energy from sunlight and use it to make food for themselves. Plants store energy in the form of a sugar, called glucose, and use it to grow, flower, and produce seeds and fruits.

Adult **green sea turtles** survive on a diet of seagrasses. These large **herbivores** average 350 pounds.



DID YOU KNOW?

Sea turtles have been around for close to 110 million years, since the time of dinosaurs. Despite this long-standing resilience, nearly all sea turtles are now endangered. Human activity, like poaching and fishing, have led to rapid declines in populations. Additionally, sea turtles have evolved a precise reproductive feature: the sex of newborn offspring depends entirely on temperature. Warm temperatures produce all female hatchlings, while cool temperatures produce only males. Higher global temperatures have caused many newborn sea turtle populations around the world to skew almost entirely female.



DISCUSSION QUESTIONS

- Choose an animal living on a coral reef. Can you trace all of the (food) energy it eats back to the sun?
- What would happen if a coral reef lost its seagrasses? Which animals would be impacted? How?

Cleaning up in a coral reef ecosystem



IN THE APP

Clean the visitors at the cleaning station.

Creatures living in an ecosystem depend on each other for food, but also for things like shelter and general hygiene. One example: reef cleaning stations. At **reef cleaning stations**, sealife gathers. Some animals go to clean, and others go to get cleaned.

This is an example of a **symbiotic relationship**. Any two species that interact closely over time have a symbiotic relationship. Sometimes both animals benefit from the relationship and sometimes only one animal benefits. In the case of the cleaner fish and the animal it cleans, both benefit; they have a **mutualistic** relationship. Cleaned animals get rid of algae, dead skin, and harmful parasites while cleaners get food.

When only one animal benefits from a symbiotic relationship, it's called **parasitism**. Parasites are organisms, tiny animals, that aggressively latch onto another organism, a larger animal also known as a host, and live off of it. Only the parasite benefits at the expense of the host.

Yellow tangs and sea turtles have a mutualistic relationship. The tangs, named for blade-like spines (tang) attached to their tails, eat algae from sea turtles' shells. While these bright reef fish get food, turtles get a potentially life-saving bath. If too much algae grows on a turtle's shell, the turtle can develop an infection called shell rot. This infection slowly rots through a turtle's shell and can sometimes be fatal.

Cleaner wrasses also clean algae from turtles' shells. And they eat parasites from sharks' gills, eyes, fins, and teeth. Because they eat both producers and other animals, wrasses are **omnivores**.



DID YOU KNOW?

Predators, like sharks, don't eat cleaners, like tangs and wrasses, at cleaning stations. Scientists aren't exactly sure why, but some believe that it's because cleaner fish have adapted a magic touch. The movement of their fins has been shown to calm predators, subduing them into a trance-like state and making them less prone to attack.



DISCUSSION QUESTIONS

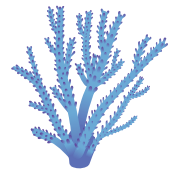
- What would happen to a coral reef if there were no cleaning stations?
- Why do you think predators don't eat cleaner animals?

Everything is connected: a case study



IN THE APP

Drag the parrotfish over to eat algae from the coral.



Everything in an ecosystem is connected. Think about the complex relationships between algae, coral, and parrotfish.

Algae can be green, brown, or red, short and fuzzy, or tall and smooth. Algae are not plants, but they can produce their own food using energy from the sun. Like plants, they help form the foundation of a coral reef ecosystem's food pyramid.

One type of algae, zooxanthellae, has a symbiotic relationship with coral. It lives inside of coral polyps, the tiny animals that make up a coral reef. As coral grows bigger, it has more surface area to soak up the sun. This is good for the algae living inside of coral, and for the coral, too.

The algae uses all this sunlight to make food (glucose) for itself by photosynthesis. As it makes food, algae releases oxygen as waste. Coral, like nearly all other animals, need oxygen to survive and the algae provides a constant supply. Additionally, the algae shares many of the sugars it produces (about 90%) directly with the coral polyps. The algae nourishes the coral as a rich source of both oxygen and nutrients.

But the relationship between algae and coral isn't that simple. If too much of the wrong type of algae grows on coral, the coral suffers. Bacteria in the water eats the excess algae, sucking oxygen from the water and suffocating coral in the process.

