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Celebrating Chemistry

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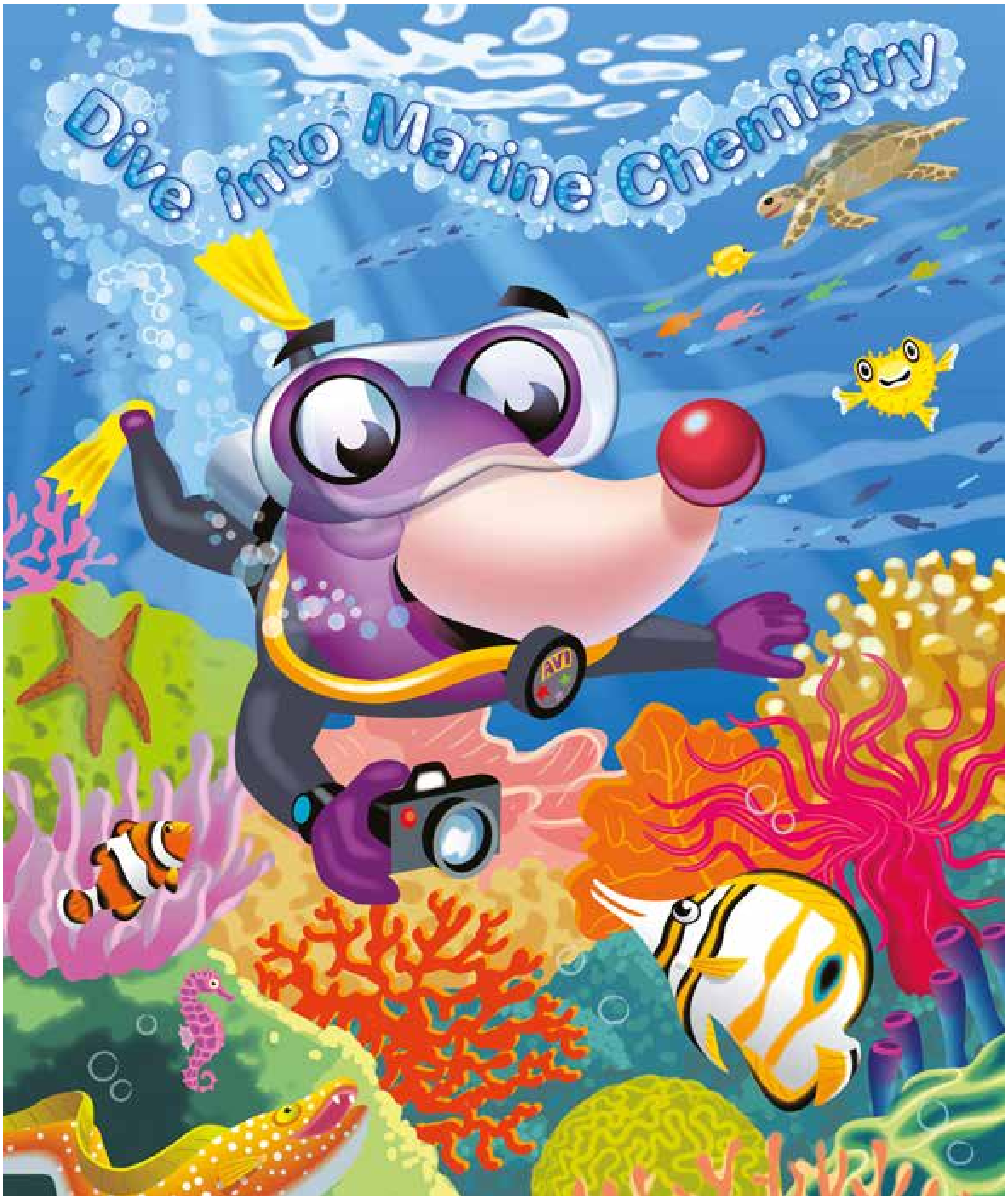


Dive into Marine Chemistry!

By Alex Madonik

When you think of the ocean, what images come to mind? Huge waves? Giant whales? Mysterious shipwrecks? Oceans cover almost three-quarters of the earth's surface and can be miles deep, so they are indeed full of wonders. Life on our planet began in the oceans, and today the oceans are full of tiny organisms that, together, weigh more than everything that lives on land! The oceans also absorb carbon dioxide and produce oxygen in a cycle that is essential for all life on earth.

Marine chemists study the oceans to understand these cycles. They also find food and useful chemicals in the oceans, in everything from fish to seaweed.

Unfortunately, these chemists also find waste products from our daily lives. Plastic bags and nets injure birds, fish, and marine mammals. Tiny plastic particles fill the water thousands of miles from land. These particles harm marine life, not only because they are dangerous if swallowed, but also because they attract oily chemicals that are poisonous to birds and fish. Chemicals that escape from factories and even our homes flow into the ocean. Pollution comes from small leaks and big spills.

The first time you visit the ocean, you might be surprised by how salty the water is. Unlike rivers and lakes, the oceans contain about 3.5% salt by weight (mostly sodium chloride — the same as table salt). You can collect sea salt by evaporating the water in the sun, as people have done for thousands of years. As the water evaporates, the salt becomes more concentrated. Certain kinds of colorful **algae** and shrimp can grow in this salty solution, which is called **brine**.

