eXpedition inc.

Life is the greatest adventure!

Destination: Deep Blue Sea

We're Go for Launch!

We're ready! We've done our final checks, we've packed our bags, we've planned our route, we've marked our destination with an X, our sat phone is at the ready, and one week of our three week window is already gone! It's time head out on our expedition to find the rare glowing jellyfish and unique long fanged viperfish that could save so many lives. Those researchers are already wondering what's taking us so long!

Ye Old Salt! A Taste of the Salty Sea Shore

As the scent of brine fills the air and we dip our toes in the water at the start of our expedition a thought may cross your mind. Have you ever wondered why the ocean is salty?

Ask students if they have ever tasted ocean water. If they have, what was it like? Seventy percent of the earth is water, and of that, 97% is salt water. Where does that salt come from? Can you see the salt in the water?

It's fairly easy to understand why the ocean is salty. The oceans have been around a very long time, so some of the salts were added to the water at a time when gases and lava were spewing from increased volcanic activity.

The carbon dioxide from the volcanos dissolved in water from the atmosphere forms a weak carbonic acid which dissolves minerals. When these minerals dissolve, they form ions, which make the water salty. While water evaporates from the ocean, the salt gets left behind. Also, every stream and river that flows into the ocean carries some amount of salt in it. The salt comes from erosion of the minerals in those waters. It is said that one fourth of the material that the Mississippi River deposits in the ocean is dissolved minerals. Ocean water contains about 3.5% salts, mostly sodium chloride (table salt), potassium, and calcium and magnesium salts. Small plants and animals (plankton) use some of the salts and the ocean floor removes some of them as well. Most of the table salt remains in the water, however, and that accounts for the taste.

The saltiness of the ocean, or its salinity, is fairly stable at about 35 parts per thousand. To give you a sense of how much salt that is, it is estimated that if you took all the salt out of the ocean and spread it

Did You Know?

What is salt? (Sodium chloride, a chemical compound that contains an acid and a base.)Make your own salt by filling a tablespoon halfway with vinegar, like the acid from the volcanoes. Sprinkle baking soda (the minerals) over the vinegar until the bubbling stops. Which ingredient is the acid and which is the base?

over the land, the salt would form a layer more than 500 feet (166 m) deep! You might think the ocean would become increasingly salty over time, but part of the reason it does not is because many of the ions in the ocean are taken in by the organisms that live in the ocean. Another factor may be the formation of new minerals.

So, lakes get water from streams and rivers. Lakes are in contact with the ground. Why aren't they salty? Well, some are! Think of the Great Salt Lake and the Dead Sea. These lakes are so salty because they do not have an outlet. Tributary rivers are constantly bringing in small amounts of salt dissolved in their fresh water flow. Once in the lake much of the water evaporates leaving the salt behind. Other lakes, such as the Great Lakes, are filled with water that contains many minerals, yet doesn't taste salty. Why is this? Partly it is because water tastes salty if it contains sodium ions (an ion is an atom or group of atoms) and chloride ions. If the minerals associated with a lake don't contain much sodium, the water won't be very salty. Another reason lakes tend not to be salty is because water often leaves lakes to continue its trip toward the sea. According to an article at Science Daily, a drop of water and its associated ions will remain in one of the Great Lakes for around 200 years. On the other hand, scientists believe a water droplet and its salts may remain in the ocean for 100-200 million years, but the average is about 3,000 years. *It is important to realize that reported residence times are **averages**, and that the actual residence time for a given water molecule may be far from the average, ex. water that flows into warm, shallow coastal waters from a river may evaporate and leave the ocean very quickly.*

Materials:

- 1 picture graph of sea water*
- 1 globe
- Per Group:
- Table salt
- Pitcher of water
- 1 plastic glass per student
- 1 teaspoon
- 1 metric measuring pitcher
- 1 plastic spoon per person
- Large spoon for stirring

Have students:

1. Measure 3 1/2 teaspoons of salt into a metric pitcher.
2. Add 1000 ml (or 1/4 cups) of water.
3. Stir the salt and water.
4. Taste the sea water by using a clean plastic spoon. How would they describe it?

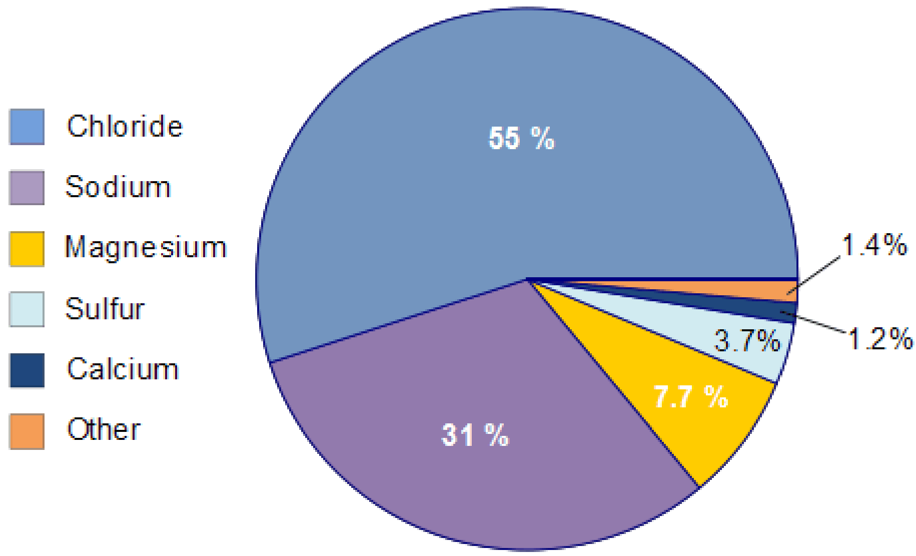
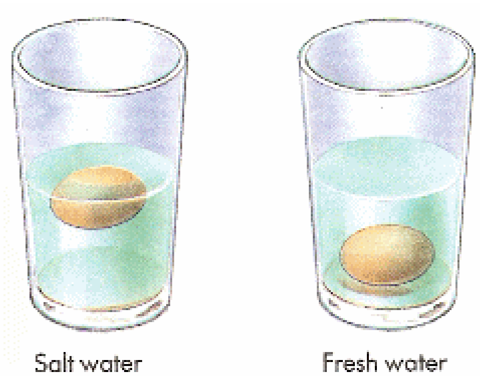


Figure 3.4.4 Ocean water contains many dissolved elements but is primarily composed of sodium and chlorine, which make up the salt in the water.

Now, Ask students if they have ever swum in salt water. Did they know it is easier to swim or float in salt water than in fresh water? Why do they think that might be? Try this experiment to demonstrate. You will need the following:

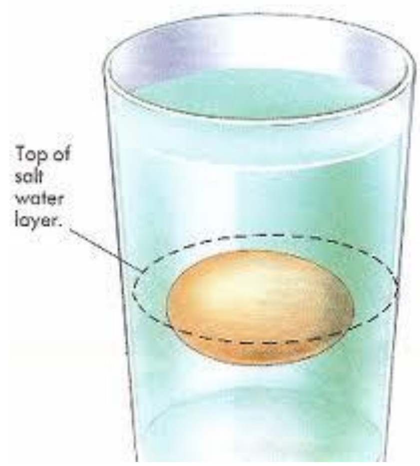
- Your glasses of salty sea water
- Warm fresh water
- 1 raw egg
- Salt (Just in case)
- teaspoon



Fill the glass about half full of warm water.
Carefully slip the egg into the glass. (It should sink to the bottom.)
With the egg in the glass, add 1 teaspoon of salt to the glass and stir gently, or put the egg in your glass of sea water. If necessary, keep adding 1 teaspoon of salt at a time until the egg floats to the surface.
Have groups explain what happened and how this would affect swimmers in salt water.

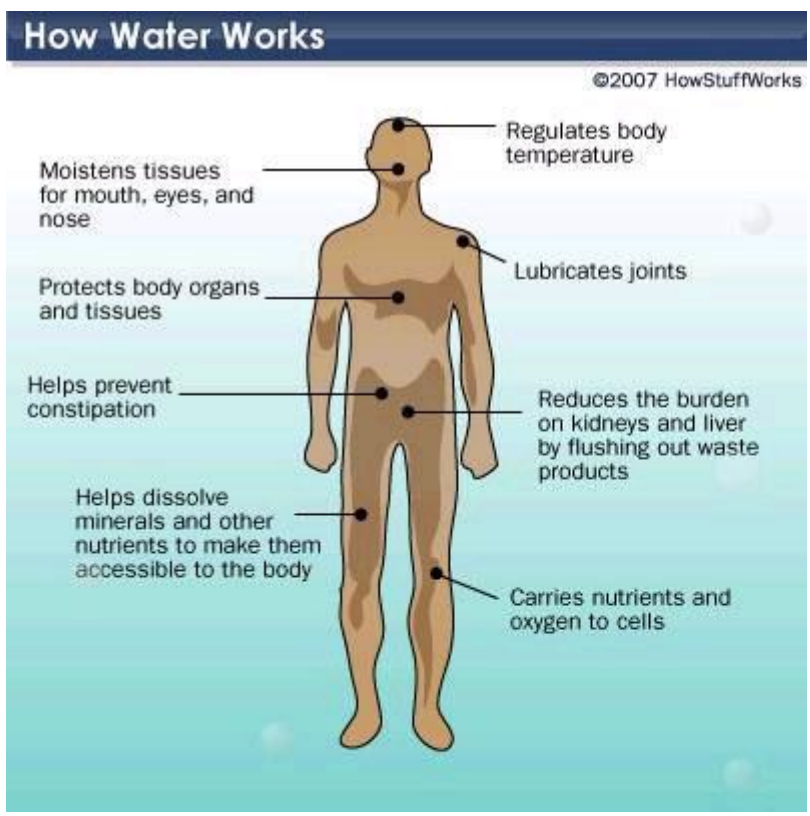
Why do objects float or sink? Placing an object that's denser (Density = Mass/Volume) than fresh water automatically sinks. In our Salt Water Egg experiment, because the egg is denser than tap water, it pushes away water particles so it can make space for itself hence the sinking motion. But in the case of the salt water, since it is heavier than ordinary tap water, it is more capable of holding the egg up - hence the egg floating. In easier words, objects sink when their own density is greater than the liquid's density.

Now you must be wondering what's in the salt that makes water denser when mixed with it? When salt is added and dissolved in water, it breaks down into ions that are then attracted to the water molecules (the smallest particle of a substance that retains all the properties of the substance and is composed of one or more atoms.) This attraction causes them to bind tightly, increasing the amount of matter per volume (density). Instead of just having the molecules hydrogen and oxygen in the water, sodium and chlorine joins the equation (since salt is made up of sodium and chlorine particles). Saltwater now has more particles in it compared to the ordinary tap water we started with. This is why saltwater is denser than tap water.



So next time we end up beached or swim in the ocean in this expedition, you already know the reason why it's so much easier to float in the open waters. In fact, an average person can float like a log with much less effort in saltwater than in fresh water. The key is, the denser the liquid the easier you'll float in it! Amazing huh?

Water Water Everywhere, but Not a Drop to Drink



Imagine you're stranded on a desert coastline by the wreck of our ship or plane as we travel on our expedition. The searing heat drains your body of fluids and your mind slows to a snail's pace. **How long can a person go without drinking water?** If at any time on our expedition, or in your regular life, you're ever stuck out in the wilderness, though you may remember or hear some incredible stories of people that defied the odds without a crumb or drop, it's a good thing to remember what survival experts call 'the Rule of Threes'. You can live 3 minutes without air, though we don't recommend trying. In a harsh environment — it's snowing, or in frigid waters, say — you have 3 hours to survive without shelter. After 3 days, you need water or you'll perish. You can make it 3 weeks without food, though we promise you that won't be fun. **Why is water**

so important? Would food or water be more important to a person in the desert? Forget food, forget sunburn, forget your coordinates; your biggest danger here is dehydration. If you don't find water soon, you'll perish, simple as that. Going without water isn't smart, and it doesn't take long before you're suffering from dehydration. Living without water is very different from living without food. In hot conditions with no water, dehydration can set in within an hour. Food is a different story. Humans can go quite a long time without food as long as they're well hydrated, though it's not very fun. **This isn't something you should test!** The main risk without water in high heat is that your body temperature will continue to rise and you'll suffer from heat stroke. Drinking water will cool you down and lower your core temperature.

Warning Signs of Dehydration

With mild dehydration, you'll experience the following:
Lack of saliva
Decreased frequency of urine
Decreased output of urine
Deep color and strong odor in urine
Moderate dehydration:
Even less urine
Dry mouth
Dry and sunken eyes
Rapid heartbeat
Severe dehydration:
No urine
Lethargy and irritability
Vomiting and diarrhea

As you stand here, getting hotter, you can't help but look at the trillions of gallons of water right in front of you. But it's salt water, and you know you shouldn't drink it. You're not sure why, but deep down you know it's off limits. But, surely a few drops won't hurt, maybe just half a cup? You'll die if you don't drink something soon, so what's the worst that can happen?

In these situations, it isn't enough to just know something's off limits. When push comes to shove, and when everything's on the line, you can rationalize (make it seem reasonable) your way around anything; even drinking sea water. So the question remains: why can't we drink sea (salt) water?

Firstly, Why Do We Need Water?

Our bodies are mostly water, between 70 and 80%, depending on whom you talk to. The water in our bodies supports many functions, including waste removal and temperature regulation. Since water is consumed and expelled by these functions, we need to constantly replenish our water reserves to survive.

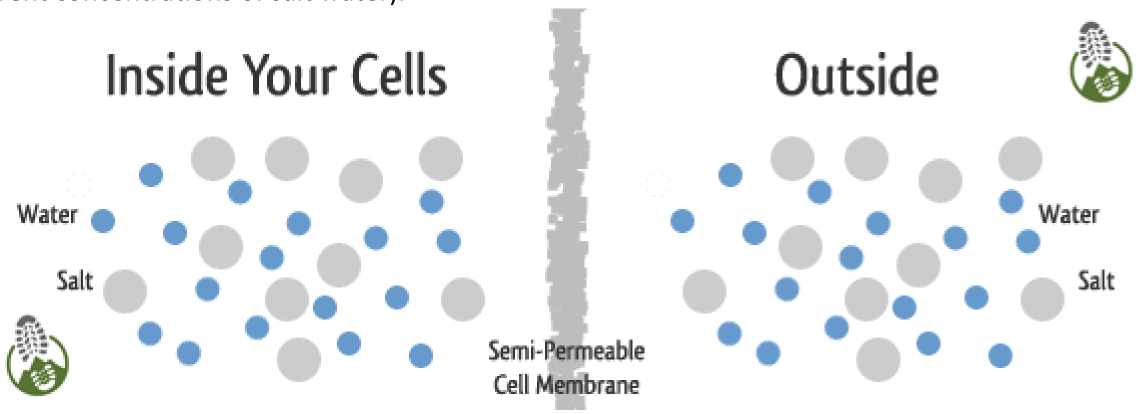
How Do Our Bodies Regulate Temperature?

In most situations, your body regulates temperature using radiation and convection. In short, this just means your body sends heat to the surface (skin), so cooler air around you can absorb the heat. But this is only effective if the external air is cooler than your body.

When the outside air becomes hotter than your body, you perspire (sweat) to regulate temperature. This is not about dampening and cooling the skin; quite the opposite actually. Your body dilates (makes them wider) the blood vessels near the skin (sending more hot blood through them) and excretes (lets out) sweat to effect evaporation. The process of evaporation requires energy, and that energy comes from the heat in your blood and skin. By consuming heat to effect evaporation, your body essentially cools itself, particularly its core (brain and vital organs).

How Do Our Bodies Absorb Water?

Some of you may remember the process of osmosis. Osmosis occurs across a semi-permeable (meaning that some things can pass through) barrier (our cell membranes). That barrier allows water molecules to pass in certain directions, depending on the concentration of water solutions on each side (imagine different concentrations of salt water).

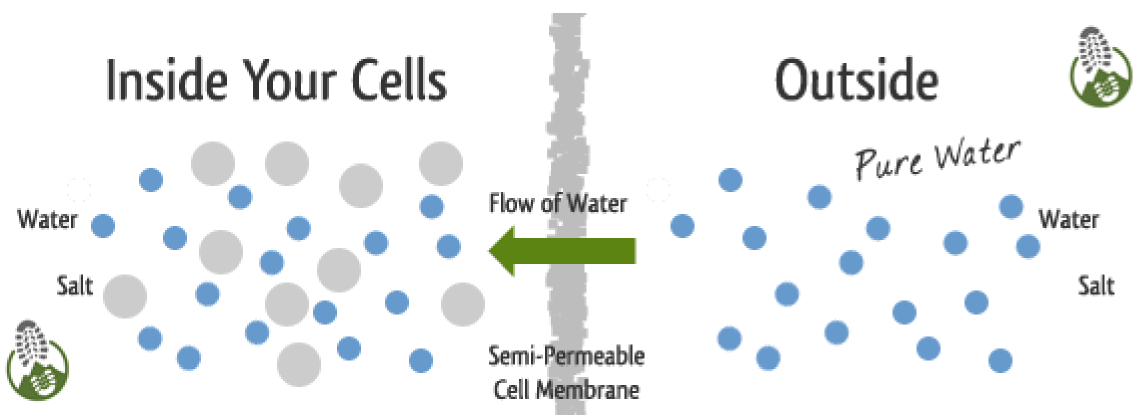


Our cells aim for this isotonic (equal) state, where the salt concentration is the same on both sides.

In normal circumstances, the saltiness of water in your cells is the same as the saltiness outside your cells. This is called an isotonic state, equal in saltiness. But when your cells consume water, the solution becomes more concentrated, and the natural process of osmosis allows water from outside your cells to pass into your cells to achieve equilibrium (this balancing act is called osmoregulation). That's how we absorb water as it's needed; it's a natural process.

Why Can't We Drink Too Much Pure Water?

Your cells are isotonic or balanced to about 0.9% saline solution. If the salinity of the solution outside the cells decreases, your cells absorb more water to get back to an isotonic (balanced) state.