When this happens, parrotfishes come to the rescue. Their teeth are specially adapted to scrape algae from coral. They are fused together and look like a bird's beak. Parrotfishes eat algae off the coral, gaining energy from the food source while cleaning up the coral.

This delicate interconnectedness makes reef systems especially vulnerable to human activity. Overfishing has caused a drastic decline in parrotfish populations over the past several decades. With only small populations of parrotfishes grazing and keeping algae growth in check, explosive algal blooms can quickly overrun a reef system. Left unchecked, these blooms can create ocean "dead zones," areas so deprived of oxygen that they are no longer able to support animal life.



DID YOU KNOW?

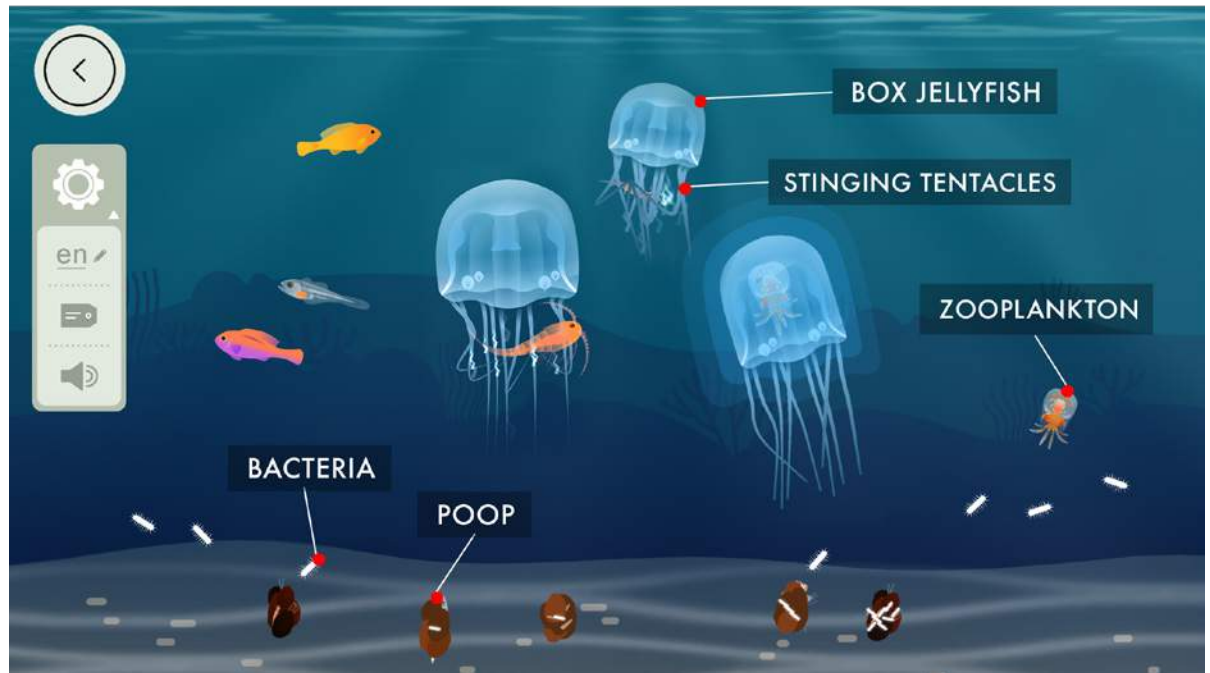
Parrotfish can be clumsy eaters. When they eat algae from the coral, parrotfish also chomp on chunks of coral and the rocky limestone layers beneath. While the algae is converted to energy, the coral fragments are pooped out as small particles of limestone. Or, in other words, the white sand you find on the beach.



DISCUSSION QUESTIONS

- How does human activity impact coral reefs?
- Why is each and every relationship within the coral reef so important?

Tiny but mighty predators: box jellyfish



IN THE APP

Feed zooplankton to the box jellyfish.

Jellyfish aren't actually fish — they belong to a group of animals called cnidarians. Corals and anemones are cnidarians, too. Like corals and anemones, jellyfish use stinging cells to deter predators and immobilize prey.