Curiously, scientists are not certain about where all the water on earth came from. When the earth formed 4.6 billion years ago, it was too hot to keep water around. It's possible that water arrived much later, carried by comets or asteroids that collided with the earth.

The salt in the ocean started out as minerals on the land that dissolved and were carried to the sea by rain. Some turned into solid rocks such as limestone (calcium carbonate), the same material that seashells and corals are made out of. Table salt is very soluble in water, so it accumulates in the ocean. Two famous bodies of water that are very salty are the Great Salt Lake in Utah and the Dead Sea in the Middle East. Because these lakes are not connected to rivers or creeks that can carry water away, the water can only evaporate, leaving behind the salt it contained. Salt mines are ancient salt lakes that completely dried up and were buried under deep layers of sediment.

The deep oceans contain many creatures that survive without light. Without light, no plants can grow there, but some creatures make energy from elements in the water such as sulfur or iron in a process called chemosynthesis. Many deep-sea creatures make their own light through a process called bioluminescence — like underwater fireflies! The deep ocean can be very cold, or it can be boiling hot near undersea **thermal vents**. Amazing creatures live there also, and chemists are still studying their secrets to figure out how they survive.

In this issue of *Celebrating Chemistry*, you'll learn more about topics like minerals in the ocean, oil spills, and bioluminescence. So join us in taking a dive into marine chemistry!

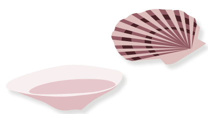
Alex Madonik, Ph.D. *is an Instructor of Chemistry at Peralta Community College in Oakland, California.*

Seashells: Antacids of the Ocean

By Jacqueline Erickson

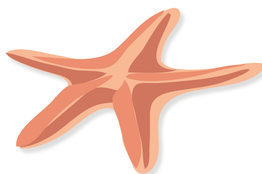
Introduction

Have you ever wondered what **coral** or seashells are made of? Coral and some seashells contain a mineral called calcium carbonate, which makes up chewable antacid tablets like Tums®. Because of the nature of calcium carbonate, coral and some seashells can be affected by increased **carbon dioxide** in the air. Follow these instructions to see how calcium carbonate is affected by carbon dioxide.



Materials

- 2 4-ounce (113 g) clear disposable cups or containers
- 1 marking pen
- 1 pack of chewable calcium carbonate antacid tablets (colored tablets preferred)
- 2 ounces (56 g) seltzer water
- 2 ounces (56 g) tap water
- Newspaper or paper towels to absorb spills



Procedures

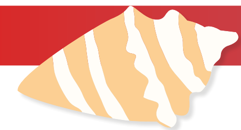
- Using the marking pen, label one cup "Tap Water" and the other cup "Seltzer Water."
- Place one chewable calcium carbonate tablet in each cup.
- Add 2 ounces of tap water to the cup labeled "Tap Water" and add 2 ounces of seltzer water to the cup labeled "Seltzer Water." Do not stir.
- Observe what happens. Is there any difference in how fast the tablets dissolve?
- Record your observations after 1, 2, and 3 minutes, using the Data Table.

What do you see?

Data Table

Observation Time	Tap Water	Seltzer Water
1 minute		
2 minutes		
3 minutes		

Safety Suggestions



- ✓ Safety goggles required
- ✓ Protective clothing suggested
- ✓ Cover your workspace with newspaper or paper towels to absorb spills
- ✓ Do not eat or drink any of the materials used in this activity
- ✓ Thoroughly wash hands after this activity
- ✓ **Disposal:** Dispose any liquid waste down the drain, and dispose solid waste in the trash

How does it work? Where's the chemistry?

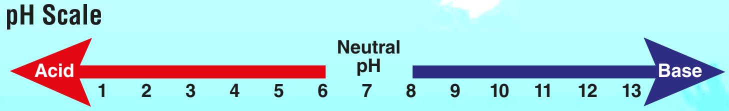
Regular tap water is neutral or slightly basic (with a pH value of 7). However, when carbon dioxide is added to water to create the bubbles in seltzer water, carbonic acid is formed, which lowers the pH value of the water making it acidic (with a pH value of 4).

The antacid tablets contain calcium carbonate, which is a base (with a pH value of 11). As bases react with acid, the acidic seltzer water dissolves the calcium carbonate tablet faster than the tap water.

Similarly, if there is more carbon dioxide in the air, the ocean will absorb the carbon dioxide, and carbonic acid will form, thus making the ocean water more acidic. Chemists call this process **acidification**.

This simple experiment demonstrates that dissolving more carbon dioxide in water could destroy seashells or coral, as they are made of calcium carbonate. Based on this principle, farmers sometimes use ground up seashells to make their soil less acidic. They work as antacids on land, too!

pH Scale



__Jacqueline Erickson__ is a Senior Development Scientist and Research & Development Project Leader at GlaxoSmithKline Consumer Healthcare in Warren, New Jersey.

Milli's Safety Tips Safety First!

