PICKERING CREEK
Audubon CENTER

Gateways to Conservation II

an environmental education curriculum for students in grades 6 – 8

CHESAPEAKE BAY GATEWAYS NETWORK

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Acknowledgements

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Project Leader: Shannon Gordon
Center Director: Mark Scallion

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Pickering Creek Audubon Center is a Chesapeake Bay Gateways site—a place to explore and learn about the Chesapeake region. Visit this and other places in the Gateways Network to experience the Bay's stories, culture, spirit and mystery. Learn about the Chesapeake Bay restoration effort and how you can contribute. Our well-being and the Bay's health are interdependent. Visit www.baygateways.net for more information.

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Contents

Grade 6: Erosion Exposes History of the Bay

Grade 7: Biodiversity Makes the Bay Better

Grade 8: Genes are the Key to Bay Biodiversity

Pre and Post Lesson Assessments

Introduction

Gateways to Conservation

The Chesapeake Bay Watershed is an important diverse ecosystem in need of protection. In order to appreciate the diversity of the Chesapeake Bay and help protect its quality, it is critical that students understand the complexities of the various ecosystems found in the Bay area and understand the effects humans have on local landscapes. Students need to witness the many living organisms that depend on the Bay area for their survival and understand the important role humans play in the health of the ecosystem. The Gateways to Conservation II curriculum expands on its predecessor, Gateways to Conservation I, and provides environmental education centers with a continuous series of fun and exciting lessons that will create an environmentally literate student body with strong academic science skills. As students progress from grade 1 in Gateways to Conservation I to grade 8 in Gateways to Conservation II, they will develop a relationship to the Chesapeake Bay and learn to appreciate everything it has to offer.

Similar to Gateways to Conservation I, Gateways to Conservation II provides an in-school lesson and an outdoor field trip experience for each grade. Each lesson addresses Maryland State Voluntary Curriculum Standards for science or social studies, and was developed with assistance from school teachers in Talbot County, MD. Although each lesson can stand alone, the lessons outlined in this book were designed to build on one another. Through repeated contact with students throughout their academic career, environmental education centers can help students not only appreciate and understand their natural environment but also gain skills and understand concepts applicable in conservation action projects. Students who participate in the entire Gateways to Conservation curriculum will understand the importance of maintaining and improving the health of the Chesapeake Bay.

Audubon

Over one hundred years ago, a committed group of Americans came together to protect birds from slaughter at the hands of plume-hunters. Hats sporting feathers and even entire birds were the height of fashion, making the hunting of egrets and other birds a highly profitable enterprise. Fortunately, the bold and dedicated efforts of a insightful group of men and women were successful in saving the Great Egret and other birds from extinction. It was these early conservationists who founded the National Audubon Society, which still includes the Great Egret in its logo.

Today, Audubon is continuing its legacy of protecting birds and other wildlife through individual action. Citizen science programs, like the century-old Christmas Bird Count, the more recently launched

Great Backyard Bird Count and the Important Bird Areas Program enlist the participation of thousands of volunteers for conservation efforts. Audubon Centers from coast to coast introduce new generations to the wonders of nature and the importance of protecting it.

As Audubon enters its second century, the conservation challenges we face are no less urgent than those that confronted our founders. Birds have long served as barometers for the overall health of the environment, and quality of life. By helping to protect birds, each person, like the men and women who worked to outlaw plume hunting, can make a conservation difference. That is the Audubon legacy.

Pickering Creek Audubon Center

In Maryland, Pickering Creek Audubon Center connects students of all ages to the environment, science and the beauty of the Chesapeake Bay. Working in partnership with local school systems, the Pickering Creek education staff provides science-based environmental education to over 16,000 children each year from eight Maryland counties and the District of Columbia. In Talbot County, Pickering Creek programs are integrated into the school curriculum for all first through eighth grade students. Since 1980, Pickering Creek has revealed to students the joy of being outside and the science behind what they see. Participants in our programs have an experience they cannot obtain from reading a book or watching nature programs on television. They are awestruck as a real Bald Eagle soars overhead, and are triumphant as they return from their first wetland adventure. Their curiosity is awakened. We have connected them with nature.

Summary of Lessons

Grade 6: Erosion Exposes History of the Bay

In-school Lesson (one-hour)

Through hands-on experiments and demonstrations this lesson teaches students how erosion has changed the land surrounding the Chesapeake Bay. Students will use a model to observe how erosion causes sediment to flow into the Bay while exposing underlying fossil layers from the Miocene period. Students will examine various types of real fossils and see how they are formed during an in-class fossil-making demonstration.

Field Trip Experience (two-hours)

Students will learn how the fossil and sediment layers visible along the coast of the Chesapeake Bay help people understand the history of the Bay area. Students will search for fossils, visit a site where erosion has exposed sediment layers, and excavate fossils using the techniques and tools of paleontology.

Grade 7: Biodiversity Makes the Bay Better

In-school Lesson (one-hour)

By examining plant samples and live animals, students will learn that biodiversity is dependent on genetic diversity. Through hands-on activities, students will understand why biodiversity is important to the Chesapeake Bay and learn that genetic information is passed from parent to offspring by either asexual or sexual reproduction.

Field Trip Experience (two-hours)

Students will examine and appreciate the wide diversity of the plant and animal life that inhabits the Chesapeake Bay region by adventuring through a variety of ecosystems and collecting data. By using various scientific tools and methods, students will determine the extent of biodiversity in areas observed.

Grade 8: Genes are the Key to Bay Biodiversity

In-school Lesson (one-hour)

By participating in several role-playing activities, students will learn how genetics, adaptations, mutations, and natural selection relate to evolution. Students will have the opportunity to experiment with selection of organisms through a game involving oysters and their Bay prevalent diseases, MSX and Dermo. Students will ultimately appreciate the need for continued biodiversity in the Chesapeake Bay area.

Field Trip Experience (two-hours)

Students will participate in fun activities that will help them understand the natural selection of birds. By hiking through different ecosystems and recording evidence of plant and animal adaptations, students will learn how local plants and animals adapt to their environment. The students will determine the benefits of the observed adaptations they encounter in the field and learn how genes play a key role in creating the great biodiversity of the Chesapeake Bay area.

Erosion Exposes History of the Bay

In-school Lesson and Field Trip Experience

Grade: 6

Pickering Creek Audubon Center

Standards of Learning

Talbot County Student Performance Objectives:

Grade 6:

Earth Space Science:
Materials and Processes That Shape a Planet - Cite evidence to demonstrate and explain that physical weathering and chemical weathering cause changes to Earth materials.

Earth History - Explain how sedimentary rock is formed periodically, embedding plant and animal remains and leaving a record of the sequence in which the plants and animals appeared and disappeared; recognize and explain that fossils found in layers of sedimentary rock provide evidence of changing life forms.

Life Science:
Evolution - Objective f: Describe how sediments of sand and smaller particles (sometimes containing the remains of organisms) are gradually buried and cemented together by dissolved minerals to form solid rock; describe that such fossils provide evidence for the long history of changing life forms whose remains are found in the rocks.
Objective g: Explain that more recently deposited rock layers are likely to contain fossils resembling existing species.

Environmental Science:
Natural Resources and Human Needs - Identify and describe how the natural change processes may be affected by human activity, such as agriculture, beach preservation, mining, development/construction, stream/river alteration.

Maryland State Voluntary Curriculum Standards of Learning:

Grade 6:

Skills and Processes:
Constructing Knowledge - Design and carry out simple investigations and formulate appropriate conclusions based on data.

Technology - Analyze the value and limitations of different types of models in explaining real things and processes.

Earth and Space Science:
Materials and Processes That Shape a Planet - Cite evidence to demonstrate and explain that physical weathering and chemical weathering cause changes to Earth materials.

Life Science:
Evolution - Objective f. Describe how sediments of sand and smaller particles (sometimes containing the remains of organisms) are gradually buried and are cemented together by dissolved minerals to form solid rock; and describe that such fossils provide evidence for the long history of changing life forms whose remains are found in the rocks.
Objective g. Explain that the more recently deposited rock layers are likely to contain fossils resembling existing species.

Environmental Science:
Environmental Issues - Recognize and explain that human-caused changes have consequences for the immediate environment as well as for other places and future times.

This lesson also meets the following State Standards:

Grade 4:

Earth and Space Science:
Materials and Processes That Shape a Planet - Recognize and explain how physical weathering and erosion cause change to Earth's surface.

Earth History - Recognize and explain that fossils provide evidence about the plants and animals that lived long ago and about the nature of the environment at that time.

Environmental Science:
Environmental Issues - Recognize and describe that people depend on, change, and are affected by the environment.

Erosion Exposes History of the Bay
In-school Lesson

Program length: 1 hour

Number of instructors needed: 2 (or 1 with help of classroom teacher)

Synopsis

Through hands-on experiments and demonstrations this lesson teaches students how erosion has changed the land surrounding the Chesapeake Bay. Students will use a model to observe how erosion causes sediment to flow into the Bay while exposing underlying fossil layers from the Miocene period. Students will examine various types of real fossils and see how they are formed during an in-class fossil-making demonstration. Students will learn that the increased flow of sediment into the Bay has negative effects on submerged aquatic vegetation and animals that live in the Bay.

Objectives

- Students will be able to describe the effect of water erosion along the coast of the Chesapeake Bay.
- Students will be able to describe how different kinds of fossils are formed between layers of sedimentary rock.
- Students will be able to list ways humans can slow down erosion and flow of sediment into the Chesapeake Bay.

Materials

See Teaching Aids for assistance preparing materials
- Photographs or overheads of coastal erosion
- Overhead projector or LCD projector for viewing photographs
- Classroom chalkboard, dry erase board, or large pieces of paper
- Real fossil samples

Fossil Model (for 2 models)
- One entire pre-made Fossil Model (to ensure students get to see a dry, completed model)
- 2 clear 70 oz containers (roughly 5.5” x 10” x 2.5”)
- 2 large paper cups or bowls
- 4 cups of Plaster of Paris
- 2 cups of water
- 4 whole seashells (such as oyster shells or shells with distinct features)
- 2 rubber worms or 2 rubber fossils
- 2 stiff brushes
- Large container of petroleum jelly
- 2 metal butter knives
- 6 cups of sand
- 2 pairs of latex gloves for mixing the Plaster of Paris
- 1 roll of paper towels
- 2 - 1-cup measuring cups

Erosion Demonstration Model Materials (for 2 models)
- 2 large rectangular shallow pans (at least 9” x 13”)
- 2 pieces of wood (2” wide x 1.5” high x 9" long)
- 2 Wave Makers
- Bucket of sand containing 16-20 cups of sand, and 2 paper cups
- 2 pillow cases
- 2 empty buckets
- 2 thin pieces of colored plastic or wood (approximately 9” x 3”)
- 2 small watering cans or cups filled with water

Vocabulary

Erosion – the carrying away of weathered soil, rock, and other materials on the Earth's surface by gravity, water, and wind

Fossils – the remains or imprint of a prehistoric plant or animal

Organic matter – plant or animal matter that is in the process of decomposing

Sediment – small pieces of rock, shell, and plant and animal matter that is moved and deposited by water, wind, or ice

Processes of Fossilization, or how fossils are formed:

> **Cast** - a fossil formed when sediment fills a space that was once occupied by an organism showing the organism's outward shape

Mold – a fossil formed when sediment fills a space that was once occupied by an organism

Permineralization (or petrification) – the process by which fossilized remains are turned into stone

Trace fossils – the fossil remains of trackways, burrows, footprints, eggs and eggshells, nests, droppings, and other types of impressions that can give insights into animal behavior

NOTE: *Fossils are not always found in rock. Some animals were trapped in tar pits. While others, like mammoths and other animals that lived during the ice age, were trapped in ice and frozen ground with their flesh, hair, and even stomach contents preserved. Extinct insects have also been found trapped in amber (fossilized tree sap).*

Erosion Exposes History of the Bay
In-school Lesson Plan

This lesson plan is broken into seven parts. This lesson takes place in the students' classroom.

Part 1. Introduction - 2 minutes

Part 2. Show the Students Photographs of Erosion - 10 minutes

Part 3. Learn How Fossils Form - 17 minutes

Part 4. Learn How Erosion Occurs - 17 minutes

Part 5. Discuss Ways to Reduce Sediment and Pollution Flowing Into the Bay - 6 minutes

Part 6. Show the Fossil Model - 5 minutes

Part 7. Review - 3 minutes

Part 1. Introduction

- Introduce yourself to the students.
- Tell the students we will learn how **erosion** exposes fossil layers in the Chesapeake Bay area, causes **sediment** to flow into the Bay, and buries aquatic vegetation living on the bottom of the Bay. Tell the students the plan you have for them today (ex. "We will first …").
- Discuss what the students learned or will learn in the field trip experience. This lesson may be used as an introduction to the field trip experience or a review of the field trip experience. Discuss erosion and its effects on the plants, animals and water quality of the Chesapeake Bay.

Part 2. Show the Students Photographs of Erosion

For this section you will need the photographs/overheads of coastal erosion. Make sure the photos are large and include sites where soil beneath trees has been carved away and sites where the Miocene fossil layer is exposed.

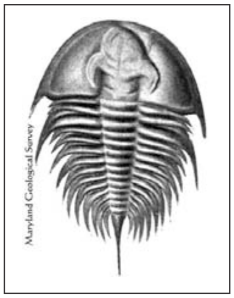
- Tell the students we will look at photographs of the Chesapeake Bay area that are like the places we will be studying in class and on the field trip.
- Show the students photographs of places near the Bay where coastal erosion has taken place. Point to these features in the photographs as you discuss them. Ask the students to identify the features and explain what they represent.
- Explain to the students how the sediment is carried by water resulting in the erosion seen in the photographs.

This is Rocky Point in southern Calvert County, Maryland. It is part of the Calvert Cliffs fossil beds that overlook the Chesapeake Bay. Sections A and B consist of Miocene sediments, with many fossil snail shells. *Courtesy of James P. Reger, Ph.D, Maryland Geological Survey.*

Part 3. Learn How Fossils Form

For this section you will need paper or chalkboard space to draw the Sediment Layer Diagram and the "Fossil Model" materials.

- Tell the students **fossils** take at least 10,000 years to form.



A. Create a Sediment Layer Diagram

For this part you will need the classroom chalkboard or dry-erase board. If possible, use different colored chalk or markers to make the different layers.

- Tell the students you will draw a diagram to illustrate how the fossil layer gets buried between layers of sediment. Over time the sediment turns into sedimentary rock.
- Draw a simple sediment layer diagram. Label and explain each layer as you draw it. (See *Sediment Layer Diagram* in Teaching Aids). The thickness of the layers is relative to the length of time the layer took to form.

NOTE: *Information in parenthesis below is background information for the instructor.*

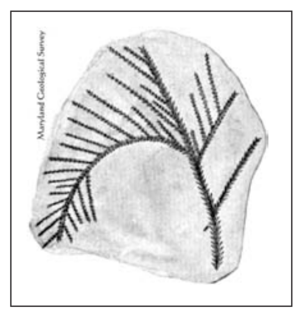
- **LAYER 1:** Tell the students, *"This first layer I am drawing was on the top of the land 140 million years ago when dinosaurs were walking around and left their tracks on the land."* (Draw pointy footprints in this layer to represent dinosaur tracks. This is the Cretaceous period of the Mesozoic Era.)
- **LAYER 2:** *"Then sediment piled up on top of this layer and created another layer about 55 million years ago. Since parts of this area could have been underwater, this sediment could have been at the bottom of a river or ocean. This is the Eocene Epoch of the Cenozoic Era."* (Make this layer a quarter as thick as the first layer.) *"About 35 million years ago, BOOM, a big fireball from outer space hit the Chesapeake Bay area. This impact created a huge crater and killed a lot of living organisms. This event is called the Chesapeake Bay Bolide."* (Draw a huge pit in this sedimentary layer to represent the Bolide crater.)
- **LAYER 3:** *"Over time, more sediment accumulated, forming a new layer about 34 million years ago. This is the Oligocene Epoch of the Cenozoic Era."* (Make this layer shaded and about half as thick as the previous layer, filling in the crater pit from the previous layer.)

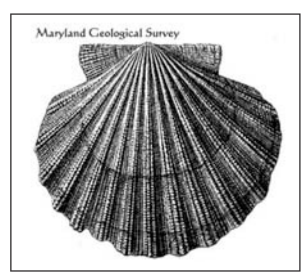
- **LAYER 4:** *"Later, this area was covered by a sea. Shells and skeletons from creatures living in the sea settled on the ocean floor. Giant Clam shells, for example, sat on the bottom of this ancient ocean. This is the Miocene Epoch of the Cenozoic Era, starting about 24 million years ago."* (Draw circles or fossil shapes in this layer to represent shells. This layer should be as thick as Layer 2.)
- **LAYER 5:** *"About 5 million years ago, this area became dry land and a different kind of sediment began to pile up. This is the Pliocene Epoch of the Cenozoic Era."* (Make this layer shaded and very thin compared to the four preceding layers.) *"After 5 million years, this layer is now on top of the land, and here you are walking around on it. The current epoch is called the Holocene."* (Draw a little person on top of this last layer.)