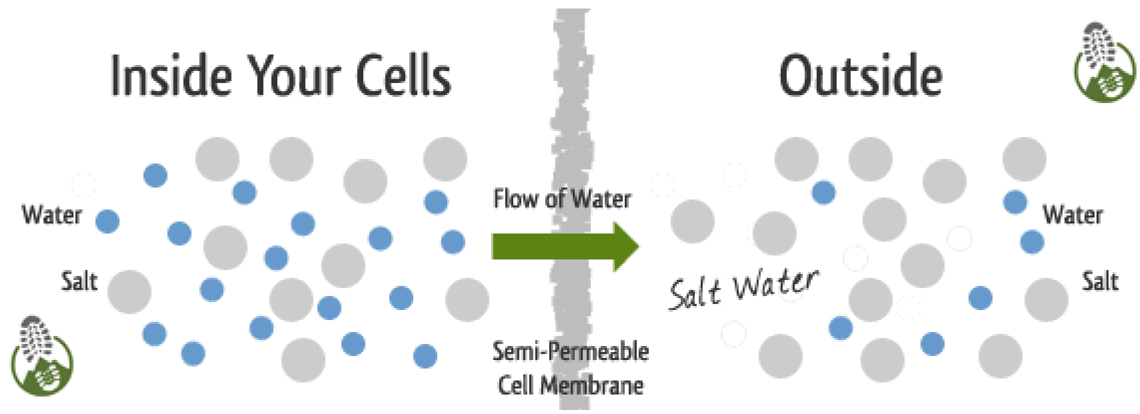
When we drink too much fresh water, excessive water passes into our cells to try to regulate the concentration (which can become futile). This causes cells to swell and sometimes burst.

When marathon runners and other endurance athletes drink too much fresh water, the solution outside their cells drops rapidly in salinity (gets much less salty), so osmosis allows water to pass into the cells as a part of osmoregulation, it's still trying to be equal. If they absorb too much water, the cells will swell and burst, which can lead to a quick death. This is why runners drink sports drinks that contain sodium and potassium, to help maintain a balanced isotonic state (and it's why they're called isotonic sports drinks).

Why Can't We Drink Too Much Salt (Sea) Water?

The opposite happens when drinking sea (salt) water. The salinity or saltiness outside your cells increases really rapidly, so osmoregulation effects a movement of water from in your cells, to outside your cells, to achieve a balanced state. So even though you may be dehydrated, your cells will actually release, rather than absorb, the water around them, making you even more dehydrated!

But why would your dehydrated body expel water when death is imminent? Well, this isn't a conscious decision by your body. It's simply molecular physics and osmosis at work. And in osmosis, water passes from low saline concentrations to high saline concentrations, in order to make them less salty, end of story.



When we drink salt water, water leaves our cells (dehydrating us further) in order to regulate (dilute) the concentration of the salt water we just drank (again, futile).

So, you should absolutely not drink sea or salt water when dehydrated. It's not just an issue of not absorbing the water, but an issue of osmosis accelerating the release of water and dehydration.

But, I need salt, right?

True, insufficient salt intake can lead to fatigue, illness, and death, although it is more common nowadays to hear about health problems associated with too much salt. According to the Salt Institute's encyclopedic site about salt, the National Academy of Sciences' recommended daily dose is 500 mg/day — though most Americans consume closer to 3,500 mg/day. (A teaspoon of salt equals about 2,000mg.) Optimal salt intake varies — it depends on a person's genetic makeup, where they live, how active they are, and other lifestyle factors. However, nobody, except for a saltwater fish, is designed to drink saltwater.

Can you survive on just saltwater and sun?

If our expedition got stuck on a deserted island, there's ocean water all around us - but we know we can't drink any because it's too salty. How can we fix that problem before we run out? What will we need? **Write student's ideas on the board. If possible, you may want to test some of them out.**

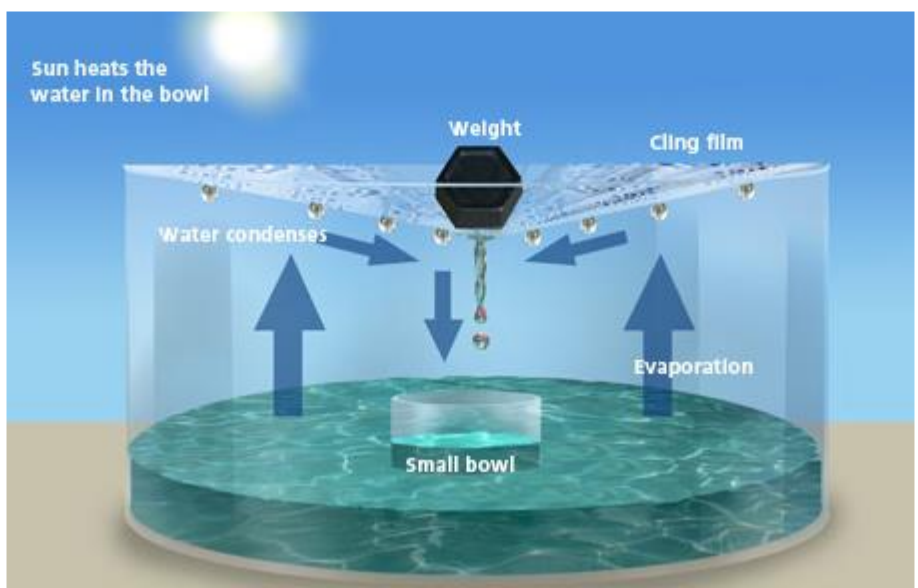
Materials:

- large bowl
- short glass or cup
- tape
- plastic wrap
- small rock
- pitcher of water
- salt
- long spoon for stirring

Here's how to turn saltwater into fresh water using the sun (and gravity) with a solar still. Solar stills are systems that use energy from the sun to distill salt water.

1. First make saltwater by adding salt to fresh water. Stir the water until the salt dissolves.
2. Now pour about two inches of saltwater in a large bowl.
3. Take an empty glass and put it in the bowl. The top of the glass should be shorter than the top of the bowl, but higher than the saltwater.
4. Put plastic wrap over the top of the bowl. Fasten the plastic wrap around the rim of the bowl with your rubber band, string or packaging tape.
5. The last step is to put something heavy right in the center of the plastic wrap, over the empty glass. That will weigh the plastic down and help you collect the water. Now you've made a solar still. It's called a still because it distills, or purifies, water.
6. Leave your still outside in the sun. Leave it alone for a few hours, or even a whole day. The longer you leave it out, the more water you'll collect.
7. When you're ready to check your still, take the plastic wrap off and look at the water that's collected in the cup. Do you think it's salty or fresh? Taste it to find out!

Ready for the science scoop on how distillation works? Rays from the sun heat up the salty water in the bowl. When the water gets warm, it evaporates and becomes a gas.



When the gas rises and hits the plastic wrap, it turns back into water droplets. Eventually, gravity makes the water droplets roll down the plastic wrap towards the rock. Then the water droplets slide off the plastic wrap into the glass. The salt doesn't evaporate, so it gets left behind in the bowl. Water evaporates in the same way from lakes, rivers, and oceans. The water heats up, turns into a gas, and then condenses to fall back down as rain.

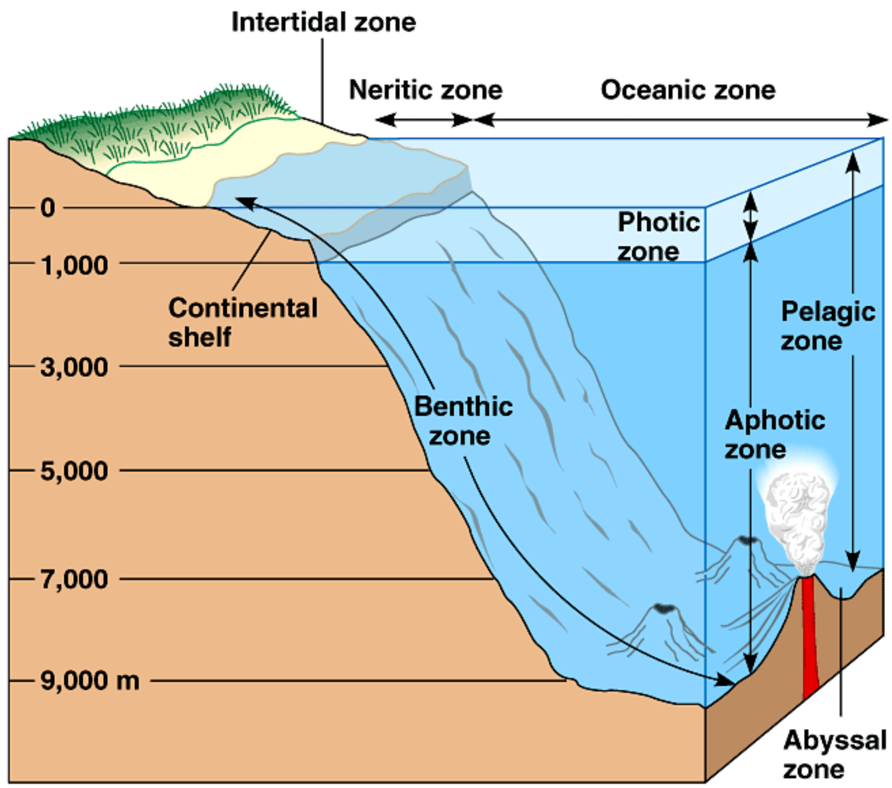
How could we make this process happen more quickly? What would we need to add? More heat? How?

These kinds of systems are really used! For example:
Peace Corps Volunteers Nicholas Hanson and Brian Newhouse helped develop plans to use solar stills to solve the problem of Cape Verde's perennial water shortage. This video illustrates how students and community members can come together to achieve lasting, meaningful results.
http://wws.peacecorps.gov/wws/multimedia/videos/solarstill/

Cape Verde receives less than seven centimeters of annual precipitation. Most of their fresh water comes from deep wells that tap the water table hundreds of meters underground. Because of the amount of water drawn from the wells, salt water is saturating the water table near the coast. (osmosis once again, trying to create balance)
Solar stills are systems that use energy from the sun to distill salt water. The first day this prototype was in operation, it distilled 1.75 liters of water. This prototype cost 17,000*escudos*, about 213 dollars.
With hundreds of kilometers of coastline around each of the nine inhabited islands providing an endless supply of seawater, and receiving hot sun almost year-round, solar stills may prove to be a promising, cost-effective alternative for fresh water.
You can use this water for drip irrigation, to take a shower, for cooking. If every person had a solar still, they wouldn't need to spend money to buy fresh water. They would only have to take water from the ocean and make vapor.

Down, Down, Down!

In order to begin to understand life below the sea, it is essential to grasp that the ocean has many different habitats that are defined by the physical and chemical properties that exist at different depths. The ocean is divided into 3main zones from the surface to the depths where light can no longer penetrate. These zones are characterized by different physical and chemical properties, such as quantity and quality of light, pressure and temperature. These properties affect what life forms can exist within those limitations.



Most (but not all) of the organisms in the ocean depend on sunlight. Plants and bacteria, such as kelp, seagrass and **photosynthetic** plankton, use light to make energy through a process called photosynthesis. Photosynthesis may sound like a big word, but it's actually pretty simple. You can divide it into two parts: "Photo" is the Greek word for "Light," and "synthesis," is the Greek word for "putting together," which explains what photosynthesis is. It is using light (red and blue specifically) to put things together. You may have noticed that all animals and humans eat food, but plants don't seem to eat much of anything. Photosynthesis is how many plants eat. They use this process to make their own food using three main ingredients: carbon dioxide, water, and sunlight.

Light is actually energy, electromagnetic energy to be exact. When that energy gets to a green plant whether above the land or below the sea, all sorts of reactions can take place to change and store that energy in the form of sugar molecules and release oxygen as a “waste product”. The sugar is then used by the plants for food, and the oxygen is breathed out into the atmosphere. This process as a whole is "photosynthesis."

These plants are then eaten by larger animals who use that energy and it goes into their cells in their bodies, which are in turn eaten by larger animals and so on. Remember the food chain? Sunlight is the basis (beginning) for this food chain. The tiniest portion of the ocean, the top 200 meters is where all this critical photosynthesis takes place!

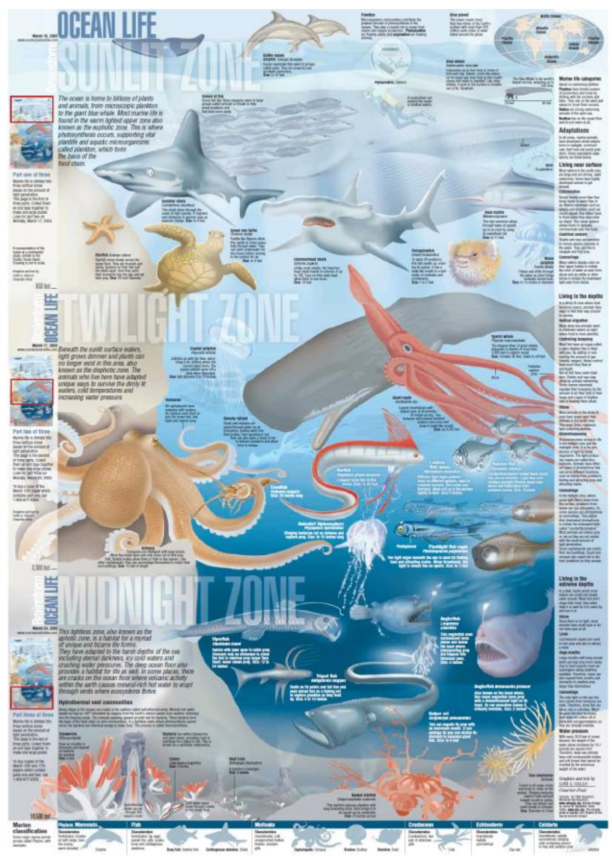
Sunlight also warms the ocean's surface. This is important because it makes the water warm enough for animals to live in it, and it is a driving force for some currents because of convection currents, where warm air or water rises and cold air or cold water sinks. (Have the students think of when they go swimming in a lake or a river. How does it feel on top of the water? How does it feel when they swim down into the water? Is it warmer or colder? Why does it feel different?)

Nature's Microworlds

As sunlight enters the ocean, it starts to be absorbed. The ocean can be broken down into three vertical zones based on how much light it receives.

The Sunlit Zone

The first zone, or **euphotic zone**, extends from the water's surface to about 50 meters depth, depending on the time of year, the time of day, the clarity (clearness) of the water and the presence of clouds. This is the part of the water column where there is still enough light for plants to photosynthesize. All plankton, kelp forests and seagrass beds are found in the euphotic zone.



The Twilight Zone

The next zone is the **disphotic zone**, which extends from about 50 meters, or wherever the euphotic zone ends, to about 1,000 meters. In this zone, there is enough light for organisms to see, but it is too weak for photosynthesis to happen and humans can't see at all. If we were to venture into the disphotic zone in our submarine expedition, we could watch the visible light disappear as we traveled deeper. Most animals here are completely transparent with large eyes. They must strain to see with the little light that reaches them, but avoid being seen themselves. Invisible in the gloom, they grope blindly for their prey. Predators wait below, using the faint light from above to silhouette their prey. Some of who have techniques to counteract their visibility, and others have equally subtle ones to detect them.

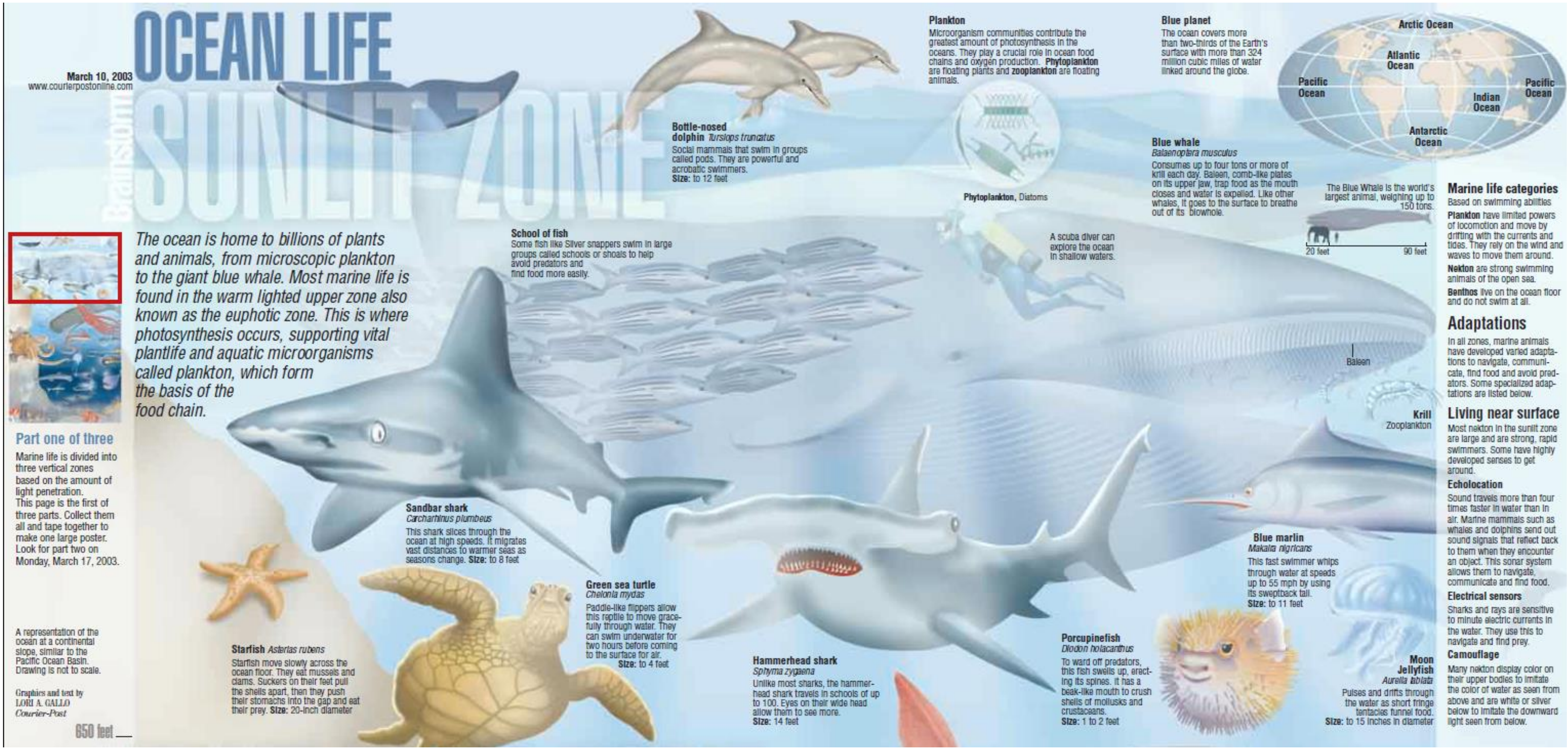
The Midnight Zone

Once we reached the **aphotic zone**, there would be no light from the sun at all, ever. The temperature drops to less than 4 degrees centigrade (39.2 degrees Farenheit). This zone extends from about 1,000 meters depth to the ocean bottom. Animals in this zone are rare, but they do exist and there are some thriving communities, which live and prosper without sunlight, ex. near volcanic or hydrothermal vents.