ALWAYS:

- Work with an adult.
- Read and follow all directions for the activity.
- Read all warning labels on all materials being used.
- Use all materials carefully, following the directions given.
- Follow safety warnings or precautions, such as wearing gloves or tying back long hair.
- Be sure to clean up and dispose of materials properly when you are finished with an activity.
- Wash your hands well after every activity.

NEVER eat or drink while conducting an experiment, and be careful to keep all of the materials away from your mouth, nose, and eyes!

NEVER experiment on your own!

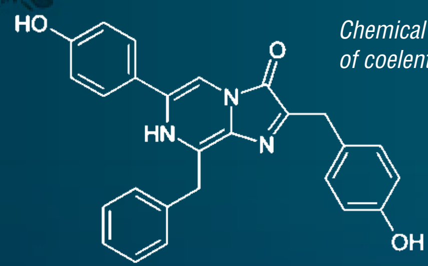
Colors Under the Sea

By Richard Rogers

When you dive into the ocean and look around, several things appear to change. The water acts like a magnifier, and colors change as the sea water filters out red light, making things appear blue. As you look around more, you see a lot of sea life in many colors. Why are some of these creatures almost invisible, while others are brightly colored?

There are many answers. Some creatures' colors help them avoid being seen. Others have vivid colors that help them appear dangerous and scare off predators. Some, like the clown fish (remember Nemo?), are colored to blend into places that are safe for them but poisonous for other fish. Still others are brightly colored to show off for potential mates.

As you go deeper in the ocean, the light begins to fade until everything around you is totally black. How do deep sea creatures know what is going on, and not run into each other? Some scientists believe that 75-90% of deep sea creatures use a natural chemical reaction that produces visible light. This process is called **bioluminescence**. It is thought that this process evolved hundreds of millions of years ago and includes several different chemical reactions. This is similar to fireflies or lightning bugs that can be seen in several parts of the U.S. This chemical reaction is not unique to any species or type, but is spread across a diverse set of creatures including squid, plankton, and even some bacteria.



Chemical structure of coelenterazine

How does this reaction work? There are two parts that are necessary. One is called a luciferin, which is the light-emitting compound, while the other is called a luciferase, which is the chemical enzyme that triggers the light-producing reaction. There are many different chemicals that can act as a luciferin, including coelenterazine, the most widely-known one in marine life.

This evolutionary "trick" helps the organisms see in the darkness. It can also help a deep sea creature send out messages like "Here I am!" to others of its kind, or it can be shut off so that the creature can hide. There are even some fish that use the light to lure others close so that they can eat them. Sometimes at night on the coast, the sea seems to light up when the smaller plankton or krill light up the whole area. Keep an eye out to see the colors in the sea.

***Richard Rogers** is a Senior Research Chemist at Grain Processing Corporation in Muscatine, Iowa.*

Word Search

Try to find the words listed below – they can be horizontal, vertical or diagonal, and read forward or backward!

ACIDIFICATION
ALGAE
ALGINATE
BIOLUMINESCENCE
BRINE
CARBON DIOXIDE
CARBONATES
CORAL
MARINE
MOLECULES
PHOTOSYNTHESIS
POLYMER
SALINITY
SEAWEEDS
SURFACTANTS
THERMAL VENTS

P	C	A	R	B	O	N	A	T	E	S	W	G	S	G
Y	H	K	E	S	D	E	E	W	A	E	S	K	I	A
B	I	O	L	U	M	I	N	E	S	C	E	N	C	E
D	T	A	T	W	M	B	R	I	N	E	Q	I	H	S
I	I	L	A	O	H	O	E	H	W	S	D	J	T	T
E	W	G	R	A	S	U	L	M	N	I	C	N	S	N
N	Q	I	J	E	W	Y	U	E	F	P	A	K	S	E
I	I	N	C	V	M	E	N	I	C	T	F	A	H	V
R	R	A	F	O	A	Y	C	T	C	U	L	G	C	L
A	P	T	N	G	R	A	L	A	H	I	L	G	P	A
M	Y	E	L	D	T	A	F	O	N	E	R	E	P	M
L	Q	A	N	I	L	R	L	I	P	X	S	L	S	R
X	E	K	O	A	U	A	T	L	A	B	J	I	A	E
O	A	N	H	S	K	Y	P	U	L	Q	Y	W	S	H
E	D	I	X	O	I	D	N	O	B	R	A	C	B	T

For answers to the word search, please visit the Celebrating Chemistry Archive at www.acs.org/ccew.

Salt Water Rainbows

By Sanda Sun

Introduction

The amount of salt in a body of water affects its density. In fact, some bodies of water, like the Great Salt Lake and the Dead Sea, contain huge amounts of salt, allowing people to easily float on the water. How can you tell when one body of water will be denser than another? Follow these instructions to compare the densities of different salt water solutions.

Safety Suggestions

- ✓ Safety goggles required
- ✓ Do not eat or drink any of the materials used in this activity
- ✓ Thoroughly wash hands after this activity
- ✓ Wear gloves to prevent stain on hands
- ✓ Cover your work area with newspaper or similar material to absorb any spills
- ✓ **Disposal:** All solutions can be safely poured down the drain. Solid materials should be disposed of in the trash.