- Ask a student volunteer to point to:
    - the oldest layer (bottom layer)
    - the youngest layer (top layer)
- Ask the students, "Which layer is older than 5 million years old but not as old as 35 million years old and has fossils of ocean creatures in it?" (Miocene layer.)
- Tell the students we will now study how fossils form.

B. Demonstrating How Fossils Form

- Tell the students we will make two models to demonstrate how fossils form between layers of sediment. Write the four types of fossils on the board and discuss each type. (Casts, molds, permineralized, trace). Show the students some real fossils.
- Split the class into two groups. Work with half of the students and have the other instructor or classroom teacher work with the other half of the students in another area of the classroom. If the classroom teacher assists you, speak clearly and walk the teacher through each step. The teacher will keep one model for use in the classroom. Keep the other one for use with your next lesson. You may need to give the teacher the pre-made model and keep both new ones if they are not dry at the end of the lesson.





Making the Fossil Model with the students:

- Coat the inside of the clear shallow container with petroleum jelly. Pour a 1-inch layer of sand into the bottom of the container.
- Tell the students, *"This sand represents sediment on the bottom of the Miocene ocean 23 million years ago."*
- Coat a shell in petroleum jelly and place the shell face-down in the sand. Tell the students this organism's shell is going to get squished between layers of ocean mud. It will form a **mold fossil** because it will be buried and will leave an impression or image behind after it decays.
- Coat the inside of another shell with petroleum jelly and place it in the sand with the inside facing up. Tell the students this shell is going to form a **cast fossil**, because the sediment is going to fill the space inside the shell. The shell will decay, leaving a three-dimensional replica behind.
- Gently wet a rubber worm or fossil mold with some water and slightly bury it in the sand. Tell the students this worm will become mineralized and form a **permineralized fossil**. Mineralized water will flow through the worm and gradually replace some or all of its **organic material**. This fossil will appear as if the worm turned to stone.
- Drag your finger through the sand to make a trench. Tell the students this represents a burrow or track left behind by an ocean worm. This track will be filled with sediment and form a **trace fossil**. Trace fossils record an organism's behavior. This particular fossil will tell us how the ancient ocean worm moved along the mud on the ocean floor.

- Have one or two students help you mix the Plaster of Paris in the paper cup. The ratio is 2 cups of plaster to 1 cup of water; the final consistency should be that of melted ice cream. Whoever handles the plaster must wear gloves. Mix the plaster with the butter knife, and wash the knife immediately.
- Gently pour the Plaster of Paris over the whole model. Do not let a student do this because you do not want the items in the sand disrupted. Tell the students the plaster represents a sediment-like mud that has slid over the ocean floor covering everything in its path.
- Tell the students we have to wait for the plaster to dry, so we will look at it later.
- Discard the paper cup in the trash.
- Wait until the plaster hardens (35-40 minutes) before you carefully lift the entire slab out of the clear container.

Part 4. Learn How Erosion Occurs

For this section you will need the Water Carving Model and the Water Flow Model materials.

- Explain to the students that we will see how water, causing erosion, can expose fossil layers. Ask if any students can describe what erosion is (the gradual wearing away of rock and soil caused, in this case, by water).

Tell the students you want them to understand how water causes erosion on the coast of the Chesapeake Bay. So, in order to help us understand this, we are going to build two models of the coast of the Chesapeake Bay.

A. Water Carving Model

1. Set-up the model

- Divide the class in half and set up two models in different areas of the classroom. An adult will work with each group of students. As in the Fossil Model activity, give the classroom teacher clear directions.
- Fill the watering cans with water.
- Place the piece of wood under one end of the pan.
- Place sand in the higher end of the pan, making a flat pile the width of the pan that is no more than 1" deep. (Do not fill up more than one quarter of the length of the pan.) (see *Water Carving Diagram* in Teaching Aids)
- Place the piece of colored plastic on top of the layer of sand.
- Place another layer of sand on top of the plastic, and pat down slightly. (This layer should be the same thickness as the preceding layer.)
- Pour water into the low end of the pan until the water is 1/4" deep at the higher end of the pan. (The water should be touching the sand but not eroding it away.)

2. Demonstrate the model

- Tell the students that the sand represents layers of sediment and the piece of plastic represents the Miocene fossil layer. Although erosion can happen with all types of soil, we are using only sand for demonstration purposes.
- Tell the students the layers of sediment represent the coast of the Chesapeake Bay and the lower end of the pan represents the Chesapeake Bay.
- Tell the students that we are going to create waves and watch how they cause erosion of the coast.
- Using the Wave Maker like a push broom, push water from the lower end of the pan towards the higher end of the pan. Go slowly so the students can see the action of each wave. Don't allow the Wave Maker to hit the sand. Allow the waves, and not the Wave Maker, to pull the sand into the lower end of the pan, exposing the colored piece of plastic (the Miocene fossil layer).
- Discuss what is happening. The waves are carving the sand away from the coast.
- Tell the students this model shows how the Miocene fossil layer became exposed around the Chesapeake Bay. Ask them, *"What caused this erosion in real life?"* (Waves caused this erosion over time. The waves may have been caused by tides, boat wakes, earthquakes, and storms.)

3. Discuss what happened
- Tell the students that while this exposure of the Miocene fossil layer may seem like a positive effect of erosion, there are also negative effects.
- Ask the students, *"What do you think is a negative effect of erosion and the flow of sediment into the Chesapeake Bay?"* (When sediment erodes, a tree or someone's house could fall into the Bay. Sediment in the Bay makes the water cloudy. Some species, such as oysters, need clean water to survive.)
- Discuss with the students how the sediment they saw flowing into the model Bay can harm aquatic plants in a number of ways. The sediment can bury submerged aquatic vegetation (SAV) and kill them. The sediment can also make the water cloudy, and the aquatic plants will not get enough sunlight to grow. When the aquatic plants die, the food web or food chain they were a part of is affected (students should understand food webs or food chains, but you may want to ask them to explain it to you). Without SAV, fish and other aquatic animals will not have a place to live or enough food to eat.
- Tell the students, "There is something we can do to stop erosion from happening. Think about what we can do while we clean up this model." (It is important to be positive and remind the students that there is something they can do to help the environment. Answers are discussed in Part 5.)

4. Clean-up
- Place the pillowcase over the empty bucket or have someone hold the pillowcase open over a sink.
- Pour the sand into the pillowcase and allow the water drain out.
- Put the sand back into the shallow pan. Repeat this for both models.

B. Water Flow Model

NOTE: *If there is not enough time to demonstrate this model, skip to the discussion in part 5.*

1. Set-up the model
- Push the sand into one end of the pan and insert the piece of colored plastic, as in the Water Carving Model. This time the sand should fill one-third of the length of the pan. (You will use more sand than in the Water Carving Model.)
- Prop up the pan on the wood block, with the sand mound at the higher end of the pan.

2. Demonstrate the model
- Tell the students that we are going to see how water flowing from the land causes erosion and brings sediment into the Bay.
- If the students had the 5^{th} grade lesson on erosion, review what they learned about the way sediment flows over the land surface and into the Chesapeake Bay - see *Gateways to Conservation for grades 1-5*.
- Ask the students, *"Where do you think the water comes from?"* (Rain, rivers, streams, and drainpipes)
- Using the watering can, pour water over the sand in the higher end of the pan. Tell the students to watch the water carve streams in the sand as it flows into the lower end of the pan. (Do not wash all

of the sand into the lower end of the pan.) The Miocene fossil layer may begin to appear as the sand erodes away.

- Ask the students to look at the trenches. Ask the students, *"Where is the sand going?"* The students will see that the flowing water picks up particles of sediment and washes them into the Bay (or the lower end of the pan).

3. Discuss what happened

- Ask the students, *" What could be a negative of this type of erosion?"* The negative effects are the same as in the previous model. In addition, the flowing water removes soil from critical places on land, such as farmers' fields and stream banks. The flowing water also picks up pollution from the land and carries it into the Bay. Chemical and biological pollutants hurt the organisms in the Bay even more.

4. Clean-up

- Clean up the model the same way as before. Save the wet sand in the extra bucket for use in future lessons.

Part 5. Discuss Ways to Reduce Sediment and Pollution Flowing Into the Bay

For this section you will not need any special materials.

- Ask the students, *"How can we reduce the amount of sediment and pollution going into the Bay due to erosion?"* (In the 5th grade lesson on Erosion, the students learned that vegetation, such as grass, traps sediment and acts as a filter for pollution before it enters the Bay. Students learned that trees were even more effective at reducing erosion and filtering pollutants.)
- Write the ways people can reduce the amount of sediment and pollution flowing into the Bay on the classroom chalkboard.
- Ways people can reduce the amount of sediment and pollution flowing into the Bay include:
    - *Planting trees.* Trees hold the soil, take in water, and filter pollutants. Roots of trees and shrubs planted along the coast will hold soil when the waves from the Bay break against the shore. Planting trees and shrubs along streams, creeks, and rivers will also help to hold soil in place against rainfall and runoff.
    - *Planting native plants.* Native plants do a better job of holding the soil and filtering pollution as compared to many non-native plants. Bayscapes are environmentally sound landscapes in the Chesapeake Bay watershed that utilize a variety of native plants to benefit the Bay. (See the *Alliance for the Chesapeake* Bay for more information.)
    - *Creating and preserving wetlands.* Wetlands play a critical role in reducing the amount of sediment and pollution that enters the Bay. (See *Gateways to Conservation for Grades 1-5*.)

- *Reducing the amount of impermeable surfaces.* Impermeable surfaces (like concrete and blacktop roads, parking lots, and driveways) do not absorb or filter rainwater.
- *Planting and preserving submerged aquatic vegetation (SAV) in the Bay.* SAV, especially Bay grasses, slows down waves and filter the water in the Bay.
- *Planting and preserving marsh grasses in marshes that are found along the coast of the Chesapeake Bay.* Similar to submerged aquatic vegetation, marsh grass slows down waves and reduces the erosion that occurs along the coast. Marsh plants filter pollution from the soil and water in which they grow. Marsh plants hold onto soil with their roots and prevent it from washing away.
- *Reducing the rip rap, bulkheads, seawalls, and breakwaters along the shore.* Rip Rap is the rocks and rubble put along the coast to stop erosion. As discussed in the 5th grade lesson on erosion, these man-made structures only send the wave action somewhere else. This does not ultimately reduce the overall amount of erosion and sediment flowing into the Bay. These man-made structures also reduce the amount of natural coastline available to organisms living in the Bay.

- *Reducing wave action in delicate areas.* Jet skis and speedboats create wakes with rapid, deep waves that accentuate erosion on the shore. No Wake Zones can be established to prevent these boats from coming into areas with sensitive shoreline or SAV.
- *Creating living shorelines.* Instead of putting riprap or jetties along the coast, people could create man-made living shorelines. Building a living shoreline involves a low offshore breakwater that allows sediment to collect in the gap between the breakwater and the coastline. Once the sediment fills in, submerged aquatic vegetation and marsh grasses are planted between the breakwater and the original shoreline. (Draw a simple diagram on the board to help illustrate this concept.) This way of restoring the coast of the Chesapeake Bay can reduce erosion and create a more natural coastline for organisms living in the Bay.

Part 6. Show the Fossil Model

For this section you will need the completed fossil model, butter knives, and stiff brushes.

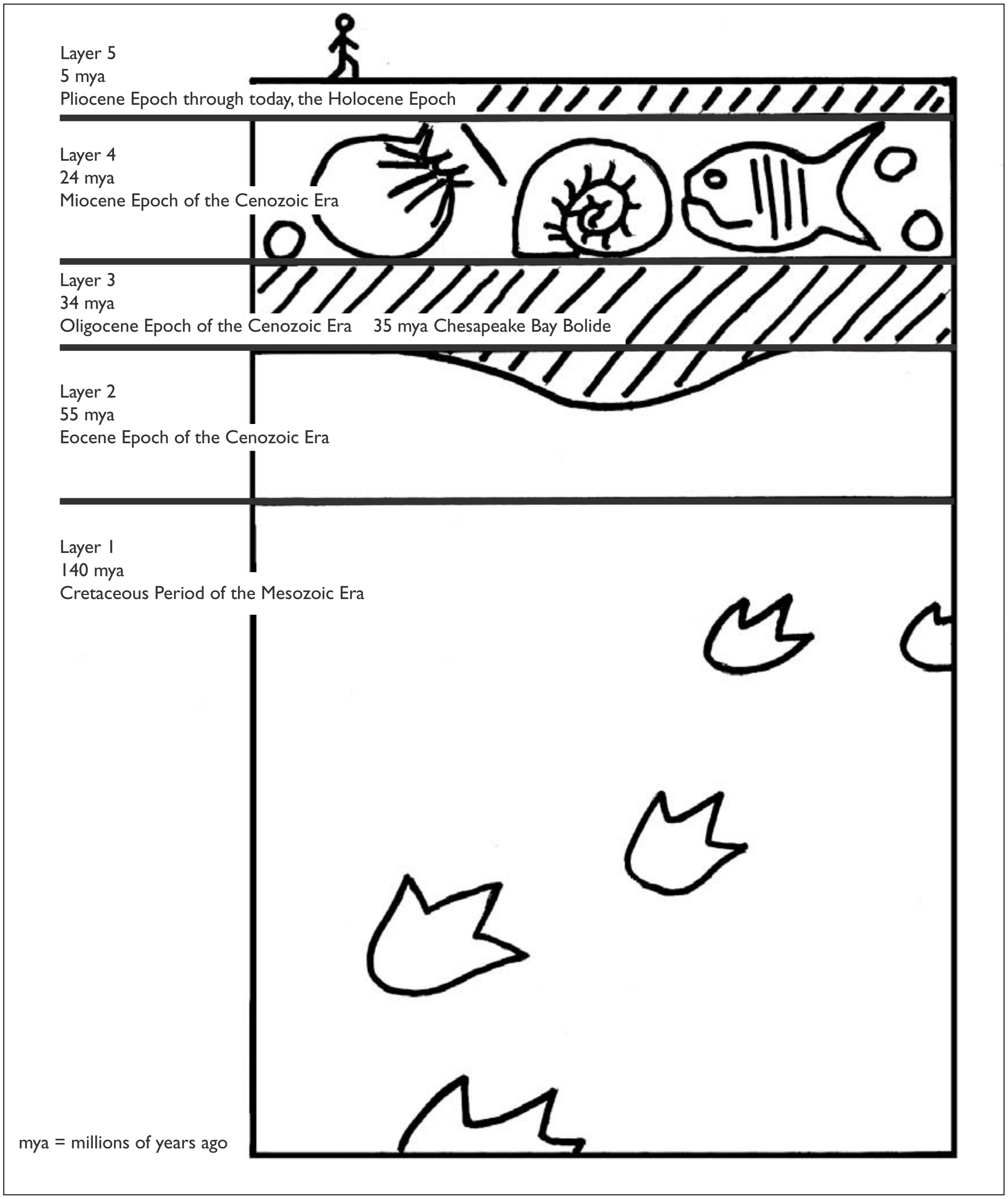
- The Plaster of Paris fossil model should be dry. It should feel rock-hard on the surface.
- Tell the students to pretend that 5 million years has passed, and it is time to check on our fossils.
- Using the butter knife, gently pry out the slab of plaster. Use a stiff brush to brush off the sand from the bottom of the slab.
- Gently remove the shells that were coated in petroleum jelly. The rubber worm should be coated in sand and plaster so it appears mineralized. The track should be filled with plaster, making an observable ridge.
- Point to and review each type of fossil.
- Carry the models around the room for students to see. (The classroom teacher can carry one model around, while you carry the other.)
- The classroom teacher can keep one of the models for future classroom use.

Part 7. Review

- Briefly review the lesson with the students.
- Discuss the photographs of erosion around the Chesapeake Bay where the Miocene fossil layer was exposed.
- Ask the students, *"While the exposure of the Miocene fossil layer seems like a good side effect of erosion, what is the negative effect of the erosion that is occurring around the Bay?"* (The sediment flowing into the Bay covers and kills the submerged aquatic vegetation and carries pollution into the Bay.)
- Ask the students, *"What are three things people can do to reduce the amount of sediment and pollution that flows into the Bay?"* (Plant trees, native plants, SAV, and marsh plants; create wetlands; create living shorelines; etc.)
- Ask the students to name the four types of fossils they learned today (ask a different student for each different type).