Animals here have powerful muscles, and many are aggressive hunters, after all, food is very rare, so if it passes by, you want to be able to catch it. Dark zone predators have to be able to deal with prey of any size, some have enormous mouths, others have teeth so large they can't even close their own mouths.. Many animals here are dark red as no red light penetrates to that depth, so the animals appear black, perfectly concealed in the darkness. And they have sensitive cells on their bodies to detect any motion.

The very bottom of the ocean, where the continental slope flattens out, is known as the abyssal plain and it covers more than half the earth's surface. It's mostly flat but in places there are massive gashes, hundreds of miles wide, the deepest of these being the Mariana Trench, dropping to over 7 miles below sea level.

There are 1,000 times fewer large animals here than higher up on the continental slopes, but in places hundreds of brittle stars march over the seabed in search of food and fish have been found right down in the very bottom of the deepest trenches. Most of these fish belong to one family, the aptly named, rat tails and they scavenge the bottom, using their sense of smell to follow odor trails of rotting carcasses.



March 10, 2003
www.courierpostonline.com

Brainstorm

OCEAN LIFE
SUNLIT ZONE

The ocean is home to billions of plants and animals, from microscopic plankton to the giant blue whale. Most marine life is found in the warm lighted upper zone also known as the euphotic zone. This is where photosynthesis occurs, supporting vital plantlife and aquatic microorganisms called plankton, which form the basis of the food chain.

Part one of three

Marine life is divided into three vertical zones based on the amount of light penetration.
This page is the first of three parts. Collect them all and tape together to make one large poster. Look for part two on Monday, March 17, 2003.

A representation of the ocean at a continental slope, similar to the Pacific Ocean Basin. Drawing is not to scale.

Graphics and text by
LORI A. GALLO
Courier-Post

650 feet

Bottle-nosed dolphin *Tursiops truncatus*
Social mammals that swim in groups called pods. They are powerful and acrobatic swimmers.
Size: to 12 feet

School of fish
Some fish like Silver snappers swim in large groups called schools or shoals to help avoid predators and find food more easily.

Plankton
Microorganism communities contribute the greatest amount of photosynthesis in the oceans. They play a crucial role in ocean food chains and oxygen production. **Phytoplankton** are floating plants and **zooplankton** are floating animals.

Phytoplankton, Diatoms

A scuba diver can explore the ocean in shallow waters.

Blue planet
The ocean covers more than two-thirds of the Earth's surface with more than 324 million cubic miles of water linked around the globe.

Arctic Ocean
Atlantic Ocean
Pacific Ocean
Indian Ocean
Pacific Ocean
Antarctic Ocean

Blue whale
Balaenoptera musculus
Consumes up to four tons or more of krill each day. Baleen, comb-like plates on its upper jaw, trap food as the mouth closes and water is expelled. Like other whales, it goes to the surface to breathe out of its blowhole.

The Blue Whale is the world's largest animal, weighing up to 150 tons.

20 feet
90 feet

Baleen

Krill
Zooplankton

Sandbar shark
Carcharhinus plumbeus
This shark slices through the ocean at high speeds. It migrates vast distances to warmer seas as seasons change. **Size:** to 8 feet

Green sea turtle
Chelonia mydas
Paddle-like flippers allow this reptile to move gracefully through water. They can swim underwater for two hours before coming to the surface for air.
Size: to 4 feet

Starfish *Asterias rubens*
Starfish move slowly across the ocean floor. They eat mussels and clams. Suckers on their feet pull the shells apart, then they push their stomachs into the gap and eat their prey. **Size:** 20-inch diameter

Hammerhead shark
Sphyrna zygaena
Unlike most sharks, the hammerhead shark travels in schools of up to 100. Eyes on their wide head allow them to see more.
Size: 14 feet

Porcupinefish
Diodon holacanthus
To ward off predators, this fish swells up, erecting its spines. It has a beak-like mouth to crush shells of mollusks and crustaceans.
Size: 1 to 2 feet

Blue marlin
Makaira nigricans
This fast swimmer whips through water at speeds up to 55 mph by using its sweptback tail.
Size: to 11 feet

Moon Jellyfish
Aurelia labiata
Pulses and drifts through the water as short fringe tentacles funnel food.
Size: to 15 inches in diameter

Marine life categories
Based on swimming abilities

Plankton have limited powers of locomotion and move by drifting with the currents and tides. They rely on the wind and waves to move them around.

Nekton are strong swimming animals of the open sea.

Benthos live on the ocean floor and do not swim at all.

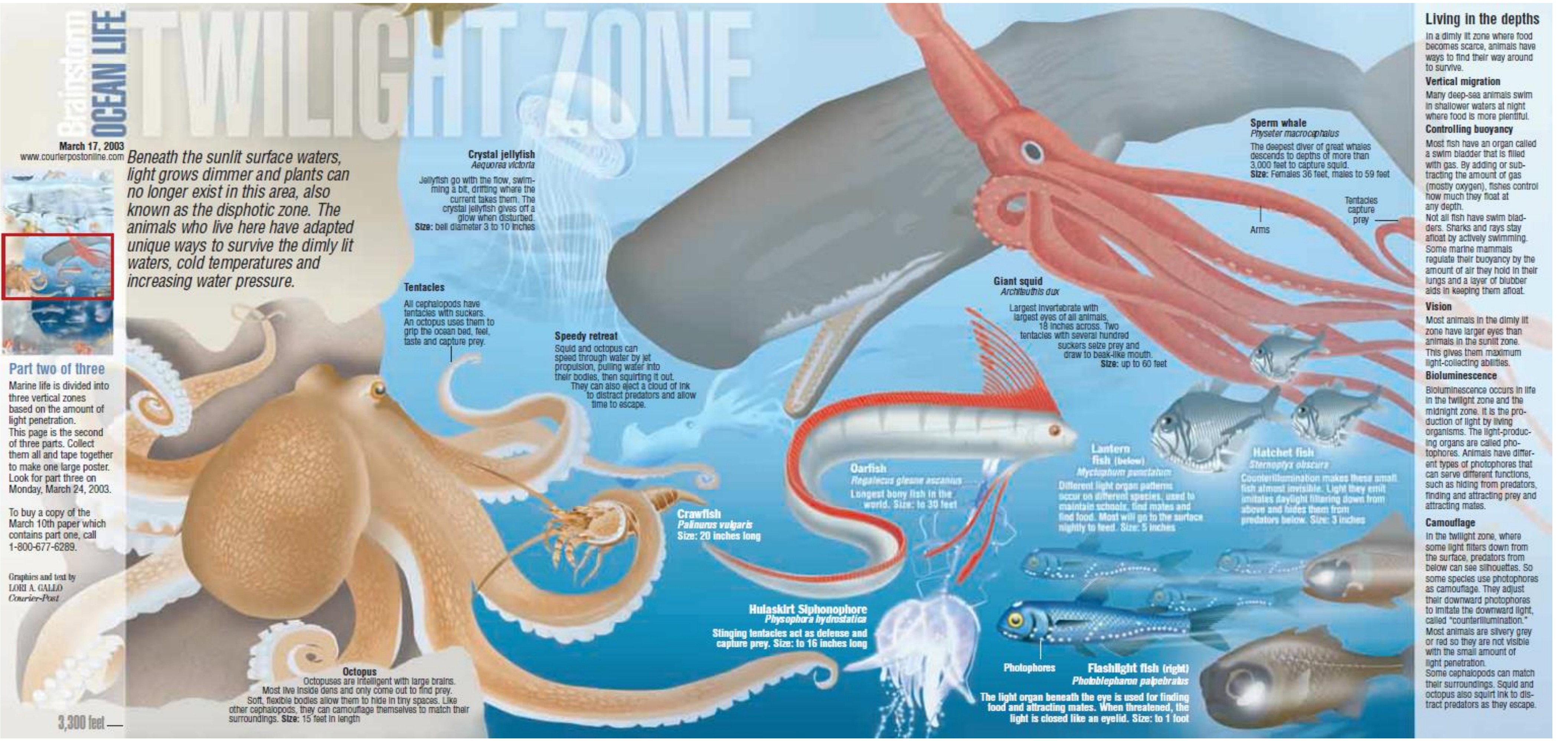
Adaptations
In all zones, marine animals have developed varied adaptations to navigate, communicate, find food and avoid predators. Some specialized adaptations are listed below.

Living near surface
Most nekton in the sunlit zone are large and are strong, rapid swimmers. Some have highly developed senses to get around.

Echolocation
Sound travels more than four times faster in water than in air. Marine mammals such as whales and dolphins send out sound signals that reflect back to them when they encounter an object. This sonar system allows them to navigate, communicate and find food.

Electrical sensors
Sharks and rays are sensitive to minute electric currents in the water. They use this to navigate and find prey.

Camouflage
Many nekton display color on their upper bodies to imitate the color of water as seen from above and are white or silver below to imitate the downward light seen from below.



TWILIGHT ZONE

Brainstorm OCEAN LIFE

March 17, 2003
www.courierpostonline.com

Beneath the sunlit surface waters, light grows dimmer and plants can no longer exist in this area, also known as the disphotic zone. The animals who live here have adapted unique ways to survive the dimly lit waters, cold temperatures and increasing water pressure.

Part two of three

Marine life is divided into three vertical zones based on the amount of light penetration.
This page is the second of three parts. Collect them all and tape together to make one large poster. Look for part three on Monday, March 24, 2003.

To buy a copy of the March 10th paper which contains part one, call 1-800-677-6289.

Graphics and text by
LORI A. GALLO
Courier-Post

Crystal jellyfish
Aequorea victoria

Jellyfish go with the flow, swimming a bit, drifting where the current takes them. The crystal jellyfish gives off a glow when disturbed.
Size: bell diameter 3 to 10 inches

Tentacles

All cephalopods have tentacles with suckers. An octopus uses them to grip the ocean bed, feel, taste and capture prey.

Speedy retreat

Squid and octopus can speed through water by jet propulsion, pulling water into their bodies, then squirting it out. They can also eject a cloud of ink to distract predators and allow time to escape.

Sperm whale
Physeter macrocephalus

The deepest diver of great whales descends to depths of more than 3,000 feet to capture squid.
Size: Females 36 feet, males to 59 feet

Tentacles capture prey

Arms

Giant squid
Architeuthis dux

Largest invertebrate with largest eyes of all animals, 18 inches across. Two tentacles with several hundred suckers seize prey and draw to beak-like mouth.
Size: up to 60 feet

Oarfish
Regalecus glesne ascanius

Longest bony fish in the world. Size: to 30 feet

Lantern fish (below)
Myctophum punctatum

Different light organ patterns occur on different species, used to maintain schools, find mates and find food. Most will go to the surface nightly to feed. Size: 5 inches

Hatchet fish
Sternoptyx obscura

Counterillumination makes these small fish almost invisible. Light they emit imitates daylight filtering down from above and hides them from predators below. Size: 3 inches

Crawfish
Palinurus vulgaris
Size: 20 inches long

Hulaskirt Siphonophore
Physophora hydrostatica

Stinging tentacles act as defense and capture prey. Size: to 16 inches long

Photophores

Flashlight fish (right)
Photoblepharon palpebratus

The light organ beneath the eye is used for finding food and attracting mates. When threatened, the light is closed like an eyelid. Size: to 1 foot

Octopus

Octopuses are intelligent with large brains. Most live inside dens and only come out to find prey. Soft, flexible bodies allow them to hide in tiny spaces. Like other cephalopods, they can camouflage themselves to match their surroundings. **Size:** 15 feet in length

3,300 feet —

Living in the depths

In a dimly lit zone where food becomes scarce, animals have ways to find their way around to survive.

Vertical migration

Many deep-sea animals swim in shallower waters at night where food is more plentiful.

Controlling buoyancy

Most fish have an organ called a swim bladder that is filled with gas. By adding or subtracting the amount of gas (mostly oxygen), fishes control how much they float at any depth.
Not all fish have swim bladders. Sharks and rays stay afloat by actively swimming. Some marine mammals regulate their buoyancy by the amount of air they hold in their lungs and a layer of blubber aids in keeping them afloat.

Vision

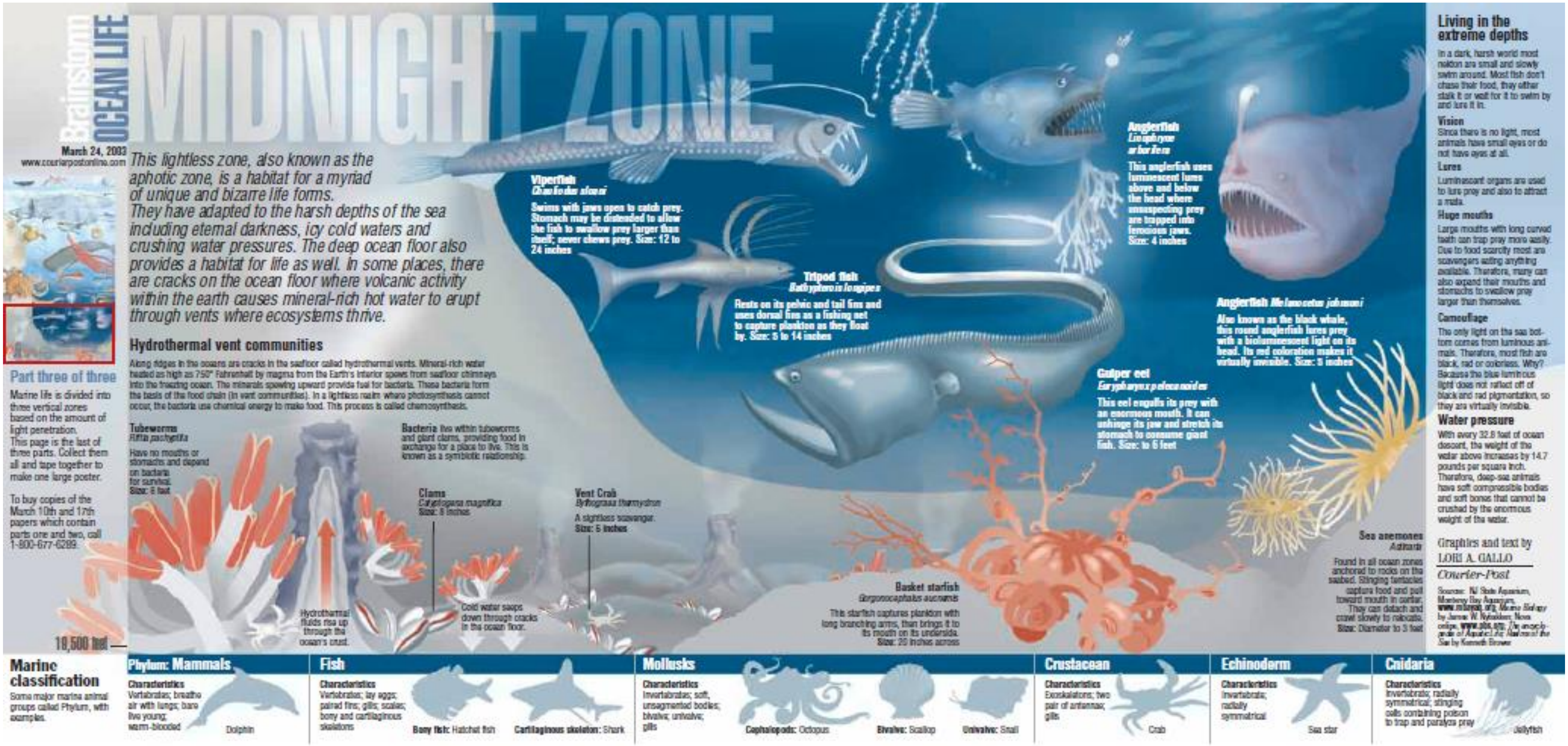
Most animals in the dimly lit zone have larger eyes than animals in the sunlit zone. This gives them maximum light-collecting abilities.

Bioluminescence

Bioluminescence occurs in life in the twilight zone and the midnight zone. It is the production of light by living organisms. The light-producing organs are called photophores. Animals have different types of photophores that can serve different functions, such as hiding from predators, finding and attracting prey and attracting mates.

Camouflage

In the twilight zone, where some light filters down from the surface, predators from below can see silhouettes. So some species use photophores as camouflage. They adjust their downward photophores to imitate the downward light, called "counterillumination." Most animals are silvery grey or red so they are not visible with the small amount of light penetration.
Some cephalopods can match their surroundings. Squid and octopus also squirt ink to distract predators as they escape.



Brainstorm
OCEAN LIFE

MIDNIGHT ZONE

March 24, 2003
www.courierpostonline.com

This lightless zone, also known as the aphotic zone, is a habitat for a myriad of unique and bizarre life forms. They have adapted to the harsh depths of the sea including eternal darkness, icy cold waters and crushing water pressures. The deep ocean floor also provides a habitat for life as well. In some places, there are cracks on the ocean floor where volcanic activity within the earth causes mineral-rich hot water to erupt through vents where ecosystems thrive.

Part three of three

Marine life is divided into three vertical zones based on the amount of light penetration. This page is the last of three parts. Collect them all and tape together to make one large poster.

To buy copies of the March 10th and 17th papers which contain parts one and two, call 1-800-677-6289.

Hydrothermal vent communities

Along ridges in the oceans are cracks in the seafloor called hydrothermal vents. Mineral-rich water heated as high as 750° Fahrenheit by magma from the Earth's interior spews from seafloor chimneys into the freezing ocean. The minerals spewing upward provide fuel for bacteria. These bacteria form the basis of the food chain (in vent communities). In a lightless realm where photosynthesis cannot occur, the bacteria use chemical energy to make food. This process is called chemosynthesis.

Tubeworms
Riftia pachyptila
Have no mouths or stomachs and depend on bacteria for survival.
Size: 6 feet

Bacteria live within tubeworms and giant clams, providing food in exchange for a place to live. This is known as a symbiotic relationship.

Clams
Calyptogena magnifica
Size: 8 inches

Vent Crab
Bythograea thermydron
A sightless scavenger.
Size: 5 inches

Hydrothermal fluids rise up through the ocean's crust.

Cold water seeps down through cracks in the ocean floor.