Materials

- 7 teaspoons (about 35 mL) salt
- 1 quart (about 1 liter) water
- 1 permanent marker
- 1 teaspoon
- 4 stir sticks or plastic spoons
- 1 set of 4 assorted food colorings
- 4 clear plastic drinking straws
- 1 small test tube or narrow jar
- 4 8-ounce (about 235 mL) foam or plastic cups

Procedures

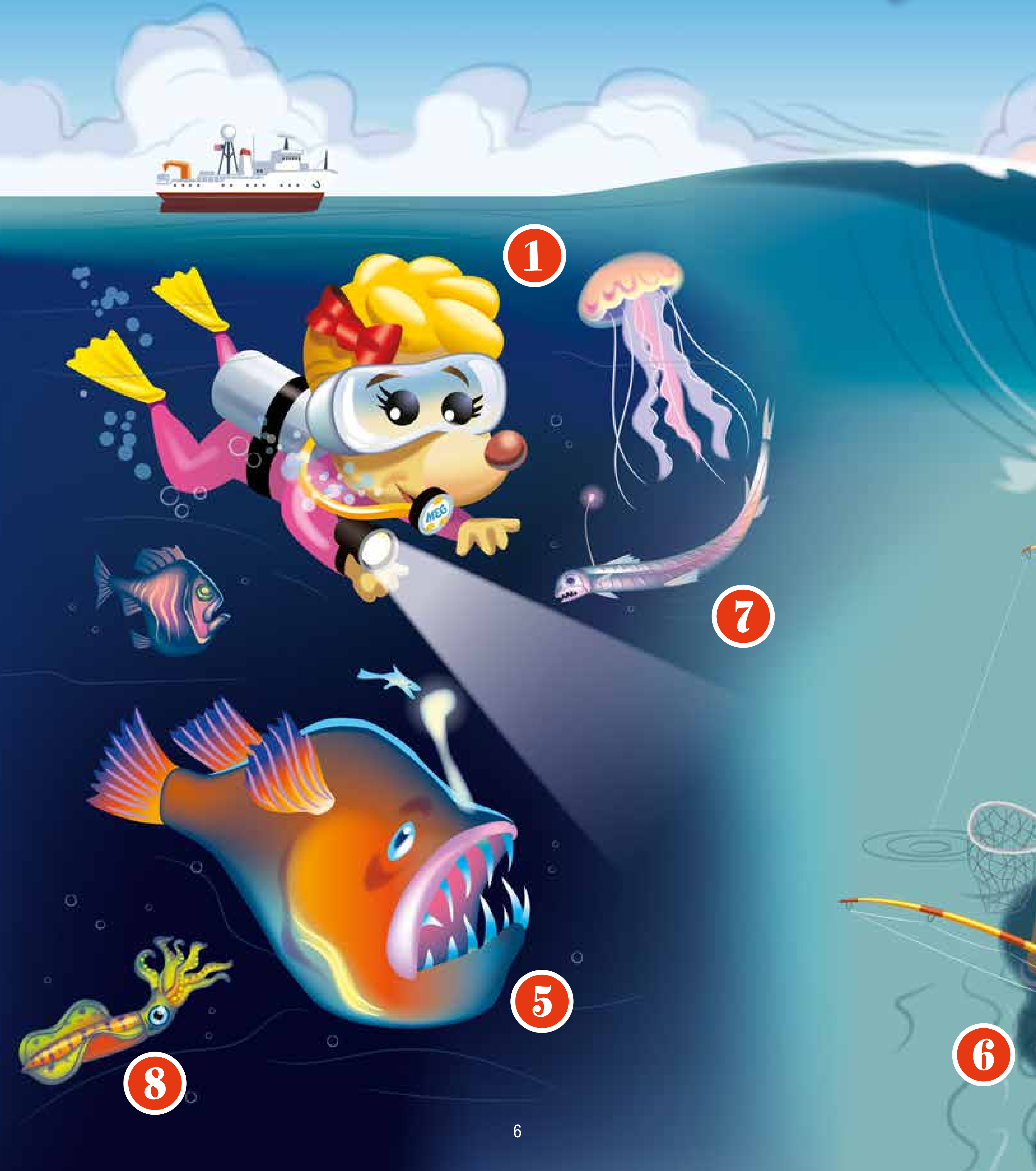
1. Label your 4 cups “0,” “1,” “2,” and “3” with the marking pen.
2. Fill each cup half-full of water.
3. Add 5 drops of yellow food coloring in cup “0.”
4. Add 5 drops of blue food coloring in cup “1.”
5. Add 5 drops of green food coloring in cup “2.”
6. Add 5 drops of red food coloring in cup “3.”
7. Dissolve 1 teaspoon of salt in the blue water in the cup marked “1.”
8. Dissolve 2 teaspoons of salt in the green water in the cup marked “2.”
9. Dissolve 3 teaspoons of salt in the red water in the cup marked “3.”
10. Dip the straw 1/2-inch into the red salt water solution in the cup marked “3.”
11. Place your index finger firmly on the other end of the straw and remove the straw from the solution.
12. Put the straw over the test tube or narrow jar and remove your finger from the straw to release the water into the test tube. If a narrow jar is used, hold it at a slant and pour the solutions down the side of jar to avoid mixing.
13. Repeat steps 10-12 with the green, blue, and yellow solutions.
14. Draw a picture of your results.
15. What would happen if you repeated the experiment but put the colored salt water in the test tube in a different order? Now try it!

