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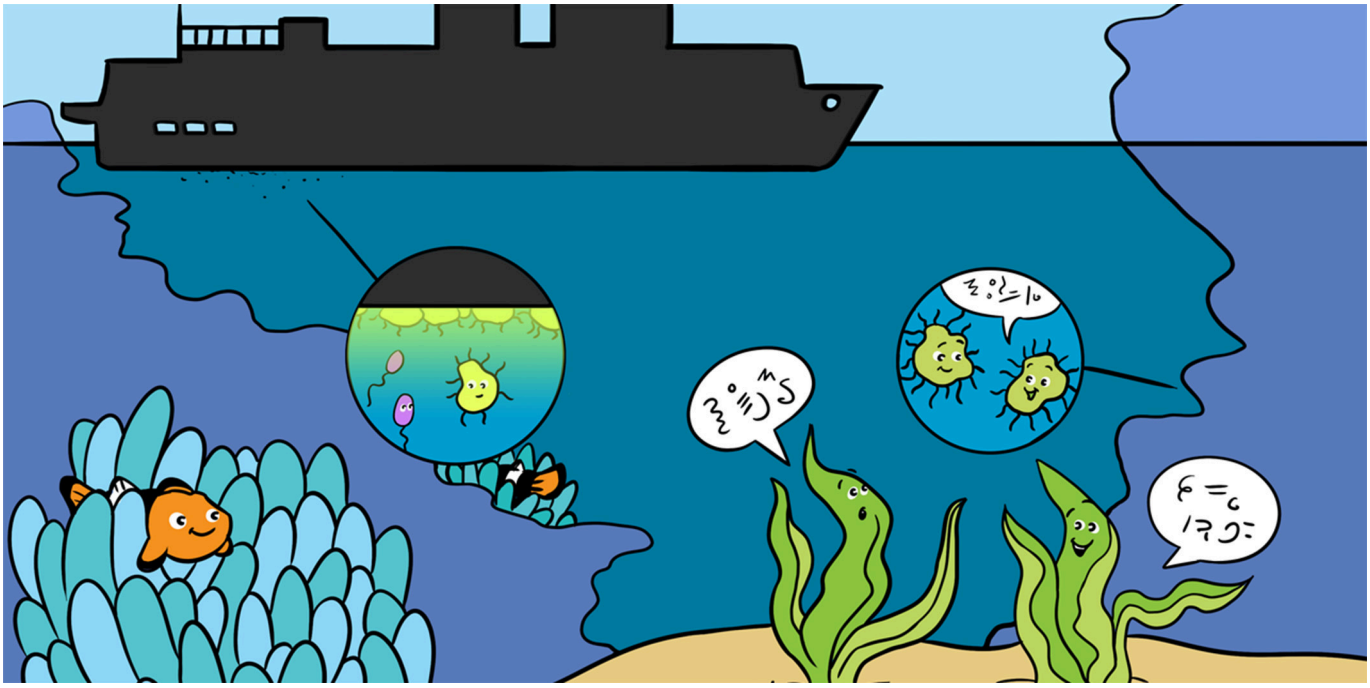

"LANGUAGE OF LIFE" OF NEMO, DORY, AND THEIR MARINE FRIENDS

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YOUNG REVIEWER:

MIMI

AGE: 10

Our oceans host more than 230,000 species of marine life. Did you ever wonder how these organisms communicate? What you saw in "Finding Nemo" is clearly not the way it works in the real world! Marine plants and animals, even those that can see and hear like Nemo and Dory mostly "talk" using special signaling compounds collectively called infochemicals. Infochemicals are the "language" of our oceans. However, this language is under threat from climate change, which is changing the production and characteristics of infochemicals. In this article, I will provide an overview of the diverse use of marine infochemicals, how climate change can disrupt the language of our oceans and what you can do to help save the language of our marine friends.

INFOCHEMICALS: THE LANGUAGE OF OUR OCEANS

We humans today use about 1,500 different languages to communicate. But do you know that the plants and animals around us also have

languages that allow them to "talk" to each other? Both land and water plants and animals have a special chemical "language" that they use to communicate. These communication chemicals are called **infochemicals** (information-carrying chemicals). When a bee visits a flower, it is not just random! The flower releases infochemicals that the bee can sense, which invite the bee to visit the flower and help the flower to pollinate. So, the next time you see a bee visiting a flower, maybe you will think about the role that infochemicals play for the beautiful flowers around us.

