Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2010 Volume III: Geomicrobiology: How Microbes Shape Our Planet

Microbes in Long Island Sound

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Introduction and Unit Goals

Science allows students to explore through hands on activities to learn about scientific concepts and ideas. This unit allows the students to understand how microbes can adversely or positively affect the survival of plants and animals in a particular habitat, Long Island Sound.

The following unit is designed for students from kindergarten to second grade. The focus will be on the role that microbes play in the survival of plants and animals and their ability to sustain life and thrive in the water. The students will learn about the characteristics of the plant life in the Sound.

The students will discover what bacteria are and how they can help or hurt plants and animals. They will also learn about germs in order to make a comparison between bacteria and germs. The students will learn about the biological processes that microbes and plants must carry out in order to survive. They will learn how rocks and minerals are transported and carried to the water through weathering and erosion and deposited on the seafloor. The students will investigate the impact that weather has on a habitat. The students will also discover the role that pollution has in the survival of a habitat and its inhabitants.

Rationale

Science is an exciting subject for students to learn. It allows students to explore, investigate, think critically and delve into a subject or experiment. They gain an understanding of the world around them, how things are created, how things work and why things look the way they do. Science allows the students to have a firsthand experience with what they are learning about, which increases their comprehension of the concept or idea being taught. The students also have a better recollection of the activities that they do on their own, than those activities they watch the teacher demonstrate. Science can often be an outlet for the reluctant reader or poor math student because science can be trial and error, allowing for mistakes to be made.

Kindergarteners enjoy the kinesthetic activities that science provides them. They like to play with things to

see how they feel, how they Sound, smell and sometimes taste, even when they should not. Science is an excellent way for students to explore using their five senses. The five senses allow a student to make their descriptions more vivid and understandable. Young students are very curious about the world around them and often want to know the "why: of so many things. Science allows students to explore through hands on activities, thus engaging all students, even those with limited attention spans.

Five and six year olds are excited about watching things change into something completely different. Therefore, watching bacteria grow before their eyes is a great way to motivate students to learn about science concepts.

The first part of this unit provides background information on the ocean environment, the seashore and plant life of Long Island Sound. Then the unit describes key aspects of the rocks and minerals and geological processes at work in the Sound. Finally, the unit focuses on the microbial life and microbial processes important to life in the Sound.

The Ocean

The ocean makes up more than two-thirds of the earth's surface. When the ocean was first forming, the rainwater washed minerals from the land into the ocean. Seawater contains many different dissolved salts and chemicals species, but is dominated by chloride, sodium, sulfate, magnesium, calcium and potassium. Sodium, potassium and calcium are among the elements eroded from rocks and minerals that wash into the oceans, which explains why the ocean contains dissolved salts or saltwater. The temperature of the ocean depends upon the intensity of the sun. It is hot in the tropics and freezing at the poles. It is cooler at deeper depths where the sun cannot penetrate than at the water's surface, which is constantly being warmed by the sun.

The ocean's waters are constantly moving and changing. As the wind blows, it puts the surface of the ocean into motion making waves, the steady up and down movement. The winds can also help to direct the currents that circulate on the water's surface. The direction of currents is influenced by the shorelines of continents and by the rotation of the Earth. Currents stir up the ocean's waters helping to supply heat, oxygen and food.

The Seashore

The seashore is ever changing because it is subjected to harsh conditions, extreme temperature shifts occurring during the day and night, as well as in the summer and winter. It is also affected by breaking waves, changes in salinity, the tides and the force of the winds.

On sandy and muddy shores, the majority of the marine organisms are filter feeders. They take in the water around them and filter it, extracting any bits of food the water may contain. In order for filter feeders to survive there must be a bountiful amount of food within the water and the water must flow fast for the food to be dispersed. These marine animals bury themselves in the sand or the mud during the day to protect

themselves from the sunlight. Animals will dig themselves deeply into the mud until there is enough moisture for them to survive. As the tide flows outward animals are in danger of drying out. Some animals will make the muddy under-layers a temporary home while others will live there permanently.

The tide brings with it carcasses of animals, decaying seaweed and feces. This organic matter provides food for some organisms such as crabs and sea urchins. However, too much organic matter can become dangerous. The sand grains can bind together, which will stop the flow of water. The deeper layers of mud will lose their oxygen helping anaerobic bacteria to flourish.

Long Island Sound

Long Island Sound is an estuary; it is a combination of fresh and salt water. Estuaries are continuously changing in terms of the conditions and composition of the water within them. The marine and plant life must be able to tolerate shifts in the salt content of the water. The Sound serves a variety of purposes, such as commercial fishing, recreational activities and disposal of waste. According to Lisa Wahle, the Sound is a major spawning ground for many species of finfish and shellfish and an essential food and rest stop for hundreds of species of migratory birds. The Sound is comprised of a variety of habitats including; salt marshes, tidal flats, rocky intertidal zones, sandy beaches, and subtital zones. These habitats support many organisms and plants.