Teaching Aids

Sediment Layer Diagram



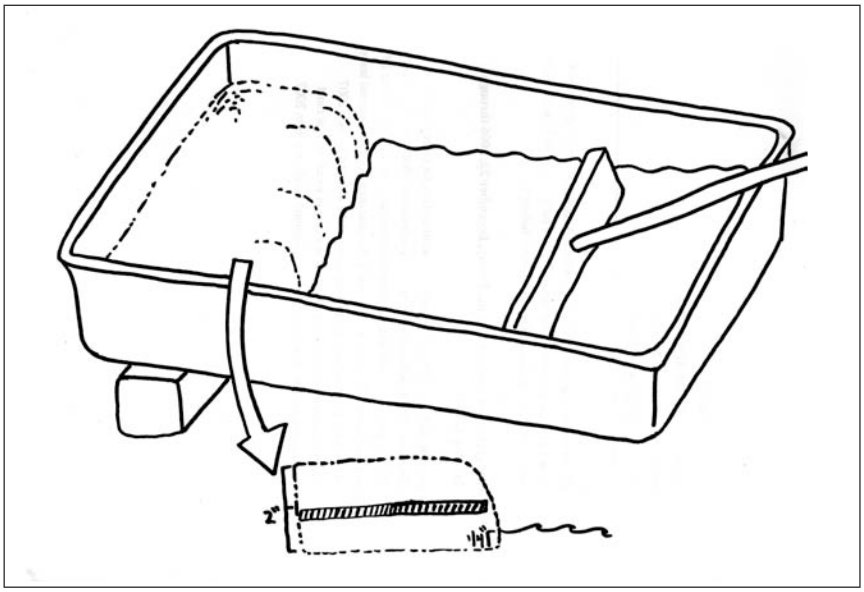
How to make the Wave Maker

Materials Needed:

- 1 piece of wood (2" wide x 8" long)
- 1 - 1" diameter dowel approximately 1' in length
- 2 - 3" wood screws
- Screwdriver

Using the wood screws, attach the two pieces of wood to each other so that the dowel is positioned perpendicularly to and centered on one end of the other piece of wood. The final result is a wooden "T".

Water Carving Model Diagram



Background information for instructor

The Miocene period of geologic history spans from about 23.7 to 5.3 million years ago. This is a popular period of geological history in Maryland because of the prevalence of exposed fossil beds throughout the state. Many people have found fossils such as sharks' teeth from this period. About 17 million years ago, sharks lived in the warm, shallow sea that covered southern Maryland. Other sea creatures included rays, seacows, whales, turtles, porpoises, clams, oysters, corals, sand dollars, ostracods (small crustaceans), and microscopic foramnifera. Remains of these animals were buried in sediment on the sea floor and were fossilized. The fossil remains of these animals from that ancient sea floor have been exposed by erosion (wind and water). The fossils found at Calvert Cliffs in southern Maryland are one of the most extensive collections of fossils from this period found in the Eastern United States (Miocene Shark Teeth, 2006).

Dinosaurs inhabited Maryland much earlier than the Miocene period (about 228 million years ago to 70 million years ago, from the Late Triassic period to the Late Cretaceous period). Dinosaurs were not as abundant or diverse in Maryland as in other regions of the U.S., although at least twelve different species have been discovered. During this geological period, parts of Maryland were covered by an ancient sea teaming with life that was similar to the one of the Miocene period (MD Geological Survey, 2006).

Extension Activities

Pre In-school activity for classroom teacher

Review lesson vocabulary words with students.

Discuss with the students the following information:

- Fossils are the remains or traces of plants and animals that were buried and preserved in sedimentary rock or trapped in organic matter.
- Many fossils represent groups of organisms that are now extinct.
- Fossils range in age from 3.5 billion years (microscopic cyanobacteria or blue-green algae) to 10,000 years (animals preserved during the last ice age)
- Some people speak of living fossils as organisms that have been on the earth for a very long time. However, these organisms are not true fossils.
- Using fossils found over the past 200 years, paleontologists and geologists have been able to piece together a history of the Earth. These scientists mark time by the appearance and disappearance of certain types of fossils.
- Discuss with the students ways scientists hypothesize about the age of a fossil. For example, by looking at the sediment layers the fossil was found in and by comparing it with fossils found nearby for which a date may already be known.

Source for information: Fossils.
Encarta website: http://encarta.msn.com/encyclopedia_761564197/Fossil.html

Post In-school activity for classroom teacher

Discuss ways people can help clean the Bay

Ask the students to research ways to reduce the amount of sediment and pollution that flows into the Bay. If there are not adequate resources in your school library and you do not have access to the Internet, provide your students with the ideas presented by the Center instructor during the lesson. You can also contact the Center for resources.

Based on the results of their research, the students can draw pictures, describe with words, or make models to illustrate one thing people can do to help reduce the amount of sediment and/or pollution that flows into the Bay. The students will explain how their chosen method reduces the amount of sediment or pollution flowing into the Bay. Encourage the students to explore a number of methods. The students can present their ideas to their classmates or, better yet, to the school staff members and parents!

Resources

Alliance for the Chesapeake Bay. Bayscapes. http://www.acb-online.org. Accessed August 5, 2006.

Chesapeake Bay Program. http://www.chesapeakebay.net. Accessed October 9, 2006.

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Denver Museum of Nature and Science. Follow a Fossil. http://www.dmns.org/main/minisites/fossil/whatfossil.html. Accessed August 19, 2006.

Duke University. Description of Alternative Devices for Shoreline Stabilization. http://www.env.duke.edu/psds/Stabilization/Categories.htm. Accessed September 17, 2006.

Encarta.Fossils. http://encarta.msn.com/encyclopedia_761564197/Fossil.html. Accessed August 19, 2006.

Living Shorelines Stewardship Initiative. www.campbellfoundation.com/html/documents/lssifinalupdated2-06.pdf. Accessed September 1, 2006.

Maryland Geological Survey Pamphlet Series. Dinosaurs! http://www.mgs.md.gov/esic/features/mddino.html. Accessed August 5, 2006.

Maryland Geological Survey Pamphlet Series. Maryland Fossils. http://www.mgs.md.gov/esic/brochures/fossils/index.html. Accessed August 5, 2006.

Maryland Geological Survey Pamphlet Series. Miocene Sharks Teeth of Calvert County. http://www.mgs.md.gov/esic/brochures/sharks.html. Accessed August 5, 2006.

Maryland School System Voluntary State Curriculum. Teaching and Learning: Science. http://mdk12.org/instruction/curriculum/science/index.html. Accessed October 1, 2006.

National Park Service. How do you Become a Fossil?. http://www.nps.gov/maca/learnhome/curricula.htm. Accessed August 19, 2006.

USGS. The Chesapeake Bay Bolide Impact: A New View of Coastal Plain Evolution. http://marine.usgs.gov/fact-sheets/fs49-98/. Accessed August 12, 2006.

Erosion Exposes History of the Bay
Field Trip Experience Lesson

Program length: 2 hours *plus travel time*
Number of instructors needed: 1 for every 15 students

Synopsis

This lesson teaches students how erosion has changed the land surrounding the Chesapeake Bay, exposed fossil layers, and increased sediment flow into the Bay. Students will learn how visible fossil layers along the coast of the Chesapeake Bay help people understand the history of organisms that once lived in the Chesapeake Bay area. Students will visit a site where erosion has exposed fossil layers along coastal areas, or they will excavate model fossils using the techniques of paleontology. Students will use a model to observe how erosion affects Bay water clarity. Students will learn that the increased flow of sediment into the Bay has negative effects on submerged aquatic vegetation and animals that live in the Bay.

Objectives

- Students will be able to observe and describe how water erosion changes the water clarity of the Chesapeake Bay.
- Students will be able to describe the exposed fossil layers along the coast of the Chesapeake Bay and the way fossils are extracted from these sediment layers.
- Students will be able to explain how erosion affects submerged aquatic vegetation and animals in the Chesapeake Bay.

Materials

See Teaching Aids for assistance preparing materials
- Secchi Disks (minimum of 1 or 1 per every 2 students - optional)
- If you have no location to take a secchi measurement, you will need a tank at least 4' tall filled with turbid water.
- Plant Samples or photos of submerged aquatic vegetation

Water Clarity Model materials (for 1 model)
- 10-gal fish tank or similar clear container filled halfway with water
- 8-10 cups of soil
- Watering can with water
- Soil Erosion Ramp
- Plastic plant heavily weighted on the bottom

Excavating real fossils
- Location of actual fossil site
- Paleontologist's toolkit (see below, 1 per team of students)
- Shovels (1 per team of students)
- Sample fossils and pictures of fossils students might find
- Fossil Excavation Worksheet (1 per team of students)
- Clipboards (1 per team of students)
- Pencils (1 per team of students)

Paleontologist's toolkit (1 for demonstration purposes or 1 per team of student excavators)
- Rock hammer
- Small masonry chisel
- Large masonry chisel
- Work gloves
- Safety goggles
- Magnifying lens
- Assorted brushes (include an old toothbrush)
- Small first aid kit of bandages
- Maps
- Waterproof field notebook and pen
- Assorted containers or heavy-duty bags
- Newspaper
- Fossil field guides

Excavating mock fossils
- Mock fossil pit
- Assorted brushes and old tooth brushes (2 per student excavator)
- Mock fossils; such as large thin pretzels and rotini or wagon wheel noodles (3 per student excavator)
- Metal butter knives (1 per student excavator)
- Small shovels (1 for every 2 student excavators)
- Fossil Excavation Worksheet
- Clipboards (1 per team of student excavators)
- Pencils (1 per team of student excavators)

Extra Activities
- A variety of actual fossils found in the Chesapeake Bay area

Vocabulary

Erosion – the carrying away of weathered soil, rock, and other materials on the Earth's surface by gravity, water, and wind

Fossils – the remains or imprint of a prehistoric plant or animal

Geologist – a scientist who studies the Earth's crust (rocks and sediment layers)

Organic matter – plant or animal matter that is in the process of decomposing

Sediment – small pieces of rock, shell, and plant and animal matter that is moved and deposited by water, wind, or ice

Paleobiologist – a scientist who studies the biology of fossilized organisms

Paleontologist – a scientist who studies fossils

Processes of Fossilization; How Fossils are Formed:

> **Cast** - a fossil formed when sediment fills a space that was once occupied by an organism showing the organism's outward shape
>
> **Mold** – a fossil formed when sediment fills a space that was once occupied by an organism
>
> **Permineralization (or petrification)** – the process by which fossilized remains are turned into stone
>
> **Trace fossils** – the remains of trackways, burrows, footprints, eggs and eggshells, nests, droppings, and other types of impressions that can give insights into animal behavior

NOTE: *Fossils are not always found in rock. Some animals were trapped in tar pits. While others, like mammoths and other animals that lived during the ice age, were trapped in ice and frozen ground with their flesh, hair, and even stomach contents preserved. Extinct insects have also been found trapped in amber (fossilized tree sap).*

Erosion Exposes History of the Bay
Field Trip Lesson Plan

This lesson plan is broken into seven parts. One Instructor can rotate through each activity with 15 students. Centers may decide to use more than one instructor in order to accommodate more students.

Each Center will need to determine the best arrangement of the activities described in this lesson. You may decide not to do all of the activities.

Before the lesson, the Center will:
- Locate a nearby fossil site or area where obvious coastal erosion has occurred
- Locate an area where students can excavate real fossils or set up an area for mock fossil excavation. (see *Fossil Site Location Information for Instructor* or *Mock Fossil Pit* in Teaching Aids)
- Locate a site where the students can take a secchi measurement of a body of water or set up a four foot tall clear tank.
- Locate a site where students can observe live submerged aquatic vegetation or use tanks of live specimens.

Part 1. Introduction - 2 minutes

Part 2. Erosion Affects Water Quality Experiment - 10 minutes

Part 3. Visit a Fossil Site/ Site of Erosion - 60 minutes

Part 4. Excavate Fossils - 20 minutes

Part 5. Investigate the Bay - 15 minutes

Part 6. Why Study Fossils? - 10 minutes

Part 7. Review - 3 minutes

Part 1. Introduction

- Introduce yourself to the students. Review the meanings of **erosion**, **sediment**, and **fossil**.
- Tell the students we will study how erosion exposed fossil layers in the Chesapeake Bay area. Erosion causes sediment to flow into the Bay and buries aquatic vegetation living on the bottom of the Bay. Tell the students the plan you have for them today (ex. "We will first …")
    - Tell the students we will get to see how erosion affects water clarity.
    - Tell the students we will see a fossil site or a site where coastal erosion has taken place.
    - Tell the students we will have the opportunity to excavate fossils like a **paleontologist**.

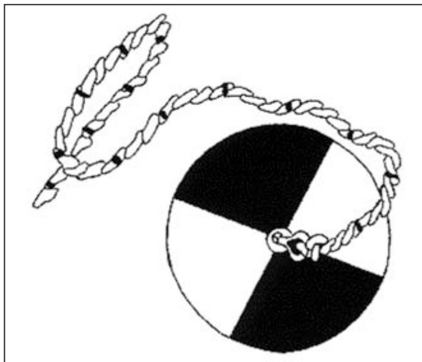
- Discuss what the students learned in class or will learn during the in-class lesson. (Note: although it is not ideal, this lesson may occur before the in-class lesson.)
    - Tell the students, "Erosion occurs along the coasts of the Chesapeake Bay." Have the students describe what erosion is or what it looks like.
    - Tell the students, "Erosion carries sediment away from the shore creating small cliffs and exposing sediment layers that contain fossilized organisms."
    - Tell the students, "While the exposure of fossils might seem like a positive effect of erosion, it has a negative effect on the plants and animals that live in the Bay."

Part 2. Erosion Affects Water Quality Experiment

For this section you will need the Water Clarity Model materials. Set up the Water Clarity Model ahead of time. Have a secchi disk or a picture of a secchi disk nearby.

A. Introduce experiment

- Tell the students, "This is a model created so we can see how erosion affects water clarity. Erosion makes the Bay cloudy, or turbid." Tell the students scientists often measure the clarity or turbidity of the water as part of monitoring the health of the Bay. Just like when they go to the doctor to get a check-up, the Bay gets regular check-ups. Scientists measure the turbidity of the Bay, just as a doctor measures your blood pressure at your check-up.
- Ask the students, *"Have you ever seen the water in the Chesapeake Bay? Do you think the Bay is healthy?"* (The students may equate clear water with healthy water. Tell the students the Bay will never be crystal clear because the water flowing into the Bay from rivers and streams is constantly carrying sediment. However, there are definitely times when the water in the Bay is not as clear as it needs to be for plants growing in the Bay.)
- Tell the students, "We are going to do an experiment to see how cloudy the water becomes when erosion occurs and sediment is washed into the Bay."



secchi disk for measuring water transparency
Courtesy of Robin Ulmer, Boquet River Association, NY

B. Conduct experiment

- Remind the students of the in-class lesson or the 5th grade lesson when they saw how water carries sediment into the Bay. Tell the students, "The ramp filled with soil represents the land surrounding the Chesapeake Bay and the clear container represents the Bay. The plastic plant represents submerged aquatic vegetation living in the Bay. An abbreviation for submerged aquatic vegetation is SAV."
- Tell the students, "The water in the watering can represents rainwater falling on the land."
- Pour the water along the top of the ramp so the soil starts flowing into the container.
- The water will become cloudy and it will be hard to see the plastic plant.
- Ask the students, *"How do think erosion affects submerged aquatic vegetation or SAV in the Bay?"* (The plants will not be able to capture the sunlight needed to make food, and the plants will die if the water stays turbid for multiple days.)

- Ask the students, *"How do you think erosion affects the animals living in the Bay?"* (The animals living in the Bay need aquatic plants for food and for places to hide from predators. Many animals will die soon after the plants die. Some animals, like ducks, swans, and geese, need SAV for food. They will not survive if there is not enough SAV.)
- Tell the students scientists measure the turbidity of the Bay by using a secchi disk. Show the students a secchi disk or a picture of one. Explain to the students how a secchi works (see *Secchi disk background information* in Teaching Aids). Tell the students they will be using a secchi disk later in the lesson to measure the turbidity of a nearby body of water.
- Tell the students we will check the water in the container later to see if it clears up.

Part 3. Visiting a Fossil Site / Site of Erosion

How you arrive at this location will vary for each Center. Some possibilities might include: meeting the students' bus at the site, hiking with the students to the site, or canoeing or kayaking to the site with the students. Depending on the fossil site, you may be able to excavate fossils with the students. If not, use this site to examine fossils and erosion, and use the mock fossil pit activity described below in Part 4 to excavate fossils.

A. Introduction

- Tell the students the rules of the site. Set boundaries. Explain whether the site is public or private property.
- Tell the students what is known about the history of the site and how the fossil layer became exposed or how erosion occurred.
- If at a fossil site, explain what a fossil is. If at an erosion site, explain what erosion is.
- Explain the different ways fossils are made (the process of fossilization).