18,500 feet

Viperfish
Chauliodus sloani
Swims with jaws open to catch prey. Stomach may be distended to allow the fish to swallow prey larger than itself; never chews prey. Size: 12 to 24 inches

Tripod fish
Bathypterois longipes
Rests on its pelvic and tail fins and uses dorsal fins as a fishing net to capture plankton as they float by. Size: 5 to 14 inches

Anglerfish
Linophryne arborifera
This anglerfish uses luminescent lures above and below the head where unsuspecting prey are trapped into ferocious jaws. Size: 4 inches

Anglerfish *Melanocetus johnsoni*
Also known as the black whale, this round anglerfish lures prey with a bioluminescent light on its head. Its red coloration makes it virtually invisible. Size: 5 inches

Gulper eel
Eurypharynx pelecanoides
This eel engulfs its prey with an enormous mouth. It can unhinge its jaw and stretch its stomach to consume giant fish. Size: to 6 feet

Basket starfish
Gorgonocephalus eucnemis
This starfish captures plankton with long branching arms, then brings it to its mouth on its underside.
Size: 20 inches across

Sea anemones
Actinaria
Found in all ocean zones anchored to rocks on the seabed. Stinging tentacles capture food and pull toward mouth in center. They can detach and crawl slowly to relocate.
Size: Diameter to 3 feet

Living in the extreme depths

In a dark, harsh world most nekton are small and slowly swim around. Most fish don't chase their food, they either stalk it or wait for it to swim by and lure it in.

Vision
Since there is no light, most animals have small eyes or do not have eyes at all.

Lures
Luminescent organs are used to lure prey and also to attract a mate.

Huge mouths
Large mouths with long curved teeth can trap prey more easily. Due to food scarcity most are scavengers eating anything available. Therefore, many can also expand their mouths and stomachs to swallow prey larger than themselves.

Camouflage
The only light on the sea bottom comes from luminous animals. Therefore, most fish are black, red or colorless. Why? Because the blue luminous light does not reflect off of black and red pigmentation, so they are virtually invisible.

Water pressure
With every 32.8 feet of ocean descent, the weight of the water above increases by 14.7 pounds per square inch. Therefore, deep-sea animals have soft compressible bodies and soft bones that cannot be crushed by the enormous weight of the water.

Graphics and text by LORI A. GALLO
Courier-Post

Sources: NJ State Aquarium, Monterey Bay Aquarium, www.mbayaq.org; *Marine Biology* by James W. Nybakken; Nova online, www.pbs.org; *The encyclopedia of Aquatic Life*; *National the Sea* by Kenneth Brower

Marine classification

Some major marine animal groups called Phylum, with examples.

Phylum: Mammals
Characteristics
Vertebrates; breathe air with lungs; bare live young; warm-blooded
Dolphin

Fish
Characteristics
Vertebrates; lay eggs; paired fins; gills; scales; bony and cartilaginous skeletons
Bony fish: Hatchet fish
Cartilaginous skeleton: Shark

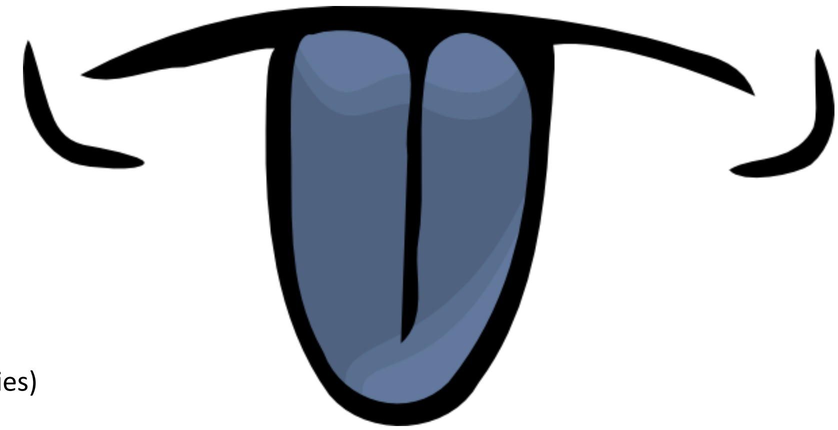
Mollusks
Characteristics
Invertebrates; soft, unsegmented bodies; bivalve; univalve; gills
Cephalopods: Octopus
Bivalve: Scallop
Univalve: Snail

Crustacean
Characteristics
Exoskeletons; two pair of antennae; gills
Crab

Echinoderm
Characteristics
Invertebrate; radially symmetrical
Sea star

Cnidaria
Characteristics
Invertebrate; radially symmetrical; stinging cells containing poison to trap and paralyze prey
Jellyfish

Deliciously Deep Blue



In honor of the depths of light, have students put together an edible model of the layers of light in the deep blue sea

Materials:

- ☐ Cups
- ☐ Spoons
- ☐ Berries (blackberries or blueberries)
- ☐ Blue Jello or pudding
- ☐ Purple Jello or pudding (option)
- ☐ Whipped Cream (dyed very pale blue with a little Jello powder or food coloring if desired)
- ☐ Optional: gummy sea creatures

Have students measure out the ingrediants to make the Jello, if not using pre-measured Jello.

Once the Jello has set, construct the layers as follows.

1. Midnight or aphotic zone: Fresh or frozen blueberries or blackberries (if unavailable, undesired, or with allergies dark blue or purple pudding, or purple gelatin cut into ½ inch cubes can be substituted, snack cups *or* home-made.)
2. Twilight or disphotic zone: Blue gelatin cut into ½ in cubes (blue gelatin snack cups *or* home-made). Or light blue pudding.
3. Sunlit or euphotic zone: Whipped cream ((dyed very pale blue with a little Jello powder or food coloring if desired.)
4. Add gummy sea creatures, ex. Swedish Fish Aqualife, to the euphotic zone, if available and desired.

Move Along, Nothing to Sea There!

For humans, the harsh and extreme conditions of the deep ocean-crushing pressure, corrosive salt water, and freezing temperatures have made deep sea exploration nearly as challenging as space exploration, and nearly as infrequent.

What is pressure? The gas molecules that make up air wiz around and bump into things. Like a ball bouncing against a wall (or your hand) when the gas bumps into things, it pushes against them. This pushing is exactly what we mean by pressure – and even if they think they've never experienced it, if we think about it a little, we can convince them it's true. Let's try a little experiment, have students:

1) Take a deep breath

2) Breath out slowly and steadily through your mouth

3) Before you've finished breathing close your mouth – but don't let the air out through your nose either, but continue blowing out against the inside of your cheeks

Feel something pushing your cheeks out and trying to part your lips? That is air pressure. When you've got your mouth open, the air on the in and out sides of your cheeks will be at the same pressure – so the air outside will push in with the same force as the air inside pushes out – so you won't feel anything, but when your ribs squeeze the air out of your lungs, there's more air jammed into the same space within your mouth – so it's like having two or three or twenty (depending on how strong your lungs are) times as many balls bouncing against the inside walls – the pushing out is stronger than the pushing in, which stretches out your cheeks.

The Earth's atmosphere has weight or force which presses down on everything on the surface. If you are at sea level, you have one atmosphere's worth of pressure pushing down on you. In other words, the pressure inside your lungs is the same as the pressure of the air around you, 1.033 kilograms on each square centimeter, or one atmosphere of pressure. It comes from every side of us, but sometimes it's easier to picture it as a column of air that goes from the top of your head to the edge of Earth's atmosphere. If you go higher, by climbing a mountain or flying in a hot air balloon, the column gets shorter; there is less air above you, and the air pressure decreases.

In the ocean, pressure works the same way, but instead of just having a column of air over you, you also have the weight of all the water above you, pressing down on your lungs. And water is much heavier than air. For every 10 meters you go below the surface, the pressure increases by one atmosphere. Our bodies are designed to withstand about one atmosphere of pressure.
At 2,500 meters, for example, you'd have 250 atmospheres of pressure on you. That's about what your big toe would feel like if an elephant were standing on it or more than 3,600 pounds pushing down per square inch! And pressures intense enough to instantly mash a Styrofoam cup to the size of a thimble.

Until recently the ocean was thought to be almost completely unproductive, not worthy of a "special trip". But today with the aid of modern research equipment scientists, biologists, and archeologists are beginning to understand the enormous variety and quantity of life down there. Exactly how deep-sea animals withstand intense pressures is not completely known, even though scientists have puzzled over this question for decades.

Scientists have been trying for decades to keep animals alive on their journey to the surface. Researchers have brought the creatures up slowly, hoping they will acclimate to the surface-level pressures on the way. Others have tried pulling animals to the surface quickly, then tossing them in a small pressure tank to bring them back to higher pressures. Animals that survived this trauma are placed in decompression chambers (similar to those used by divers) to see if they can adjust to shallow-water pressures for long-term study.

But such processes take a physiological toll on the animals. Over the years, only a few deep-sea organisms have been kept alive at the surface for more than a few days.

Recently, scientists have found ways to catch, recover and keep marine animals healthy at their natural pressures. Working with Gérard Hamel, an engineer at the Université Pierre et Marie Curie, Shillito developed a chamber to capture deep-sea creatures while keeping them under their natural pressure the whole way up. In the summer of 2008, the pair made headlines when they retrieved a live deep-sea fish from a record depth — more than two kilometers below the surface on vents in the Mid-Atlantic Ridge.

Now the group is testing ways to transfer its catches from the sampling device into a pressurized tank and take them to the lab, with no decompression in the process. Once in the lab, the animals are placed in pressure chambers designed to re-create the home environment. Video cameras, and in some cases a small viewing window, allow scientists to observe the critters.

Such pressurized chambers are being used in a handful of laboratories to keep deep-sea shrimps and crabs alive for long-term studies. Scientists use such high-pressure chambers to compare the physical links between shallow-water and deep-sea animals, hoping to help answer long-lingering questions about the origins of current deep-sea species.

The majority of distant observation of the deep sea depends on manned submersibles and remotely operated vehicles (ROVs) carrying various cameras and recording instruments. In development are autonomous underwater vehicles (AUVs) which are capable to roam on their own and return to the surface occasionally for fuel and maintenance. They transmit their information to satellites, which beams back to laboratories on land.

Even though there are remarkable advance in deep sea technology over the last 20 years, most of the deep remains unexplored. This is because only a handful of submersibles can dive depths greater than 3300 feet – and 60% of the ocean is more than 5,000 feet deep. It is believed it won’t be long until we can dive extra depths to see and learn more.

Underwater Hovercraft?

As part of our expedition, we need to see how we could send our own AUV down below to gather info about the depths. Just how could we get them down, and back up?

Be an engineer and design a mini unmanned submarine that moves in the water like a real submarine. The challenge is that their submarine must be able to float, sink and hover steadily (without touching the top of the water or resting on the bottom).

The whole class can share:

- Large container or tub
- Water

Each group will need:

- Small container with a lid (pill container, film canister, plastic bottle, etc.)
- Variety of small, heavy objects (coins, marbles, screws, washers, etc.)
- Variety of small, light objects (paper clips, fabric pieces, cork, beads, etc.)
- Rubber bands or string
- Water
- Paper
- Pen

Have students complete the three challenges below, and record their trials and results in their notebook or on the included worksheet and discuss their results as a group. What was most/least effective in each of the challenges:

Fill the container with water and set all the small objects and rubber bands or string nearby. The small container is your submarine.

1. **Figure out how to make it float** on top of the water, using any of the objects. Write down what you did and the materials you used. How many different ways can you find to make it float?
2. **Now figure out how to make your submarine sink** to the bottom of the container, using any of the objects. Write down what you did and the materials you used. How many different ways can you find to make it sink?
3. **Figure out how to make your submarine hover** in the middle of the water, using any of the objects. That means no part of it can be touching the top of the water, and no part of it can be touching the bottom of the container. Write down what you did and the materials you used. How many different ways can you find to make it hover?

What's happening?

Density is defined as weight per volume. The formula is **Density = Mass/Volume.** In the submarine, the volume stays constant. The density changes by adding or taking away the different objects.

When two or more forces act on an object, the result is the cumulative effect of those forces. The buoyant force is the net upward force (or uplift) exerted by a fluid on a submerged object. Gravity counters this force by pulling down on an object while the buoyant pushes the object up. If an object's density is more than that of the liquid, it will sink (force of gravity is *greater than* the buoyant force). If an object's density is less than that of the liquid, then it will float (force of gravity is *less than* the buoyant force). If an object's density is the same as that of the liquid, it will hover (force of gravity is equal to the buoyant force).

First, figure out how to make your submarine float on top of the water, using any of the objects.

1. Write down what you did and the materials you used.

2. How many different ways can you find to make it float?

Now figure out how to make your submarine sink to the bottom of the container, using any of the objects.

1. Write down what you did and the materials you used.

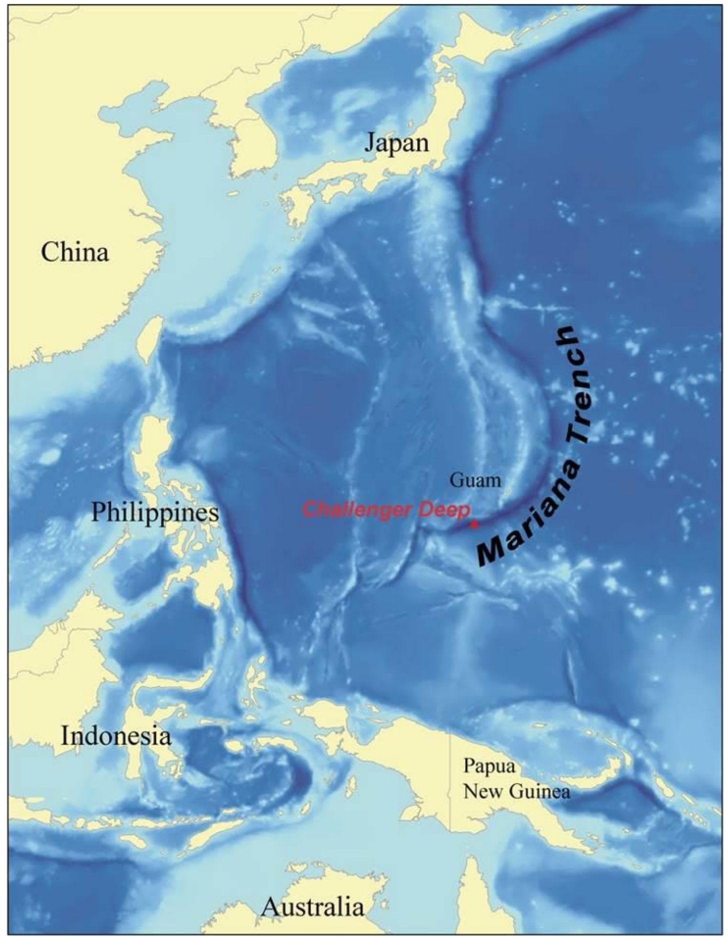
2. How many different ways can you find to make it sink?

Figure out how to make your submarine hover in the middle of the water, using any of the objects. That means no part of it can be touching the top of the water, and no part of it can be touching the bottom of the container.

1. Write down what you did and the materials you used.

2. How many different ways can you find to make it hover?

Imagination feeds exploration!



Ask the students, "What is the highest point in the world and where is it located?" (Answer: Mt. Everest at 29,035 feet, located on the borders of Nepal and China.) Then, ask the students where the deepest point of the Earth is (Answer: Mariana Trench). If a student answers correctly (or you can provide it after a few guesses), write "We've Arrived! Mariana Trench" across the top of one side of the blackboard.

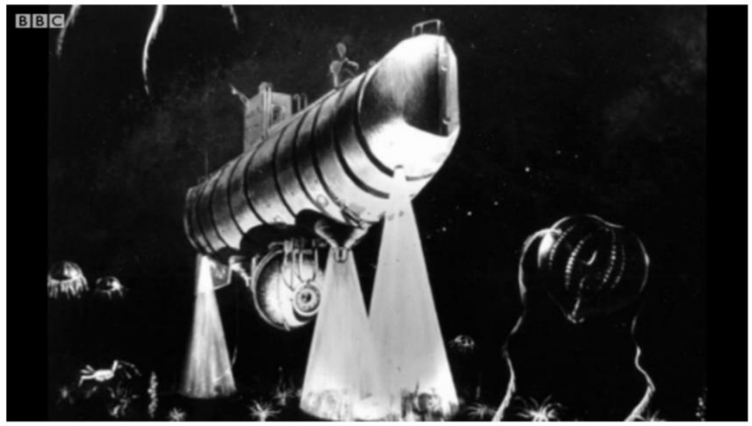
Now that we've arrived at the Mariana Islands, we need to get down to the bottom of the sea. this is the deepest part of the ocean and the deepest location on earth. It is 36,201 feet—almost 7 miles—deep. Explain that if you placed Mt. Everest at the bottom of the Mariana Trench, the peak would still be 7,000 feet below sea level.

How are we going to do it? Brainstorm with students about how we are going to accomplish our goal of finding those rare, valuable, and important jellyfish! **Who has been down there? How many people do students think have been to the bottom of the sea?** Only three people! A good way to learn, like other expeditions and scientists do, is to learn from those who have gone before us.

There have been 12 men on the moon so far, and until 2102, only two men at the deepest point on Earth. Exploration is often dangerous. Now there have been a grand total of three!

Ask students to imagine what the Mariana Trench is like. Brainstorm what type of living conditions might exist down there and write responses on the board. Student replies may include: cold, dark, little life, scary, vast, etc.

More than 50 years ago, two men climbed into a massive, blimp-like submersible, descended about 35,800 feet (10,912 meters) to the deepest point in the ocean, and became the first people to observe the dark underworld of one of Earth's most extreme environments. **What did they see? What was it like? What can we learn in order to complete our own mission and expedition?**



As we gear up to repeat the epic journey, watch as Don Walsh, himself, tells the BBC about their remarkable deep-sea feat (and hearing that ominous cracking sound) and view their submarine with a "Working space the size of a household refrigerator, and a temperature of a refrigerator too!" http://www.bbc.co.uk/news/science-environment-17060355

The short documentary "Mariana" at the following link illustrates the descent of Don Walsh and Jacques Piccard, to the bottom of the Mariana Trench, the deepest point on Earth. http://www.wired.com/video/mariana/757568980001 Note: there is a commercial before the video.