Plant Life

Phytoplankton are microscopic marine plants floating near or on the surface of the water. They contain chlorophyll and are dependent on sunlight in order to live and grow, which is why most phytoplankton can be found floating on the upper part of the ocean where sunlight is plentiful. Besides sunlight, they also need carbon, which they get from carbon dioxide (CO_2) because these phototrophs are also autotrophs, as well as nitrogen, phosphate and sulfur, which they will convert into proteins, fats, and carbohydrates. Jellyfish, shrimp and whales are some of the marine animals that will feed on phytoplankton.

Diatoms capture the energy from the sun during photosynthesis and convert this energy into carbohydrates that will be passed on to other marine life as food or an energy source. Many of the ocean's herbivores feed on phytoplankton. Phytoplankton produce oxygen so that other species in the water and on land can survive, including humans. However, an excess of phytoplankton can pose serious health risks. Dinoflagellates, a red phytoplankton, causes "red tides" that are toxic. Clams will eat the dinoflagella toxins, causing a health risk to those that eat these clams. Even an excess of non-toxic algae can cause lethal hypoxic or low oxygen levels in the water. The dead and dying algae, as they decompose, use up massive amounts of dissolved oxygen causing the oxygen levels in the water to drop dramatically, which can become dangerous to other marine organisms.

All types of algae contain chlorophyll allowing them to be able to make their own food through photosynthesis and CO_2 fixation. Plants are autotrophs because they make their own food, sugar or cellulose, by fixing or

capturing the CO_2 from the atmosphere during photosynthesis. There must be chlorophyll, sunlight and carbon dioxide in order for photosynthesis and CO_2 fixation to transpire. Algae also require water and other nutrients for their survival. In the presence of all these components, algae will flourish, rapidly reproducing in large numbers. This sudden outburst in algal growth is called an algal bloom. These blooms occur as waste, which contains the nutrients algae need in order to reproduce quickly, is dumped into the water. Algal blooms can be extremely harmful to the other organisms living in the water. Bacteria will use the oxygen in the water to break down the dead algae. When the bacteria use too much, the other organisms do not have enough oxygen to survive and will die.

Brown algae is macroalgae or seaweed or kelp as it is more commonly known, and can be found floating near the surface of the water. Brown algae are the largest of all the algae as it flourishes. Organisms eat seaweed and also use the seaweed to protect themselves from predators. Different types of seaweed are distinguishable by their pigments: red, brown and green. In the tightly packed beds of the brown alga kelp, small fish and invertebrates are found to protect themselves from predators. The green algae are eaten by finfish and invertebrates.

Eelgrass is a vascular plant or true plant that can be found in shallow water. The Eelgrass blades are thin in order for small finfish and shellfish to protect themselves from predators. Eelgrass beds are essential for bay scallops to survive. During the first weeks of their lives the baby scallops attach themselves to the blades to protect themselves as they grow.

Vascular plants such as Spartina are more commonly found in the salt marshes of Long Island Sound. These plants can tolerate tremendously high amounts of salinity. The two most important vascular plants that grow in the marshes are the saltwater cordgrass and the saltmeadow grass. These plants are important both alive and dead. The dead parts of the plant are a source of food for fiddler crabs, worms, snails, and other marine life. Bacteria will continue to break down the plants further, releasing nutrients into the water.

Rocks

Rocks provide the sediment that creates the seabed, beaches and shoreline surrounding Long Island Sound. Rocks also provide a solid substrate for filter feeders, which are found along the seashore, to attach themselves to. According to the book, Rocks: Earth Science Discovering the Secrets of the Earth, rocks are comprised of a mixture of minerals. There are three types of rocks; igneous, sedimentary and metamorphic. Igneous rocks are formed as molten rock known as lava (at the surface) or magma (below the ground) solidifies. Sedimentary rocks are formed from the breakdown of pre-existing rocks and the broken grains are deposited in layers by the wind, water and/or glaciers. The layers will harden into sedimentary rock over time. Metamorphic rocks are found deep in the Earth's crust as heat, pressure or both transforms other types of rocks to form completely new rocks, such as marble, which is metamorphosed limestone, and minerals. such as diamonds.

Sedimentary Rock

Sedimentary rocks are formed from the fragments of other rocks and often contain distinct and visible layers or strata. The fragments of the rocks are carried by rivers, oceans or wind and deposited into beaches, deltas

and sand dunes. There are three types of sedimentary rocks, clastic, chemical and organic rocks. Clastic rocks are made of smaller pieces of rocks, which are weathered from other rocks. Chemical rocks are deposited using some form of chemical action, such as precipitation of minerals from solution. Organic rocks are made of materials produced by living things, such as shells making up reef limestone or plants making up coal.

