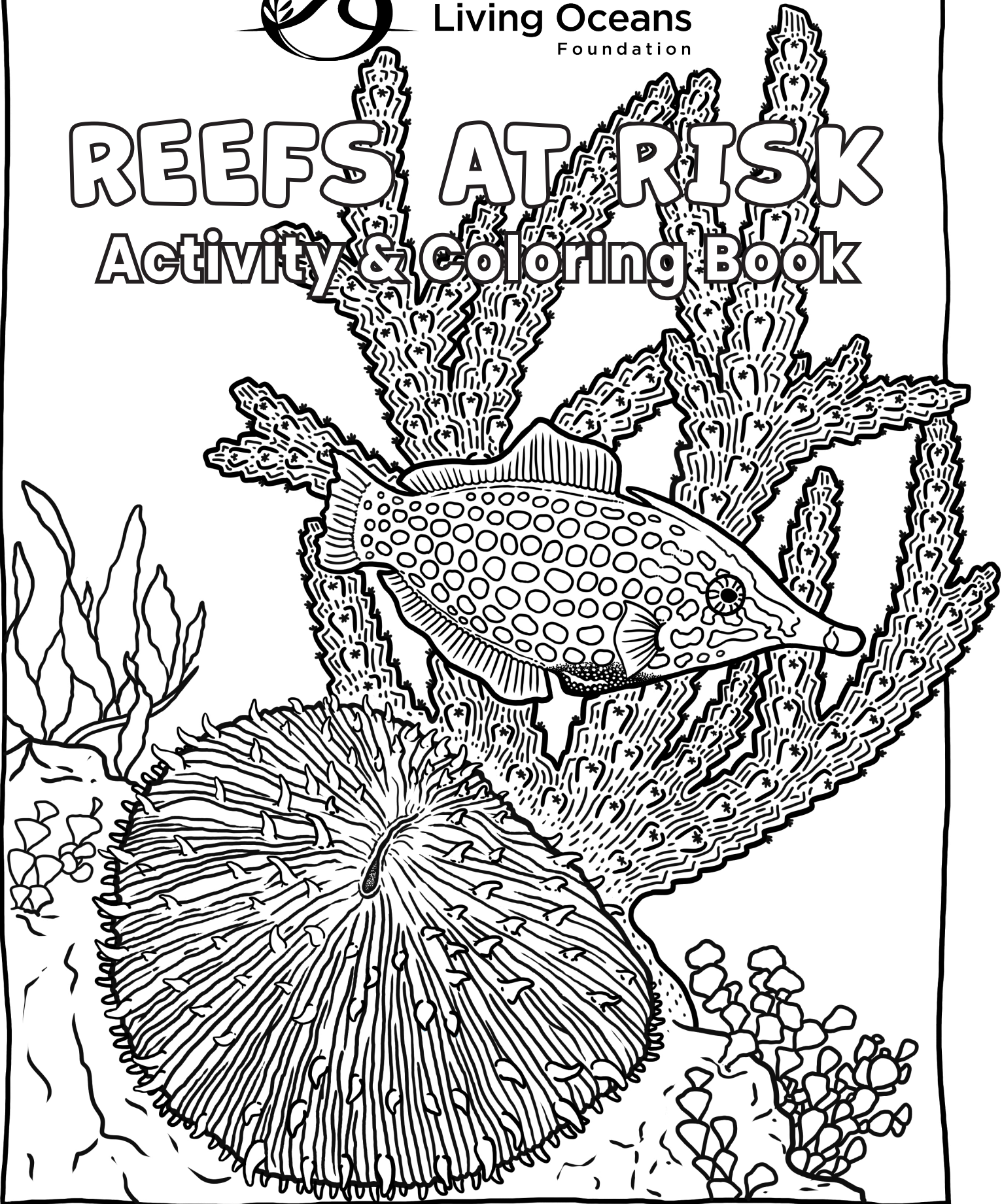




Khaled bin Sultan
Living Oceans
Foundation

REEFS AT RISK

Activity & Coloring Book



Illustrations by Ryan Sobel

STUDENT WORKSHEETS

THIS BOOKLET BELONGS TO: _____

INSTRUCTIONS: Read the information below and make sure to follow the instructions provided on each page. Use the indicated boxes to provide your answers.

UNDERSTANDING CLIMATE CHANGE

Just like the seasons change throughout the year, Earth experiences natural cycles of warming and cooling. In spring and summer, it gets warmer as the Earth tilts toward the sun, and in fall and winter, it cools down as the Earth tilts away from the sun. Similarly, Earth goes through long-term warming and cooling periods due to various natural factors, like changes in the sun's intensity and volcanic activity. However, human activities are causing an unusually rapid warming. In the past century, most of this warming has been attributed to human actions, which release **greenhouse gases** like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) into the air. These gases act like a cozy blanket, trapping heat in the Earth's atmosphere.

COLOR THE GREENHOUSE GAS BLANKET. DRAW ARROWS INDICATING WHERE THE HEAT GOES. LIST THE THREE GREENHOUSE GASES ON THE DIAGRAM.

