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How can nanoparticles help coral reefs?

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Abstract

Did you know that coral reefs are like incredible underwater cities built by corals? They protect coastlines and provide homes for many marine species, including tiny algae that live inside the coral. These algae have a special deal with the coral – they share nutrients and give the coral its colorful beauty. But there's trouble! Rising ocean temperatures from climate change stress the corals. This makes coral lose their colorful algae partners in a process called coral bleaching. It's bad news for both the corals and the reefs.

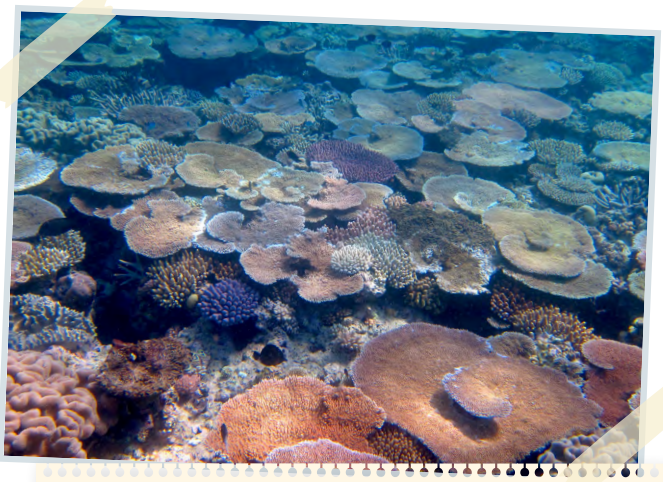
We made a drug for the algae to help fight the harmful effects of stress. The algae are small, so we made ceria nanoparticles that the algae can easily absorb. This protected the algae from harm, even when seawater temperatures were warm!

Introduction

Coral reefs protect coastlines from erosion and flooding by strong waves during storms and hurricanes. They also provide a home for nearly a quarter of all marine species! Some of these marine species are microscopic **algae** that live inside the coral **cells**. In the safety of the coral's shelter, the algae **photosynthesize** using green pigments like **chlorophyll**. This process provides nutrients to both the algae and coral. The association between the algae and the coral gives the coral most of its color. The mutually useful relationship between algae and coral is called **symbiosis**.

Unfortunately, as ocean temperatures rise due to **climate change**, the coral become stressed. When it's stressed, it loses its symbiotic algae (and their color). We call this change **coral bleaching** because the coral looks white. Coral without its symbiotic algae usually dies. Once a reef dies, it rarely comes back. The coastlines lose protection and other marine species lose their home.

Scientists have noticed that stressed coral has increased levels of highly reactive **molecules** that contain oxygen (called free radicals or **reactive oxygen species**). Both algae and coral cells produce these reactive molecules. We had an idea for a drug that might reduce them in both partners. But these free radicals are very small, so we needed to figure out a way to reach them with the drug. In the lab, we made **ceria nanoparticles** that can counteract these free radicals. We set off to test if these small particles could prevent bleaching and protect coral reefs.



The Great Barrier Reef in Australia. Coral reefs are essential habitats for many marine species, including algae, oysters, urchins, and many fish. **Photo:** Liza Roger

Methods

We used algae and **sea anemones** to model the coral. Sea anemones are relatives of coral and easier to experiment with in the lab (Fig.1).

We mixed specific chemicals to make the ceria nanoparticles. We coated the nanoparticles with a **polymer**. This helped keep the nanoparticles suspended in water. Then we added a glowing dye to the nanoparticles so that we could see them better under a **microscope**. Our glowing nanoparticles were taken up by the algae in seawater. We measured absorbance over 3 weeks. This told us if the nanoparticles had a negative effect on the algae growth and multiplication.

We measured the amount of free radicals inside the algae that had received the nanoparticles and those that had not (the **control**). We also wanted to see how well the nanoparticles worked at different temperatures. We tested them at a normal seawater temperature (27°C/81°F) and at a warmer, stressful temperature (34°C/93°F).

The algae with ceria nanoparticles were then delivered to the sea anemones. We used a microscope to check if we could see the nanoparticles glow inside the algae within the anemone. If they did, we had been successful!

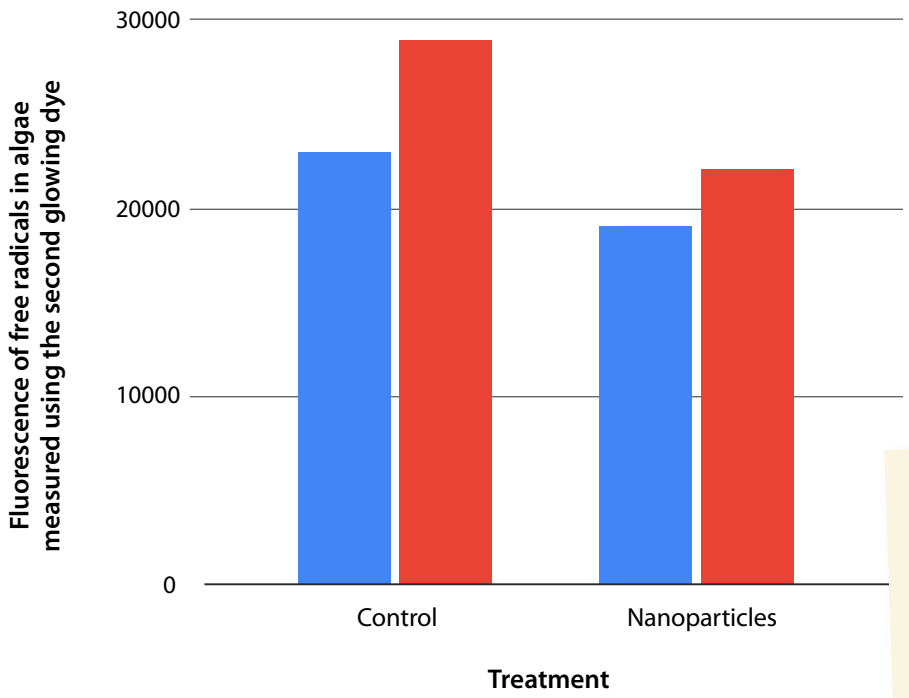
Figure 1:
Sea anemones are relatives of coral. We used them to model the coral in the lab.