Sedimentary rocks form in lakes, rivers and shallow seas or basins close to the edge of land. The pattern in which the sedimentary rocks carried by the rivers are laid down changes based on the changing pattern of a flood or drought. As the sedimentary rocks are dependent on the materials the river delivers and deposits, their layers vary in texture and thickness. Most sedimentary rocks are formed under the sea or at the seafloor.

These rocks are valuable in providing a record of how they formed, the conditions, water depth and climate under which they formed, as well as the time when they were laid down, which can be determined from the fossils found within the strata or layers of the rock.

Igneous Rock

Igneous rocks begin as liquid or molten rock. They are the most uniform of all the rocks because the molten rock is constantly churning and mixing its ingredients. Igneous rocks make up the floor of all of the oceans and thus, cover about seventy percent of the surface of the earth. Igneous rocks can be categorized into two groups, extrusive or intrusive.

Extrusive or volcanic rocks are rocks that have reached the surface before they have cooled. Extrusive rocks include ash and lava. Molten rock or magma erupts from a volcano and will flow, cool and then turn into solid rock. Magma is a mixture of liquid and a few solid pieces. The liquid fraction of magma is a mixture of dissolved chemicals, some of which are gases. The rate at which the magma or lava cools determines the nature and size of the crystals that will form. If the magma/lava cools rapidly, the crystals will stop growing and will be small. If the magma/lava cools slowly, the crystals continue to grow and will be large, for example granite.

Intrusive rocks are rocks that have cooled while still inside of the earth's crust. Intrusive rocks cool more slowly because the rocks surrounding them act as insulation. Gases are not eliminated because these rocks will remain under pressure as they form. Crystals will grow in magma that is cooling very slowly, which happens deep in the earth. Some intrusive rocks are formed close to the surface, making sheets of rock forming between others called dikes or sills (East Rock, West Rock and Sleeping Giant are all examples of intrusive dikes/sills). The cooling of these types of rock sheets will be quick and the crystals will be smaller. The minerals that form during this slow cooling of rock depend in part on the temperature at which they melt. The crystals that grow first will usually be formed the best and have the most perfect of geometrical shapes.

Metamorphic Rock

Metamorphic rocks are rocks that were either sedimentary or igneous rocks. The most common feature of these rocks is that they consist entirely of crystals, however, they are not always interlocking and have a tendency to face the same direction. There are several different ways in which rocks can be changed, so there are many different types of metamorphic rocks. The type of metamorphic rock formed depends on the amount of heat, pressure, the original texture of the rock being changed as well as the minerals the rock is made of. As the amount of heat and pressure increases, the metamorphic rocks produced from a typical mud deposit will be shale, then slate, then, phyllite, schist and finally gneiss. Metamorphic rocks are commonly found in places in which mountains once formed.

Weathering and Erosion

Weathering is the process by which rocks are broken down. As rocks break down they can be fragmented into a variety of sizes ranging from a huge boulder to fine clay. River, ice, waves and wind play a role in the processing of the pieces of fragmented rock. Mechanical weathering is the process by which rocks are fragmented and disintegrated into smaller pieces. However, the rock's mineral composition is not changed. Chemical weathering alters the rock to form new minerals.

Mechanical Weathering

Mechanical weathering is the result of rock fragments bouncing down a riverbed or being ground up along the bottom of a glacier and carried along by the glacier, which is how Long Island and Long Island Sound were formed. This process will cause sharp edges to become rounded and large boulders to become worn down into grains of sand. The longer the weathering process takes place, the more a rock will be broken down and the smaller it will become.

Chemical Weathering

Chemical weathering occurs in places where water or other fluids and minerals are in constant contact. Agents of weathering are oxygen, air pollution, water, carbonic acid and other strong acids, such as sulfuric acid from sulfur emissions and nitric acid from auto emmissions. These components will combine with the rock and minerals to form clays, iron oxides and salts.

The most important element in chemical weathering is water. Water combines with the carbon dioxide in soil to form carbonic acid. The carbonic acid will slowly dissolve away the minerals within the rock. The carbonic acid will decompose the insoluable rock into a water soluble product that will travel into the groundwater. If there are high concentrations of dissolved minerals in the water, this can cause the water to be hard. The water can also hydrate minerals by absorbing into the mineral lattice, this is especially true for clay minerals. Through hydrolysis, the water can break down the minerals, for expample silicates and granite are decomposed by this process. Chemical weathering can change the color of a rock, break it down or cause it to form different materials, such as rust or clays, which will form new varieties of rocks.