The diagram illustrates the greenhouse effect. It shows a cross-section of the Earth with a sun on the left and a thermometer on the left side. On the right, there is a sun, a thermometer, and a factory emitting smoke. A large, dotted area above the Earth represents the atmosphere, with a teardrop-shaped callout containing many small circles representing greenhouse gas molecules. Below the Earth, three chemical structures are shown in circles with banners underneath: carbon dioxide ($\text{O}=\text{C}=\text{O}$), nitrous oxide ($\text{N}=\text{N}=\text{O}$), and methane ($\text{H}-\text{C}-\text{H}$).

WHAT ARE SOME HUMAN ACTIONS THAT ADD GREENHOUSE GASES INTO THE ATMOSPHERE?

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Just like a fever can make you feel sick, Earth's rising temperature affects its health too. Scientists watch important signs, like how warm the whole planet is getting. Changes are showing up all around us, like coral reefs bleaching, sea levels rising, and glaciers melting. **Climate change** doesn't just mean hotter days. It causes a mix of things like changing weather patterns, shifts in rain fall, and even impacting ocean chemistry.

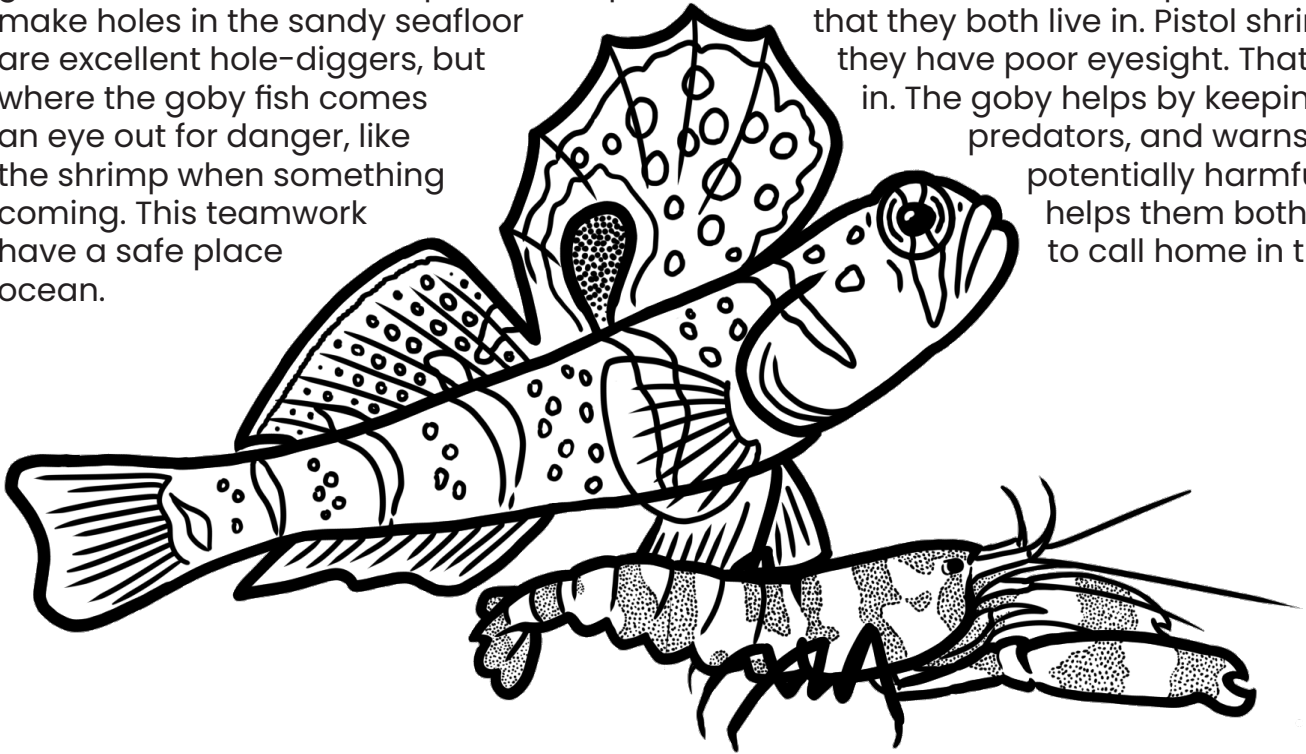
WHAT ARE SOME OTHER SIGNS THAT THE CLIMATE IS CHANGING?

CORALS' PARTNERS

Corals have tiny partners called **zooxanthellae** that live within their tissues. Corals and zooxanthellae form a **symbiotic relationship**, both benefiting from their partnership. Zooxanthellae give corals their color. More importantly, they also **photosynthesize**, providing corals with up to 95% of the food that they need to survive. Without them, corals won't survive for long. In return, corals provide nutrients to the zooxanthellae and a safe home to live in.