- Explain the difference between the fossils and the original **organic matter**.
- Explain the ages of the fossils at the fossil site.
- Tell the students to look for sediment layers. Point out the different layers of sediment and explain how the upper layer was deposited on top of the bottom layer. Ask the students, *"Which layer is the youngest?"* (The top layer.)

B. Looking for fossil layers and signs of erosion
- Show the students sample fossils found at the site.
- Explain to the students the rules for collecting fossils at this site. (Rules will vary for each site – perhaps it is private property and you need a permit, etc.)
- Tell the students, "Fossils are not found everywhere. **Paleontologists** do research to find the best site for fossils."
- Remind the students that the sediment surrounding a fossil tells us as much as the fossil itself. A paleontologist records as much information about the fossil and its location as possible. Untrained fossil collectors are not always careful. They sometimes disturb the site without gathering information.
- Tell the students, "Today we are going to be paleontologists and not fossil collectors! We are going to study the site and learn from the fossils we find."
- Explore the site with the Center instructor pointing out: sediment layers, potential locations of fossil layers, a fossil, a place where erosion has caused a tree to fall into the water, or a place where erosion has carved a cave or hollow area out of the bank.

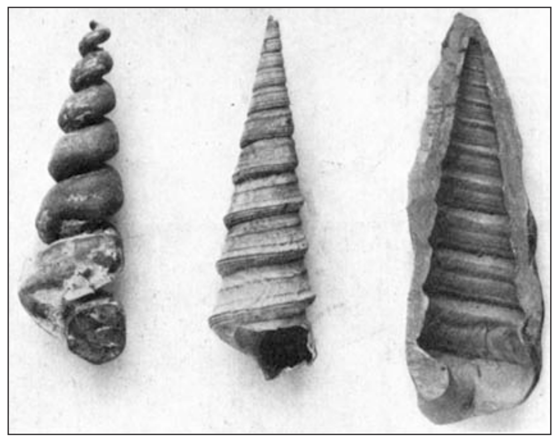
Part 4. Excavating Fossils

Depending on the site students will do Part 4a (excavating real fossils) or 4b (excavating mock fossils).

4a. Excavating real fossils
For this section you will need the Paleontologist's Toolkit and materials for excavating real fossils. Before the students' arrival, mark off quadrants for student teams using wooden stakes and string to limit excavation to a particular area.
- Show the students the site. Explain that markers divide up the site. Paleontologists place markers in order to keep track of where a fossil was found. Explain how the markers correspond to natural landmarks nearby.
- Students will be using tools and may be encountering rocks or steep banks in this activity. Remember that safety is your most important goal!
- Show the students the paleontologist tool bag. Remind the students that a paleontologist is usually excavating fossils from rock or hard sediment. Tools include:
    - A rock hammer for chipping fossils out of surrounding rock. This tool can hurt the fossil as well as the person using it. Use with care!
    - A small masonry chisel for chipping fossils out of the rock and for cleaning fossils once they have been removed. Use with care!
    - A large masonry chisel. Use with care!
    - Work gloves for handling sharp rocks and sharp fossils.

- Safety goggles to protect eyes from flying pieces of rock.
- A magnifying lens for closely examining small fossils and fossil fragments.
- Assorted brushes (including an old toothbrush) for cleaning fossils once they are removed from surrounding sediment.
- A small first-aid kit of bandages. (Make sure you have this.)
- Maps for finding fossil locations.
- A waterproof field notebook and a pen for recording data.
- Assorted containers or heavy-duty bags for protecting fossils and carrying them back to the lab.
- Newspaper for wrapping fossils (especially sharp ones).
  (from: Fossil Collecting in the Mid-Atlantic States, 1991)

- Demonstrate how to carefully excavate fossils. Remind the students, "If you dig too fast and do not look closely at the sediment, you could destroy a fossil or overlook a fossil because it is so small."
- Encourage the students to examine every piece of what might look like a shell or rock in your quadrant. Some fossils, such as the teeth of sharks, skates, and rays could be very small.
- Divide students into teams. Assign an adult to monitor a maximum of two teams.
- Introduce the adult monitor to the students. Explain all rules and safety concerns to the students and the adults before they begin excavating.
- Ask the adults to help you keep the students safe. Ask the adult chaperones to notify the lead Center instructor and the classroom teacher immediately if a student is not following instructions.
- Hand out the data sheets, clipboards,, and pencils to each group. Go over the worksheet with the students before giving them their tool kits.



- Remind the students to record the distance from nearby landmarks under the Location column on the worksheet. Use landmarks that will be there years from now. A small shrub would not be a good landmark. A large oak tree or building would be good landmark. A large rock, a cliff, or the water's edge would be the best kind of landmark.
- Remind the students to use all their tools, especially the brushes to clean off their fossils.
- After 20 minutes, ask the teams to pack up and meet in a designated area with the fossils they have found.
- Ask the students, *"Was extracting the fossils exciting?"* Share the fossils with the group.
- Ask the students, *"Can you imagine how patient a paleontologist must be?"* A paleontologist might spend hours excavating what they think could be a great fossil. The fossil could turn out to be a common, unexciting fossil or not a fossil at all. A paleontologist must be patient and persistent."
- Ask some adults and a few responsible students to check the sites for tools left behind and, if necessary, remove the quadrant markers.
- Ask the students to complete their fossil worksheets, and then hand them in to the classroom teacher.

4b. Excavating mock-fossils

For this section you will need the "Paleontologist's Toolkit" and "Excavating mock fossils" materials. Make sure the site is set up prior to student arrival. Know where and how many fossils are hidden. Make sure there is a variety of mock fossils in each plot. Also vary the way the fossils are placed into the pit (some flat, angled and vertical).

- Explain to the students that this is a mock fossil pit. We will use a mock fossil site to practice their excavation skills. The actual fossil site may be too dangerous or on private property. The site may be waiting for a paleontologist to excavate it.
- Show the students the site. Explain that markers divide up the site. Paleontologists put up markers in order to keep track of where a fossil was found. Explain how the markers correspond to natural landmarks nearby.
- Show the students the paleontologist tool bag. Remind the students that a paleontologist usually excavates fossils from rock or hard sediment. See Part 4a for a detailed tool description.
- Hand out the data sheets, clipboards and pencils. You may need to have the students work in pairs.
- Go over the worksheet with the students.
- Show the students the mock fossils for which they will be looking. Explain to the students, "We are using this item as a mock fossil to simulate the experience of a paleontologist. If paleontologists are not careful when they are extracting fossils from rock, the fossils can break. The mock fossils are fragile enough that they will break if we are not careful when extracting them from our sand pit."
- Tell the students how many mock fossils they can each find in order to clean out their plot.

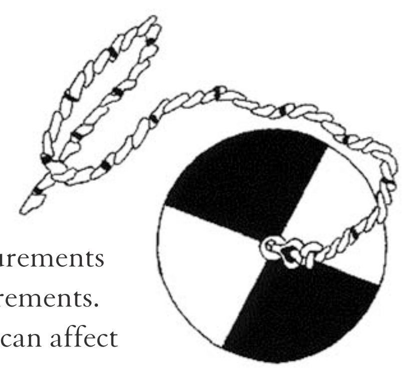
(You can remind the students, most of the time, paleontologists do not know how many fossils, if any, are in their plots.)

- Remind the students to record their plot number and the distance from nearby landmarks, under the Location column on the worksheet. Remind the students to use landmarks that will be there years from now.
- Hand out tool kits and assign digging plots.
- Remind the students to use all of their tools, especially the brushes to clean off their fossils.
- Tell the students, "Work carefully so you don't break your fossils." Tell the students to not stand on a plot until they know every fossil has been excavated.
- Students who finish first can assist other students.

- Encourage the students to describe and draw pictures of the mock fossils on their worksheets. This is exactly what paleontologists do in their field notebooks!
- When the group is getting restless (about 15 minutes) or when most of the fossils have been extracted, ask the students to pack up their supplies and gather together.
- Ask the adults and a few responsible students to check the site for tools left behind. If necessary, remove the quadrant markers while one instructor talks with the students.
- Ask the students to carefully organize the supplies and give the classroom teacher their worksheets.
- Ask the students, *"Was extracting the fossils exciting?"*
- Ask the students, *"Do you think it would be more exciting if the fossils were real? Do you think a paleontologist finds exciting fossils all the time?"*
- Ask the students, *"Can you imagine how patient a paleontologist must be?"* A paleontologist might spend hours excavating what they think could be a great fossil. The fossil could turn out to be a common, unexciting fossil or not a fossil at all. A paleontologist must be patient and persistent.

Part 5. Investigating the Bay

For this section you will need the secchi disks.
This part of the lesson can be done when you encounter the Bay or a large body of water. For example, you can investigate the Bay near the fossil site, the erosion site, or on the way back to the Center. Centers without an adequate location can set up a tank to simulate the Bay. The tank should be clear, at least four feet tall, and the water made cloudy. A platform beside the tank would enable the students to stand over the tank to take a secchi measurement.



- Locate a place where you can take a secchi disk measurement. Ask two or more students to take the measurement as you walk them through it. If you have enough secchi disks at your Center, you can ask the students to work in teams and take measurements while you walk them through the steps.
- Discuss the measurement as it relates to weather conditions, other measurements taken by other groups, and any other factors that could affect the measurements. For example, the amount of shadow or glare on the surface of the water can affect the secchi measurement.
- If possible, show the students various species of submerged aquatic vegetation (SAV). If there are no live specimens to examine, use large photographs or slides.

- Show the students the differences between the plants and any interesting characteristics (see SAV *background information* in Teaching Aids).
- Discuss other organisms that are affected by the death of SAV such as young fish, Blue Crabs, Black Ducks, Canvasback Ducks, and Redhead Ducks.

Part 6. Why Study Fossils?

For this section you will not need any special materials.

- Tell the students that by closely studying fossilized organisms and their body parts, **paleobiologists** make hypotheses about what the environment was like when the organism was alive. A paleobiologist is a scientist who studies the biology of the fossilized organisms. For example, if a paleobiologist finds a fossilized organism that looks similar to a modern-day clam, he or she hypothesizes that the area where the fossil was found might have been a body of water many years ago.
- Ask the students, *"What do you think a scientist would conclude about the history of an area where many of the fossilized animals have very long claws and long limbs for climbing?"* (A paleobiologist might think these animals climbed trees and that the area where their remains were found had many tall trees at the time the animals were alive.)
- Tell the students how hypotheses about past environments help scientists understand the environmental history of an area. A **geologist** who studies rocks and sediment layers formulates hypotheses about an area just as a paleobiologist does. Together, these scientists can build a timeline showing us how the area that is now an Education Center changed over time.
- Paleobiologists, paleontologists, and geologists who study the history of an area can make hypotheses about how the area will change in the future. For example, the area where we are could have a historical pattern of changing from a body of water to an area of dry land and back again several times. Then, scientists might conclude that the dry area where we are standing might become a body of water again in the future.
- Ask the students, *"If we wanted to try and figure out what happened in an area over the past thousand years, would we look at fossils?"* (No, we would need to look at organisms preserved in another way because a fossil takes at least 10,000 years to form. We would use other geologic methods to study the landscape, as well.)
- Ask the students, *"If it takes 10,000 years for a fossil to form, can you think of other ways organisms can be preserved more quickly?"*

Mummification is when an organism is dried out or the moisture is removed. Dried fruit is an example of mummification.

Preservation occurs in peat bogs, which are bogs containing decaying organic material. The peat bogs are acidic and this preserves the organisms. This is similar to how people preserve pickles in vinegar.

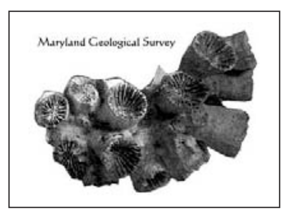
Ice can keep an organism frozen for many years.

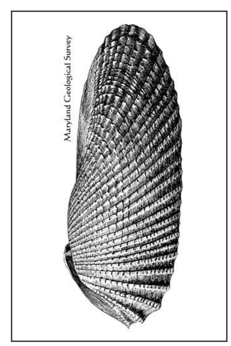
Organisms become coated in travertine (a calcium carbonate salt that comes from natural spring water). Some students may have seen calcium carbonate, also called lime, when it formed around the lid of their fish tank. Calcium carbonate is whitish in color and breaks apart easily, like eggshells. Eggshells are mostly made up of calcium carbonate. (See *Fossils* in the Resource list for examples)

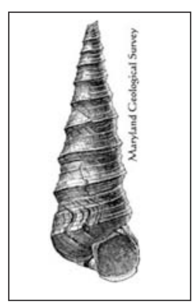
- Ask the students, *"Have you heard the term Global Warming?"* (Global Warming is a term used to describe how the earth is currently getting warmer.) Tell the students that Global Warming is connected to what they are studying today, because in order for scientists to figure out if the globe is getting warmer, they need to look at the environmental history of an area.
- Tell the students that even though scientists cannot look at fossils to tell what happened 1,000 years ago, they can look at preserved organisms, samples of ice, eroded areas, and deposits of sediment to make hypotheses about what an area was like 1,000 years ago. They can then predict or hypothesize about the site 1,000 years in the future.
- Ask the students, *"What do you think will happen to this area in one thousand years?"* (More erosion could take place. A coastal area will not be there because of erosion. If the students make predictions about the weather, remind them that scientists use data to back up their hypotheses.)

Extra Activity-Examing Real Fossils

For this activity you will need some actual fossils and a place to gather the students. If time and supplies permit, show the students some real fossils. The fossils should be from the Chesapeake Bay area and the time periods discussed in this lesson.







- Explain to the students where the fossils came from and how they should be handled.
- Allow the students to carefully touch the fossils if possible.
- Tell the students information about each fossil. Tell the students how you know what kind of fossil it is.
- Remind the students paleontologists do research to find the best site for fossils and they gather information from the surrounding sediment to tell them about the fossil itself. A paleontologist records as much information about the fossil and its location as possible.

- Fossil collectors are not always careful. They sometimes disturb the site without gathering information. (You may not know much about your fossils because they were found by careless fossil collectors.)
- Discuss with the students whether everyone can be a fossil collector.
- Ask the students, *"Once all the fossils are collected from a site, will there be any more fossils? What if all the fossils were in the hands of fossils collectors?"* Once all the fossils are collected from a site, no one will be able to enjoy seeing fossils at the site where they were originally located. Fossils are valuable historical artifacts. Some fossils are more valuable than others. It is important to make sure information about a fossil is kept with the fossil itself. Sometimes fossils must be removed from a site so that more people can enjoy them. Many museums, colleges, universities display and help preserve fossil collections with detailed information.
- Tell the students everyone excavating fossils must act responsibly and follow the rules and regulations of excavating fossils at a particular site.

Part 7. Review

- Briefly review the lesson with the students and tie all the pieces of the lesson together.
  1. Ask, *"How did the fossil layers become exposed around the Chesapeake Bay?"*
  (Through erosion of sediment by wind, water in the form or waves and rainfall, and ice.)
  2. Ask, *"What is a negative side effect of erosion, and who or what is affected?"*
  (Increased sediments and pollution in the Bay; all filtering animals, SAV and all organisms that breath oxygen or need the sunlight to survive.)
  3. Ask, *"Who or what needs SAV?"*
  (Fish need SAV to hide in. Some birds and mammals need to eat SAV. All organisms need SAV, because SAV keeps the Bay healthy by also filtering pollutants from the water and reducing erosion.)
  4. Ask, *"How can piecing the environmental history of an area together help scientists predict what is going to happen to that area in the future?"*
  (They can study the changes that occurred through fossils, ice temperatures, and rock layers.)

Teaching Aids

How to make the Soil Erosion Ramp for the Water Clarity Model
Materials needed: (based on a clear 10-gallon fish tank)

- 2 pieces of wood (approximately 1” x 4” x 16”)
- 1 piece of wood (approximately1” x 7.5” x 16”)
- 1 piece of wood (approximately 4” x 4” and 20” tall) or object of similar size
- 12 wood screws
- Screw driver
- Wood caulk

Directions for assembly:
All wood should be sanded. To build the trough, screw the two 1” x 4” x 16” pieces to the outside of the long sides of the 1” x 7.5” x 16” piece. Use three screws per side. Caulk the inside seams between the base and sides of the trough to prevent moisture and soil from getting caught. Use the 4” x 4” piece of wood or other object to prop up one end (the higher end) of the trough while the other end (lower end) of the trough rests on the edge of the fish tank. The trough should be at a small enough angle so that the soil does not slide off before the water is added to run the model.

Fossil site location information for instructor
There are many ways to find fossil sites or beaches near your Center. You can consult a local museum that has a natural history exhibit and speak to the resident archaeologists, paleontologists, or geologists. You can also consult references such as Fossil Collecting in the Mid-Atlantic States for well-known locations (Burns, 1991). A detailed description of fossil sites in Calvert County, Maryland, can be found on the Maryland Geological Society’s Fact Sheet #10, at http://www.mgs.md.gov/esic/fs/fs10.html.