Gases and acids also play a role in chemical weathering. Oxygen will combine with metals such as iron and manganese commonly found in minerals, to form oxides. Other factors that contribute to chemical weathering are air pollution, volcanic steam vents and abandonded mine sites.

Erosion

Erosion occurs after rocks have been broken down during the process of weathering. Erosion is the movement of rocks, soils and other parts of the earth. Erosion happens very slowly but eventually can make big changes in the landscape. It is mostly caused by water, ice and wind. The broken down rocks are carried along and deposited to other areas by the ocean currents, streams and rivers, the flowing of rain, waves along the shores of lakes and oceans, flowing glaciers and the wind.

Prokaryotes: Bacteria and Archaea

Prokaryotes are single-celled microscopic organisms and make up most of the life on this planet. Prokaryotes comprise two of the three Domains of life on Earth, the Domain Bacteria and the Domain Archaea. The majority of bacteria have a positive impact on nature, such as extracting nitrogen from the air making it available for plants to use in protein production, breaking down the remains of dying things recycling the carbon and other elements and production of food for humans.

Prokaryotes including bacteria are responsible for many tasks necessary for life to survive on earth. Every bacterial cell uses energy, grows and develops, interacts and changes its environment and reproduces. These activities cause changes in the chemistry and properties of the surrounding environment on a small scale, such as the Sound to a global scale. Prokaryotes live in the most diverse environments on earth. They can inhabit the air, soil and water. They also live on the surfaces of plants and animals. The types of prokaryotes that will be discussed further are bacteria, especially cyanobacteria and archaea.

The Cyanobacteria

Cyanobacteria used to be called blue-green alage, however pigments can also be black, yellow, green or red. These bacteria have chlorophyll-like pigments that trap light energy during the process of photosynthesis. When a body of water contains a rich supply of nutrients, cyanobacteria may bloom and the water will become a pea green color and be accompanied by a foul odor. Some species of cyanobacteria can contain toxic substances or heavy metals that are harmful to both fish and humans.

Magnetotactic Bacteria

Magnetotactic bacteria create miniature magnets out of molecules and atoms; especially iron that becomes saturated within their surroundings. These bacteria collect the iron atoms and molecules in sacks called magnetosomes. Inside the megnetosomes, a chemical reaction takes place, in which chemical rearrangements will generate the iron mineral magnetite, which has magnetic properties. When the magnetotactic bacteria die and decay, they will leave behind tiny chains of magnetic particles that are encased in layers of rock.

Extremophilic Archaea

Archaea are another kind of prokaryote, they are also microscopic and unicellular. Many archaea are considered extremophiles because they can be found in very harsh conditions that would kill other creatures such as boiling waters, immensely salty pools and volcanic vents. These extremophiles have a protective layer of molecules and enzymes to help them thrive in these intense conditions. For example, halophiles a type of archaea live in an extremely salty environment. Halophiles are capable of keeping all the fluids from flowing out of their cells by either producing solutes or pulling in solutes, usually potassium chloride, from the outside to create a balance between the inside of the cells and the salty water outside. However, not all archaea are considered extremophiles. Many live in waters with normal temperatures and conditions. They can be found floating alongside algae in the oceans.

Beneficial Bacteria

Not all bacteria are considered to be harmful. Some bacteria thrive in oil. They break down oil's dangerous chemicals and convert them into substances that are harmless. Ochrobactrum anthropi is used to clean the oceans after an oil spill or a gasoline leak in the soil under a gas station.

Our skin is covered with bacteria that are responsible for forming a protective barrier against harmful bacteria, fungi and other disease causing organisms. Our bodies also have billions of bacteria in our digestive system. These bacteria are responsible for breaking down nutrients into a form our bodies can actually use.

Harmful Effects of Bacteria on Marine Plants and Animals:

Blooms

According to the article, Phytoplankton Are Microscopic Marine Plants, hurricanes can affect the microbial life in the oceans. As hurricanes race across the Atlantic Ocean, they may be partly responsible for the phytoplankton blooms that occur there. Two to three weeks after a hurricane hits, NASA satellites have shown that there is a greater than normal growth of phytoplankton. As the hurricane goes by, it leaves a trail of phytoplankton blooms behind. This is evident by the dramatic change in chlorophyll levels.

The extreme hurricane winds stir up the waters of the ocean bringing up nutrients and phytoplankton to the water's surface. The phytoplankton gets more sunlight, which helps them grow and spread, thus creating blooms. As the quantity of these plants increases, it affects the amount of carbon dioxide in the air. As the phytoplankton grow, they will absorb carbon dioxide. The carbon dioxide is carried to the ocean floor as organic carbon when these plants die and sink. This allows atmospheric carbon to penetrate the deep ocean. This natural process contributes to the carbon cycle.