In the drawing you see below, there's another cool symbiotic relationship between gobies (a kind of fish) and pistol shrimp. These two animals can partner to make holes in the sandy seafloor that they both live in. Pistol shrimp are excellent hole-diggers, but they have poor eyesight. That's where the goby fish comes in. The goby helps by keeping an eye out for danger, like predators, and warns the shrimp when something potentially harmful is coming. This teamwork helps them both have a safe place to call home in the ocean.

These two animals can partner to make holes in the sandy seafloor that they both live in. Pistol shrimp are excellent hole-diggers, but they have poor eyesight. That's where the goby fish comes in. The goby helps by keeping an eye out for danger, like predators, and warns the shrimp when something potentially harmful is coming. This teamwork helps them both have a safe place to call home in the ocean.

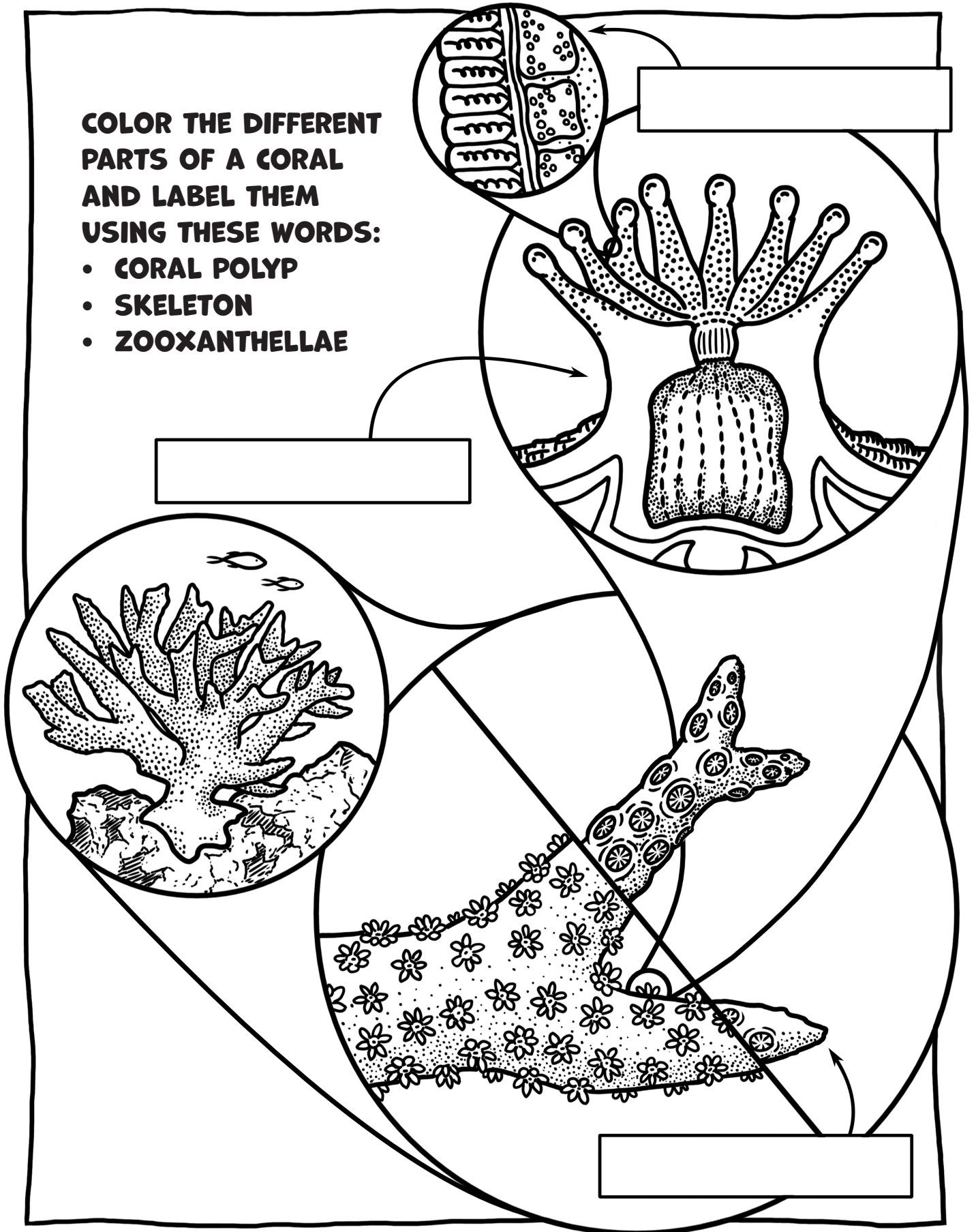


PROVIDE ONE OTHER EXAMPLE OF A SYMBIOTIC RELATIONSHIP. LIST EACH ANIMAL AND DESCRIBE EACH ANIMALS' RELATIONSHIP WITH THE OTHER.