Sanda Sun, Ph.D. *is a Professor of Chemistry at Irvine Valley College in Irvine, California.*

How does it work? Where’s the chemistry?

The density of the solution increases as the amount of salt increases. The denser solutions stay on the bottom, and the less dense solutions float on top of solutions of greater density. The result is a four-colored rainbow! The rainbow effect would not form if the order were reversed. The denser solution would fall downward and contaminate the less dense solution.

Dive into Marine Chemistry!



By Lily L. Raines

1. The letters S-C-U-B-A in scuba diving stand for "self-contained underwater breathing apparatus." Scuba divers use tanks containing regular air, with 80% nitrogen and 20% oxygen, or they can use air with a higher oxygen content (32-36%) to avoid decompression sickness (also known as "the bends"), which can happen if someone dives too deep and comes up too quickly.

2. Seawater contains many minerals, including gold! There are almost 20 million tons of gold dissolved in all the earth's oceans. However, it is so dilute it cannot be extracted. Looks like the Moles can't get rich off of seawater!

3. Seashells are the main source of calcium carbonate found in sedimentary rocks, like limestone. Seashells can be used to repair damaged oyster reefs, to treat wastewater, to make cement and calcium supplements, and to adjust soil acidity in farms.

4. Kelp is a type of seaweed that grows mainly in cool waters off the west coast of North America. Because kelp use **photosynthesis** to convert sunlight to energy, they do not normally exist deeper than 49-131 feet beneath the surface.

5. Some fish contain more heavy metals than others (such as mercury) due to bioaccumulation. This happens when fish eat a compound, or absorb it through their skin, faster than they can break down and excrete it. Biomagnification is when this process continues as you move up the food chain. This is why many of the fish that you should eat less of, such as tuna and swordfish, happen to be high up the food chain. Visit the Community Event page at www.acs.org/ccew to learn more.

6. Not all mercury is the same! Sometimes we add *ethyl* mercury to flu vaccines to help keep them free from bacteria and fungi. The type of mercury that can make people sick from seafood is called *methyl* mercury. This small chemical difference makes a big difference in our health and safety!

7. Many organisms that live deep in the ocean can't get any visible light, so they use chemosynthesis instead. To do this, they store energy from chemical reactions with inorganic (non-carbon containing) compounds as organic (carbon containing) compounds like sugars. Most animals that use chemosynthesis get their iron and sulfur "food" from hydrothermal vents.

8. Many deep sea creatures use bioluminescence to help them see in the dark, to find each other, and to lure their food to them. You can see examples of bioluminescence in plankton on the surface at one of the world's five bioluminescent bays.

Lily L. Raines, Ph.D. *is the Manager of Science Outreach at the American Chemical Society in Washington, D.C.*

Seaweeds: Nature's Marine Chemists

By Melanie Daniels,
Sheila Kanodia,
and Cary Supalo

What looks like a plant but has no roots, stems, or flowers, and lives in water? If you guessed seaweed, you are right! This amazing family of algae has more than 10,000 varieties across the world. Some types are microscopic, while underwater forests of giant kelp can be 40 feet tall!

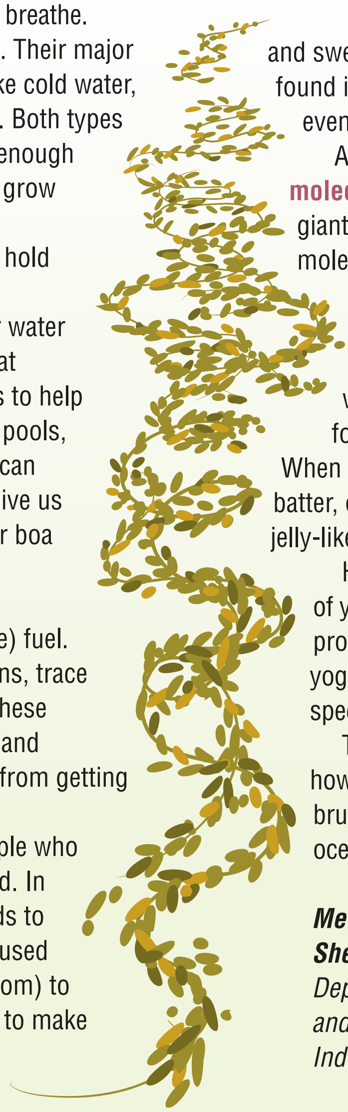
Seaweeds provide food and homes for many fish, abalone, crabs, and sea otters. Seaweeds are strong, and can help protect ocean habitats from wave damage. Seaweeds are also an ecosystem's 'chemists.' They use photosynthesis to turn sunlight into chemical and metabolic energy, and to capture carbon dioxide from the water and release oxygen. Seaweeds and other algae also make most of the world's oxygen, which we need to breathe.

Seaweeds are found in many colors and shapes. Their major colors are red, green, and brown. Red seaweeds like cold water, and green seaweeds prefer warmer tropical waters. Both types live close to the shore, where the water is shallow enough for sunlight to reach them. Seaweeds need light to grow and make their own food.