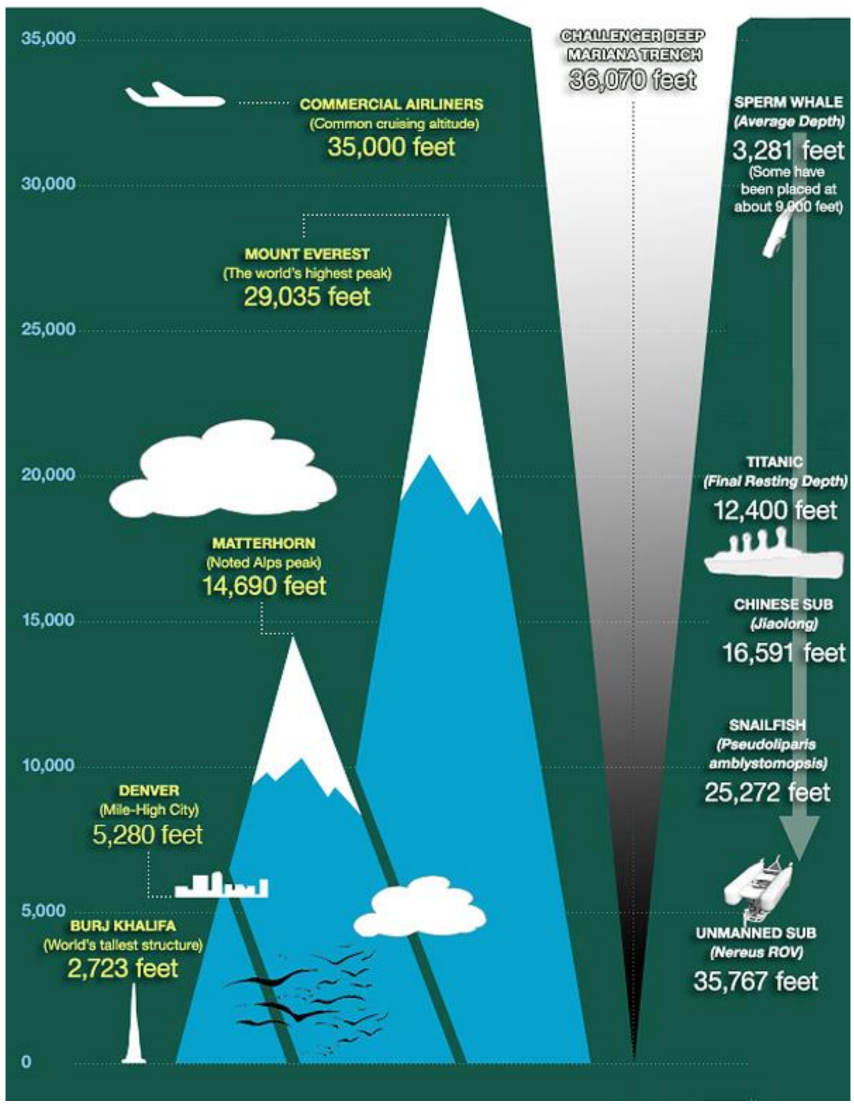
Where is a place in the world that your students have heard about that they would like to discover on our next expedition or in their own life? Have them explain what it is about this place that interests them. What would they do to get there? Would they raise their own funds? Would they ask people for help and money? How long would they be willing to work in order to go there? Why? How long do they think scientists waited to go back down into the mysterious Mariana Trench?

Though the two scientists expected someone would be back down within two years, fifty-two years later, no one had been back, until March 26, 2012, when James Cameron, a National Geographic explorer, made a record-breaking solo dive to the Challenger Deep in the Mariana Trench in a custom-built submersible that he co-designed. You have to imagine the possible before you can go and do it. There are just five manned submersibles in the world that can reach the abyssal plane and between them so far, they have explored less than 1% of it.

Photograph by Charlie Arneson DEEPSEA CHALLENGER preparing for a dive

For this expedition, Cameron squeezed into a pilot sphere (round space, like the inside of a ball) so small he could not extend his arms. He was the sole occupant in a complex, 24-foot-long (7.3-meter-long) craft made primarily of highly specialized glass foam. As he maneuvered on the ocean floor amid unexplored terrain and strange new animals, Cameron filmed footage for a feature-length documentary and collected samples for historic research. Why? To promote exploration and scientific discovery.

In his own words, "I've always dreamed of diving to the deepest place in the oceans. For me it went from a boyhood fantasy to a real quest, like climbing Everest, as I learned more about deep-ocean exploration and became an explorer myself in real life. This quest was not driven by the need to set records, but by the same force that drives all science and exploration … curiosity. So little is known about these deep places that I knew I would see things no human has ever seen. There is currently no submersible on Earth capable of diving to the 'full ocean depth' of 36,000 feet. The only way to make my dream a reality was to build a new vehicle unlike any in current existence. Our success during seven prior expeditions building and operating our own deep-ocean vehicles, cameras, and lighting systems gave me confidence that such a vehicle could be built, and not just with the vast resources of government programs, but also with a small entrepreneurial team. It took more than seven years to



design and build the vehicle, and it is still a work in progress. Every dive teaches us more, and we are continuing to improve the sub and its systems daily, as we move through our sea trials."

We're finally at the deepest part of our oceans after going to our Moon 44 years ago. To reach the deepest part of the Mariana Trench, James Cameron descended past some pretty amazing milestones. It took him over two hours to reach the bottom, but here is a glimpse of the amazing journey in under a minute. https://www.youtube.com/watch?v=Y2tm40uMhDI or here http://video.nationalgeographic.com/video/environment/habitats-environment/habitats-oceans-env/cameron-how-deep/

The dive was part of the DEEPSEA CHALLENGE expedition, a partnership with National Geographic that took Cameron, along with fellow pilot Ron Allum and a team of engineers, scientists, educators, and journalists, to the greatest depths of the ocean—places where sunlight doesn't penetrate and pressure can be a thousand times what we experience on land. After years of preparation, the team went to the Mariana Trench, a 1,500-mile-long (2,400-kilometer-long) scar at the bottom of the western Pacific Ocean. There, about 200 miles (320 kilometers) from Guam, Cameron continued the work that Don Walsh and Jacques Piccard, the first men to dive the trench in the submarine Trieste, started 52 years earlier.

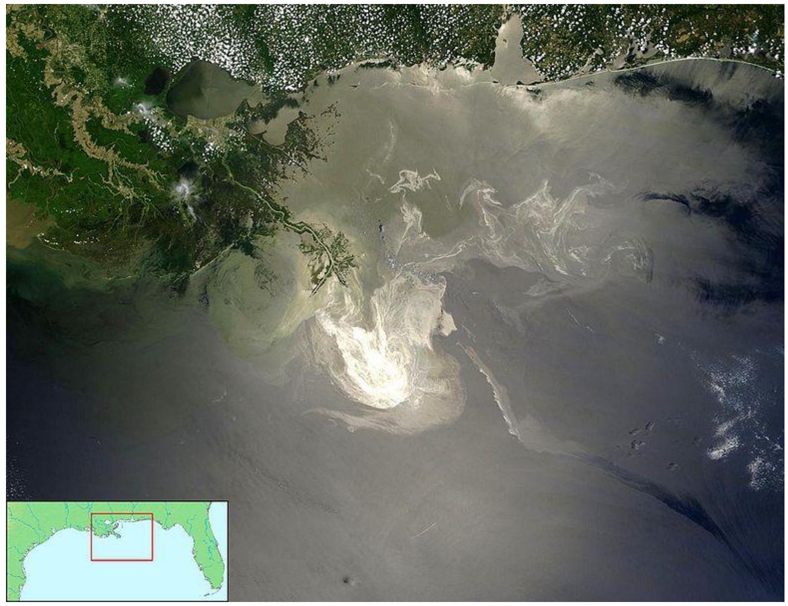
While the Trieste was not equipped to take pictures or get samples, Cameron and his DEEPSEA CHALLENGER submersible were armed with multiple cameras and a mechanical arm for scooping up rocks and animals.

Several hours prior to the dive, Cameron's support team dropped a phone booth sized unmanned vehicle down the trench. The vehicle gives off a chemical signature which attracts sea life, and Cameron attempted to meet up with that vehicle on the sea bottom to take 3-D video of those sea creatures.

The descent took 2 hours and 36 minutes. After spending several hours on the ocean floor, the ascent took 70 minutes and the submarine was found without difficulty using Microsoft co-founder Paul Allen's helicopter. Cameron's submarine, the 12 ton, 25-foot-long Deep Challenger, cost $8 million (which he partially financed himself. Despite the high cost of the ship, it can be (and already has been) used on multiple dives) and came equipped with a sediment sampler, a robotic claw, temperature/salinity/pressure gauges, an 8-foot tower of LED lights, 3-D cameras, and a "slurp gun" for nabbing small sea creatures to study them (and make them think they were being eaten by a

very strange predator indeed!)

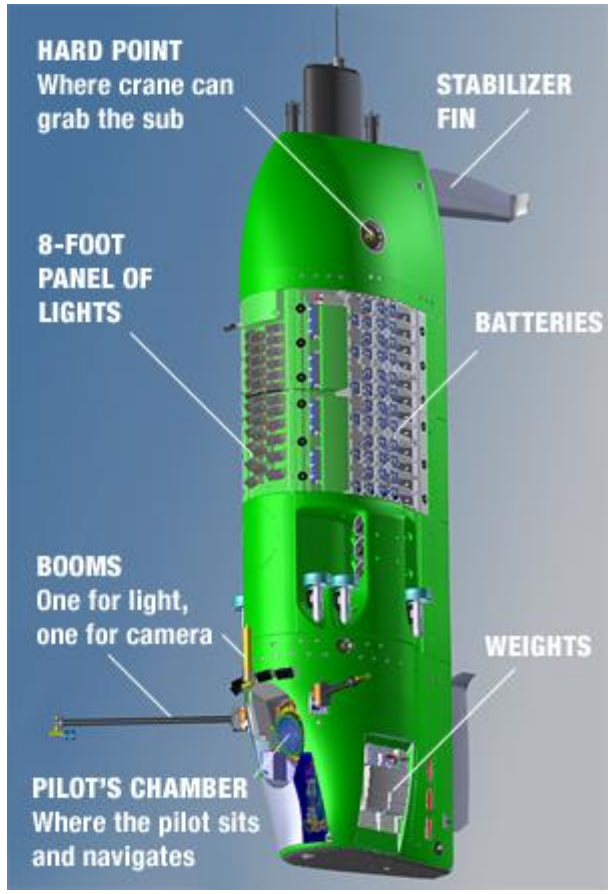
These samples could enable groundbreaking discoveries: Studying the forces that shape these trenches could help us to better understand the earthquakes that cause devastating tsunamis; studying the fauna that survives there could lead to breakthroughs in biotechnology and our understanding of how life began.



It also helps scientists learn what causes and helps prevent accidents like the oil spill off the coast of Louisiana in May 2010, one of the biggest oil spills in history, it is estimated that over 205 million gallons of oil were released into the Gulf. The mean (average) water depth of the Gulf is 1,615 meters.

How does the Deepsea Challenger submarine work?

In the following video link the team's project manager David Wotherspoon reveals how the sub works. Also, he explains how it has been put together and carved from giant blocks of newly designed foam and glue that is as strong as steel. How they tested it (wondering will it float? Will it sink? Will we survive?)



http://www.bbc.co.uk/news/science-environment-17436824

First ever video footage of the bottom of the trench:
http://www.youtube.com/watch?v=FGzaUiutuRk

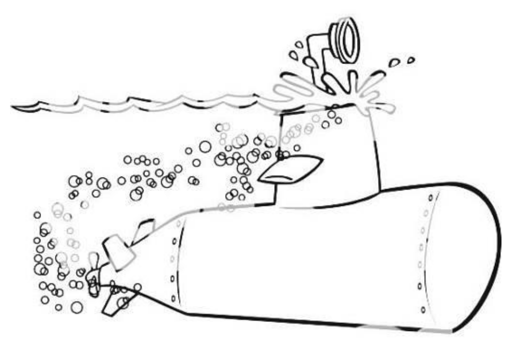
Deep sea exploration is important for us as we depend on the deep sea for food and other important resources. A growing amount of gasoline we use to fuel our cars comes from oil reserves located deep beneath the sea. In addition to this, scientists are using ingredients from deep sea organisms to produce new medicines to fight diseases. It is hoped that we can all benefit from these resources in the future.

Four other teams are diving to the deepest part of the ocean, the Mariana Trench, which lies 11km (seven miles) down in the western Pacific. One of them is Triton submarines, a Florida-based company. Their team has been in the Bahamas to test out a prototype submersible, which their full-ocean-depth model will be based on. It has a 6 inch thick completely clear bubble for the pilot to sit in.

Watch their first test dive here: http://www.bbc.co.uk/news/science-environment-17046179 **Which sub design do the students prefer? Why?**

Traveling Under the Seas

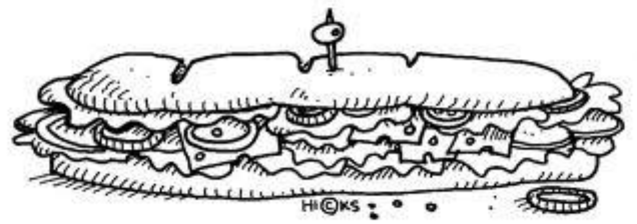
Now that we're at the Mariana Islands, in order for us to bring our own expedition to the bottom of the Mariana Trench, we're going to need a submarine! And in order to get her started we need to know how it works!



To do this type of experiment, and to describe what's happening it's helpful for students know what the following terms mean.

The Word is a Verb!

Holding 'Word Auctions' is a fun way to help students review definitions, parts of speech, key points in grammar and comprehension while having some good fun. Basically, students in small groups are given some 'money' with which to bid on various definitions or statements about a word. These definitions include correct and incorrect elements (*ex. you might say a submarine is a verb, or be a bit tricky by saying it can be an adjective and a noun, which is true, but will they believe you?)* , the group which 'buys' the most correct answers wins the game.



- Submarine: Submarine can be used three different ways. First, as an adjective, ex. submarine plants, in which it simply is describing something as being underwater. Secondly, it can be used as a noun (person, place, or thing). Either as a naval vessel designed to operate underwater (which fits our purposes), or it can be a name for a large sandwich on a long split roll.

- Friction: Friction is a noun, which means it's a thing, since it's not a person, and probably not a place. The word it comes from means a rubbing of two things together and that's really what it is. It is the force that resists motion between bodies in contact <the *friction* of a box sliding along the floor> <lubrication reduces *friction*> Now, sometimes we also say that there is friction between people but that means disagreement between persons or groups.

- Pressure: Pressure is also a noun, meaning it's a thing, and it's used in several different ways. **1 :** the application of force to something by something else in direct contact with it <keep steady *pressure* on the gas pedal> **2a :** the action of a force against an opposing force (ex. one is pushing up, the other down, pressure is in the middle) **b :** the force applied over a surface divided by its area **c :** the force exerted on something as a result of the weight of the atmosphere

- Buoyancy: Also a noun! Buoyancy is an object's (or diver's) tendency to float. You can think of buoyancy as an object's "floatiness" since buoyancy means the tendency of a body to float

Did You Know?

You can't smoke on a submarine, it's not only bad for your body, it's dangerous, the sub has flammable materials, and no one wants a sub filled with smelly smoke! Nicorette chewing gum was invented in 1967 in Sweden for men on submarines who would otherwise become agitated without the nicotine fix that cigarettes provided. In 1978, Nicorette was introduced to the general public and is now used as an aid to giving up smoking. The chewing gum contains nicotine, the addictive element in cigarettes.

or to rise when in a fluid <the *buoyancy* of a cork in water>
2 : the power of a fluid to put an upward force on a body placed in it <the *buoyancy* of seawater>

- Positive buoyancy: The object or person floats upwards in the water or remains floating on the surface.
- Neutral buoyancy: The object or person neither sinks downwards nor floats upwards, but remains suspended in the water at a single depth.

- Negative buoyancy: The object or person sinks downwards in the water or remains on the bottom.

- Gravity: Another noun! Gravity attracts all objects towards each other. The bigger an object is, and the closer you are to it, the stronger its gravitational pull is, such as the earth and an object on its surface. The Earth pulls on objects tending to draw them toward the center.
- Stabilizing fins: Noun which means fins or small wings mounted on a ship or aircraft in such a way as that it prevents unwanted rolling or spinning motions of the vehicle and contributes to the ship’s stability, allowing it to move forward and not simply spin in place.
- Hydrodynamics: A noun! A branch of physics that deals with the motion of fluids (especially incompressible ones, meaning you can’t squish them down) and what happens with forces when solid objects, creatures, boats, people, etc. are immersed in fluids and the motion of both the fluids and the objects.
- Stability: An adjective this time and it means that something is not likely to change suddenly or greatly and is not easily changed or affected. That means if your ship has stability it isn’t suddenly wobbling or spinning all over the place, or bouncing up and down.

Going to Sea in a Barrel

The first submarine was invented and demonstrated in 1620. English inventor Cornelius von Drebbel is credited with building the first working submarine. He actually built three, which all functioned. The American Revolutionary War saw the appearance of the first combat submarine---a wooden shell that was powered by a single operator using hand-cranked propellers. The craft was a conglomeration (collection or hodge-podge) of air vents and valves, which gave it limited mobility and submersion ability. Today's nuclear-powered subs can reach lengths of 560 feet and stay submerged for 120 days.

The first motorized submarine was built by John Holland, and it became the U.S. Navy's first commissioned sub in 1900. Dubbed the USS Holland, it had two motors: a gasoline engine for surface movement and an electric one for submerged motion. The first nuclear-powered submarine, the *Nautilus*, (named after the famous first and very imaginary submarine in the book *20,000 Leagues Under the Sea*) was launched 50 years later in 1954. It later journeyed under the polar ice cap to the North Pole in August 1958, demonstrating the capability of submarine vessels.

Now we need to build our own submarine that will survive the crushing depths here at the Mariana Trench!

In diving down to the Mariana Trench, we want to sink at the beginning of the dive to get down our desired depth, and then remain neutrally buoyant (at the one depth) until we ascend.

We're All Sinking in a Clear Submarine!

In the following project, we will investigate how changes in buoyancy affect whether a submarine dives or surfaces. We will build our own miniature submarine to use in our own Mariana Trench dive and test different levels of buoyancy with our model. We will change the level of buoyancy by adding different amounts of air and water to our model submarine.