CORAL ANATOMY

COLOR THE DIFFERENT PARTS OF A CORAL AND LABEL THEM USING THESE WORDS:

- CORAL POLYP
- SKELETON
- ZOOXANTHELLAE



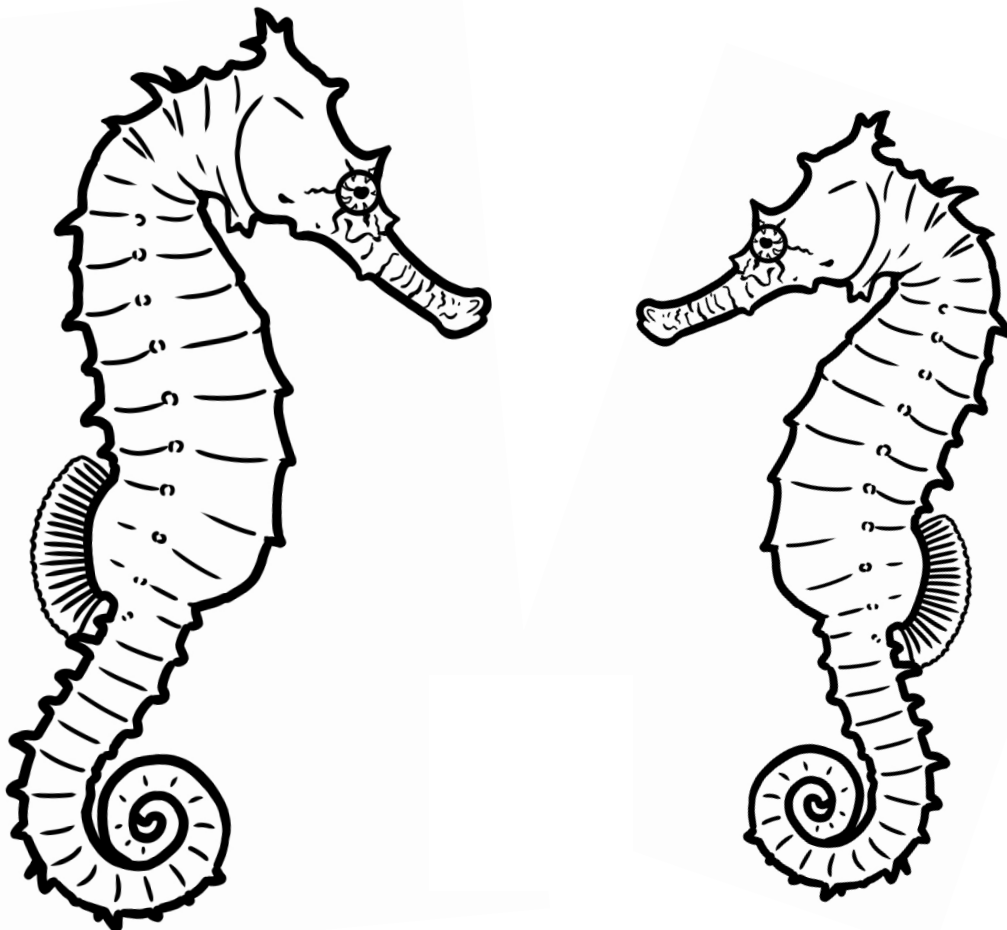
CORALS IN TROUBLE: BLEACHING

Climate change is also having a profound impact on wildlife and **ecosystems** around the world, even in the ocean. As the Earth warms up, some of that heat is absorbed by the ocean, increasing its temperature.

Warmer than usual waters can stress corals, just like a fever stresses our bodies. When corals are stressed, they expel the zooxanthellae into the surrounding water. The corals appear white or “bleached,” revealing their hard calcium-like skeleton underneath. If high water temperatures continue, corals might starve and die without their partners; however, if conditions improve, the zooxanthellae can be reabsorbed into their tissues, continuing their relationship.