The shore has rocky places for the seaweeds to hold onto. The largest seaweeds are brown, and are tall enough to reach the light when anchored in deeper water far from shore. Sargassum is a type of seaweed that doesn't have to anchor itself. It uses gas-filled sacs to help it float. Other types of seaweed can survive in tidal pools, where the temperature, saltiness, and water levels can change quickly. The names of different seaweeds give us clues about their shapes. What do you think feather boa kelp looks like? Or sea lettuce?

Seaweeds have many uses. They are used for medicine, fertilizer, food, and possibly (in the future) fuel. Seaweeds give us fiber and many important vitamins, trace elements, and minerals we need for good health. These minerals include calcium, magnesium, potassium, and iodine. Seaweeds have been used to keep wounds from getting infected. They may also help in treating cancer.

Some people call seaweed a sea vegetable. People who live near the ocean discovered how to use it as food. In China and Japan, people dry sheets of red seaweeds to use in soups or for wrapping sushi. Seaweeds are used in Wales (a country that is part of the United Kingdom) to make laverbread. In some places, seaweed is used to make noodles. In Belize, seaweeds are mixed with milk and sweet spices to make a drink called dulce. Seaweeds are found in many snack foods, including some crackers and even ice cream.



As they grow, seaweed 'chemists' create many new **molecules**, including natural **polymers**. Polymers are giant molecules that are made by putting many small molecules together. For example, starch is made from sugar molecules. Seaweeds make natural polymers called alginates. One of the most common **alginates** is known as sodium alginate. This substance absorbs water, growing in size as it does, and provides support for seaweeds. Alginates are typically sold as powders. When mixed with water, they can be as thin as pancake batter, or as thick as cream cheese. In the ocean, it forms a jelly-like substance.

Have you ever been to the dentist to get a mold made of your teeth to see if you needed braces? If so, the dentist probably used an alginate. Alginates are also in foods like yogurt and ice cream, because they give these foods that special thick and creamy texture that we know and love.

The next time you think about the ocean, remember how seaweeds help you every day. When you take a breath, brush your teeth, or eat a healthy snack, seaweeds, the ocean's chemist, are part of your life.

Melanie Daniels *is an Educator in Fairfield, California;* ***Sheila Kanodia, Ph.D.*** *is Forensic Scientist at U.S. Department of Homeland Security in Oakland, California; and* ***Cary Supalo, Ph.D.*** *is President and Founder of Independence Science in Princeton, New Jersey.*

Oil Spill!

By Alex Madonik

Introduction

How do you clean up an oil spill at sea? In this activity, you'll try out different methods of cleaning oil spills. It's time to act like environmental chemists and engineers, and use your knowledge to try and clean up the "mini-oil spill" you create! You can do this activity on your own or in a small group.

Safety Suggestions

- ✓ Safety goggles required
- ✓ Protective clothing suggested
- ✓ Cover your work area with newspaper or a similar material to absorb any spills
- ✓ Do not eat or drink any of the materials used in this activity
- ✓ Thoroughly wash hands after this activity
- ✓ **Disposal:** Separate as much oil as possible from the water. Oil wastes should be disposed of in the trash. Water containing small amounts of oil should be mixed with detergent and poured down the drain.

Materials

- 1 quart (about 1 liter) tap water
- 3 drops blue food coloring
- 1 aluminum pie pan
- 1 plastic spoon for skimming oil from the pie pan
- Paper towels
- 2 feathers (purchase from a craft store to ensure the feathers are clean)
- 1 tablespoon (15 mL) vegetable oil
- Various items that might absorb oil, such as cotton balls, paper towels, oil-absorbing facial tissues, and discarded pieces of fabric
- 1-2 drops of "grease-fighting" dishwashing detergent
- Tweezers or tongs for handling the types of products that might absorb the oil
- 1 small plastic cup for collecting skimmed oil and water

Procedures

1. Fill your aluminum pie pan half-full of tap water. Add 3 drops of blue food coloring and stir. This is your ocean!
2. Add 1 tablespoon of vegetable oil to the water and stir. Describe what happens to the oil. This is your mini oil spill!
3. Draw what a clean feather looks like in Table 1. Place one feather in the oily water. After 30 seconds, remove the feather from your oil spill, and draw what you see in Table 1. Based on what you observe, what impact do you think an oil spill might have on birds?
4. Use the spoon to skim the oil from the surface of the water. Put any recovered oil into the small cup. Try to take only the oil off the surface, and not remove water. Rate your success at removing the oil.
5. Test the items you think will absorb the remaining oil and see which one removes the most oil. Record your results in Table 2.
6. Add 1-2 drops of "grease-fighting" dishwashing detergent to the oily water in your aluminum pie pan. Stir it with the spoon. Describe what happens to the remaining oil.
7. Take your second feather and dip it into the pie pan. After 30 seconds, remove the feather and compare it to the one you dipped into the oil spill at the start of the experiment. Describe or draw what you see in Table 1.

How does it work? Where's the chemistry?