Jellyfish tentacles are lined with thousands of these stinging cells;



they're called cnidocytes. Movement or tasty smells trigger the cnidocytes. When predator or prey approach, jellyfish inject them with a paralyzing — and sometimes lethal — venom.

Box jellyfish are one of the ocean's most venomous predators. One of their favorite foods is zooplankton.

Zooplankton are tiny drifters of the ocean. These microscopic organisms are incredibly diverse and include numerous kinds of miniscule animals, algae, fungi, bacteria, and the eggs of larger animals.

Because box jellyfish are transparent, we can easily see how they digest food, like zooplankton, and turn it into energy. When food enters a jellyfish's stomach, digestive enzymes break it down into tiny nutrients. Nutrients provide proteins, fats, carbohydrates, vitamins, and minerals necessary for growth and repair. They're also packed with stored energy.

The jellyfish both eats and poops through the same opening, called a manubrium: its mouth. Bacteria decompose the jellyfish's poop so that the nutrients in it can support new life and growth.



DID YOU KNOW?

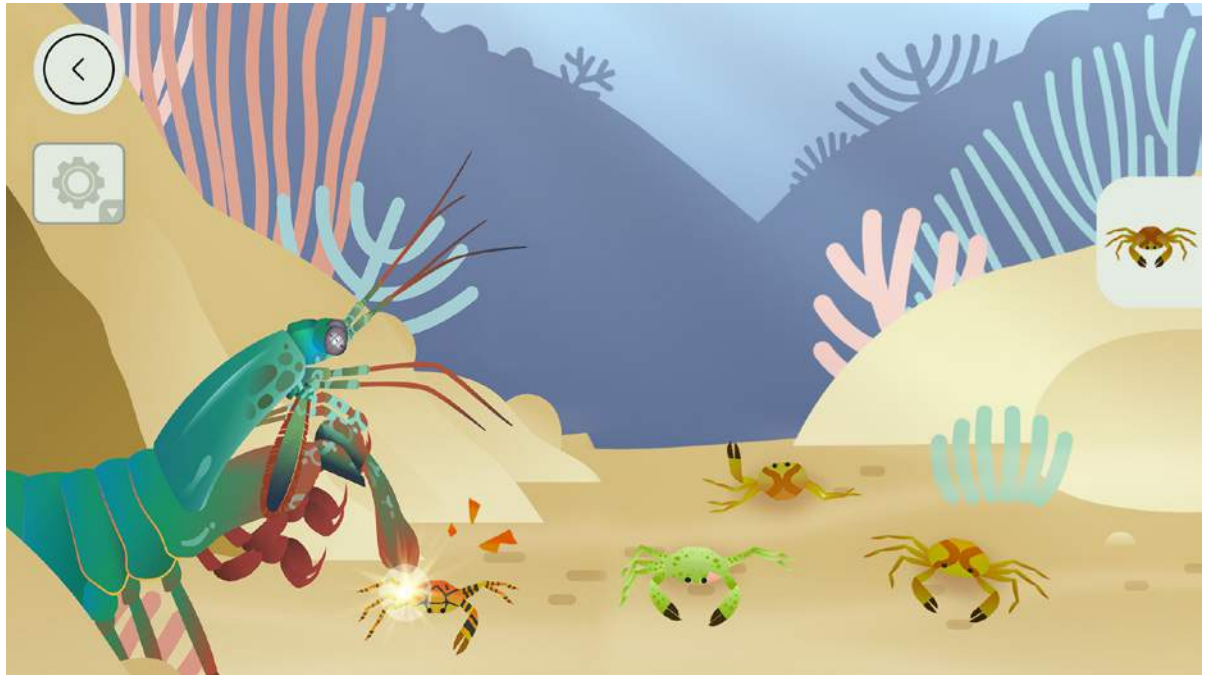
Jellyfish don't have brains! But they have 24 eyes, six each in four different pockets. Four of their eyes always look up and help the jellyfish navigate.



DISCUSSION QUESTIONS

- How are decomposers important to an ecosystem?
- What might happen to an ocean if there were no more bacteria to break down and recycle the nutrients in poop?

Tiny but mighty predators: peacock mantis shrimp



IN THE APP

Feed crabs to the peacock mantis shrimp.