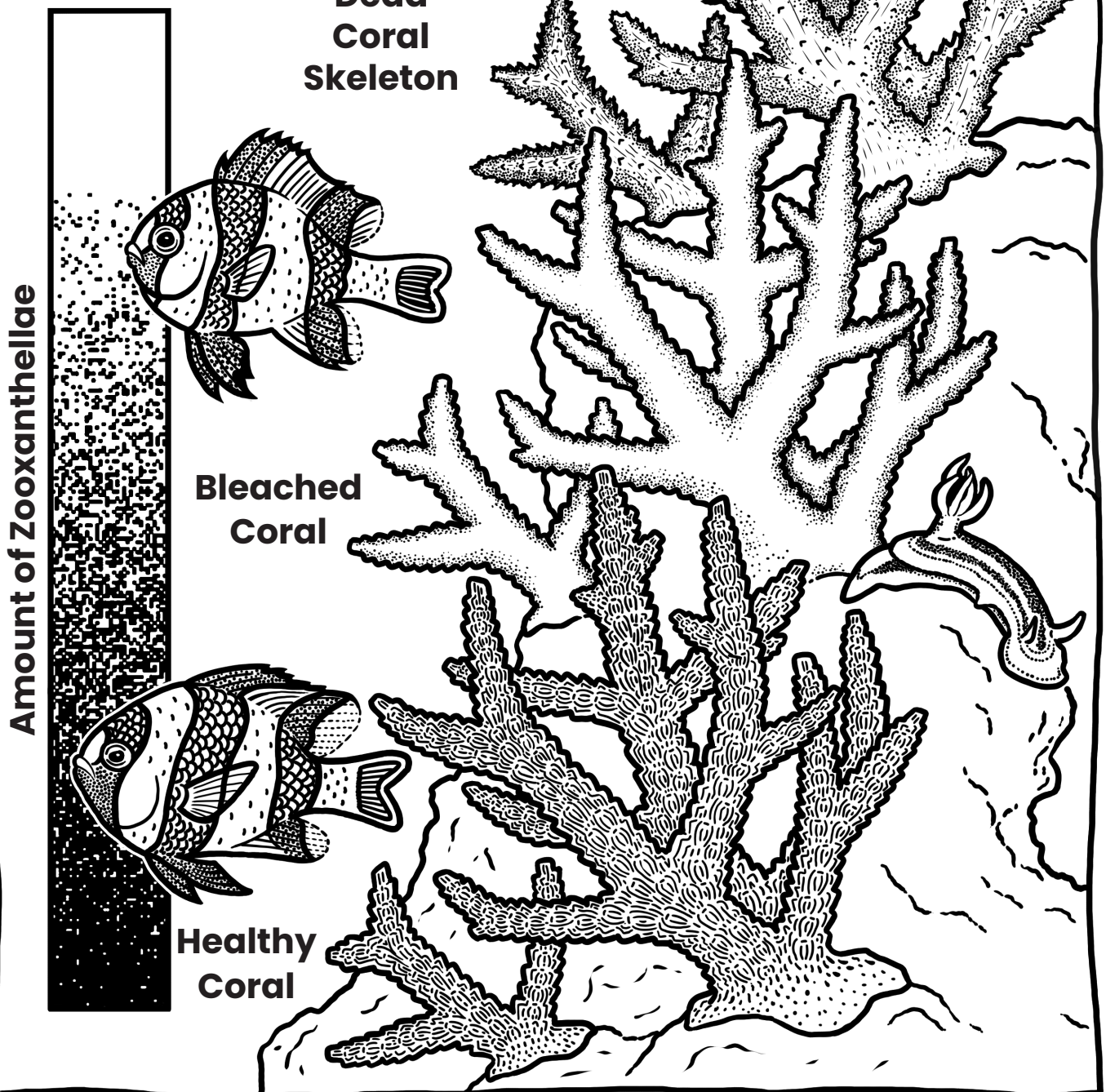
When you’re not feeling well, your body works hard to get better. But if another illness comes along, it makes your recovery even more challenging, and your body has to put in extra effort. Similar things can happen to bleached corals. When corals bleach, they’re already under a lot of stress and not getting the right nutrients from their partners, the zooxanthellae. If something else, like harmful chemicals or a coral disease, shows up when the corals are already struggling, it becomes even tougher for them to get better.

Most coral bleaching happens when the ocean gets too warm. But other things can cause it too, like too much sunlight, changes in water chemistry, and even pollution from chemicals.