Oil and water don't mix because water is a polar substance and oil is a non-polar substance. Oil will float to the surface of the water since it is less dense than water. Skimmers are machines used to remove the oil that is sitting on the surface of the water. In a real oil spill, chemists and engineers not only have to clean the water, but they also have to clean any animals that may have gotten oil on their fur or feathers. **Surfactants**, or soaps, are used to help break apart the oil into little droplets within the water. Then, microbes can break down the oil to clean the water in a way that scientists and engineers doing the cleanup cannot.

Alex Madonik, Ph.D. *is an Instructor of Chemistry at Peralta Community College in Oakland, California.*

What did you see?

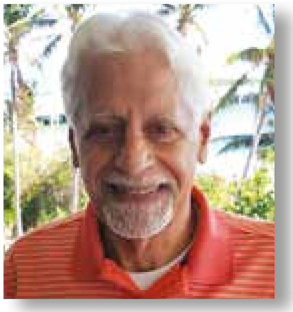
TABLE 1

Clean feather	Feather in oil spill	Feather in oil spill with dishwashing detergent

TABLE 2

Oil-Absorbing Item	How Well Did It Work? (1 = worst, 5 = best)					
	0	1	2	3	4	5
	0	1	2	3	4	5
	0	1	2	3	4	5
	0	1	2	3	4	5

The Adventures of Meg A. Mole, Future Chemist



Dr. Frank J. Millero
Ocean Chemistry Researcher

Personal Profile

- Favorite food – Italian
- Favorite color – Blue, like the ocean
- Favorite pastime/hobby – Reading books by Robert Ludlum and watching sports
- Accomplishment you are proud of – His high school, undergraduate, and graduate students who have published papers from their labs studies with him
- About your family – Wife Judith, two sons, one daughter, and two granddaughters
- Fun fact – For years, he ran every day, and participated in 10 marathons and a half-marathon in Rome, Italy. Now, he enjoys swimming for 30 minutes every evening in his pool at home.

In honor of this year's Chemists Celebrate Earth Week theme, "Dive into Marine Chemistry," I traveled all the way to Miami, Florida to meet with Dr. Frank J. Millero, Professor Emeritus in the Department of Ocean Sciences at the University of Miami, Rosenstiel School of Marine and Atmospheric Science.

Dr. Millero explained to me that he "studies the physical properties of the world's oceans and other natural waters." Most of his team's studies, he told me, involve learning about the impact of carbon dioxide in the world's oceans. I was not quite sure why they study this, so I asked him to tell me more.

"We are interested in how CO_2, a product from burning fossil fuels, ends up in the oceans," he said. "This addition of CO_2 causes the surface waters to have a lower pH, a problem known as ocean acidification. My research group has been taking measurements aboard research cruises for many years." The team adds the data they and other researchers collect into a database that allows them to track the effects over time. Their results and those of other workers are published in scientific journals.

I was very interested in how they do their work, and what tools they use. He told me, "Most of the equipment that we use, we have developed ourselves." I know safety is a very important aspect of all scientific work, so I wanted to know more about the personal protective equipment they used. "We normally do not need to wear safety glasses on cruises; however, in the lab when working with acids we would use them," he said.

Dr. Millero told me he was interested in chemistry at an early age. "I sold seeds to buy my first chemistry set in grade school. I used the set to study the properties of natural systems (local waters and salts) … and had only one explosion! In junior high and high school, I enjoyed studying chemistry, math, and Edgar Allen Poe's poetry."

His interest in the sciences continued on after high school. After graduation, he went to a small college (Thiel College) to work on his bachelor's degree. "I had a math teacher who used calculus to study the Sputnik space flights," he recalled. "After injuring my knee playing football, I transferred to Ohio State, where I took every chemistry course that was available, which included all the laboratory courses in physical chemistry and calculus. Before going to graduate school, I worked a summer at the National Bureau of Science under the direction of Roger Bates, a solution chemist. I made thermodynamic measurements on solutions and decided I wanted to get my Ph.D. in physical chemistry, so I got my Ph.D. at Carnegie Mellon."

After graduating from Carnegie Mellon, Dr. Millero took a job with ExxonMobil working on automobile air pollution. "Later, I saw an ad for a position at the University of Miami," he explained, "and I have been studying the chemistry of ocean waters ever since." He has enjoyed teaching marine chemistry to undergraduate students and marine physical chemistry to graduate students, and many of his students have gone on to careers in chemistry and published papers on the field.

"I retired from teaching at the end of 2015," he told me, "but I still have ongoing research projects and am active in studies of ocean chemistry. I have also enjoyed helping my granddaughters with their many projects in chemistry."

Minerals from Sea Water

By Al Hazari

Have you ever had chocolate candy flavored with sea salt? Or, enjoyed delicious sea salt caramel ice cream?

Table or regular salt is mostly sodium chloride. But recently, sea salt has become popular in fancy foods. What does sea salt have that regular table salt doesn't? It contains minerals from the sea. As a result, sea salt seems to taste 'less salty' and more 'minerally' than regular salt.

For this reason, some people, including famous chefs, find that sea salt tastes better than salt from underground salt mines. Some say it is also more nutritious and healthy. However, there is little or no health benefit to using sea salt over other forms of sodium chloride.