Fossil Excavation Worksheet
(see end of Teaching Aids section)

Mock fossil pit
Find a level location for your mock fossil excavation site or mock fossil pit. Clear the area of any leaves and sticks and mark off the outer area of the pit. The following diagram is based on accommodating 30 students. You may want to adjust your fossil pit to accommodate your needs. Adding approximately 13 tons of washed masonry sand will create a pit about one foot deep. Use only biodegradable items for the mock fossils, such as hard pretzels.

- Rope off the quadrants where the fossils will be hidden using small wooden stakes and string (refer to the bold lines in the diagram below). Approximately 182' of string is required.
- Bury the fossils. Place the fossils between 3-6 inches deep. Experiment with the mock fossils and mock fossil pit before using the fossil pit for the first time.
- Prepare index cards with numbers 1 – 30 on them. Place a numbered index card in each quadrant where you have hidden the fossils.

Mock Fossil Pit Diagram

- Each block is a 2' x 2' square, making the dimensions 14' x 16'.
- Bold lines indicate where string markers should be placed around the plots.
- Numbers indicate where a student can be assigned to dig (students should stand outside of their assigned plots and not disrupt another person's plot).

1	**2**	**3**	**4**	**5**	**6**	**7**
8						**26**
9			**27**			**25**
10			**28**			**24**
11			**29**			**23**
12			**30**			**22**
13						**21**
14	**15**	**16**	**17**	**18**	**19**	**20**

Secchi disk background information

A secchi disk is an instrument used to measure water's transparency, or the amount of sunlight able to pass through the water column. It is an 8-inch (20 cm) disk with alternating black and white quadrants attached to a rope with measured intervals. One uses a secchi disk by lowering it into a body of water until the disk can no longer be seen. This depth is called the secchi depth, and allows researchers to determine the water's transparency. Transparency can be an indicator of the level of anthropogenic impact on the water. If a secchi disk is used to measure the transparency of a body of water and the results are compared between seasons and years, the data can be used to study the effects of human activity on the body of water (Davies-Colley, 1993).

There are three factors that inversely affect the transparency of water: water color, algae, and suspended sediments (Davies-Colley, 1993). Tannins from decaying plant matter stain water and make it the color of tea. Increased plant material in a body of water can decrease transparency. Algae are small, green, aquatic organisms whose populations depend on the amount of nutrients in the water, specifically nitrogen and phosphorus. Increased nutrient runoff from sewage treatment plants, septic tanks, and lawns or fields containing fertilizer, increases algal growth, decreasing water transparency. Suspended sediments can arise through resuspension from the water's bottom, and from runoff from construction sites, agricultural fields, and urban areas. As the body of water becomes filled with suspended sediments, the secchi depth decreases because the water transparency decreases.

The following secchi disk method was proposed by Davies-Colley and others:

- Use a disk of an appropriate diameter for the clarity range (20 mm for 0.15-0.5 m, 60 mm for 0.5-1.5 m, 200 mm for 1.5-5 m, 600 mm for 5-15 m), painted matte white or black and white quadrants. Use a graduated line and attach a weight to hold the line vertical.
- Lower the disk in a sunny area, as near to mid-day as possible.
- Allow sufficient time (preferably two minutes) when looking at the disk near its disappearance point so the eyes can adapt completely to the light level.
- Record the depth at which the disk disappears by counting the measured marks on the string. Slowly raise the disk and record the depth of reappearance. The secchi depth is the average of the depths of disappearance and reappearance.
- The water depth should be at least 50% greater than the secchi depth so that the disk is viewed against the water background, not bottom-reflected light.

Another great resource of information about secchi disks can be found at:
U.S. Environmental Protection Agency. "Monitoring and Assessing Water Quality."
http://www.epa.gov/owow/monitoring/volunteer/stream/155.html. Accessed November 2006.

SAV background information

Submerged aquatic vegetation (SAV) plays a necessary and integral role in the Chesapeake Bay (MDDNR Mute Swan Task Force). They are a primary food source for some waterfowl. SAV beds provide habitat and shelter for fish, shellfish, and invertebrates. The beds decrease erosion by decreasing wave energy and slowing currents, causing an increase in water clarity and a decrease in the amount of suspended sediments in the Bay. In addition, SAV absorbs excess nutrients in the Bay and oxygenates the water.

Populations and distribution of SAV in the Bay have decreased in the past decades (MDDNR Mute Swan Task Force). This is primarily due to a decrease in water transparency and an increase in algal growth on the plants. These changes have occurred because of the increased level of nutrients and suspended sediments in the Bay.

When submerged aquatic vegetation die off, the food chain is altered, turbidity of the water increases, and the amount of food for migrant and wintering waterfowl is reduced. The upper Bay region is one of the critical habitats for migratory waterfowl. Several species dependent on SAV have shown a decline in numbers as the abundance of submerged vegetation remains low.

The most prevalent type of SAV in your area depends on where you are located on the Chesapeake Bay. (The following information is from: "Bay Grasses," Chesapeake Bay Program.)

Wild celery (*Vallisneria americana*) - dominant in the Upper Bay
Description: Long, ribbon-like leaves that cluster at the base of the plant. Leaf edges slightly serrated. Rounded tip. A light green stripe runs down the center. Tiny, white flowers.
Distribution: Fresh to brackish water.

Redhead grass (*Potamogeton perfoliatus*) - dominant in the Middle Bay
Description: Broad, oval leaves that clasp the stem. Clusters of tiny flowers.
Distribution: Fresh to moderately brackish water.

Eelgrass (*Zostera marina*) - dominant in the Lower Bay
Description: Linear, ribbon-like leaves that occur along joints of the stem. Rounded leaf tips. Thick creeping rhizome. Similar to wild celery but grows in different salinity. Often occurs with widgeon grass.
Distribution: Salty water.

Coontail (*Ceratophyllum demersum*)
Description: Densely branched stems. Leaves in whorls of 9 to 10. Stiff and flattened leaves are forked with teeth on one side. Whorls are denser toward the tip of the stem. Looks like a raccoon's tail. Has no true roots.
Distribution: Fresh to slightly brackish water.

Horned pondweed (*Zannichellia palustris*)

Description: Long, thread-like leaves are opposite or in whorls along branching stems. Tips of leaves taper to a point. Distinctive horn-like, slightly curved fruits. Usually the first species to appear in the spring. Dies back in summer.

Distribution: Fresh to moderately brackish water.

Other useful websites with pictures and information about SAV:

Chesapeake Bay Field Office, U.S. Fish and Wildlife Service. Decline of Submerged Plants in Chesapeake Bay. http://www.fws.gov/chesapeakebay/savpage.htm. Accessed October 14, 2006.

Chesapeake Bay Program. Bay Grasses. http://www.chesapeakebay.net/info/baygras.cfm. Accessed October 14, 2006.

Maryland Department of Natural Resources. Bay Grasses Identification Key. http://www.dnr.state.md.us/bay/sav/key/. Accessed October 14, 2006.

University of Maryland Center for Environmental Science, Horn Point Laboratory. http://www.hpl.umces.edu/resecol/sav.htm. Accessed October 14, 2006.

Fossil Excavation Worksheet

Name: ______________________________ Date of Excavation: ________________

Draw a picture of your fossil	Describe the texture, color, weight, etc. of your fossil	What is the location relative to landmarks?

Extension Activities

Pre Field-trip activity for classroom teacher

Review the Vocabulary words with the students.

Discuss with the students the following information:
Fossils are the remains or traces of plants and animals that were buried and preserved in sedimentary rock or trapped in organic matter. Many fossils represent groups of organisms that are now extinct. Fossils range in age from 3.5 billion years (microscopic cyanobacteria or blue-green algae) to 10,000 years (animals preserved during the last ice age) Some people speak of living fossils as organisms that have been on the earth for a very long time. However, these organisms are not true fossils (Encarta, 2006). Using fossils found over the past 200 years, paleontologists and geologists have been able to piece together a history of the Earth. These scientists mark time by the appearance and disappearance of certain types of fossils.
Discuss with the students ways scientists hypothesize about the age of a fossil – for example, by looking at the sediment layers the fossil was found in and by comparing it with fossils found nearby for which a date may already be known.

Post Field-trip activity for classroom teacher

Be a paleobiologist

Cut out the fossil pictures from the Common Maryland Fossils sheet. Give each student a fossil and have him or her answer the following questions on a piece of paper.

1. *Do you think your fossil looks like an organism that is alive today? If yes, what organism or organisms?*
2. *What parts of the fossil made you think of the organism that is alive today? List all the parts you see on your fossil.* (For example, some of the parts you might see would be a shell, mouth, leaves, roots, or legs.)
3. *Where do you think this organism lived? Why?*
4. *How do you think this fossil was preserved? What could have happened to the ancient organism causing it to be preserved? For example, do you think it fell into a mud pit?*

Ask the students to share their fossils with other students in the room. Ask them to find another fossil that looks like theirs, and therefore might be related to their fossil. Ask the students to join others with similar fossils. Walk around and tell the students the time period their fossil was alive. Within groups, ask the students to compare their stories about what they think happened to their fossil. Ask each group to work together to decide what happened to their ancient organisms.

Tell the class the time periods that each group's fossils existed and the ages of the fossils. Some teachers and students may be able to explain what Maryland was like during that time period – for example, whether the area was a jungle or ancient sea. This is not essential to the exercise. It is more important for the students to develop a possible environmental history about what life was like for their fossilized organisms and to explain what could have caused them to become fossilized.

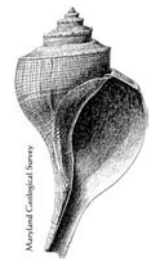
You may also want to initially divide the students up into groups based on the number of fossil pictures in each time period on the Common Maryland Fossils sheet. Have the students work independently to answer the questions above. You can have the students write a story, using facts they know or can find about their fossil's time period, habitat, and feeding habits.

Please use the following source for more information on common Maryland Fossils:
Maryland Fossils. Maryland Geological Survey Pamphlet Series. Retrieved from
http://www.mgs.md.gov/esic/brochures/fossils/index.html. Accessed August 5, 2006.

Common Maryland Fossils

pictures courtesy of the Maryland Geological Survey

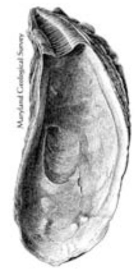
Pleistocene Epoch – 500,000 years ago



Fulgar canaliculatum

Mya arenaria

Barnea (Scobina) *costata*



Ostrea virginica

Miocene Epoch – 5 million years ago

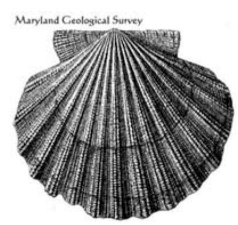
Carcharias
(Prionodon) *egertoni*

Echphora quadricostata

Surcula biscatenaria

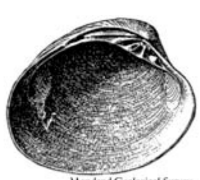
Astrangia lineata

Spisula (Hemimactra)
subponderosa



Pecten (Chlamys) *madisonius*

Eocene Epoch – 35 million years ago



Moratoria ovata var *pyga*

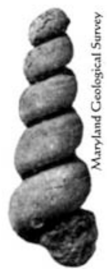
Strepsidura subscalarina

Turritella mortoni

Venericardia planicosta

Common Maryland Fossils *(continued)*

pictures courtesy of the Maryland Geological Survey

Cretaceous period – **65 million years ago**		Jurassic period – **150 million years ago**	Triassic period – **210 million years ago**
 *Turritella vertebroides*	 *Magnolia auriculata*	 *Dioonites buchianus*	 *Cheirolepsis münsteri*

Carboniferous-Permian period – **245 million years ago**

Alethopteris serlii

Sphenopteris lescuriana

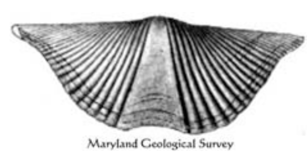
Allorisma terminale

Asterophyllites equisetiformis

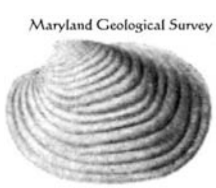
Devonian period – **370 million years ago**

Eatonia sinuata

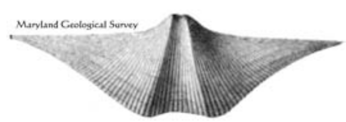
Spirorbis gyrus



Spirifer mesastrialis



Grammysia arcuata



Spirifer disjunctus

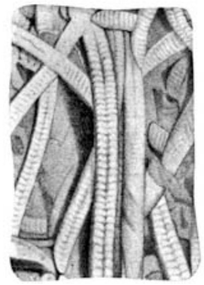
Palaeaster clarki

Common Maryland Fossils *(continued)*

pictures courtesy of the Maryland Geological Survey

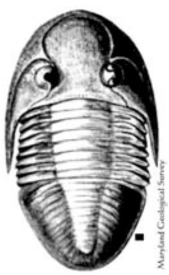
Silurian period – **410 million years ago**

Palaeaspis Americana



Arthrophycus harlani

Ordovician period – **440 million years ago**

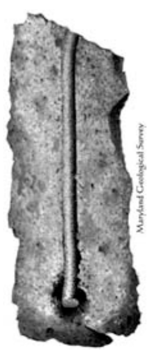


Isotelus maximus

Diplograptus foliaceus

Cambrian period – **520 million years ago**

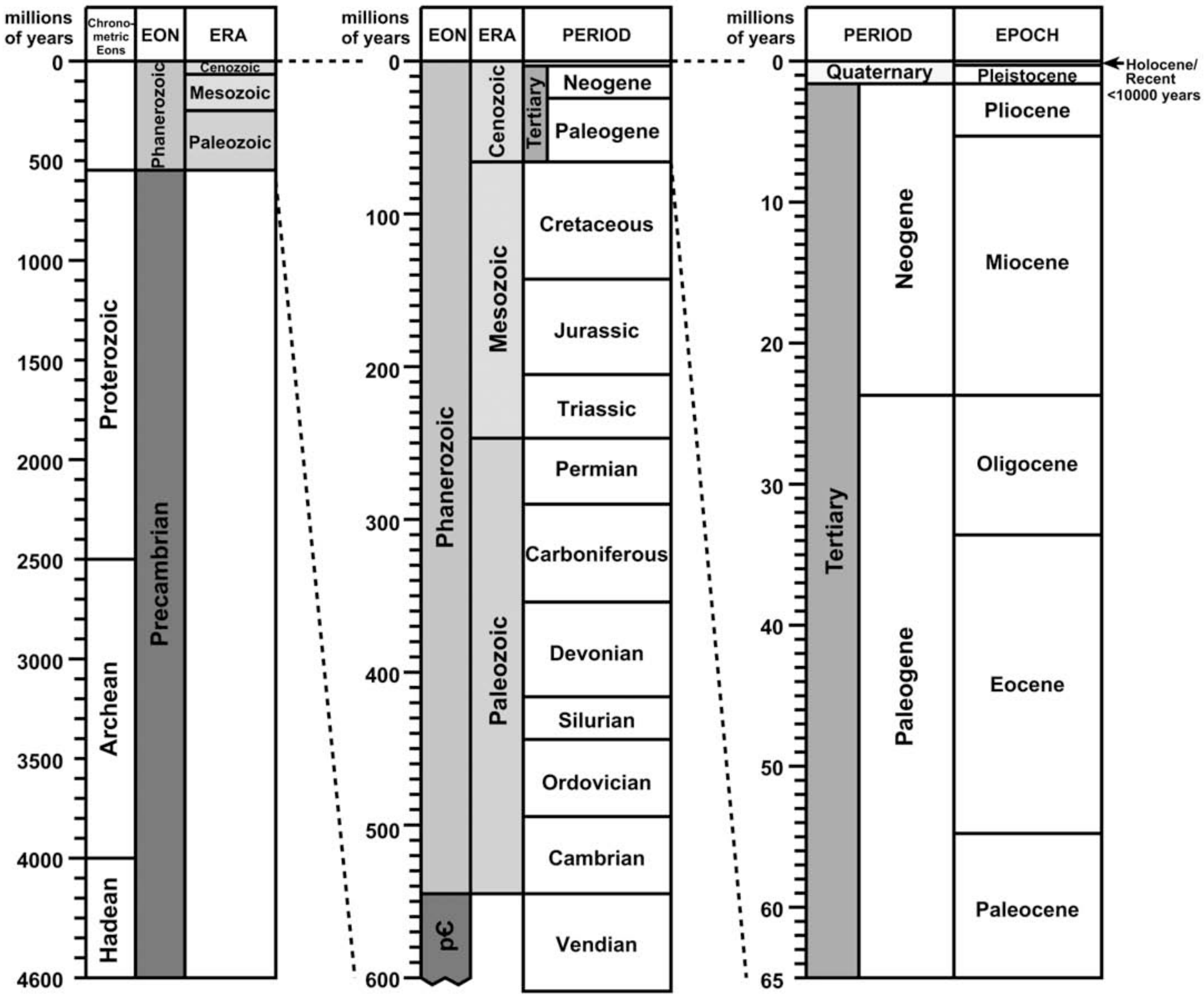
Olenellus thompsoni



Scolithus linearis

Geologic Time Scale

(Based on data from Gradstein and Ogg, 1996 (Phanerozoic); and Harland et al., 1990)



References:
Harland, W.B. *et al.*, 1990. A Geologic Time Scale, 1989 edition. Cambridge University Press: Cambridge, 263pp. ISBN 0-521-38765-5
Gradstein, F. and Ogg, J., 1996. A Phanerozoic time scale. Episodes, v.19, no.1&2.