Materials and Equipment

- ☐ Printed out copies of the howtoons.com instructions graphic for student groups
- ☐ 2-liter soda bottle (1 per sub)
- ☐ Water bottle, standard size, approximately 500-700 mL
- ☐ Drill with a 3/32-inch drill bit; or an equivalent sized nail and a hammer, be sure to confirm, but this size should create a hole that will fit the paper clip you'll be inserting
- ☐ Sharp Scissors (or razor blade, ex. box cutter, Razor blade or knife (ONLY used by competent adults)
- ☐ Pen or needle
- ☐ Needle-nose pliers
- ☐ Large paper clips (2 per sub)
- ☐ Metric liquid measuring cup
- ☐ Permanent marker
- ☐ Chopsticks

- [ ] Stiff ruler
- [ ] Rubber bands (3 per sub)
- [ ] Waterproof sealant (such as silicone)
- [ ] Bathtub (or kiddie pool), filled with water
- [ ] Lab notebook
- [ ] 2 Liter Bottles

Making the Propeller

To begin making the propeller, cut the bottom half off the 2-L soda bottle. Cut the bottom, as shown by the howtoons.com worksheet, to make a propeller shape that has five separate curved blades. This can be a bit difficult because the plastic is thick in certain places. Note: An adult carefully use a razor blade or a knife to help you with this tricky step. See the image for a picture of the finished propeller.

1. Drill or use a hammer and nail to create a hole in the small water bottle cap and two holes in the propeller, one in the center and another just off center. Be sure to wear safety goggles when using any kinds of tools.

2. Using scissors, cut a small circle of plastic out of the remains of the 2-L soda bottle. The circle should be about the same size and shape as the submarine (small water bottle's) bottle cap. This piece will go in between the bottle cap and the propeller and will serve as a washer—the propeller needs a slippery surface against which to spin. Using a pen or a needle, carefully make a hole in the middle of the washer, big enough for the tip of a paper clip to easily fit through. Use caution if you use a needle so you don't poke yourself.

3. Straighten one end of one of the paper clips and feed it through the hole in the top of the bottle cap, then through the washer, and finally through the center hole of the propeller. The propeller fins should be facing down, curved away from the bottle cap.

4. Bend the inside end with the needle-nose pliers, looping it through the second off-center propeller hole to secure the paper clip and two pieces together.

5. You will use the water bottle for the submarine, but first you need to add measurement markers on it to help you fill the submarine with different amounts of water during your trials. Using a metric liquid measuring cup, pour water into the bottle, 20 mL at a time, each time drawing a line with a permanent marker where the top of the water is. When you are done, you can label the lines (20 mL, 40 mL, and 60 mL ...500 mL) for easier measuring later.

Making the Submarine

1. To make the submarine, have an drill or use a hammer and nail to create two small holes in the bottom of the water bottle, just like the holes in the propeller—one in the center and one slightly off-center.

2. Straighten one end of the second paper clip and use chopsticks to insert the straight end of the paper clip through the hole of the water bottle, from the mouth of the bottle into the centered hole at the end of the water bottle. This step is tricky!

3. Once you get the straight end out, use the pliers to bend the end over and hook it into the other off-center hole to secure it.

4. Use the chopsticks again to hook a rubber band onto the paper clip hook inside the water bottle submarine.

5. Without letting go of the rubber band, hook the other end of the rubber band loop through the paper clip hook inside the bottle cap propeller. If it is too difficult to pull the rubber band using chopsticks, use another paper clip to make a hook and use this to pull the rubber band to the hook in the bottle cap propeller. Make sure the rubber band is tight—the submarine's rubber band needs good tension or it won't be able to move. If the rubber band is too loose, try a smaller size. See Figure 3 for a picture of the connected assembly with a 2-L bottle submarine. *Note:* (a 2-L bottle is used in this figure because it is bigger, making the assembly easier to see—remember, you are using a smaller water bottle).

Figure 3. This is the connected assembly. The 2-L bottle is used only as a larger visual aid—you will be using a smaller water bottle for the submarine body.

6. Connect the ruler as a stabilizing fin, using two rubber bands. Place the ruler perpendicular and so it is just centered to the submarine. Attach it with two rubber bands that form an "X" around the bottle and the ruler.
7. Using the waterproof sealant, make sure that the paper clip holes are fully sealed. Water can easily move in and out of the submarine if there are still holes, which will affect the experiment. Give the sealant enough time to dry before proceeding with the experiment—see the sealant's instructions.

Umm, How Can You Tell if an Object (or Submarine) Will Float or Sink **Before** We Go For a Ride? Testing the Submarine's Buoyancy

A simple way to determine whether and object will float, sink, or do neither, is to use *Archimedes's Principle*. Archimedes's Principle explains that there are two forces at work to determine if an object will float or sink.

1. Gravity and the Weight of the Object - This pushes the object down

2. Buoyancy or Buoyant Force - This pushes the object up.

Easy! If the force from the weight of the object is greater than the force from buoyancy, the object sinks. If the buoyant force is greater than the force from the weight of the object, the object floats. (Hint: iPhones sink). There is an unequal amount of force, the push one direction is stronger than the push from the others.

Now all that is left is to figure out how much the buoyant force for a given object is. The simplest way to do this is to weigh the water that the object displaces. The buoyant force on a given object is the same as the weight of the water it displaces. It follows then that:

- **An object floats up** if the weight of the water it displaces is more than its own weight. The downward force is less than the buoyant force, causing the object to float.
- **An object sinks down** if the weight of the water is displaces is less than its own weight. The downward force is greater

than the buoyant force causing the object to sink.

- **An object remains suspended at one level** if the weight of the water it displaces is exactly the same as its own weight. There is an equal amount of force coming from every direction. The downward force is equal to the buoyant force causing the object to remain where placed.

1. Now students should fill your submarine with different amounts of air and water using the marks they made earlier. Starting at 0 mL, test each mark for buoyancy. They will need a data table in their lab notebook to keep track of their experiments and results. See the one below for an example.

Amount of Water (mL)	**Amount of Air (mL)**	**The submarine: (sinks, rises, or stays level)**	**Buoyancy is: (positive, negative, or neutral)**
0 mL	500 mL		
20	480 mL		
...	...		
480 mL	20 mL		
500 mL	0 mL		

2. Each time, after they fill the submarine bottle with the desired amounts of air and water, tighten the bottle cap and use the propeller to twist the rubber band around several times to build up potential energy. Why will this propeller work? Look at it. What makes it force the submarine forward instead of backward? Which way should it spin? Be sure they count and record in their lab notebook how many times they've twisted the rubber band around and remind them to *twist it the same number of times for every trial.* Have students submerge the submarine in the bathtub or pool of water and let it go under adult supervision. What happens to the submarine? If their submarine:
    - Sinks - this result is negative buoyancy.
    - Rises - this result is positive buoyancy.
    - Stays level - this result is neutral buoyancy.
3. Have students keep testing, emptying, refilling, and testing their submarine until they have found a good range of buoyancy.

4. Make a graph of your class data to help you analyze the results. You could make two graphs, one of Buoyancy vs. Air Volume (mL) and another of Buoyancy vs. Water Volume (mL). Do they show the same or different relationship?

5. Have students think about their results and make a conclusion. How did the amounts of water and air affect the buoyancy of your submarines? Why do they think buoyancy is important for the hydrodynamics and stability of submarines?

When you see a **submarine** underwater in a movie, it probably seems as if it's moving very slowly, but actually, submarines move very fast. The fastest submarine can travel over 40 knots, which is over 75 kilometers per hour! Moving and maneuvering a large submarine underwater is a tricky task because of the forces involved: gravity, buoyancy, pressure, and friction.

First, think about the force of **friction** and how it is different when moving in the water. Have you ever tried running in a pool? Then you know it is much more difficult to run through water than to run through air. That is because water is more dense than air, and it is actually pushing back on you when you move. Moving though water creates a lot of friction, and submarines are designed to minimize this force by having a hydrodynamic, bullet-like shape. Submarines are also made of very strong materials, like steel, to resist the forces of high **pressure** the submarine encounters as it dives deeper under the water.

Due to the immense pressure beneath the surface of the water, submarines hulls must be incredibly strong. As a matter of fact, submarines have two hulls: an outer hull that is waterproof and a stronger inner hull. It is the space between these hulls that allows the sub to float or sink.

But, submarines are large, heavy ships that are often built with steel, so how in the world do they float in the water? The answer is **buoyancy.** How does buoyancy work?

Everyone has experienced the fact that things feel lighter under water than they do out of water. This is due to a buoyant force upward. The buoyant force is equal to the weight of the liquid that the object displaces. To see how this works, you need to understand the various forces at work in the air and underwater. While these

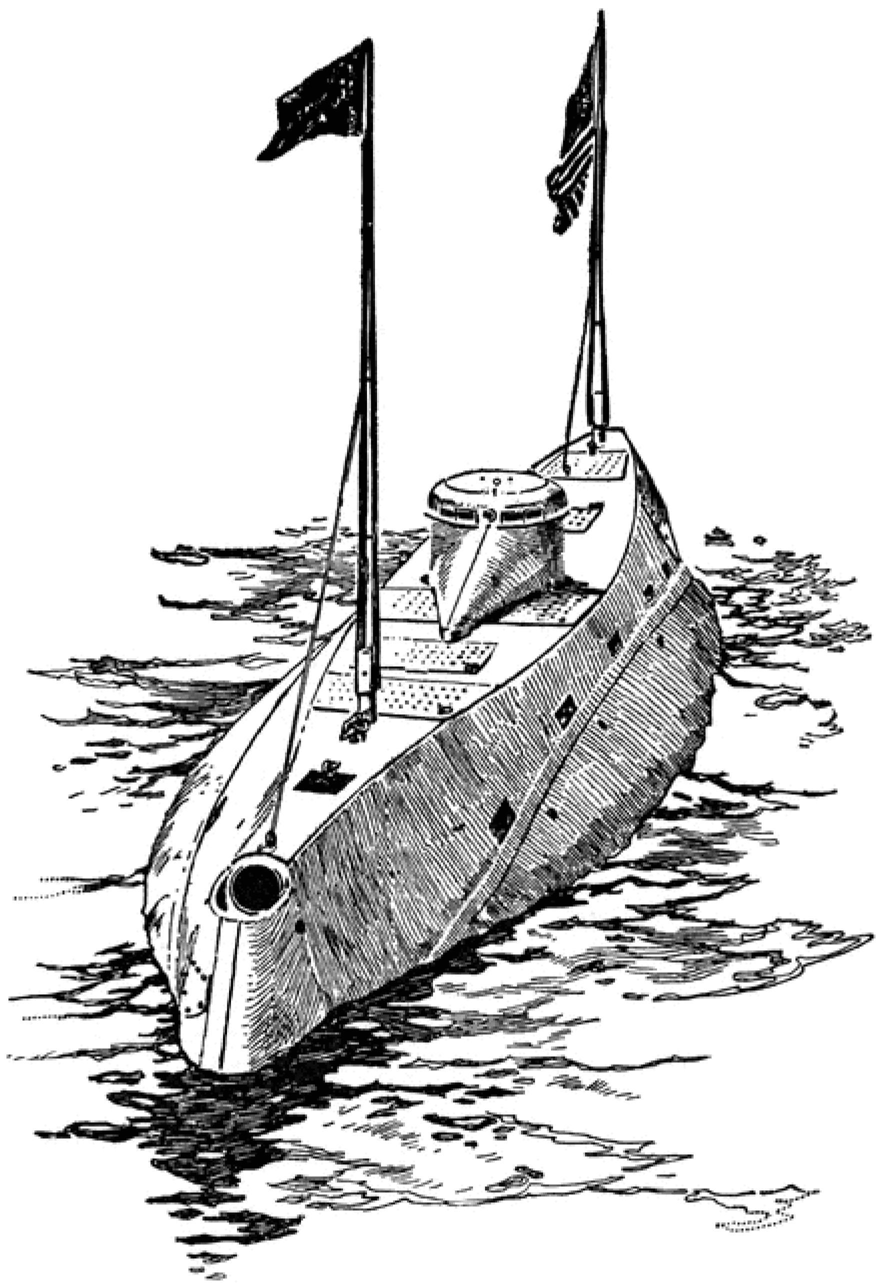
two different environments seem very different to us, water and air are actually very similar. Both are **fluids**, which are substances with mass but no shape. On Earth, an object immersed in a fluid (such as a fish or submarine in water or you and I in the air) experiences two major forces:

- The downward pull of **gravity**
- The upward push of **buoyancy**

When an object (fish, ship, rock, diver, you) is submerged in the water, water is pushed aside to make space for the object. For example, if you drop your new iphone in a full glass of water, not only will you have a serious communication problem, but you will have a nasty little spill from the water that overflowed the glass. The amount of water pushed aside to make space for the iPhone (now dripping onto the floor) is exactly the same volume as the iPhone. We say that this water has been *displaced*.

When an object or diver displaces water, the water surrounding it has the tendency to try to fill in the space the object now occupies. The water pushes against the object, exerting force and pressure on it. This pressure pushes the object upwards, and is called the *buoyant force*.

If you submerge an empty gallon milk jug in a bathtub, it displaces (takes the place of, or the space of) a gallon of water. The water in the bathtub then pushes up on the jug with a little more than 8 pounds of force, the weight of a gallon of water, shoving it up. An object with greater volume is pushed up with greater force because it displaces more fluid. Of course, if the object is denser (and therefore heavier) than water, like your iPhone, it doesn't matter how much water or how little it displaces -- it will still sink.



We can't change from negative to neutral buoyancy on a whim because we can't change the amount of water our submarines displace, we have to change something internally.

A submarine or a ship can float because the weight of water that it displaces is equal to the weight of the ship. This displacement of water creates uses that upward force (*buoyant force*) and acts opposite to **gravity,** which would pull the ship down. Unlike a ship, but rather like a fish or a diver, a submarine can control its buoyancy, thus allowing it to sink and surface at will as it displaces a volume of water that weighs more, less, or equal to what the submarine weigh s. In this last case, the forces of buoyancy and gravity cancel each other out, and the submarine stays at that level, it has neutral buoyancy.

How? Located between the two hulls are the ballast tanks. These can be filled with either water or air depending on the desired reaction. At the front of the vessel are the trim tanks, which are filled first so the front of the craft rises or falls first. Some submarines have fuel ballast tanks which, when emptied of fuel, can be used as additional ballast tanks. Manipulation of the ballast tanks causes the submarine to float or sink. When the tanks are full of air, the increased buoyancy (lessened density) of the craft causes it to rise to the surface. When water is let into the tanks, the buoyancy decreases (density increases) and the craft will sink. Water is moved in and out of the tanks by a system of pumps or valves.

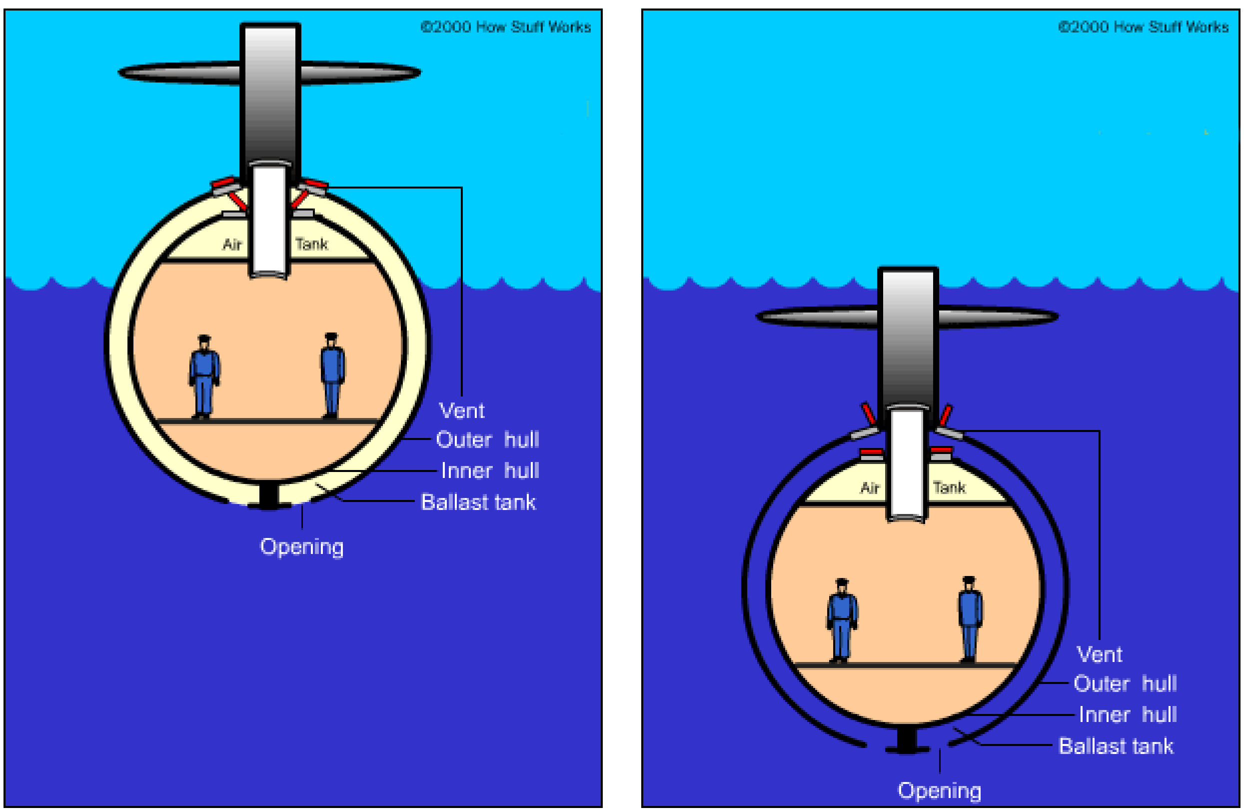


Figure 1. At http://science.howstuffworks.com/transport/engines-equipment/submarine1.htm you can play this java tutorial showing how a submarine dives and surfaces by changing how much water it stores in the ballast tank. On the left, the ballast tank is empty, and the submarine is at the surface. On the right, the ballast tank is full, and the submarine dives underwater. (Freudenrich, C. and Brain, M.,

2000.; images ©How Stuff Works.)

When on an expedition, we'd really like a nice stable trip, not a wobbly wacky sub ride. So, stabilizing fins, do they really do any good? Let's find out!

Testing the Submarine's Fin

1. Fill the submarine bottle about three-quarters full with water and screw on the bottle cap. The cap is not supposed to move with the propeller, so make sure it is screwed tightly.

2. Using the propeller, twist the rubber band around several times to build up the potential energy. Why will this propeller work? Loot at it. What makes it force the submarine forward instead of backward? Which way should it spin? Be sure you count and record how many times you've twisted it around in your lab notebook and *twist it the same number of times for every trial.* Submerge the submarine in the bathtub or pool of water and let it go. Be sure to have an adult with you if you are testing this in a pool. What happens to the submarine? If your submarine:
    - Sinks - let some water out.
    - Floats - add more water.
    - Moves forward - you are ready to start!

How does the submarine move forward and backward?