Seawater covers 70% of earth's surface, and contains important mineral resources. There are a small number of major minerals in seawater, along with many minor (or "trace") minerals. The major chemical elements are sodium, chlorine, magnesium, sulfur, calcium, and potassium. A few examples of the minor elements, those present in amounts less than about 400 PPM (parts per million), are bromine, nitrogen, phosphorus, iodine, and manganese. There are also almost 20 million tons of gold dissolved in all the earth's oceans! However, extracting any of these minerals is very difficult. Today, direct extraction of the mineral resources is limited to salt and magnesium.

Seawater contains about 3.5% dissolved salts by weight. This means that if you evaporate 100 grams of seawater, you are left with 3.5 grams of salt. Sea salt (sometimes called "bay salt" or "sun salt") is produced through evaporation of the seawater, usually with little processing. Besides sodium chloride (table salt), it contains many trace minerals and elements. The minerals may add flavor and may also introduce a color to sea salt.

Sea salt comes in a variety of colors depending on where in the world it is extracted. The colors range from white to pink, black, green, orange, blue, and others (see photo). For example, the translucent pink hues of Himalayan Pink Salt (from Pakistan) come from the presence of 84 trace minerals including potassium, magnesium, and calcium. Iron oxide is the main element that gives the salt its signature color. The salt comes from deep under the Himalayan mountain range, where ancient seas evaporated more than 200 million years ago. Another example is Brittany Grey Sea Salt, from France. It has a grey color that comes from minerals that are absorbed by the crystals from clay in the salt ponds. Finally, Persian Blue Salt is one of the rarest salts on earth and is harvested from the remnants of an ancient salt lake in Iran. The salt crystals seem to interact with light and produce its unique color.

Sometimes, additives are manually mixed with white sea salt to introduce a specific color. Hawaiian Red Salt comes from the addition of small amounts of alae, or red volcanic clay, to the unrefined sea salt. Cyprus Black Salt's jet-black color is due to the addition of activated charcoal. The charcoal helps give the salt a unique flavor as well as more nutritional benefits.

With all these interesting colors of delicious table salt, why worry about extracting magnesium from the ocean? In the human body, every cell requires magnesium to function. Magnesium compounds are used as laxatives and antacids (for example, Milk of Magnesia). Many people add Epsom salts (magnesium sulfate) to their bath or spa. Seawater contains a bit more than 1,000 PPM magnesium. That's about one gram in a liter of seawater. In the U.S., two-thirds of magnesium metal, and many magnesium salts, are extracted from seawater.

In summary, seawater contains many minerals and metals. The extraction of minerals and metals from seawater is happening now. But the need for more of these substances to produce everyday consumer products is likely to increase in the future. How much more money would we be willing to pay for these seawater resources?

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Words to Know

Acidification: the process of carbon dioxide dissolving in water, which creates carbonic acid.
Algae: many different types of plants, from tall to tiny, that grow in the ocean.
Alginate: a water-soluble polymer created by algae.
Bioluminescence: the ability of certain animals (such as fireflies and deep-sea creatures) to create light using chemistry.
Brine: highly concentrated salt water, ranging from a mildly salty mix, where fresh water enters the ocean, to over 30% salt in the Dead Sea.
Carbon dioxide: also called CO_2, this invisible gas appears in small amounts in regular air, and is created when animals exhale, people burn fuels, volcanoes erupt, or plants decay.
Carbonates: minerals formed when CO_2 dissolves in water, including the most common type, chalk (calcium carbonate). Corals and seashells are made of carbonate minerals.
Coral: tiny sea creatures that grow together to form giant colonies called coral reefs.
Marine: a word describing anything about the oceans.
Molecules: tiny, individual chemical parts of the world around us. Everything is made of chemicals.
Photosynthesis: how plants create food by taking in carbon dioxide and turning it into useful molecules such as sugar, using sunlight for their energy.
Polymer: a giant molecule built from long chains of smaller molecules.
Salinity: the saltiness of water.
Seaweeds: the many kinds of red, green, and brown plants that grow in the ocean.
Surfactants: chemicals, like soap, that dissolve in both water and oil and help them mix.
Thermal vents: places in the deepest parts of the ocean where incredibly hot water shoots out of cracks and holes in the ocean floor made by volcanoes.

What is the American Chemical Society?

The American Chemical Society (ACS) is the largest scientific organization in the world. ACS members are mostly chemists, chemical engineers, and other professionals who work in chemistry or chemistry-related jobs. The ACS has nearly 157,000 members. ACS members live in the United States and different countries around the world. Members of the ACS share ideas with each other and learn about important discoveries in chemistry during scientific meetings held around the United States several times a year, through the use of the ACS website, and through the many peer-reviewed scientific journals the ACS publishes. The members of the ACS carry out many programs that help the public learn about chemistry. One of these programs is Chemists Celebrate Earth Week, held annually during the week of Earth Day on April 22. ACS members celebrate by holding events in schools, shopping malls, science museums, libraries, and even train stations! Activities at these events include carrying out chemistry investigations and participating in contests and games. If you'd like more information about these programs, please contact us at **outreach@acs.org**.

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The activities described in this publication are intended for elementary school children under the direct supervision of adults. The American Chemical Society cannot be responsible for any accidents or injuries that may result from conducting the activities without proper supervision, from not specifically following directions, or from ignoring the cautions contained in the text.

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