Resources

Burns, Jasper. Fossil Collecting in the Mid-Atlantic States; with localities, collecting tips, and illustrations of more than 450 fossils specimens. The John Hopkins University Press; Baltimore, MD. 1991.

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Davies-Colley, R.J, W.N. Vant, and D.G. Smith. 1993. Colour and Clarity of Natural Waters. Retrieved from http://dipin.kent.edu/secchi.htm. Accessed September 23, 2006.

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National Park Service. How do You Become a Fossil?. http://www.nps.gov/maca/learnhome/curricula.htm. Accessed August 1, 2006.

University of Maryland Center for Environmental Science, Horn Point Laboratory. Aquaculture and Restoration Ecology. http://www.hpl.umces.edu/resecol/sav.htm. Accessed September 23, 2006.

Biodiversity Makes the Bay Better

In-school Lesson and Field Trip Experience

Grade: 7

Pickering Creek Audubon Center

Standards of Learning

Talbot County Student Performance Objectives:

Grade 7:

Skills and Processes:
Constructing Knowledge - Design and carry out simple investigations and formulate appropriate conclusions based on data.

Life Science:
Diversity of Life - Compile evidence to verify the claim of biologists that the features of organisms connect or differentiate them - these include external and internal structures (features) and processes.

Maryland State Voluntary Curriculum Standards of Learning:

Grade 7:

Skills and Processes:
Constructing Knowledge - Design and carry out simple investigations and formulate appropriate conclusions based on data.

Life Science:
Diversity of Life - Compile evidence to verify the claim of biologists that the features of organisms connect or differentiate them - these include external and internal structures (features) and processes.

Genetics - Explain the way that genetic information is passed from parent to offspring in different organisms.

Biodiversity Makes the Bay Better
In-school Lesson

Program length: 1 hour
Number of instructors needed: 2
(1 with help of classroom teacher)

Synopsis

By examining plant samples and live animals, students will learn that biodiversity is dependent on genetic diversity. Through hands-on activities, students will understand why biodiversity is important to the Chesapeake Bay and will learn that genetic information is passed from parent to offspring by either asexual or sexual reproduction.

Objectives

- Students will be able to differentiate between asexual and sexual means of reproduction.
- Students will be able to list plant species that reproduce asexually and sexually and animal species that reproduce sexually.
- Students will be able to explain that genetic material is the source of diversity and organisms that reproduce sexually have greater genetic diversity.
- Students will be able to explain that even though some organisms look similar, they cannot reproduce because they are genetically different.
- Students will be able to explain why biodiversity is essential for maintaining and improving the health of the Chesapeake Bay.

Materials

See Teaching Aids for assistance preparing materials
- Live plant samples, models, or photos of plants that reproduce asexually (Ex. Spider plant, strawberry, potato)
- Live samples or photos of other asexually reproducing organisms such as fungus, amoebae, bacteria, etc.
- Gene Activity pieces - minimum of 1 set per every 5 students

- Live animals, mounts, models, or photos that show the anatomical features of the animals including at least:
    - Two different morphs of the same species (Ex: Blue and Black color morphs of Northern Diamondback Terrapins)
    - One other similar animal that is in a different genus (Ex: an Eastern Box turtle)

Vocabulary

Asexual Reproduction - mode of reproduction in which offspring arise from a single parent and inherit the genes of that parent only

Biodiversity - the variety of life that can be found on Earth

Chromosomes – the microscopic structures within cells that are made up of DNA

Gene - the basic physical unit of heredity, carried on chromosomes

Genetic Diversity - the amount of variation in the genetic material of a population or species

Genus (pl. genera) – in biological classification, a subgroup of a family; genera are further divided into species

Natural Resource - something from the natural environment (water, air, trees, fuels) that is used to meet one's needs and wants

Offspring - the product of reproduction by an organism or organisms

Sexual Reproduction - mode of reproduction involving two parents, usually involving meiosis, gamete formation, and fertilization

Species - organisms whose members are alike and successfully reproduce among themselves

Subspecies – subgroup of a species; designates a subpopulation of a species that is genetically distinguishable from other populations of the same species and capable of interbreeding with them

Viable Offspring - the product of either asexual or sexual reproduction that has the ability to reproduce

Biodiversity Makes the Bay Better
In-school Lesson Plan

This lesson plan is broken into seven parts. This lesson takes place in the students' classroom. For the Gene Sorting Activity, you will either need access to chalkboard space around the room or plan to have students work in groups at tables.

Part 1. Introduction - 2 minutes

Part 2. Learn About Genes and How They are Passed From Parent to Offspring - 5 minutes

Part 3. Illustrate Gene Sorting During Reproduction - 20 minutes

Part 4. Differentiate Between Genus and Species - 5 minutes

Part 5. Compare Live Animals - 20 minutes

Part 6. Why is Biodiversity Important to the Bay Area? – 5 minutes

Part 7. Review - 3 minutes

Part 1. Introduction

- Introduce yourself to the students.
- Tell the students we will learn how living organisms reproduce and create a diversity of plant and animal life around the Chesapeake Bay area. Tell the students the plan you have for them today.
- Discuss what the students learned or will learn in the field trip experience. This lesson may be used as an introduction to the field trip experience or a review of it. You should discuss what biodiversity is and explain that the Bay would not be healthy without it. The students will be learning that genetics is responsible for the biodiversity that occurs in nature.
- Ask the students fo think of different organisms found in the Chesapeake Bay and on the land surrounding the Bay. Write the list of organisms on the board.

Part 2. Learn About Genes and How They are Passed From Parent to Offspring

For this section you will need the samples of plants and other organisms that reproduce asexually.

- Ask the students, *"What are genes?"* (**Genes** are the basic physical unit of heredity carried on **chromosomes** found inside cells.)
- Tell the students, "Genes are material that is passed from parent to **offspring** during reproduction. They contain information that determines the characteristics of the offspring, such as height; coloring; and whether it has hands, fins, bark, etc.
- Explain that all living things contain genes, and that the genetic material is passed from one generation to the next during reproduction.
- There are two basic ways for organisms to pass on their genes. Introduce the vocabulary word **asexual reproduction**.
- Show the samples of plants that reproduce asexually. Explain that the offspring of these organisms are copies of the parent and have the exact same genes. Thus, asexual reproduction does not increase **genetic diversity** because there is no change in the genetic material.

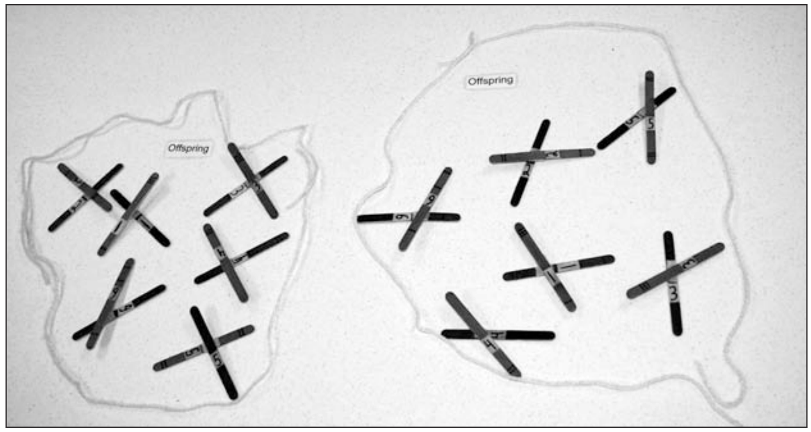
- In addition to plants, other organisms like bacteria, amoeba, and fungi can reproduce asexually. Show live samples or pictures of these organisms.
- Tell the students that the other way organisms pass on their genetic material is through **sexual reproduction**.
- Explain that organisms that undergo sexual reproduction, like some plants and most animals, need to have a male and female unite in some way. When they do, genetic information is combined during the creation of the offspring. The combination allows genes from each parent to come together to form a new unique individual with its own genetic information. Thus, genetic diversity is increased.
- Ask the students if they have studied the ways that pollen is transferred to flowers, uniting male and female genetic information. This is an example of sexual reproduction.

NOTE: *The students may already understand how animals undergo sexual reproduction, but the details of this type of union do not need to be discussed for the purposes of this lesson. It is important to remember the potential eagerness some 7th grade students may have to provoke you to have this discussion. Direct their focus towards the genetic side of the lesson.*

- Restate that organisms that reproduce asexually make exact copies of themselves so no genetic diversity results. Sexual reproduction, on the other hand, increases genetic diversity because the offspring receives half of its genes from one parent and half from the other.

Part 3. Illustrate Gene Sorting During Reproduction

For this section you will need the Gene Activity pieces.



The purpose of this part of the lesson is to help students understand how asexual reproduction results in an exact genetic copy of the parent and sexual reproduction allows for the mixing of genetic information from two parents. This lesson assumes that the class has studied or will further study reproduction and cell division. The details surrounding cell reproduction and cell division are too complex to teach the students in this one-hour lesson; this activity has attempted to simplify these complex processes. More detailed information about reproduction and cell division has been provided for the instructor's benefit (see *Background information on cell reproduction and division* in Teaching Aids). If the students have covered the details of cell reproduction and division in class already, then you can move quickly through this activity.

- Divide the students into small groups and give each group a set of activity pieces. The groups can work at their desks if the desks are pushed together, or at the chalkboard. You will lead them through this activity as a class.
  NOTE: *If the students are at their seats, it may be helpful to do the activity along with them on the board.*

A. Asexual reproduction

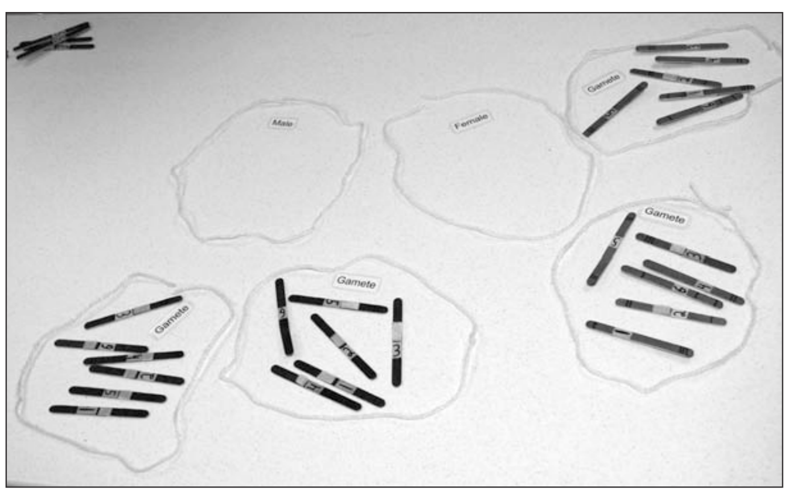
- Tell the students that we will first see how genes are transferred in asexual reproduction, and then we will look at what happens during sexual reproduction.
- Tell the students to get all the Xs of one color out of their bags. Make sure they have 2 sets of Xs labeled 1-6 that are all the same color.
- Ask the students to draw one large circle on the chalkboard or use 2 pieces of string to make one large circle on their tables. Have them label the circle "parent."
- Tell the students to place one set of colored Xs into the parent circle. Tell them to make sure they have numbers 1-6, and remind them that the numbers are in two places on the Xs so they do not mistake the number 1 for a number 11. Tell the students that these are the parent's chromosomes, which contain the parent's genes. The dark bars on the chromosomes represent the parent's genes.

- Explain to the students that when the parent is ready to reproduce, complicated processes make duplicate copies of all the chromosomes so that one set can stay with this cell and one set can go into another cell.
- Have the students place the second set of the **same color** chromosomes numbered 1-6 next to their matching number.
- Tell the students, "We now have a cell with twice as many chromosomes as it needs."
- Ask the students, *"What do you think happens next?"* The students may or may not have covered mitosis in class yet, but for now they just need to understand that the genes are copied and the cell will divide into two cells.
- Ask the students to split the big circle into 2 smaller circles and label one circle "offspring" while the other is still the "parent." Each small circle should now have one set of Xs (1-6).
- Tell the students that reproduction is now complete and there are two cells or individual organisms with the exact same genetic information.
- Have the students give you their full attention and ask them, *"Why might it be bad to have entire populations made up of individuals with the same genes?"* The students' answers will vary:
    - Life would be very boring because everyone would be the same;
    - If all the organisms were the same, a disease could kill the entire population because none of the individuals would be resistant to the disease;
    - If the climate changes (gets warmer or colder), the entire population might die because none of the individuals would be able to adapt to the change.
- Ask the students, *"Why is asexual reproduction a good method?"*
    - All the individuals have the same genes, which could be a good trait in a stable environment.
    - Asexual reproduction is fast and simple, so organisms can make many copies of themselves in a short amount of time.
    - Asexual reproduction makes it easy for scientists to clone plants with the desired characteristics. This helps people working in agriculture.
    - During asexual reproduction, it is not necessary to have a mate.

B. Sexual reproduction

- Tell the students that we will now see how sexual reproduction results in offspring with genes that are different from either parent.
- Ask the students to take the chromosomes out of all the circles and keep them in their colored groups.
- Have the student groups make 2 parent circles, labeled "male" and "female."
- Tell the students to place all of one color of chromosomes in the circle labeled female (this means two sets of Xs with numbers 1-6 on them). Animal cells are diploid or have doubles of each chromosome, so both sets are placed into one cell.
- Tell the students that the male and female have different chromosomes so they will need to get the other colored sets of chromosomes out of their bag.

- Tell the students to place both sets of the other color chromosomes (numbers 1-6) into the circle labeled male. Check that the students have two sets of Xs labeled 1-6 in the male cell.
- During sexual reproduction, the chromosomes separate into 2 cells, and each cell becomes a new cell called a daughter cell. Tell the students to take one set of Xs labled 1-6 from each cell and put them aside. Tell the students we will focus on what happens to one daughter cell.
- The same process happens in both the male and the female cell.
- Tell students to make four new circles and label them "gametes".
- Tell the students to separate the chromosomes by pulling the Xs apart and put one half of each X into one of the gametes. Tell the students that each of the two gametes under the male should get a number 1 through 6 piece of the same color. The other color, which represents female, should also be split and a number 1 though 6 piece should go into each gamete under the circle labeled female.
- The male and female circles should now be empty.
- Tell the students that they do not need to know the definition of a gamete, but you want them to remember these gametes and how they look because these gametes are the key to sexual reproduction.
- Tell the students they are now going to see how the genes on the chromosomes get mixed up in sexual reproduction. (The pieces of the chromosomes in the gametes are known as chromatids, but this fact is not important to this activity, and may confuse the students. If the students already know what a chromatid is, then you can use this term)
- Tell the students to make two big circles, each made by combining one male gamete with one female gamete. Therefore, a circle with one color sticks (chromatids) should be combined with a circle containing sticks (or chromatids) of a different color. Tell the students they should end up with two big circles. Tell the students to label these two circles "offspring".
- Once they have done this, tell the students to make Xs again (complete chromosomes) within the offspring circles by matching up the numbers and sticking the two halves together. The students will see how the Xs now contain pieces from the male and female.
- Tell the students that in the end, each offspring should have 6 chromosomes (or Xs). The offspring now has all of the necessary genetic material and will begin to grow.
- Ask the students, *"Are the offspring's genes exactly like the mother's or the father's?"* (No, they are unique!)
- Explain that often times, you do not get two complete offspring like we did here. Sometimes, the gametes get lost and never combine with one another to form an offspring.
- Tell the students to break apart their chromosomes and make 12 complete Xs of one color and 12 complete Xs of the other color. Once they do this, they should put all the chromosomes and all the pieces of string into their bag.
- Ask students if they have any questions.
- Collect the supplies.