Submarines are propelled, on the surface and beneath, by propellers, or screws, at the rear of the vessel, but there is a trick to this movement. When the propeller spins, it can also spin the submarine, taking away any forward movement. Without stabilizing fins, a submarine would just be a spinning tube going around and around under water. Submerged maneuvering is accomplished by the use of finlike structures called hydroplanes. Much like a fish's fins, or the flaps on an airplane, the hydroplanes can be angled to propel the sub up or down or to make turns. The fins also stabilize the sub to prevent the entire vessel from spinning. The stabilizing fins resist spinning by adding a force of friction, canceling out the spinning motion, which allows the propeller to push the submarine forward. The submarine can also move backward by changing the direction that the propeller spins.

3. Next, do a series of tests as you change the position of the stabilizing fin. Test ten different positions and observe the results each time, always recording them in your lab notebook. You will be testing the submarine without fins, and then with the fin centered, to the left, and to the right. Those three positions will each be tested at the middle, front, and back of the submarine, giving a total of nine tests, plus one for the submarine without a fin. Be sure when you shift the fins left or right that you select one increment, in inches, and use that same increment for every trial. Also, be sure that when you shift the fin forward or backward that you select a different increment, in inches, and use that

same increment measured from the center of the bottle. You should record your results in a data table in your lab notebook like this one:

Direction of Movement	**Other Observations**
No Fin	
Middle: Fin Centered	
Middle: Fin to the Right Side	
Middle: Fin to the Left Side	
Front: Fin Centered	
Front: Fin to the Right Side	
Front: Fin to the Left Side	
Back: Fin Centered	
Back: Fin to the Right Side	
Back: Fin to the Left Side	

4. How did the presence of the stabilizing fin affect the movement of your submarine? What was the best fin position? Why do you think stabilizing fins are important for the hydrodynamics and stability of submarines?

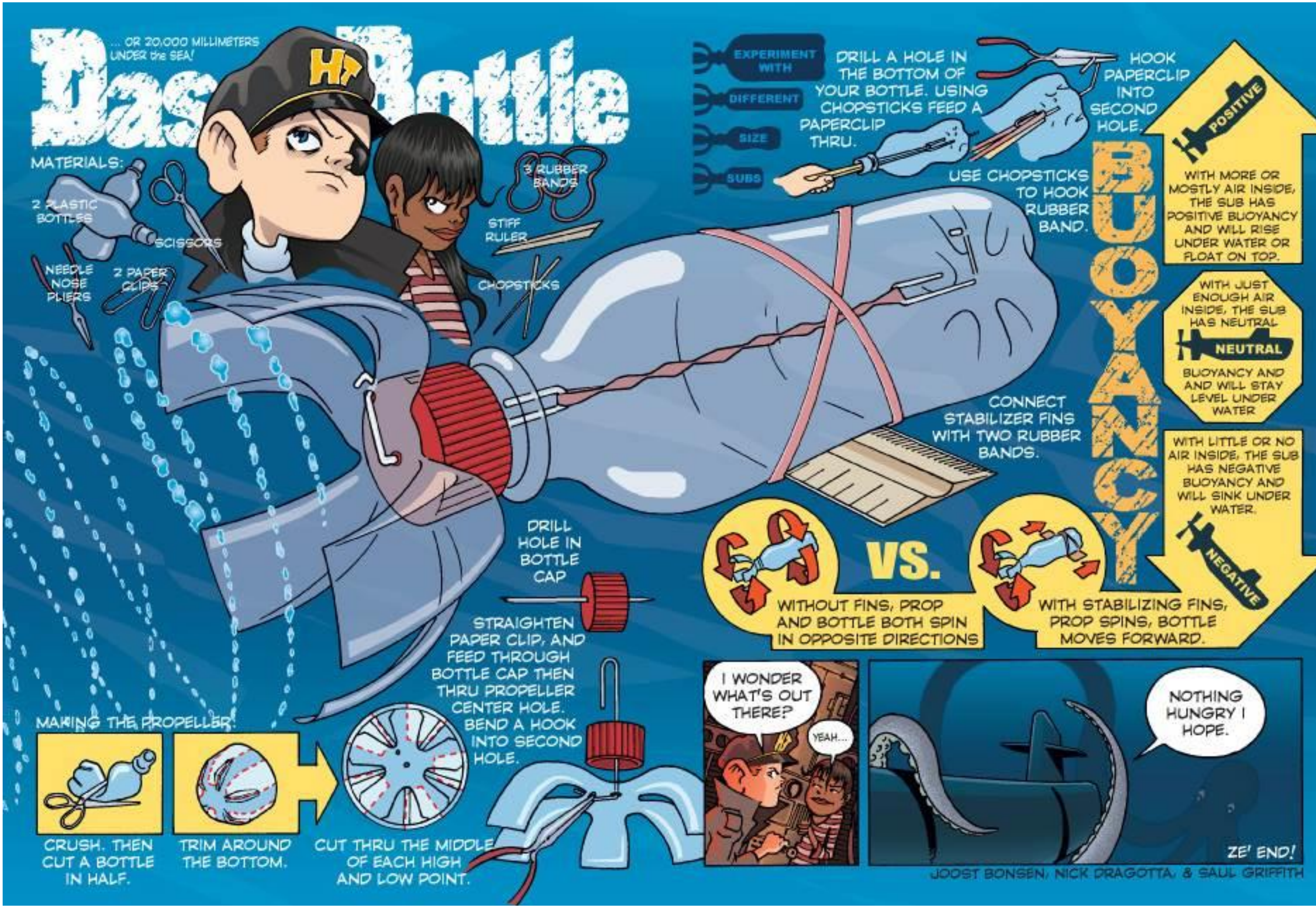
Variations

- What happens if you fill the bottle with liquids other than water? Do you think you will get the same results? Try these other liquids and see what happens:
  - Alcohol
  - Mineral oil
  - Vegetable oil
  - Syrup

- You can also try using different-sized bottles for your submarine. The bottle cap will fit into soda bottles of various sizes. How do the different sizes compare? Do you use the same amounts of air and water?
- Try making the propeller from a water bottle instead of from a 2-L soda bottle. This would reduce the amount of drag the propeller produces, but it could also be a weaker propeller. Is it more efficient to use a smaller propeller or a larger one?

Here are a few more ways you can change and test the stabilizing fins:

- Try long versus short fins. Use different materials that are different lengths as stabilizing fins. Is longer always better?
- Continue shifting the fins by small increments to the right or left. Use the measurements on the ruler to guide you as you shift an inch at a time to the right or left. Do more subtle changes have a different effect on the submarine's movement than large changes?


Das Bottle
... OR 20,000 MILLIMETERS UNDER the SEA!
MATERIALS:
2 PLASTIC BOTTLES
SCISSORS
NEEDLE NOSE PLIERS
2 PAPER CLIPS
3 RUBBER BANDS
STIFF RULER
CHOPSTICKS
EXPERIMENT WITH DIFFERENT SIZE SUBS
DRILL A HOLE IN THE BOTTOM OF YOUR BOTTLE. USING CHOPSTICKS FEED A PAPERCLIP THRU.
HOOK PAPERCLIP INTO SECOND HOLE.
USE CHOPSTICKS TO HOOK RUBBER BAND.
BUOYANCY
POSITIVE
WITH MORE OR MOSTLY AIR INSIDE, THE SUB HAS POSITIVE BUOYANCY AND WILL RISE UNDER WATER OR FLOAT ON TOP.
WITH JUST ENOUGH AIR INSIDE, THE SUB HAS NEUTRAL
NEUTRAL
BUOYANCY AND AND WILL STAY LEVEL UNDER WATER
WITH LITTLE OR NO AIR INSIDE, THE SUB HAS NEGATIVE BUOYANCY AND WILL SINK UNDER WATER.
NEGATIVE
CONNECT STABILIZER FINS WITH TWO RUBBER BANDS.
DRILL HOLE IN BOTTLE CAP
STRAIGHTEN PAPER CLIP, AND FEED THROUGH BOTTLE CAP THEN THRU PROPELLER CENTER HOLE. BEND A HOOK INTO SECOND HOLE.
VS.
WITHOUT FINS, PROP AND BOTTLE BOTH SPIN IN OPPOSITE DIRECTIONS
WITH STABILIZING FINS, PROP SPINS, BOTTLE MOVES FORWARD.
MAKING THE PROPELLER:
CRUSH. THEN CUT A BOTTLE IN HALF.
TRIM AROUND THE BOTTOM.
CUT THRU THE MIDDLE OF EACH HIGH AND LOW POINT.
I WONDER WHAT'S OUT THERE?
YEAH...
NOTHING HUNGRY I HOPE.
ZE' END!
JOOST BONSEN, NICK DRAGOTTA, & SAUL GRIFFITH

Flowing Fields of Salt: Watercolor Painting with Salt and Glue

Materials

- watercolor paper
- watercolor paints (pan, tube, or liquid watercolor paints)
- paint brushes
- Elmers Clear or Blue School Glue Gel
- salt
- (option) circle punch: 1 inch or longer

Have students create art inspired by the salt harvesting fields of San Francisco Bay and the play of salt water and sunshine along the seashore. The white starbursts seen throughout the paintings are pockets of salt on the liquid watercolors.

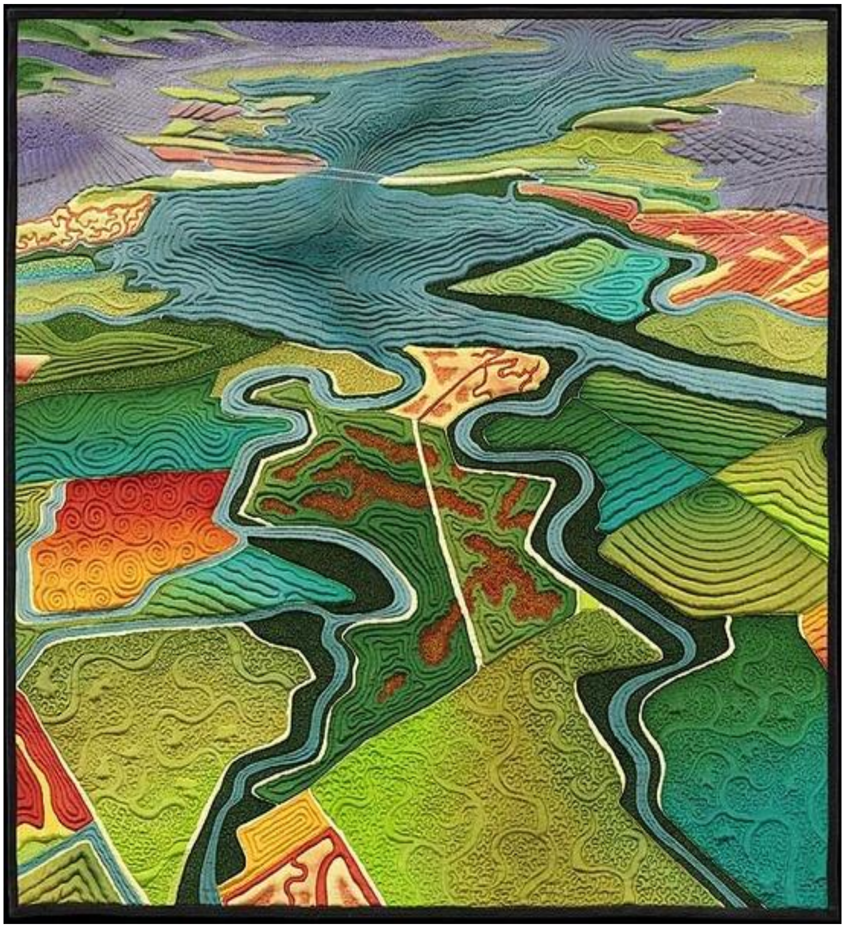
This art is made using watercolor paint, glue and salt, and involves squirting, painting and sprinkling with the kind of freedom that kids love.

Adding glue, which acts as a resist, creates wonderful texture.

Instructions

If you are unable to track down Elmer's Blue School Gel locally, you can use the clear one, either way, wonderful textures are created. Whether you use pan, tube, or liquid watercolor paints, remember to encourage the students to vary the intensity of the color for more interesting results.

1. Have students drizzle and squirt some glue onto a sheet of watercolor paper. Allow to dry completely (this may need to be overnight).



Title: Fields of Salt, Linda Gass Artist Statement: Although the landscape in this artwork may look like farm fields, it is actually salt ponds used for industrial salt production. These ponds used to be essential wetlands of San Francisco Bay. Copyright ©2007 Linda Gass. Photograph by Don Tuttle

2. Paint over the dried glue with watercolor paints. Sprinkle salt on sections of the painting while it is still wet. Once it dries, you'll notice how the salt absorbs the surrounding water and pushes the pigment away, leaving behind a white, speckled effect.

3. Once the paint has dried, use a cloth or dry sponge to gently remove the salt. Notice all the great textures that have been created.

4. Extension: Isolating small areas by cutting out shapes with a punch, opens up all sorts of artistic possibilities and allows students to piece it all together in new ways.

Battleship!

Although many people are familiar with game Battleship, math is not one of the strategies that usually come to mind, but it should be. Battleship requires students of all ages to practice thinking and problem solving skills that are critical to understanding mathematics. For the youngest players, it is a game of memory, logic and strategy while the more experienced players will realize that they need to use probability skills.
While playing the game, students become familiar with the following:

- Grids
- Columns
- Rows
- Points
- Graphs
- Ordered pairs

Teach Algebra with Battleship Game Math

Concept(s): One of the primary concepts that is taught when playing the Battleship game is plotting and naming points on coordinate grids.

Ordered pairs represent the location of points on the coordinate plane. Knowing the x- and y-
axis along with the x- and y-
coordinates of an ordered pair are vital when plotting points in the coordinate plane. This is a mathema
tical concept that appears frequently in daily life. It's used when giving geographic loc-
ations, when creating statistics charts, and to measure distance.

Playing Battleship will give students the ability to use the following techniques in a non-stressful way.

- X-axis
- Y-axis
- A point contains an x- and y- coordinate
- Origin
- Quadrants
- How to locate a point
- How to name a point

Materials:

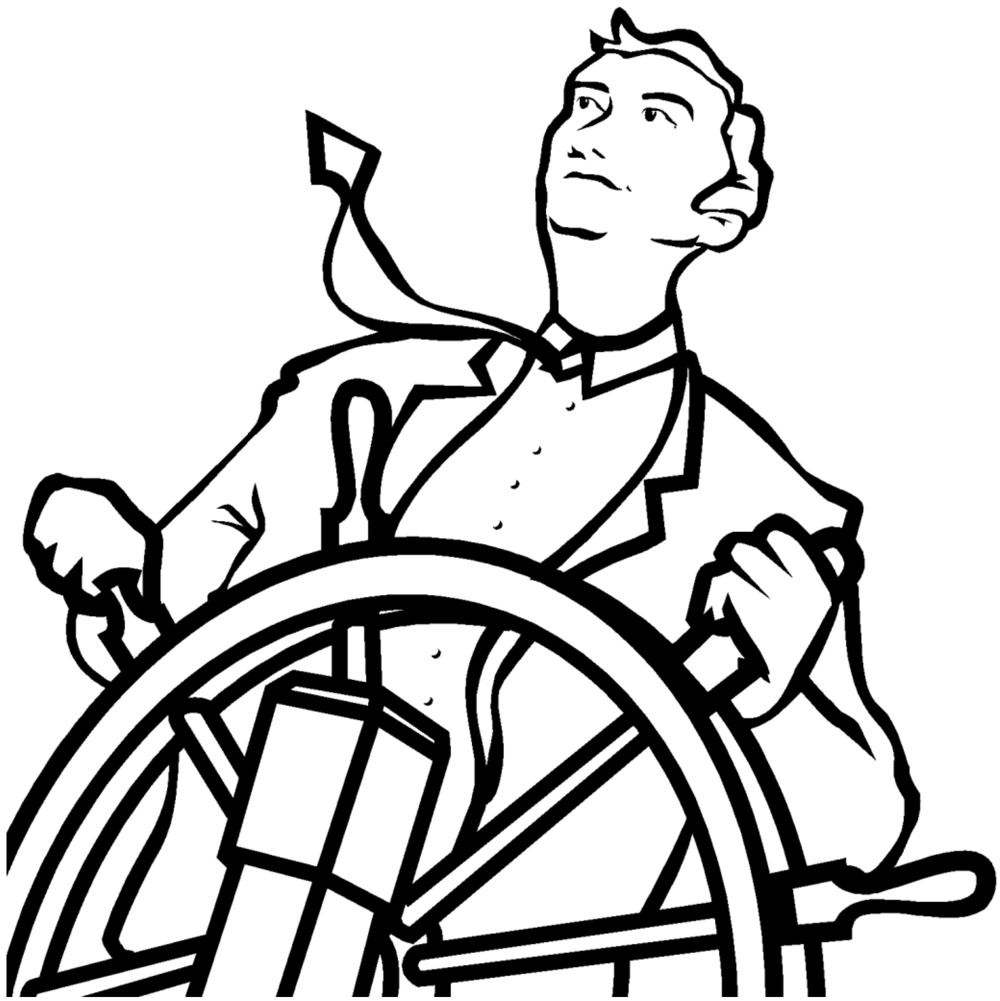
- Printouts
- Pencils
- Whiteboard

Place students in pairs to complete the Vocabulary Match activity. Each group has a set of cards containing "Term Cards" and "Illustration Cards". Read the term and definition on your term card. Use that definition to match the term card with its appropriate illustration card.

The coordinate plane below the fold should be left blank. After the example round, the teacher will have the students begin the activity.

What Students will do:

Each student will join a peer to complete the Vocabulary Match activity. Every pair will receive Vocabulary Match cards and a set of instructions. Even if students are unfamiliar with the terms being presented, they should still complete this activity to the best of their ability.



Students will use the terms acquired in the Vocabulary Match activity as well as their problem solving skills to complete the next activity, a game of Battleship. Throughout the game, their understanding of the terms previously introduced will be measured. This will allow the Teacher to see what points may need to be stressed and to clear up any misconceptions that exist.

Give each the "Battleship" activity sheet. Have a student read the instructions for the activity.

Instructions:

If not using the included sheet, instruct students to fold a sheet of graph paper in half and draw 2 coordinate planes (see a sample image).

```
                  + y-axis
                  |
                  + 3
                  |
                  + 2
                  |
                  + 1
 -5  -4  -3  -2  -1  |  1   2   3   4   5
--+--+--+--+--+--+--+--+--+--+--+--
                 /|            x-axis
                / +-1
          origin |
                  +-2
                  |
                  +-3
                  |
```

They should draw one coordinate plane above the fold and one below. Each plane should be labeled from -5 to +5 on both the x and y axis. The bottom coordinate plane should be left blank, this is where the opponent's ships will be labeled and shots fired (coordinate pairs) marked.