Peacock mantis shrimps are **carnivores**. These predators hide in their reef burrows and wait for food to come to them. When prey approaches, the shrimp strikes with bullet-force and speed. Thanks to a spring-like mechanism, the shrimp stores elastic energy in its arm. The release of all this stored energy triggers a punch faster than a .22-caliber bullet that's loaded with 200 pounds of force.

The punch can break through hard, protective crab shells, allowing the shrimp to eat the soft meat inside of the crab.

The mantis shrimp's punch is so fast and powerful that it creates a flash of light in a phenomenon known as cavitation. The speed of the punch creates a tiny pocket of air in the water. This pocket of air implodes with so much force that it generates a shock wave strong enough to emit light.



DID YOU KNOW?

Peacock mantis shrimps are tough guests for an aquarium. Their punch is so strong it can crack and sometimes shatter aquarium glass.



DISCUSSION QUESTIONS

- The peacock mantis shrimp must use energy to power its punch. Can you think of other examples of animals that use energy in order to eat?
- How and when do you use energy to get food or eat?

Amazing feats for survival



IN THE APP



Feed the shark. Add hiding places for prey.

Reef sharks are apex predators. They're at the top of the food chain and will eat almost any other consumer. These sharks can grow up to 6 feet long and weigh as much as 220 pounds. Their powerful jaws and sharp teeth are specially adapted to swiftly debilitate large prey and cut through tough flesh and bone.

To survive alongside large, strong predators like reef sharks, many animals, including the **clownfish** and the **big blue octopus**, have developed behaviors to avoid being eaten. **Camouflage** and **commensalism** are just two of these remarkable feats.

Camouflage is a defense mechanism that enables animals to conceal themselves — to hide in plain sight — by blending into their surroundings.

An octopus can camouflage into many surfaces thanks to **chromatophores** on its skin. Chromatophores are groups of elastic, sac-like cells that are filled with red, brown, and yellow pigments. By expanding and contracting these cells, an octopus can expose different pigments and change the texture of its skin. This allows octopuses to mimic the appearance of virtually anything in their surroundings, including rocks, coral, plants, and sometimes even other animals.

Commensalism is another way prey protect themselves from predators. Like mutualism and parasitism, it's another symbiotic relationship between organisms of different species. In **commensal relationships**, one organism benefits while the other remains unaffected.

Clownfish, sometimes called anemonefish, have a commensal relationship with anemones.

Sea Anemones, while they look like plants, are actually marine animals. Like coral and jellyfish, they're cnidarians, complete with venomous tentacles. Clownfish have adapted a unique immunity to anemone venom. They are covered in a thick layer of mucus that protects them from the anemone's stings. So, clownfish are able to live within the safety of the anemone's tentacles while potential predators are quickly deterred by painful stings.

This unusual relationship provides clownfish with the perfect nesting grounds. A female clownfish will lay her eggs in the anemone's tentacles. There, a male will aggressively take guard and fan the eggs with his tail to oxygenate them. After 6 or 7 days, the eggs hatch and the clownfish larvae sink to the seafloor, where they develop protective mucus layers of their own.



DID YOU KNOW?