Part 4. Differentiate Between Genus and Species

For this section you will not need any special materials

- Tell the students, *"Now we know how sexual reproduction mixes up the genes from two parents and forms an offspring."*
- Ask the students to think about what would happen if the gametes were from two different types of animals. Ask, *"Do you think the gametes could combine and form an offspring?"* (No, if the animals are two different **species**).
- Tell the students we will now learn that genes in one species are very different from the genes of another species and most of the time the gametes can not combine to make an offspring.
- Review with the students the classification system used to identify organisms. Write Kingdom, Phylum, Class, Order, Family, Genus, and Species on the board vertically.
- Remember that "Kingdom" is the broadest classification and "Species" is the most specific. Every living organism has a two-part scientific or genus-species name (Ex. *Canis lupus* for Timber Wolves). Species can sometimes be broken down into smaller classifications called **subspecies**.
- Explain to the students that organisms within the same species have genes that are very similar. That is why they can produce **viable offspring**. Organisms within the same **genus** (but not the same species) are still similar, but there is enough difference that their genes do not combine correctly. They would either produce no offspring or offspring that could not reproduce itself (Ex. Horse (*Equus caballus*) + Donkey (*Equus asinus*) = sterile Mule, non-viable)

Part 5. Comparing Live Animals

For this section you will need the live animal, models, mounts or photos to demonstrate genus and species. The animals used in this lesson are only examples. You may choose to use animals living in or around your Center.

- Tell the students you will now be bringing out live animals to observe. Tell the students these are wild animals that frighten easily, so they should move slowly and speak quietly. Also, they are **not** allowed to touch the animals, for everyone's safety. Explain where the animals came from, why we have them, and why the students should never handle wildlife without adult supervision.

NOTE: *It will be easier for the students to compare the two animals if they can look at them at the same time. If you cannot hold both animals at once, have another adult assist you. You may also put the animals in containers that are easy to carry.*

- Walk around the classroom with two animals that are morphs of the same species (Ex: Blue and Black Diamondback Terrapins, color morphs of *Malaclemys terrapin*). Have the students observe the animals' body parts, coloring, movement, etc. Ask, *"What is similar about these two animals?"* (Both have a shell with concentric circles on the scutes, webbed feet, spotted skin, etc.). *"How are they different?"* (The coloring on their faces, one is slightly large, etc.).
- Based on their observations, have them decide where these animals might live, what they might eat, and other details about their lives (See Background information on turtles in Teaching Aids).
- Ask the students, *"Do you think these animals are the same species and thus able to reproduce?"* (Yes! The only thing different about them is their coloring, just like people have different colored eyes and hair.)
- Put away one of the animals and take out the one from a different genus (Ex: an Eastern Box Turtle, *Terrapene carolina*). Have the students compare these two animals as before and decide where the new animal might live, what it might eat, and other details about its life.
- Ask the students, *"Do you think these two animals could reproduce?"* (No! Even though they are both turtles, they look different, live in different habitats, eat different food, and their genes are not similar enough for them to be able to reproduce. In fact, not only are these two animals different species, they are not even in the same genus!)

Part 6. Why is Biodiversity Important to the Bay Area?

For this section you will not need any special materials

- Ask the students, *"If a species becomes extinct (dies out completely) will it ever exist again?"* (No)
- Ask the students, *"If there was only one species of plant, what do you think might happen?"* (The landscape would be boring. There would not be different kinds of plants to provide food and shelter for different animals. There would not be different kinds of plants to filter and clean polluted water before it flows into the Bay. There would not be different kinds of plants to hold the soil and keep it from eroding into the Bay. People use plants for many purposes, including as medicines. If a plant species becomes extinct a cure for a disease might be lost.)
- Ask the students, *"Do you like birds? What if there was only one species of bird? What do you think might happen?"* (Different birds benefit ecosystems in different ways. Some birds like finches transport seeds from one place to another while other birds like vultures eat dead animals and help prevent the spread of disease from dead animals.)

- Ask the students, *"If a landscape is destroyed, can it be recreated?"* (Yes, but never exactly)
- Ask the students *"Do you think humans are part of the diversity of the earth? Are there reasons for humans to care what happens to plants and animals we may never see?"* (Yes. It is important for us to care for all the reasons we just discussed.)

Part 7. Review

- Briefly review the lesson with the students, tying all the pieces together.
    - Genes contain information that is passed from generation to generation and determine the characteristics of an organism.
    - Genes are passed through asexual or sexual reproduction. Asexual reproduction makes an exact copy of the parent and does not create genetic diversity. Sexual reproduction requires a male and a female to unite and combine genetic information, which creates genetic diversity.
    - Individuals in the same species can reproduce but individuals in different species have genes that are not similar enough to produce viable offspring.
    - Genetic diversity within a population gives rise to biodiversity within an entire ecosystem.
    - A diverse Chesapeake Bay will support more and a greater variety of life. The Bay will be healthier and more fun for humans to enjoy.

Teaching Aids

Background information on asexual plant reproduction
New plants can grow by the separation of parts of the original plant. When fragmentation, or division, occurs, an offspring is created by the breakup of a single part of the plant. By planting parts of the tuber of a potato, one can create new potatoes with the same genetic makeup. When weeds are broken apart, they can regrow from each fragmented underground stem. In *Marchantia*, fragmentation of the thallus gives rise to vegetative reproduction. When raindrops hit the plants, these structures are splashed out and may germinate into completely new plants. With these vegetative structures, many clones can be formed from one original parent. Bulbs and Rhizomes are also examples of asexual reproduction.

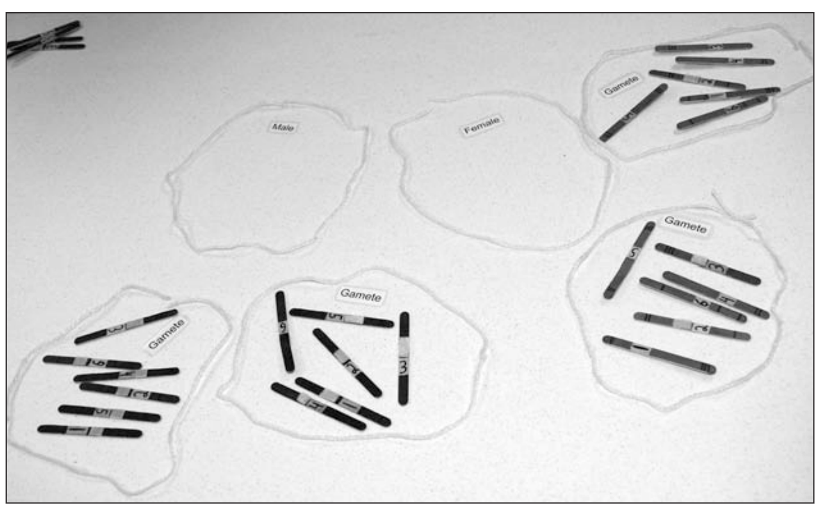
Asexual reproduction has advantages and disadvantages. One positive aspect is that it can create individuals rapidly and in large quantities. Secondly, bypassing the sexual process can help a plant in times of dryness since motile sperm require water to fertilize the egg. Another advantage lies in the fact that plants with the desired characteristics can be cloned for economic reasons such as agriculture (UC Berkley, 2006; BBC, 2006).

Background information on cell reproduction and division
Simple cell division is an example of asexual reproduction. During simple cell division or cell fission, a parent cell duplicates its chromosomes and splits into two daughter cells that are exactly like the original parent. Mitosis is a series of events in a cell that results in two nuclei and the equal distribution of genetic material into two daughter cells. As a result of mitosis the parent cell becomes one of the daughter cells. Some organisms can reproduce asexually through the processes of fragmentation, spore formation, budding, regeneration, and binary fission.

Sexual reproduction results from the union of gametes (which contain half the number of necessary chromosomes), to form a cell that contains the correct number of chromosomes. Meiosis is the process of cellular division in which the daughter cells receive only half the number of chromosomes as the parent. Similar to mitosis, the parent cell becomes one of the daughter cells (Allen and Baker, 1972).

Creating the gene activity pieces
You will need one set of paper labels for each student group (Maximum five students per group). A set contains the following labels:

- 1 “parent” label
- 1 “male” label
- 1 “female” label
- 4 “gamete” labels
- 2 “offspring” labels



You will also need to make sets of paper chromosomes (or Popsicle stick chromosomes). A set contains two groups of 12 chromosomes for a total of 24 chromosomes. Each group is a different color. Each chromosome comes apart and forms two chromatids during sexual reproduction. Below are directions for making one set of paper chromosomes. Each group of students (maximum of 5 students per group) receives one set of activity pieces.

- Using two different colors of paper, cut out 24 chromosomes (12 of each color). A chromosome is made of two paper strips that are crossed in the shape of an X (the pieces need to come apart during the activity). You can also use Popsicle sticks instead of paper. After laminating the chromosomes, use Velcro to attach each half of the X to the other to form complete chromosomes.
- Label each set of colored X chromosomes one through six, two times. (Write the number on both **chromatids**, or on each half of the X.)
- Add gene bands to the chromosomes to distinguish them. For example, there are two red #1 chromosomes, and four chromatid pieces of the #1 chromosome. Mark one chromatid of each #1 chromosome with the same banding pattern. Examples of patterns include: different numbers of bands, location of the bands on the chromatid, and thickness of the bands. Make a different pattern for the other two chromatids of the #1 chromosomes. Repeat for all the chromosomes of one color, so there are six identical chromosomes, although for each X, the halves are different from each other. For the second group of 12 chromosomes, you can repeat the patterns used in the first group.
- Attach magnets to the back of each chromosome if you plan on doing the activity on a chalkboard.
- Cut six pieces of string (3 feet long) for each student group.
- Put all of the materials into small bags for each student group.

Background information on turtles

The Diamondback Terrapin

The diamondback terrapin is the Maryland State reptile. Terrapins are predators who prefer unpolluted brackish water (University of Delaware, 2006). The diamondback terrapin eats snails, clams, crabs, and some marsh plants. The diamondback terrapin's range is along the Atlantic and Gulf coasts, from Cape Cod to Texas. The diamondback terrapin is believed to be the only species of turtle that lives exclusively in brackish water. Brackish areas including tidal marshes, estuaries, and lagoons, contain a mixture of fresh and salt water.
The reptile's whitish skin contains black spots and markings, in a pattern unique to each turtle.

Common Eastern Box Turtle

Four subspecies of the common box turtle are recognized in the U.S., where they occur in the eastern states from Maine down to the Mexican border and beyond. They are not native to Maryland. Various "intergrades" also occur. These "intergrades" show characteristics of two or more of the sub-species and are found in regions where the subspecies overlap. Three-toed box turtles prefer woodlands and damp brush. Their diets consist of worms, insects and various wild fruits and plants (National Zoo, 2006).

Extension Activities

Pre In-school activity for classroom teacher

Review lesson vocabulary with students and relate the vocabulary to concepts that the students have learned or are currently learning in your classroom.

Resources

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Biodiversity Makes the Bay Better
Field Trip Experience Lesson

Program length: 2 hours
Number of instructors needed: 1 for every 15 students

Synopsis

This field experience will allow students to examine and appreciate the diversity of the plant and animal life that inhabits the Chesapeake Bay area. Students will hike through a variety of ecosystems surrounding the Bay and investigate different plant and animal populations. Students will use GPS units to collect data for analysis on site, for use back in the classroom, and for use in future field studies.

Objectives

- Students will be able to identify plants living in a variety of Chesapeake Bay ecosystems.
- Students will be able to use handheld GPS units to determine their exact location.
- Students will be able to determine species richness and species relative abundance in a designated area.
- Students will be able to explain why biodiversity is important to the health of the Bay.

Materials

See Teaching Aids for assistance preparing materials
- 10m tape measure
- Small field markers such as flags or poles with colored tape
- String
- Plant Diversity Data Sheet (1 per every 3 students)
- Clipboards (1 per every 3 students)
- Pens/pencils
- Field guides for identifying trees, plants, ferns, flowers, etc.
- GPS units (1 per group)
- Simple calculators (3 minimum, or 1 per every 3 students)
- First Aid kit
- Backpacks to carry clipboards and equipment

Vocabulary

Biodiversity - the variety of life that can be found on Earth

Ecosystem - a group/community of organisms interacting with their environment

Invasive species - plants or animals that out-compete and crowd out native species for space, light, and nutrients, they are considered to be invasive.

Native species - a species that has lived in a particular area for an extended period of time

Non-native species - plants and animals that are not native to an environment, whether introduced intentionally or accidentally.

Relative abundance - the number of organisms of a particular kind as a percentage of the total number of organisms within a given population

Species richness - the total number of different species found in a given area

Biodiversity Makes the Bay Better
Field Trip Experience Lesson Plan

This lesson plan is broken into six parts. If there are more than 15 students in the class, divide them into groups of 15 students maximum and rotate through the four ecosystems.

Suggested locations include a forest, wetland, field, stream edge, etc. If you are in a location with only one broad ecosystem (ex. forest), try to find areas with different terrain (a vernal pool, sloping ground, rotten logs, etc.). Times include travel between locations.

Part 1. Introduction - 5 minutes

Part 2. Explore Ecosystem A - 25 minutes

Part 3. Explore Ecosystem B - 45 minutes

Part 4. Explore Ecosystem C - 20 minutes

Part 5. Explore Ecosystem D - 20 minutes

Part 6. Review - 5 minutes

Part 1. Introduction

For this entire lesson you will need the clipboards, pencils, Plant Diversity Data Sheets, and field guides, GPS units, calculators, first aid kit, and backpacks.

- Introduce yourself and give the students some quick background information on the Center including where the bathrooms are, whether they will eat lunch at the Center.
- Ask the students, *"What is an ecosystem?"* (The collection of living, non-living, and dead things that function together within an environment).
- Explain to the students that we will be hiking through several different ecosystems and will be focusing on the diversity of life that can be found in each area. We will be using handheld GPS units to record the exact locations we visit, field guides to identify as many plant species as possible, and mathematical formulas to measure the biodiversity of the area.
- Divide students into groups of three. Give each group one clipboard, pencil, Plant Diversity Data Sheet and field guide(s). Explain to the students that they are responsible for their own equipment and that they cannot lose any of it. **The instructor should keep the calculators until they need them in Ecosystem B.**
- Quickly go over the datasheet with the students.
- Go over any rules that must be obeyed on the hike.
- Hike to your first ecosystem.

Part 2. Explore Ecosystem A

This should be a well-diversified ecosystem. Remember to point out and warn students to avoid poison ivy if this is a problem in any of your study areas.

- Ask the students, *"What kind of ecosystem are we in? What characteristics of the land or plants tell you that it is that type?"* (Have the students look at whether or not there is canopy, if any water is present, whether or not there is ground cover, etc.).
- Ask the students to define **biodiversity** (All the variety of life within a given ecosystem, including microscopic organisms, plants, and animals).
- Tell the students that we will be focusing on the diversity of life by taking a closer look at the plants growing in this area.
- Teach the students how to use the GPS units. Have the students determine the GPS coordinates of this area, and record it on their datasheets under Ecosystem A.
- Tell the students that by working in teams and using the field guides, they should identify as many plants (including trees, shrubs, grasses, and ground cover) as they can in 10 minutes. Ask them to write the names of the plants they identify, where they are found (Ex: canopy, mid-story, understory, near the water, in the water, close to other plants or not, etc) and any identifying characteristics on their datasheet.
- Tell the students the boundaries of the investigation area, then let them explore the area.
- After 10 minutes, gather the students together and have them share what kinds of plants they identified and where each plant was found.
- Ask if any group found a plant that they were not able to identify. Have everyone visit these plants together. If another group has already identified the plant, have that group explain what characteristics they noticed that helped them identify it. If no group has identified the plant, help the students use the field guides to identify it. (This activity is designed to help the students learn how to observe identifying characteristics of plants and how to properly use field guides).
- Total up the number of different species that were identified. Ask the students, *"Is this site diverse? Why or why not?"*(Answers will vary)
- Visit groups of plants that look similar. Determine whether similar groups of plants are found everywhere in the ecosystem or only in certain areas. Try to have the students help you determine why certain plants are found in one place and not another. For example, is elevation, water level, or shade an important factor in determining where certain plants grow?
- Ask the students *"Do you think the plants living here could grow in other ecosystems? Or are they specially adapted to this one?"* (Answers will vary)
- Ask the students to gather their equipment and hike to the next site.

Part 3. Explore Ecosystem B

This area should be the same type of ecosystem as the first but in a different location. Make sure to set up the study plot ahead of time. Up to 15 students can work together in the same plot to thoroughly cover it in the allotted time.

A. Explore and gather data

- Ask the students, *"What kind of ecosystem are we in now?"* (The same kind!) *"Do you expect to find more or less biodiversity here compared to the first ecosystem?"* (Similar!) *"Why or why not?"*
- Tell the students that they have just made a hypothesis and that they will now test that hypothesis by examining a study plot and filling out the Plant Diversity Data Sheets.
- Have the students determine the GPS coordinates of this area, and record it on their datasheets under Ecosystem B. If your GPS unit is accurate enough, you can have the students record the coordinates for each corner of the plot.
- Students will continue to work in their groups of three within the single large class plot. This time, assign one person in each group to use the field guide to identify unknown plants (they should be able to recognize some from the first ecosystem). Assign another student in each group to count the number of individual plants (they can count while the plant is being identified). Assign a third student in each group to record the information.
- Break the large plot into smaller sections so that each student group of three works in a certain area and the plants do not get counted multiple times.
- Tell the students they must remain in the plot the entire time.
- Allow the students at least 15 minutes to study the plot. Walk around and help any group who is having trouble with identification.
- Encourage student groups to help one another.