Crustaceans of Long Island Sound

Recently, the lobster and crab populations in Long Island Sound have been dying off. Scientists are puzzled as to the cause of these deaths; it could be several different types of bacteria or other chemical conditions in the Sound itself. A parasitic paraamoeba is possibly to blame for the lobster's deaths. This organism will enter the nervous system and begins to destroy and swallow up the nerve tissue. Once this parasite has entered the lobster's body, death will occur within twenty-four hours. This condition is known as "limp lobster syndrome".

Another factor in the dying off of the lobster is a bacterial infection, which eats away at the exoskeleton of the lobster. This condition is known as shell disease or chitinolytic shell disease. This is a common disease for crustaceans. There are more than thirty different strains of bacteria that can cause this shell disease. It is most likely to occur in overpopulated areas, because researchers believe that damage to the outer shell is caused when aggressive lobsters fight or when they molt, which can help the bacteria enter the lobster's shell.

Gaffkemia has also caused the dying off of lobsters in the Sound. The bacterium Aerococcus viridians var. homari will infect the lobster's circulatory system. It will invade the heart and blood vessels. This will hinder the circulation and flow of blood flow and possibly may cause the lobsters to hemorrhage to death. This condition is also known as red tail.

Cyanobacteria, Rocks and Oxygen

Cyanobacteria make energy from sunlight through photosynthesis, which creates oxygen as a waste product. As the cyanobacteria thrive, more and more oxygen is created. However, overly high oxygen levels can poison the cyanobacteria, killing the cells. During Earth's early history when cyanobacteria first evolved, the oxygen levels eventually decreased until they attained a level compatible with cyanobacteria growth.

According to the NASA article, Iron Record: Ancient Rocks Tell the Story of Oxygen, and Life, this cycle of growth and decline is evident in the rocks that formed during the Precambrian period on Earth. These ancient rocks display the concentration of iron gradually increasing as the cyanobacteria population thrived, then the iron bands abruptly stop, which suggests that when the oxygen levels were too high, the cyanobacteria quickly died off.

Rock composition allows scientists to determine the environmental conditions during a given period of time. Rock composition is dependent upon the environment in which a rock is formed. Oceans containing more dissolved oxygen will create different types of rocks than oceans that are oxygen free.

Iron and the Ocean

Iron is one of the most abundant metals on the planet, making up roughly five percent of the Earth's crust. It occurs in many minerals and ores, including hematite, magnetite, pyrite, limonite and siderite. All organisms on earth use iron in some way or another. Animals use iron-rich proteins during redox reactions involved in the formation of energy (ATP), which is used to drive life processes. Iron is found in high concentrations in many soils and rocks and in some groundwater as dissolved iron, but occurs in limited amounts in the ocean.

Iron is necessary for life but is scarce in the ocean. Sunlight plays an important role in helping to cycle iron and make it available to marine plants and animals. Sunlight energy transforms iron-which molecules into more loosely-bound configurations of iron allowing bacteria, plankton, phytoplankton and other microorganisms to easily take hold of and use the iron. Bacteria need to manufacture small molecules, siderophores, to help them obtain iron from their environment.

Photosynthesis

Photosynthesis is the transformation of energy from sunlight into chemical energy of the cell in the form of ATP and includes the production of cell biomass by CO_2 fixation. Oxygen is produced as a waste product of photosynthesis with the 'O' in oxygen coming from the water. Three key components to photosynthesis are sunlight, carbon dioxide and water (H_2O). Plants, algae or photoautotrophic bacteria will strip elections from water molecules to make ATP and transfer the electrons to carbon dioxide, This process involves the conversion of energy from sunlight, water and carbon dioxide into sugar, which is an organic compound, and releases oxygen as a waste product.

Sugar produced by photosynthesis is a source of carbohydrates, and is also used to make fats and proteins. Many living things on the earth depend on these fats, proteins and carbohydrates to derive their basic source of energy. Many living things are dependent upon the process of photosynthesis in order for them to thrive. Photosynthesis takes carbon dioxide from the atmosphere, creates energy, which makes it possible for

mammals to live on earth and replenishes the oxygen in the earth's atmosphere.

Carbon Cycle

Carbon is constantly being recycled in order to produce organic compounds, which all living things are made up of and need in order to survive. Key components of the carbon cycle include photosynthetic organisms and microorganisms. Photosynthetic organisms take in carbon in the form of carbon dioxide and covert the carbon dioxide into carbohydrates using the sun's energy and chlorophyll pigments. These organisms are then consumed by animals, fish and humans, who in turn use the carbohydrates for energy and further convert the remaining carbon to cellular biomass. Some carbon dioxide is released into the atmosphere during cellular respiration, however a large portion of the carbon is returned to the ground as animals and plants die. Many bacterial cells, fungi and other microorganisms will consume the dead organic matter and release atmospheric carbon dioxide, which is reused by the plants.