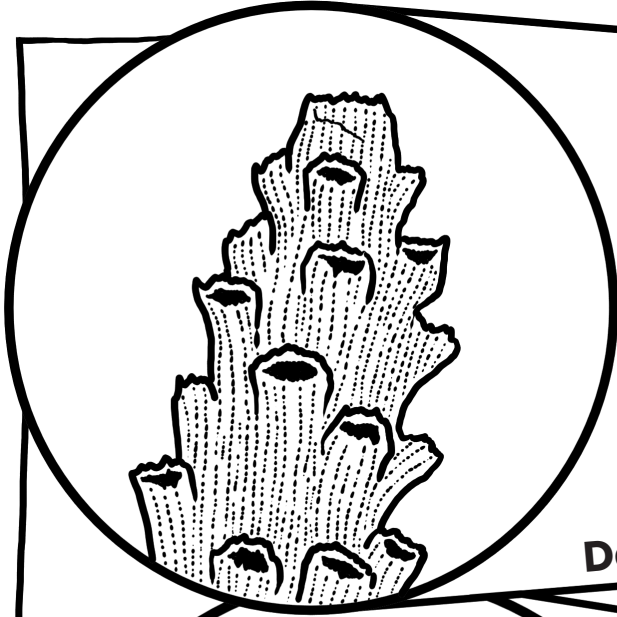


CORAL BLEACHING

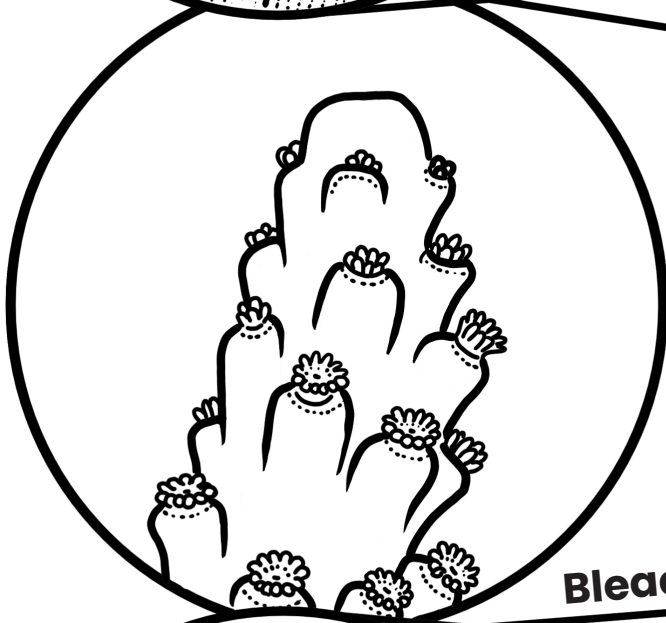
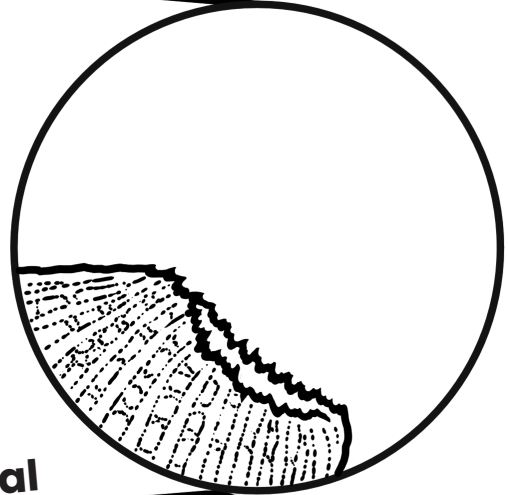
COLOR EACH CORAL TO SHOW HOW MANY ZOOXANTHELLAE SHOULD BE IN HEALTHY, BLEACHED, AND DEAD CORALS ON THIS PAGE AND THE NEXT ONE.



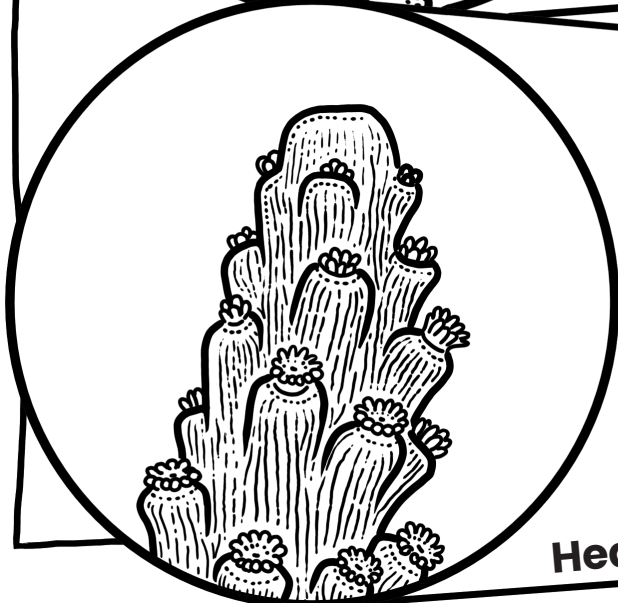
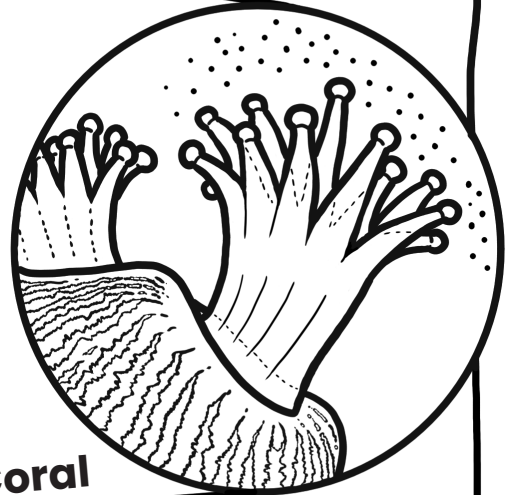
CORAL BLEACHING