Results

We made several important discoveries from our experiments:

- The algae took up the ceria nanoparticles within 30 minutes.
- After 3 weeks inside the algae, the nanoparticles did not impact algae growth.
- Algae that had nanoparticles inside were successfully delivered to the sea anemones.
- The ceria nanoparticles inside the algae helped decrease the amount of free radicals at both temperatures (Fig.2).

Please see Figure 2 on Page 3



How do the nanoparticles affect the amount of free radicals in algae?

Figure 2:
The amount of free radicals in untreated algae (the control) and ceria nanoparticle treated algae. Free radicals are an indication of stress in algae. We tested these amounts one hour after exposure at two different water temperatures: 27°C (81°F) and 34°C (93°F).

Discussion

We were amazed how well the ceria nanoparticles worked inside the algae! After 3 weeks, the algae continued to grow normally. This showed us that the ceria nanoparticles can be given to algae at a safe dose. This was important as we did not want to damage the algae while trying to protect them.

The nanoparticle-based drug reduced free radical concentration in the algae. This happened at both normal seawater temperature and warm seawater temperature. This protected the algae when they faced **thermal stress**.

We plan to test the ceria nanoparticles on algae and coral taken from the ocean. This will confirm if our results with the anemone transfer to coral. We also want to check how long the nanoparticle-based treatment is effective for.

We have discovered that our ceria nanoparticles can help reduce the risks of bleaching. But other applications of nano-based treatment could also help fight things like coral diseases and boost growth.

Conclusion

Our research may help coral survive warmer ocean temperatures, but there's more we can do! Climate change is ongoing, and we must act to stop our oceans from getting warmer. You can help slow down climate change in lots of small ways.

- Turn off lights, computers, TVs, etc. when you're not using them.
- Walk or ride your bike instead of hopping in the car for short journeys.
- Put on a sweater instead of turning up the heat. And open a window in warmer weather, rather than blasting the air-conditioning.

You can also contact your local representative. Ask them what water companies are doing to reduce their carbon dioxide emissions, which cause climate change. Together, we can protect our marine life and the environment.

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Glossary of Key Terms

Algae - a large, diverse group of photosynthetic organisms. The microalgae we looked at live inside coral and have a special relationship with them. They provide nutrients and help give coral its color.

Cell - the smallest and most basic unit of life. Some tiny organisms (e.g. bacteria and yeast) consist of only one cell. Large plants and animals have many billions of cells.

Ceria nanoparticles - extremely small particles with diameters less than 10nm (nanometers). In this study they had a diameter of around 4nm. They are composed of cerium oxide or CeO_2.

Chlorophyll - green pigments in plants, including algae, that help them capture energy from sunlight and use it to make energy through a process called photosynthesis.

Climate change - changes in the Earth's temperature and weather patterns, caused by human activities that release greenhouse gasses into the atmosphere.

Control - a sample that isn't changed or tested. We need this to make sure our experimental treatment actually made a difference.

Coral bleaching - a process where stressed corals lose the tiny algae living inside them. The loss of algae makes coral look white, which is a sign of poor coral health.

Microscope - an instrument that makes small objects appear larger. It allows scientists to see tiny details that are not visible to the naked eye.

Molecule - a particle made up of a group of atoms that are chemically bonded.

Photosynthesis - the process by which plants, like algae, use sunlight to turn water and carbon dioxide into sugars and oxygen.

Polymer - a very big molecule made up of many smaller molecules layered together in a repeating pattern.

Reactive oxygen species (ROS) - highly reactive molecules (free radicals) produced by both algae and coral cells when they're stressed.

Sea anemones - small marine animals with many tentacles arranged around their mouth, like petals on a flower. Sea anemones live attached to rocks or directly to the seafloor.

Symbiosis - a mutually beneficial relationship between two different organisms, such as the partnership between coral and algae.

Thermal stress - stress caused by changes in temperature. Here, this refers to the harmful effects of warm water on coral and their algae partners.

Check your understanding

1. What is the relationship between algae and coral?
2. What is coral bleaching?
3. How did we plan to prevent bleaching using nanoparticles?
4. What evidence did we find to show the nanoparticles were successful at reducing the stress that causes bleaching?
5. Why is the relationship between algae and coral important for coral reefs? In pairs, create a poster to show the impact of the relationship between the two organisms.

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