Nitrogen Cycle

The transformation of nitrogen is essential for all life on earth. It is the vital component in nucleic acids and amino acids. Nitrogen is the most common gas in our atmosphere, however animals and many plants cannot use nitrogen in its gaseous form. The nitrogen cycle depends on microorganisms, which trap the nitrogen.

The nitrogen cycle begins with nitrogen fixation, the trapping of nitrogen gas from the atmosphere by bacteria like cyanobacteria. Previously trapped or fixed and therefore bioavilable, nitrogen comes from dead plants and animals in the soil. During the process of nitrogen fixation microorganisms in the water and the soil play an important role because they contain the enzyme systems needed to trap the atmospheric nitrogen and convert it into compounds that can be used by plants. The gaseous nitrogen is transformed to ammonia, which is used to fertilize plants.

Nitrogen is also found in the soil as urea, which is contained in urine. Soil bacteria and other microorganisms will process the urea, forming a mixture of amino acids. The amino acids are then broken down by microbial metabolism and the accumulated ammonia can be used directly by plants.

Finally, mineralization occurs, the process whereby complex organic compounds are converted into inorganic compounds and ammonia. The majority of the ammonia is transformed into nitrite ions by bacteria called Nitrosomonas, during which the bacterial cells gain energy for their metabolic needs. The nitrite ions are transformed and further oxidized to nitrate ions by Nitrobacter, which again gains energy from the process. The nitrate is used by plants as a nutrient or can be freed into atmospheric nitrogen by certain microorganisms, including denitrifying bacteria.

Water Cycle

The water cycle is the constant movement of water rotating between the surface of the earth and the atmosphere. The water cycle is made up of several stages, evaporation, condensation, and precipitation. Water from lakes, ponds, and other bodies of water evaporates as the water absorbs energy in the form of heat from the sun; the water then changes into a gas, water vapor. Air containing water vapor will rise and begin to cool because it is losing heat. Once it has lost enough heat it will condense or become a liquid again in the form of tiny water droplets. The droplets form clouds. As the droplets in the cloud grow, they will become too big to stay in the atmosphere. The cloud will release precipitation in the form of rain or snow depending on the atmospheric temperature. Then the cycle will begin all over again.

Iron Cycle

All organisms play a role in the cycling of iron in some way, including plankton, bacteria and other microorganisms. Plants on land obtain their iron from the soil and then organisms eat these plants. Another organism eats the previous organisms, which ate the plant. Eventually the organisms will die and decompose, the decaying matter will release minerals back into the soil. The cycle will then continue and repeat. In the ocean, iron is consumed as the sun breaks down the iron at the surface into loosely configured atoms of iron and oxygen. The loosely configured particles allow bacteria, plankton, phytoplankton and other microorganisms to consume the iron.

Pollution in the Water

Contaminated water contains a chemical poison, a biological poison or an infectious agent. Physical pollution occurs as sand or soil turns the water cloudy or cyanobacteria bloom during summer and their remnants give the water a thick consistency similar to pea soup. Chemical pollution occurs when inorganic or organic waste enters the water. Biological pollution occurs when microorganisms from human waste, food processing and meat packing plants and medical facilities enter the water.

Microorganisms can alter the environment. As phosphate accumulates, the algae in the water will grow rapidly. The algal blooms supply nutrients to other microorganisms that use up the oxygen and multiply rapidly. Then the protozoa, small fish, crustaceans, and plants will die and land on the bottom of the ocean floor. The anaerobic bacteria like Desulfovibrio and Clostridium will thrive in the mud and produce such gases as hydrogen sulfide and carbon dioxide. The hydrogen sulfide gas gives the water the smell of rotten eggs. Algae produce the gas dimethyl sulfide, which is the strong smell all along the Sound in West Haven and New Haven.

Acid gases from the chimneys of factories and motor vehicles will mix with fog, rain and snow. This mix results in acid rain, which will damage forests and kill fish. Acid rain also contributes to the chemical weathering of rocks as described above and releases aluminum, which is washed into lakes, rivers, streams and oceans and causes fish to overproduce a sticky mucus. This sticky mucus will clog their gills, making it difficult for the fish to breathe. The polluted water will damage fish eggs and eventually all the fish will die off.

As it rains, animal wastes, paved surfaces, lawns and other areas that contain heavy metals, organic contamination and pesticides, release these pollutants which travel down the road and into the water. Thus, when it rains, this contaminated water becomes a part of the oceans, ponds and lakes and affect the plants, animals and fish, possibly killing some of them.