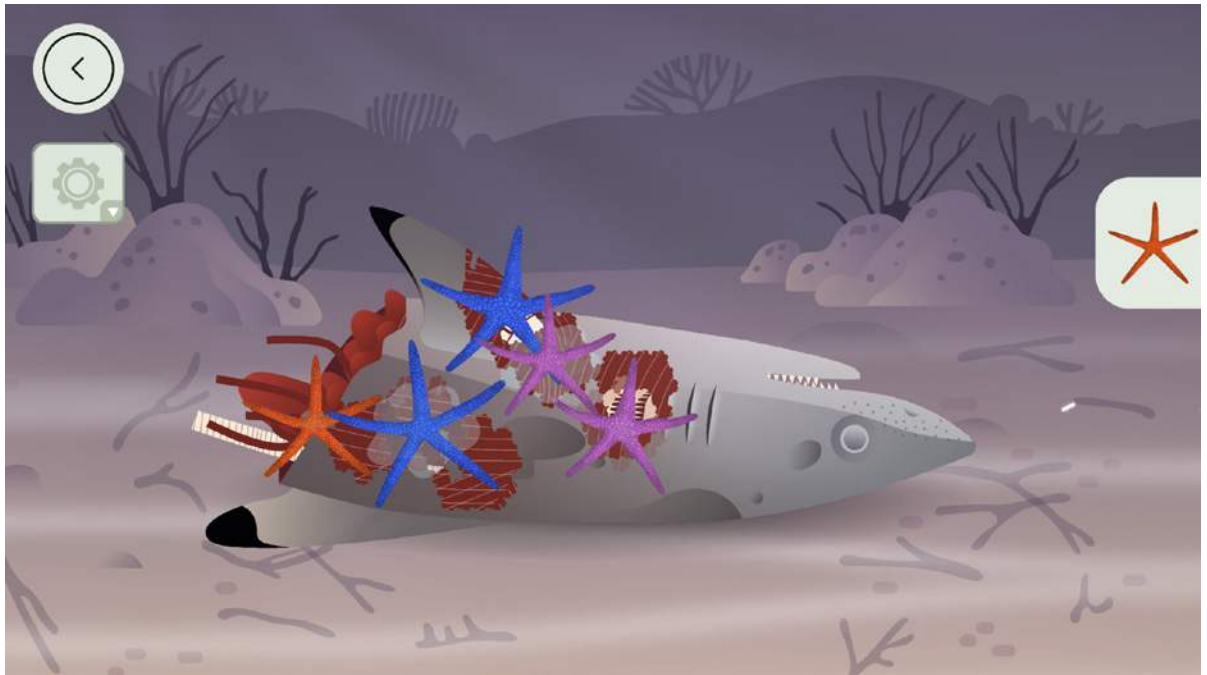
Because they have such voracious eating habits, shark teeth wear down quickly and break. Fortunately, sharks have developed a unique anatomical ability. Multiple rows of teeth run along their jawlines, enabling sharks to continuously shed old, worn teeth and replace them with brand new ones.



DISCUSSION QUESTIONS

- Can you think of any other animals that use camouflage to avoid being eaten?
- Can you think of an animal that has an adaptation that helps to eat? An animal that has adapted to avoid being eaten?

Life after death in the food chain



8

IN THE APP

Add sea stars to the seafloor or the shark.



All living things eventually die. When they do, they become food for **detritivores**, organisms that eat detritus. Detritus can be leaves that have fallen off plants, the molted shells or skins of animals, the remnants of anything dead, or poop. **Detritivores** are crucial to all ecosystems; they make **decomposition** happen. Decomposition is the process of recycling valuable nutrients from dead organisms so that they can be used again by living organisms.

There are two types of detritivores: **decomposers** and **scavengers**. **Scavengers**, like crabs or sea stars, eat **carrion**, decaying meat, from the carcasses of recently deceased animals, breaking the remnants down into smaller pieces and beginning the decomposition process.

Linckia sea stars are scavengers on coral reefs. Though often called starfish, sea stars are not fish. They are echinoderms, a type of animal

that includes sea urchins and sea cucumbers. Sea stars eat by pushing their stomachs out from their mouths and turning them inside out, in a process called **eversion**. Digestive enzymes liquify the dead prey so that it can be absorbed directly into the stomach. Once the sea star finishes eating, its stomach muscles contract, drawing the stomach back into its body and expelling anything inedible.

Bacteria and other **decomposers** continue the process that sea stars and other scavengers start. Bacteria break down the remaining nutrients in organic matter, eat what they need, and release the rest into the environment as waste. Plants and other producers eventually absorb these recycled nutrients and the cycle continues.



DID YOU KNOW?

Bacteria are important not only for the health of an Indo-Pacific reef system but also (potentially) for the health of our planet. Scientists hypothesize that the ocean bacterium pelagibacterales, the most abundant organism in the world, help regulate global climate.

These bacteria, scientists believe, produce a special chemical compound that helps clouds form more easily over ocean waters. Clouds reflect solar radiation back into space and help keep Earth's surface cool by blocking out the sun. While the exact relationship between bacteria and clouds is still uncertain, one thing is for sure—without bacteria, the world as we know it would be a very different place.



DISCUSSION QUESTIONS

- How would a coral reef be impacted if there were no starfish?
- Detritivores are found in every habitat. Think about the animals near your home. Which ones do you think are detritivores?

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