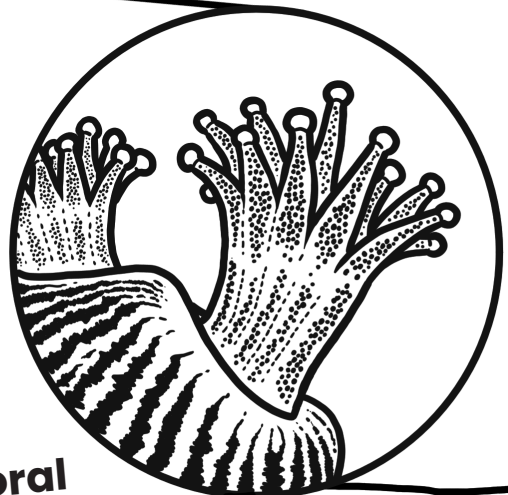
Dead Coral



Bleached Coral



Healthy Coral



MASS BLEACHING EVENTS: A DISTURBING TREND

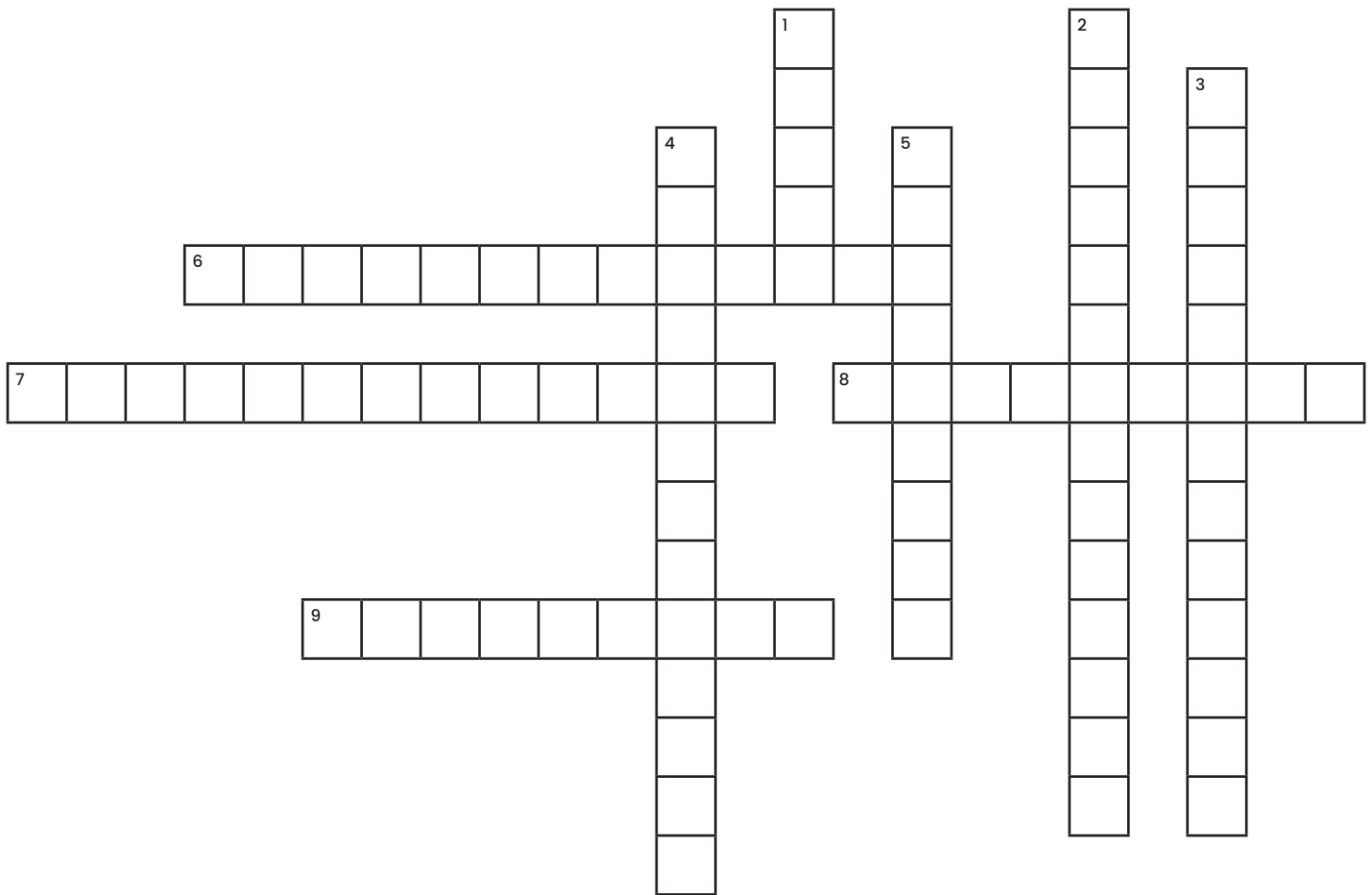
Mass bleaching occurs when many corals in one area, or even across large parts of the ocean, all experience a stressful event at the same time. Entire reef systems can be affected that can span tens to even thousands of kilometers. The main cause of these events is when the sea temperatures stay high for a long time. Scientists are worried because, over the past few decades, these events are occurring more often and are becoming more severe. This is yet another warning sign that something bad is happening in our ocean.

If we don't take action to stop putting lots of greenhouse gases into the atmosphere, mass bleaching will continue to harm coral reefs. It's not just the corals that will be in danger. Corals are the foundation of the coral reef **ecosystem**. When corals bleach, this disrupts the entire coral reef ecosystem and impacts the countless marine species that depend on the reef for survival.

WHAT ARE SOME ANIMALS OR PLANTS THAT LIVE IN THE CORAL REEF ECOSYSTEM, AND HOW DO THEY RELY ON IT?



SOLVE THIS FUN CROSSWORD PUZZLE BY USING THE NEW WORDS YOU'VE LEARNED IN THIS BOOKLET.