Activities

Lesson 1: Plant life in Long Island Sound

Students will learn the role the plants of Long Island Sound play in the growth and depletion of the marine life in the Sound.

Lesson 2: Cycling

Students will learn about the carbon cycle and nitrogen cycle and their role in both our lives and the lives of marine organisms.

Discuss with the students what each of the cycles are and how our lives are affected by these cycles. Discuss with the students how marine organisms are affected by each of the cycles.

Lesson 3: Invisible Critters

Students will learn what a germ is. Students will learn what bacteria are.

Materials: vegetable oil, sugar, cinnamon (optional), paper towels, soap, three tin pie plates

Explain to the students that bacteria, just like germs, are very tiny. Even though we cannot see them they are still there.

The term germs refers to viruses and certain bacteria that can make you sick, just like they do to plants and animals. But there are some steps we can take to stop germs from spreading and making us sick.

Germs and bacteria can both be harmful and helpful, but when most people hear these two words they only think of the harmful kind.

We are going to do a little exercise to show how important it is to wash your hands properly in order to wash away the germs (bacteria).

Explain to the students that the sugar, cinnamon and vegetable oil are germs.

Procedure:

Step 1: Pour some sugar into a pie plate.

Step 2: Pour a few drops of vegetable oil into each student's hand over a pie plate. Have the students rub the vegetable oil into their hands.

Step 3: The students will dip their hands into the pie plate with sugar and rub into their hands.

Step 4: Sprinkle their hands with cinnamon.

Step 5: Divide the class into two groups. One group will wash their hands only in warm water the other group will wash their hands in warm water and soap.

Questions to Ask:

How does the sugar mixture feel?

Which group was able to wash away the germs? How much time did it take?

Why is it important to use soap when you wash your hands?

If you don't use soap when you wash your hands what can happen?

Extension: Explains how germs spread

Spray your hands or the student's hands with water. Touch colored construction paper with your hands. This demonstrates how germs spread.

Lesson 4: Bacteria and Plants

Students will learn the role bacteria play in the role of plant survival in Long Island Sound.

Discuss with the students how cyanobacteria and archaea help plants to thrive in the Sound and how they can sometimes cause the plants or animals to flee or die off.

Lesson 5: Bacteria Up Close and Personal

Students will create a Winogradsky Column, using both a sample from Long Island Sound and a pond.

Materials: 4-16 ounce water bottles, tape, saran wrap, samples of mud from Long Island Sound and a pond, samples of water from Long Island Sound and a pond, camera, journals (one per student), pencils and crayons.

Procedure for making the Winogradsky Column:

Step 1: Label each 4-16 ounce bottle as follows: 1) Long Island Sound sunlight and 2) Long Island Sound darkness and 3) Pond sunlight and 4) Pond darkness

Step 2: Place mud from Long Island Sound in two bottles

Step 3: Place straw into each of the bottles.

Step 4: Add the water from Long Island Sound to the bottles 1 and 2, fill completely and Continue to top the water off to replace any water lost to evaporation over the course of the activity.

Step 5: Rip off two pieces of saran wrap and place loosely over the of bottles

Step 6: Cover the top of each bottle loosely with saran wrap and masking tape.

Repeat steps 1-6 with Pond water and mud sample.

Step 7: Take a picture of each bottle.

Step 8: Place one bottle from the Sound (#1) and Pond (#3) in the sun and the other bottles (#2 and # 4) in a dark spot in the room or a closet. Each should be stored in a well-ventilated area with loose covers to avoid a buildup of hydrogen sulfide gas.

Consult and follow safety guidelines for your school.

1. Post the pictures of each column on a bulletin board. Label the pictures with the type of water sample and whether it is getting sunlight or is in the dark. Label with the date.

2. The students will observe the columns each day and record their discoveries. Take a picture of the bottles each day the student's observe the bottles. This will allow you to make comparisons throughout their discoveries.

Possible questions to ask students:

What changes have you noticed?

Why do you think these changes have occurred?

What is causing the bacteria to grow?

Does the presence of sunlight or darkness make a difference in the growth of the bacteria? Why do you think that?

Lesson 6: Water Everywhere

Students will learn about the water cycle.

Materials: water samples from Long Island Sound, pond, and tap water, containers for each type of water, saran wrap, 3 elastics

Procedure:

Explain to the students the parts of the water cycle; precipitation, condensation, and evaporation. Provide examples of each of the stages.

Draw a picture on chart paper to illustrate the water cycle for the students.

Then explain that they will be creating an experiment to see condensation and evaporation in action.

Procedure for evaporation experiment:

Step 1: Place a sample of each type of water in a separate container. Label each container.

Step 2: Mark a line where the water is at top.