INFOCHEMICALS

Information-conveying chemicals that can help microbes, plants, and animals to talk to each other.

What about marine animals and plants, those that live in the oceans? We know that some marine animals communicate using sounds, like the dolphins producing clicking sounds or the singing of whales [1], but this is not the only way for marine organisms to talk to each other. Marine organisms mostly talk to each other using infochemicals, which are known as the "language of life" in the sea [2]. Infochemicals carry instructions, telling marine organisms whether they should eat, fight with, run from, or make babies with the creature next to them! Marine plants use infochemicals to protect themselves from their enemies or to invite helpful bacteria to live on them, which can benefit the plant. Infochemicals can be simple molecules or complex compounds and are present just about everywhere in the marine environment. This science of studying marine infochemicals and how they help organisms communicate and manage their day to day life is called marine chemical ecology. People who study marine chemical ecology are called marine chemical ecologists.

WHICH MARINE ORGANISMS USE INFOCHEMICALS AND WHY?

Infochemicals are used by many different organisms, from **microbes**, like tiny bacteria, all the way up to gigantic sharks. Keep reading to see how various marine organisms use infochemicals in their day-to-day lives in the ocean.

MICROBES

Tiny organisms like bacteria, fungi, and viruses that are not visible to the naked eye, so special microscopes are needed to see them.

Bacteria

Even very simple organisms like bacteria "talk" to each other using infochemicals. When bacteria start to grow on solid surfaces in the ocean, like hulls of ships and oil rigs, they start producing a slimy community called a "biofilm," where lots of bacteria live and take shelter. These marine biofilms can emit infochemicals, telling other bacteria to join and live in the biofilm. Infochemicals released by bacterial biofilms can also attract other types of marine organisms, like tiny **algae**, larvae of animals like mussels, and barnacles. These organisms respond to the infochemicals by locating and settling on the solid surfaces where the biofilms are growing.

ALGAE

The aquatic version of land plants. Algae are simple plants that do not have flowers, roots, stems, or leaves. They can be very diverse, from single-celled forms to multi-cellular forms like seaweeds.

Phytoplankton

Phytoplankton are microscopic, unicellular (one-celled) algae that live in the oceans. Did you know that 50% of the oxygen you breathe is produced by phytoplankton drifting around in the oceans? Even drifting algae like phytoplankton have enemies like bacteria and grazers. Like the way humans clean their teeth every morning with a toothbrush, phytoplankton like *Nitzschia* can produce a burst of defense chemicals every morning, to clean the biofilm around them and thus stay healthy. Other plankton can form clusters as soon as they sense the presence of infochemicals released by predators. They make big enough clusters so that they cannot be consumed by the predator. Smart guys!

Seaweeds

Seaweeds, also called macroalgae, also use infochemicals to communicate. Seaweeds can both make infochemicals themselves and benefit from the infochemicals of helpful bacteria that grow on the seaweeds. Marine macroalgae are very rich sources of food for bacteria, and they also provide bacteria with a safe place to hide from predators. Some of the infochemicals produced by the seaweed's helpful bacteria help the seaweed grow and develop properly. We would not have sushi without these helpful bacteria. The seaweed *Pyropia* is used to make sushi. Good bacteria helps *Pyropia* to have the right shape and size to make sushi.

Not all bacteria are good for seaweeds, though. Seaweeds also have bacterial enemies that can make seaweed sick and even lead to death. To combat these bacterial enemies, some seaweeds produce infochemicals known as defense chemicals that can keep the enemy bacteria away or reduce their settlement while encouraging the settlement of the helpful bacteria. This selection process is called "microbial gardening." Some seaweed does not produce defense chemicals themselves, but rather harbor certain helpful bacteria that can produce defense chemicals to protect the algae. Defense chemicals are not just used against harmful bacteria but also against other colonizers [3], like larvae of mussels, barnacles, and some other kinds of algae. These colonizers can compete with the seaweed for food or other resources or can reduce the amount of light that reaches the algae, interfering with photosynthesis. Infochemicals can also keep the seaweeds safe from grazers that want to eat them, like snails and plant-eating fishes. These infochemicals sends message to the grazer, "Hey, I am toxic and will attack you with my defense weapons if you try to eat me."