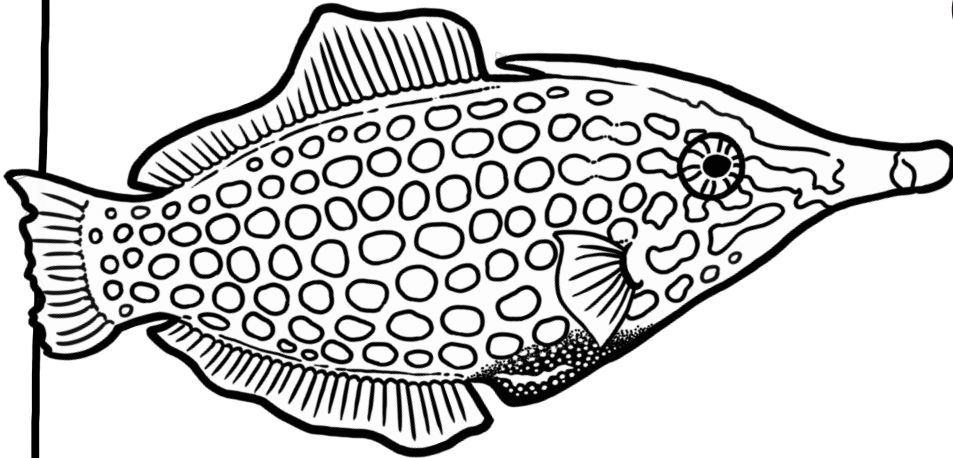
DOWN

1. These marine animals create a hard calcium carbonate skeleton beneath their soft bodies, which helps build reefs.
2. The process that plants or other organisms use to convert light energy into chemical energy.
3. A long-term shift in average temperature and weather patterns.
4. Gas in the Earth's atmosphere that trap heat, including carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and fluorinated gases.
5. When zooxanthellae are expelled from a coral's tissues due to extreme changes in environmental conditions, causing the coral to appear white.

ACROSS

6. Yellow-brown symbiotic algae that live in the tissues of corals and other marine invertebrates.
7. Large-scale bleaching events are typically triggered by a rise in average sea temperature for prolonged periods of time.
8. An ecological level of organization that includes all the living factors, the nonliving factors, and how they interact.
9. A close ecological relationship between the individuals of two (or more) different species.

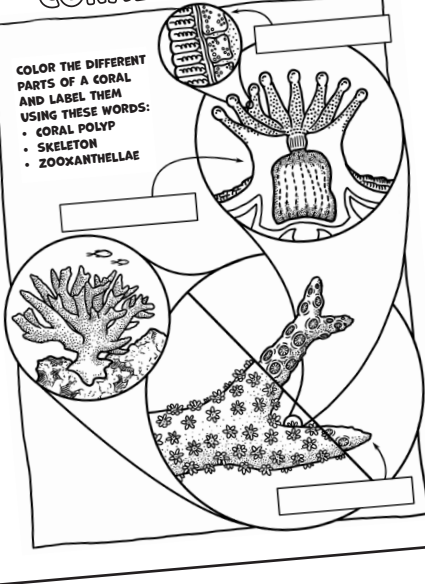
SEE WHAT LIES BENEATH!



CORAL ANATOMY

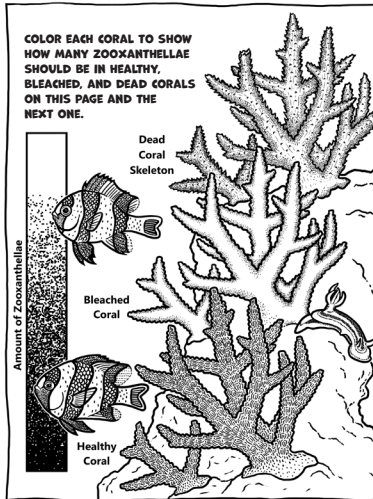
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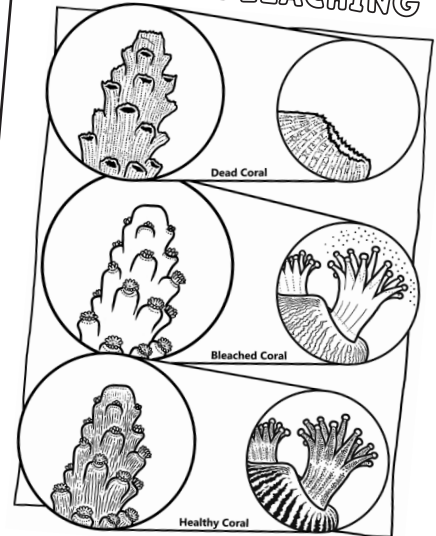


CORAL BLEACHING

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CORAL BLEACHING



**Khaled bin Sultan
Living Oceans
Foundation**

The Khaled bin Sultan Living Oceans Foundation is a US-based nonprofit environmental science organization. The Foundation was established to protect and restore the world's oceans through scientific research, outreach, and education.