Placing Your Fleet

First have students decide where to place their own fleet within their grid. If using graph paper, on the coordinate plane graph that is above the fold, have students plot the locations of five ships. The ships must be placed vertically or horizontally (never diagonally) and must remain within +5 and -5 on both axis.

The five ships will follow these specifications:

- Aircraft carrier -- 5 points long
- Battleship -- 4 points long
- Submarine -- 3 points long
- Destroyer -- 3 points long
- PT-Boat -- 2 points long
- Ships cannot occupy the same square.

1. To place a ship, check how many boxes are covered by the ship and then write the first letter of the name of the ship in the boxes it covers. For example, a Cruiser covers three boxes so you would pick any three adjacent boxes and put the letter C in each box. Keep your fleet location secret from your opponent! When each player has marked their fleet on their grid, begin play.

The Game

Note: It is a good idea to familiarize all students with the rules of the game by playing one game with the whole class trying to guess where you have placed your ships.

1. Students play this game in pairs. They will keep their graph papers in front of them, folded. That way, when they lift up the fold, they will see the graph with their plotted ships above the fold (for easy access as the player answers his opponent's questions) and the blank graph flat on their desks so they can record the locations of their opponent's ships as they guess the ships' coordinates.

2. Students take turns guessing coordinates that might be the locations of their opponent's ships. (For example, a player might ask, Have you a ship at x coordinate 4, y coordinate -2? If the opponent does have a ship at that location, he or she **must** respond in the affirmative or say whether the shot is a "miss" or a "hit", and, if it is a "hit", AND what type of ship it is.

3. The student who asked the question notes on his or her graph that the opponent does have a ship there.) If they choose a coordinate where their opponent has placed one of his/her ships, they get to guess another coordinate.

4. As they play the game, each player should record all his/her right and wrong coordinate guesses on the blank coordinate graph. When the player has guessed all the coordinates of a ship, his or her opponent must "give up the ship that has been sunk" by telling the opponent of his/her success.) Gradually, students narrow down the exact locations of all of the opponent's ships.

5. Students keep track of what they have shot on their lower grid, and the ships they have sunk by crossing off the list of ships, or checking them off at the bottom right of your print-out.

6. The winner of the game is the first person who guesses the locations of (sinks) each of his/her opponent's ships.

Questions about rules:

- Can you move your ship from its initial location? [no]
- Can you give false clues about the location of your ship? [no]
- How do you win the game? [the first person to sink their partner's ships using the clues given will win the game]

Group Play: Two teams with an equal number of students (if possible).

- Each team will receive one sheet numbered graph paper on which to draw their battleships.
- Each team will draw five battleships. Each battleship must contain four ordered pairs on the numbered graph paper (reduce the number of battleships and/or the number of ordered pairs for classes that are working in the first quadrant only).
- Teacher collects the graph paper with battleships from each team.
- Teams take turns calling out ordered pairs to try to sink other team's battleships. (Teacher can indicate if the shot is a hit or a miss.) *This can also be done by having teams in two separate classrooms, with two separate instructors, who pass the guesses back and forth.*
- The first team to sink all opposing battleships is declared the winner.

- For an upper grades review of linear equations, the teacher might want to add in this rule: once a battleship has been hit by two or more ordered pairs, the opposing team can sink the battleship in one more shot by calling out the equation of the line that contains the battleship.

Teacher should circulate during game to see if all students are participating by keeping an accurate record of the ordered pairs on their individual pieces of graph paper.

Whole-class Activity: teacher vs. students, sink "The Captain before she sinks you!

Give each student a copy of the graphic organizer with directions, a table for coordinates fired at the Captain and fired at them, and a coordinate plane to keep track of their ships.

As the Teacher/Cap'n, the teacher will have the plane where everyone could keep track of when they hit or missed the Captain's ships on the white board, or on a coordinate grid made on the floor tiles.

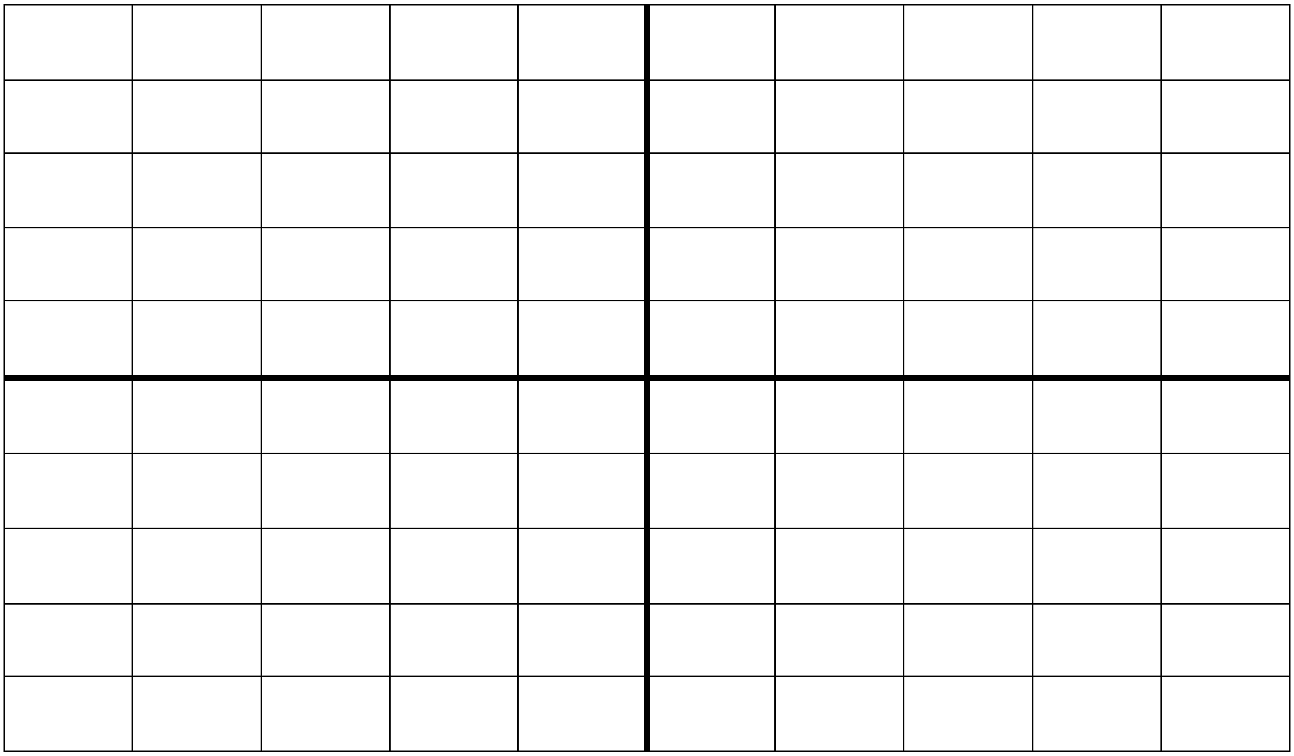
After labeling parts of the graph (x and y axis, origin and quadrants), the rest of the game remains the same as regular Battleship.

Reviewing Skills While You Play:

1. With each shot made, you may ask students to identify the **quadrant** or **axis** where the point was located.
2. You could also give them multiple options for the location by pointing at my coordinate plane to check that they understand how to read ordered pairs, i.e. knowing the difference between (-2, 3) vs. (3, -2) vs. (2, -3)
3. You can focus on points on the x-axis and y-axis, which the students always mix up.
4.You are able to give hints to check their

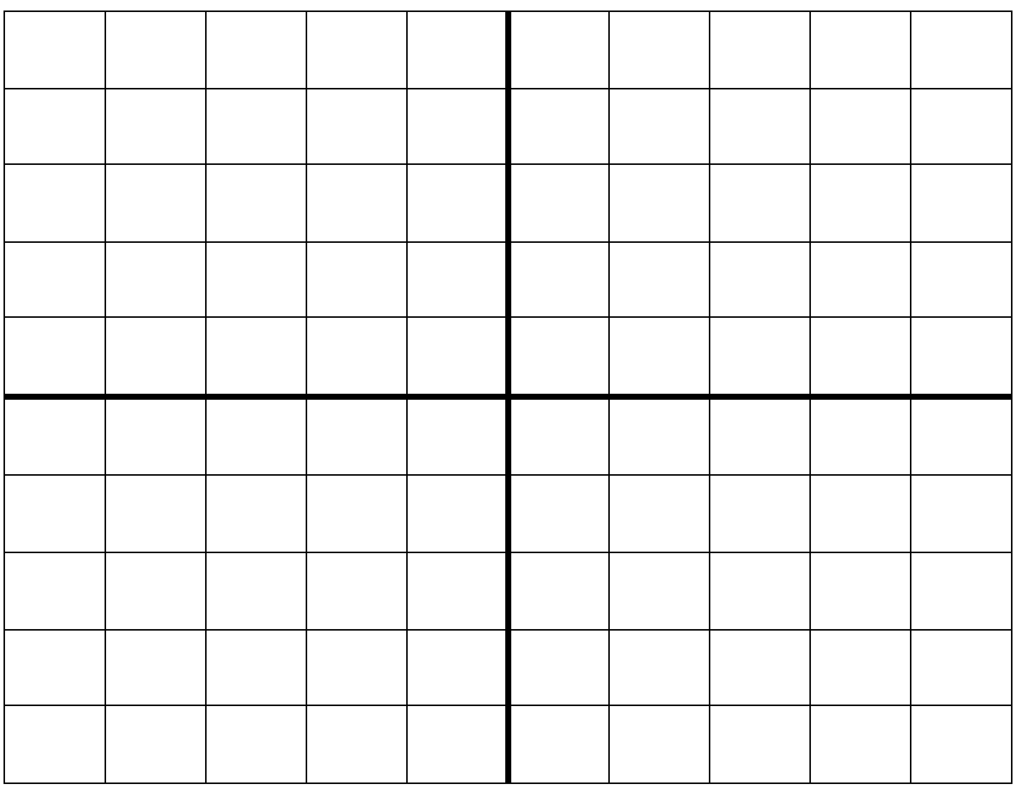
understanding, i.e. "One of my ships is located along the y-axis" or "I have a ship in Quadrant II" and then see if the next student fired at the right area.

5. You may also connect the game to graphing linear equations by having your aircraft carrier located along the line y=x (a parent function), discussing how to figure out where that line would be and then aiming at points along it.



Place the following ships on your grid. Ships cannot occupy the same square and must be placed horizontally or vertically. For example, a Cruiser covers three boxes so you would pick any three adjacent boxes and put the letter C in each box. Keep your fleet location secret!

- ☐ Aircraft carrier -- 5 points long
- ☐ Battleship -- 4 points long
- ☐ Submarine -- 3 points long
- ☐ Destroyer -- 3 points long
- ☐ PT-Boat -- 2 points long



Keep track of the shots (ordered pairs) you have made against your opponent on this lower grid, and the ships you have sunk by checking off the ships on the list.

- ☐ Aircraft carrier -- 5 points long
- ☐ Battleship -- 4 points long
- ☐ Submarine -- 3 points long
- ☐ Destroyer -- 3 points long
- ☐ PT-Boat -- 2 points long

NAME: ________________
DATE: __________

SINK the CAP'N!

Sink the Captain's fleet before he sinks yours!

Fired at Me
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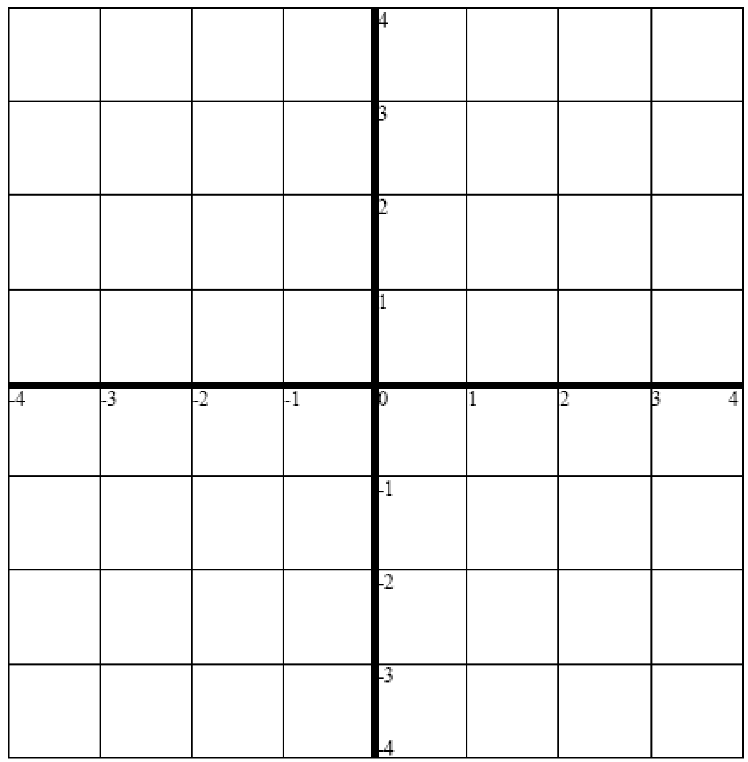
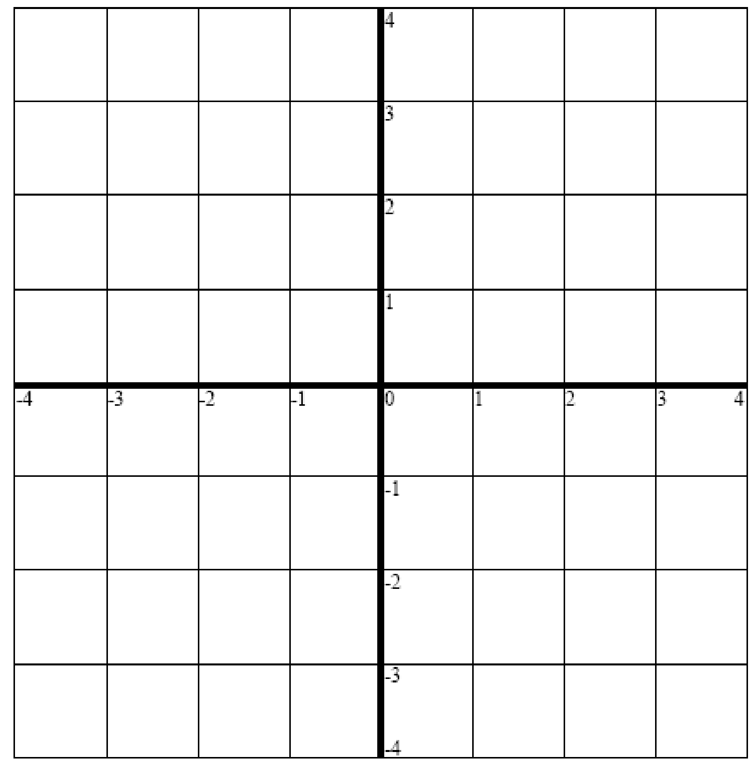


MY GRID (put your ships here)



CAP'N D's GRID (keep track of when you hit him here)

Fired at Cap'n D
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DIRECTIONS

Place 5 ships on your grid (LEFT):

- ✓ 1 aircraft carrier - 5 points long
- ✓ 1 battleship – 4 points
- ✓ 1 submarine – 3 points
- ✓ 1 destroyer – 3 points
- ✓ 1 PT boat – 2 points

Label the coordinate planes:

- ✓ x-axis
- ✓ y-axis
- ✓ origin
- ✓ Quadrants I, II, III, IV

Keep track of all attacks:

- ✓ Mark **X** for hits
- ✓ Mark ● for misses
- ✓ Write all coordinate points in the tables

Vocabulary Match Cards

Term Card

Ordered Pair: a pair of numbers used to locate a point on a coordinate grid

Term Card

y-coordinate: The second number in an ordered pair, which the distance to move up or down from (0, 0)

Term Card

y-axis: the vertical axis on the coordinate plane

Term Card

x-axis: the horizontal axis on the coordinate plane

Term Card

x-coordinate: The first number in an ordered pair, which tells the distance to move right or left from (0, 0)

Term Card

Coordinate Grid: a grid formed by two perpendicular number lines called axes.

Illustration Card

(2, 3)

Illustration Card

(2, 3)

The number 3

Illustration Card

(The bold line)

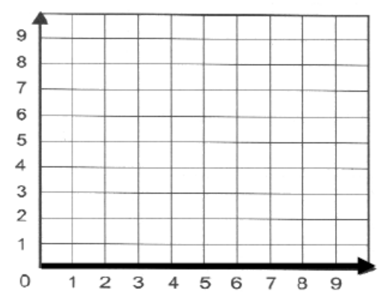


Illustration Card

(The bold line)

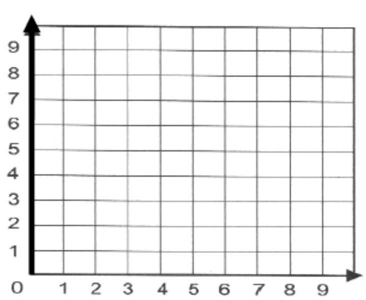
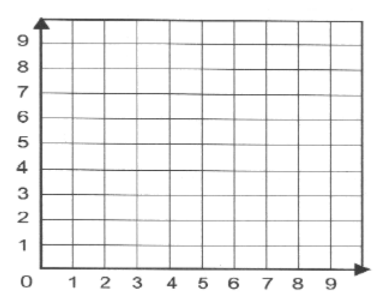


Illustration Card

(2, 3)

The number 2

Illustration Card



Samples of Sources and Resources

- BBC Ocean http://www.bbc.co.uk/nature/habitats/Deep_sea#p00hn502
- Ocean Zones http://howtosmile.org/record/13888
- Deep Sea Geysers http://education.nationalgeographic.com/education/activity/deep-sea-geysers/?ar_a=1
- http://kimiachemyst.blogspot.com/2010/05/chemistry-home-experiment-make-things.html
- http://globetrooper.com/notes/why-cant-we-drink-sea-salt-water/
- http://explorable.com/salt-water-egg-experiment
- Lesson Plan: Graphing on the Coordinate Plane using "Battleship" game: http://www.teachforever.com/2007/09/lesson-plan-graphing-on-coordinate.html
- Painting with Watercolors and Glue: http://www.sweethappylife.com/2012/activities/preschool-activities/painting-with-watercolors-glue-and-salt/
- http://artclubblog.com/2013/02/05/watercolour-painting-with-salt-and-glue/