Sponges and Corals

Like some ocean plants, there are some non-mobile animals in the ocean too, and some of these, like sponges and corals, can also produce infochemicals. Infochemicals are very important for both plants and non-mobile animals, because they do not have other

ways to communicate, like eyes, ears, noses, or mouths. They also spend their whole lives in one place and cannot run away when an enemy is around. So, they have to use infochemicals to fight against their enemies.

Fishes and Other Animals

Young reef fishes, like the orange clown fish Nemo, can also sense and respond to infochemicals. These fish are attracted to infochemicals that are released from areas where a lot of coral lives, and they can use these infochemicals, along with the sounds of the reef, to locate reefs where they can live until they grow up. Communication using marine infochemicals does not just happen in water. Some gaseous infochemicals can also be transmitted into air, where some seabirds, like albatrosses and petrels, can sense them. For example, when phytoplankton are attacked by grazers like zooplankton (which are tiny animals that some fish feed on), an infochemical called dimethylsulphide (DMS) is released into the air. The birds sense the DMS and it helps them to track areas packed full of tasty fishes.

These are just few examples of how marine animals use infochemicals to communicate. Infochemical communication is present everywhere in the ocean and it is very important for keeping the marine ecosystem healthy.

CLIMATE CHANGE IS CONFUSING THE INFOCHEMICAL LANGUAGE!

Most of you have probably heard about climate change and the damaging effects it is having on many different ecosystems. Climate change is affecting our oceans in a number of ways. It is causing ocean temperatures to rise and the seawater to become more acidic (also known as ocean acidification). All these changes can be dangerous for the organisms that live in the ocean, but there is more. The changes in the ocean caused by climate change can also potentially interfere with infochemicals, making it very difficult for marine organisms to communicate properly. Over the last decade, research has shown that ocean acidification can do several things to infochemicals: acidification can (a) change the molecular structure of the infochemicals [4], (b) cause them to be produced differently, and (c) prevent the infochemicals from being recognized by other organisms [5].

An experiment was performed to demonstrate the effect of acidification on infochemical communication. Clownfish larvae (the same type of fish as Nemo) raised in seawater with a normal pH of 8.15 could use infochemicals to tell the difference between good and bad places to live and between fish that were related to them and fish that were not related. However, when the larvae of clown fish were raised in seawater with a pH of 7.8, which is more acidic, they

could no longer sense infochemicals appropriately and the larvae were attracted to infochemicals that they normally avoided under normal pH. So, another negative affect of climate change could be that it confuses the language of life in the sea.

DO YOU WANT TO HELP SAVE THE LANGUAGE OF OUR MARINE FRIENDS?

There are many things all of us can do to help save the language of our marine friends. One way is to reduce how much plastic you use. Unfortunately, a lot of plastic waste ends up in the oceans. You may wonder how plastic can disrupt the infochemical language. Scientists have recently shown that plastics that are in the ocean for a long time can accumulate biofilms that release the infochemical DMS, which I discussed earlier. This DMS can get into the air and may confuse seabirds that use the scent of DMS to help them find food. Another way to help our marine friends is to slow down climate change. Man-made carbon dioxide (CO_2) emissions are the main cause of climate change. You can help to slow down climate change by choosing to do things that produce less carbon dioxide. For example, you can ride your bike to school instead of traveling by car or bus. We need to educate the citizens of the world, using science, and encourage them to protect our blue planet and the language of infochemicals. Maybe you and your friends can form a team to help educate people about the danger climate change poses to communication in our oceans. We all need to make a conscious effort to help save our blue planet and the language of our marine friends!

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CONFLICT OF INTEREST STATEMENT: The author declares 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 REVIEWER

MIMI, AGE: 10
Hi! My name is Mimi. I am interested in genetics, neurology, and anything to do with DNA. When I am older, I want to become a police officer and use DNA analysis to track down criminals.

AUTHOR

MAHASWETA SAHA
I am a Research Fellow at Plymouth Marine Laboratory (Plymouth, United Kingdom) and a marine chemical ecologist by training. My passion is to investigate 'language of life' of our oceans.

My day to day work involves collecting seaweed samples from the intertidal areas, bringing them back to the lab and processing for further chemistry and microbiology work. I also run climate change experiments to investigate the effect of climate change stressors on different types of seaweeds and their associated bacteria. My profession gives me the opportunity to travel and present my research worldwide, meet new people, visit different places and enjoy different food and traditions.

In my free time, I enjoy gardening, bird watching, photography.
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