Step 3: Place saran wrap around the top of each container. Step 4: Place elastic or piece of tape around the rim of each container.

Step 5: Place containers in sun.

Step 6: Each day have the students check the containers to see what is happening with the water.

This will help them to understand how pollution affects the marine life, using the water cycle.

Lesson 7: Rocks Usefulness

Students will learn about the minerals rocks provide.

Lesson 8: Rock Formations

Students will learn about the weathering and erosion of rocks.

Materials: plastic wrap, clay, water, paper (enough for each student or group of students), camera

Procedure:

Step 1: Take the water and wet the clay. Work the water into the clay with your hands until soft and moist.

Step 2: Divide the clay into two equal pieces or roll it into a ball, or other shape.

Step 3: Wrap each piece of clay into the plastic wrap.

Step 4: Place one piece of clay in the freezer.

Step 5: Place the other piece of clay on a table or counter.

Step 6: Let the clay stay in the freezer and on the table or counter overnight.

Step 7: The next day, take the clay out of the freezer and unwrap both pieces.

Step 8: Make observations about how the clay pieces look? Do they look different? How? HINT: the clay from the freezer should have some cracks.

Step 9: Take a picture of each piece of clay. Have students draw a picture of what each piece of clay looks like, be sure to label their pictures with freezer and table.

Step 10: Repeat steps 4 9 for several days.

Observe the clay pieces each day and see how the cracks change over time.

Lesson 9: Attracting Iron

Students will learn about minerals in marine sand, with emphasis on iron minerals.

Materials: sand from the ocean, saran wrap, magnet, paper plate, chart paper, markers. This can be done as a whole group activity or in small groups, if in small groups you will need enough plates and magnets for each group.

Procedure:

On a piece of chart paper write the title Our Prediction.

Then, write the two headings: The magnet will attract the sand and the magnet will not attract the sand.

Write the students names under what they predict will happen.

Step 1: Pour sand on to a plate.

Step 2: Place a piece of saran wrap on the magnet. (Easier to clean off the magnet)

Step 3: Place the magnet slowly over the plate until the magnet attracts the sand.

Step 4: Remove the saran wrap from the magnet. I recommend that only the teacher do this.

Possible Questions to Ask:

Who can explain what happened with the magnet and the sand?

Why do you think this happened?

What was in the sand that made it cling to the magnet?

Modification: instead of using sand you can use an iron enriched cereal and water. You can also have them use a variety of items.

Lesson 10: Hurting Our Oceans

Students will learn about pollution and its affect on the life of the Sound.

Discuss with the students the different kinds of pollution and what effect they have on the marine life in the Sound. Also, discuss ways in which they can help to stop the pollution of the Sound.

Teacher Resources

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"Photosynthesis." Biology Encyclopedia forum. Available from http://www.biologyreference.com/Ph-Po/Photosynthesis.html Internet: accessed 24 July 2010. The Website explains the process of photosynthesis.

"Phytoplankton Are Microscopic Marine Plants." National Ocean Service Available from http://oceanservice.noaa.gov/facts/phyto.html. Internet: accessed 30 June 2010. The website describes what phytoplankton are.

"The Microbial World: Winogradsy Column: perpetual life in a tube." Available from http://www.biology.ed.ac.uk/research/groups/jdeacon/microbes/winograd.htm Internet: accessed 30 May 2010. This website provides instructions on how to make a Winogradsky column.

"What's Happening to Lobster's in Long Island Sound?" Available from http://praise.manoa.hawaii.edu/news/eh59.html Internet: accessed 30 May 2010. The website explains the dieing off of the lobsters in Long Island Sound.

"Weathering of Rocks." Water Encyclopedia. Available from http://www.waterencyclopedia.com/Tw-Z/Weathering-of-Rocks.html Internet: accessed 25 June 2010. The website describes weathering of rocks.

Student Resources

Ravage, Barbara and Brunelle, Lynn. "Bacteria." Milwaukee:Gareth Stevens Publishing; 2004. This book explains different types of bacteria.

http://www.rocksforkids.com/RFK/howrocks.html A website explaining how rocks are formed.

Appendix: District Standards

In science, students are required to be able to observe and describe differences between living and nonliving things in terms of growth, offspring and need for energy from "food" and to make scientific observations using their five senses and distinguish between an object's observable properties and its name or its uses. Students will discuss how living and non-living things affect a habitat and its inhabitants. Students will observe the changes that occur as bacteria grow and water evaporates.

In writing the students are required to learn to write what they "see", include words that describe what they smell and taste, and organize their writing in sequential order so it makes sense to the reader. Students will use pictures and words or sentences to describe the changes they see over time with the bacterial growth in the Winogradsy Column and the weathering of rocks.