B. Report and analyze data

- After 15 minutes, gather the groups together.
- Have the whole group determine the **species richness** of the entire plot (add up the total number of different species found in the plot) and record it on the bottom of the data sheet. For example, there may be 15 different species in our plot, so your species richness value is 15. Explain that species richness is one way to measure biodiversity, but we need to look at another factor to get the full picture.
- Total up the number of plants counted for each species in the entire plot. Record this in the third column entitled, "Number of individuals in entire plot."
- Total the number of all plants found and record it on the bottom of the data sheet.
- Hand out a calculator to each group. Have the groups calculate the **relative abundance** of each species. Take the total number of a single species of plant from the third column and divide it by the total number of all the plants found (the number just recorded at the bottom of the data sheet.)

The relative abundance is another measure of biodiversity and tells us what percentage of the plants in the plot is made up of a specific plant type. (Relative abundance has no units, but it can be expressed as a percent as in this case.)

- Determine whether the plot is diverse by examining the values calculated. Both species richness and relative abundance should be considered when determining the diversity of a plot.
    - A plot can have high species richness but not be diverse if the relative abundance of one plant is much higher than the others. For example, if you identified 1 poison ivy, 1 dogwood, 1 holly, 1 greenbriar, and 50 phragmites in a plot, we would say that the plot has good species richness (5 types of plants) but the relative abundance of Phragmites is much greater than all the other plants. This unevenness is often seen in areas that have been disturbed or in which an invasive plant has taken over.
    - A plot that is not diverse might only have two species growing in it with similar relative abundance (4 blackberry and 5 marsh elder).
    - A plot that is populated by only 1 type of plant is not a diverse ecosystem (like a corn or soybean field).
- Collect the calculators.
- Tell the students to gather their belongings and hike to the next ecosystem.

Part 4. Explore Ecosystem C

This should be a completely different ecosystem than the first two.

- Ask the students, *"What kind of ecosystem are we in now? Do you think the diversity in this ecosystem is higher or lower than in the last? Why or why not?"* (Answers will vary)
- Have the students determine the GPS coordinates of this area, and record it on their datasheets under Ecosystem C.
- Walk around the site as a group and identify unknown plants. Record your findings on the Plant Diversity Data Sheet. Depending on how much time is left, you may have to identify the plants for the students instead of having them use field guides.
- Ask the students, *"Why might one area be more diverse than another?"*
    - Recent disturbances by humans (clearing for development or spraying with herbicides) or natural disasters (fire or hurricane) will change what can grow or is growing in an area.
    - Different areas have different microclimates. Does one area get more sun than the other? Could one area get flooded more than the other? Some microclimates are so specific that only very specially adapted plants can grow.

- People or wildlife might currently be disturbing an area. Herbivores could be eating the plants in one area and not the other, and humans may be walking along a path, disturbing the plants.
- People might be managing the landscape by planting or removing specific plants.

- Ask the students, *"Do you know what it means if a plant is native?"* (The plant evolved in this area) *"What about non-native?"* (The plant did not evolve in this area but was introduced, either accidentally or intentionally, by humans).
- Have the students brainstorm reasons why non-native species might be harmful to an ecosystem.
    - Native animals often do not use the non-native plants for food or shelter, so the animal's habitat is diminished.
    - Non-native species can often grow unchecked because they have no natural predators. These are called **invasive species**.
    - Invasive species are called such because their reproduction interferes with other plant growth, using nutrients and crowding out native species.
    - Invasive species can quickly and seriously degrade the quality of ecosystems by altering natural processes and reducing biodiversity.

- Tell the students we can help increase the biodiversity of the area around our homes and neighborhoods by planting native species and pulling out non-native ones. (Non-native invasive species common in this area include Phragmites, English Ivy, Japanese Honeysuckle, Purple Loosestrife, and Autumn Olive.)
- If there is time, brainstorm what kinds of animals might specifically use each plant (as food, shelter, nesting material, etc.) If time is short, move on to the next ecosystem.

Part 5. Explore Ecosystem D

This area should be similar to Ecosystem C where students can try to visually determine if the site has good plant diversity. It would be best if the site is a monoclture of plants (like a wetland covered in Phragmites or an agricultural field). The students will not need the data sheets for this ecosystem exploration.

- Have the students look around the site. Ask, *"Are there plants growing in this ecosystem?"* (Yes.)
- Ask the students, *"Does there seem to be good plant diversity at this site?"* (Answers will vary). If the site is a monoculture, discuss why (Ex. it was planted by humans, it has been taken over by invasive species, it has been heavily disturbed recently, etc.).

- Ask the students, *"Why is it important for an ecosystem to have good plant biodiversity?"*
    - A diversity of plants can support a greater diversity of wildlife. For example, diverse plant life usually means that a greater variety of animals will be able to find everything they need to live. (Deer eat green briar, birds eat nuts and seeds, insects live in trees and rotten logs, etc.)
    - Different plants perform different functions that benefit the Bay. (grasses have branching roots that hold in the soil and keep it from eroding into the Bay, trees provides shade and shelter, small plants provide protection for insects, wetland plants filter water before it flows into the Bay.)

    - We might not be able to replace something once it is gone. Some natural landscapes took hundreds of years to form, and if all of one type of area is destroyed, we may never be able to recreate that kind of area again. If a plant or animal goes extinct, we can never get it back.
    - If a disease that targets one type of plant sweeps through, not all of the ecosystem would be killed. (For example, Chestnut Blight killed the American Chestnut population, throughout the trees' natural range in the Eastern United States. Chestnuts trees made up about 50% of the eastern hardwood forests in the late 1800s. The blight killed Chestnut trees from 1900 until 1940.)

Part 6. Review

- Summarize everything that was talked about during the field trip.
    - Ecosystems contain a variety of plant species that provide different benefits to the area and other life around them.
    - Biodiversity can be measured by species richness or relative abundance. Both should be considered when determining if an area is diverse or not.
    - Native plants attract native wildlife and are good to plant around your own homes, while invasive species can upset the balance of life in an ecosystem.
    - Maintaining the biodiversity of the Chesapeake Bay area is necessary to maintain a healthy Chesapeake Bay.
- Gather everything and return to the lunch area or bus.

Teaching Aids

How to set up study plots

In Ecosystem B, the students need to identify and count the plants in a 10m square plot. Feel free to adjust the size of the group or the size of the plot if there is not enough safe space.

- Prepare your field markers by tying colored tape, bandanas, or string to short poles. You will need 4 poles per study plot.
- At Ecosystem B, measure out as many 10m square plots as you need. A good study plot will include plant life that is representative of the ecosystem and is safe for the students.
  NOTE: *you may choose to pull out poison ivy, greenbriar, or other plants with thorns if they pose a serious threat.*
- Mark the corners of each plot with a field marker.
- Optional: You may tie string between the poles to further define the boundaries of the plot.

Plant Diversity Data Sheet

(*see next page- copy as two-sided worksheets*)

Plant Diversity Data Sheet

Name(s):____

Ecosystem A

Location and type: ____

GPS coordinates: ____

Species name	Identifying characteristics	Where found

Name(s): ____________________

Ecosystem B

Location and type: ____________________

GPS coordinates:

Species name	Number of individuals		Relative abundance of entire plot (%)
	in your area	in your entire plot	

Total number of plants found: ____________________

Species richness of entire plot: ____________________

Name(s): ______________________________

Ecosystem C

Location and type: ______________________________

GPS coordinates: ______________________________

Species name	Identifying characteristics	Where found

Extension Activities

Pre Field-trip activity for classroom teacher

Review lesson vocabulary with students and help them relate the terms to what they are learning in class.

Post Field-trip activity for classroom teacher

Audubon Announcer

The Audubon Announcer is a fictitious, futuristic radio broadcast about how the Bay ecosystem is affected by global warming. It touches on the ideas of adaptation and sexual versus asexual reproduction.

Give each student or group of students a copy of the Audubon Announcer radio broadcast and the question worksheet. They should be able to use the information they learned during the lesson plus the information in the transcript to answer the questions on the worksheet.

AUDUBON ANNOUNCER TRANSCRIPT

HEADLINE NEWS:

Reporter Ms. E. N. Viron:

Global warming affects the Chesapeake Bay ecosystem

The famous and beautiful ecosystem of the Chesapeake Bay has suffered major damage over the last several decades due to the effects of Global Warming. The Bay has historically been home to a huge diversity of plants and animals that are well adapted to the local climatic conditions. Unfortunately, with water temperature and water levels rising steadily over the last several decades, some organisms have not been able to adapt well to their new environment. The result has been an interruption in the delicate food-web, which makes the Bay unique. With more on the story here is an exclusive report by Mr. Chez A. Peake, a scientist with the National Audubon Society.

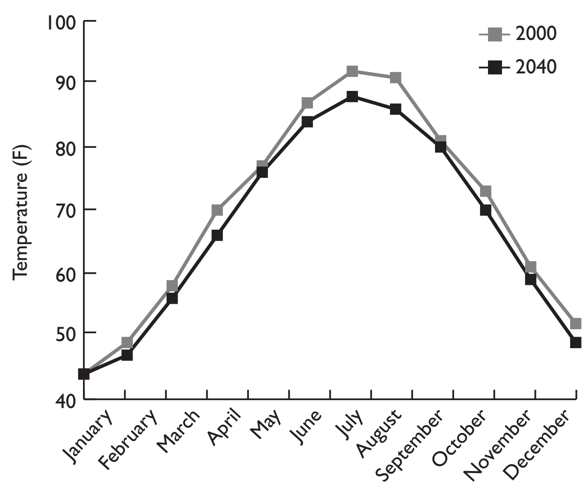
Mr. Chez A. Peake:
We at the Audubon Society have been studying the Bay ecosystem and all of its inhabitants for the past 40 years. Here are just some of the changes we have observed. First of all, there has been a devastating effect on Bay grasses. One example is eelgrass, which typically reproduces asexually through creeping rhizomes. For some reason the eelgrass has not adapted well to the warmer water temperatures. Initially, we were seeing a decline in the abundance of these grasses. Of course this also affected several waterfowl species including redhead ducks, Canada geese and black ducks that eat the grasses.   Also, blue crabs and several species of small fish and invertebrates rely on eelgrass for food, shelter and breeding grounds. Ring-billed gulls, common terns, and other bird species that typically eat small fish and aquatic insects have also been mysteriously affected. Fortunately, however, nature often has a way of repairing itself. Over the last couple of years we have noticed that eelgrass is starting to become more abundant. This could be due to the fact that the grass has the ability to reproduce sexually during times of stress. Hopefully animals, which all reproduce sexually, will be able to adapt to the climatic changes and return to their native homes.

WEEKEND WEATHER:

Expect a warm wet weekend!
Saturday highs will be around 95ºF with 90% humidity
Sunday thunderstorms will bring major rain and possible flooding

Average Highs for 2000 and 2040 are shown to illustrate the effects of global warming on the climate in the Bay area.

Average High Temperatures for 2000 and 2040



COMMUNITY CALENDAR:

The Chesapeake Yacht Club meets Monday to celebrate the opening of a new harbor created by the rising water.

City Council meets Thursday to discuss property loss due to rising water.

Worksheet for Audubon Announcer Activity

Name:_______________________________________

1. Why do you think the Bay grasses initially had trouble adapting to the new conditions in the Bay?

2. How would the ability to reproduce sexually help the eelgrass adapt to changes in the Bay's climate?

3. Do you predict that the animals that rely on the eelgrass will be able to adapt to the Bay's new conditions once their food source returns? Why or why not?

4. If the eelgrass population does not recover, what do you think might happen to the populations of Canada geese, blue crabs, and common terns? Think about both short-term and long-term effects.

5. Looking at the weather report graph what was the average increase in temperature between 2000 and 2040 in January, April, and October?

6. What evidence do you see in the Audubon Announcer that the human community has also been affected by Global Warming?

Answers for Audubon Announcer Worksheet

Name: ____________________ KEY _____________

1. Why do you think the Bay grasses initially had trouble adapting to the new conditions in the Bay?

(Asexually reproducing organisms produce exact copies and therefore have less ability to adapt to change.)

2. How would the ability to reproduce sexually help the eelgrass adapt to changes in the Bay's climate?

(Sexual reproduction creates more genetic diversity. Some offspring may be better adapted to warmer water temperatures.)

3. Do you predict that the animals that rely on the eelgrass will be able to adapt to the Bay's new conditions once their food source returns? Why or why not?

(The animals will be able to adapt because they reproduce sexually and the offspring that are better able to handle warmer temperatures will survive to reproduce. Thus the population over time will adapt to the new environment.)

4. If the eelgrass population did not recover what do you think might happen to the populations of Canada Geese, blue crabs and common terns? Think about both short term and long term effects.

(In the short-term all populations would decline; in the long-term hopefully they would adapt. Canada geese could find a new food source or migrate elsewhere, blue crabs could find a new place to hide and raise young, and common terns could look for other food sources or migrate.)

5. Looking at the weather report graph what is the average increase in temperature between 2000 and 2040 in January, April, and October?

(January = same; April = 4ºF; October = 3ºF)

6. What evidence do you see in the Audubon Announcer that the human community has also been affected by Global Warming?

(The yacht club gets a new harbor and there has been property loss due to rising waters.)

Resources

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Maryland School System Voluntary State Curriculum. Teaching and Learning: Science. http://mdk12.org/instruction/curriculum/science/index.html. Accessed October 1, 2006.

The Nature Conservancy. The Global Invasive Species Initiative. http://tncweeds.ucdavis.edu/methods.html. Accessed September 16, 2006.

Genes are the Key to Bay Biodiversity

In-school Lesson and Field Trip Experience

Grade: 8

Pickering Creek Audubon Center

Standards of Learning

Talbot County Student Performance Objectives:

Grade 8:

Life Science:
Genetics – Investigate and explain that in some kinds of organisms all the genes come from a single parent, whereas in organisms that have sexes, typically half of the genes come from each parent; Identify evidence to support the idea that there is greater variation among offspring of organisms that reproduce sexually than among those that reproduce asexually.

Evolution – Recognize and describe that evolutionary change in species over time occurs as a result of natural variation in organisms and environmental change.

Maryland State Voluntary Curriculum Standards of Learning:

Grade 8:

Astronomy:
Interactions of Hydrosphere and Atmosphere – Recognize and describe the various factors that affect climate.

Life Science:
Evolution – Recognize and describe that evolutionary change in species over time occurs as a result of natural variation in organisms and environmental changes.

Environmental Science:
Environmental Issues – Recognize and explain how human activities can accelerate or magnify many naturally occurring changes.

This lesson also meets the following State Standards:

Grade 7:

Life Science:
Genetics - Explain the ways that genetic information is passed from parent to offspring in different organisms.

Genes are the Key to Bay Biodiversity

In-school Lesson

Program length: 1 hour

Number of instructors needed: 2
(1 with help of classroom teacher)

Synopsis

Students will expand their understanding of how sexual reproduction leads to the mixing of genes and variety within a species. Students will learn how biodiversity and adaptation relate to natural selection and evolution. Students will experiment with selection through a game involving oysters and the bay-prevalent diseases, MSX and Dermo. Students will look at data to determine how the climate of an area affects its biodiversity, and they will observe adaptations of plant and animal communities in their schoolyard.

Objectives

- Students will be able to describe the difference between sexual and asexual reproduction.
- Students will be able to describe how an organism's method of reproduction affects the genetic diversity of its offspring.
- Students will be able to describe their local climate using scientific data.
- Students will be able to explain how genetics is involved in adaptation and natural selection.
- Students will be able to list ways humans can select for specific traits of an organism.

Materials

See Teaching Aids for assistance preparing materials

- 2 examples each of plants that reproduce sexually and asexually - live specimens or pictures
- 3 - 4 decks of playing cards with different colors/patterns
- Climate Data Sheets (school's location and other location within the U.S) (1 per student).

Vocabulary

Adaptation – a characteristic, arising from natural selection, that that improves a population's chance of survival and reproduction

Asexual reproduction - mode of reproduction in which offspring arise from a single parent and inherit the genes of that parent only

Biodiversity - the variety of life that can be found on Earth

Climate - the average temperature and rainfall for a particular place over hundreds of years

Evolution - changes in species as a consequence of processes such as mutation and natural selection

Gene - the basic physical unit of heredity carried on chromosomes

Natural selection - a process in which some individuals with genetic traits that improve their survival or reproduction have more offspring surviving to reproductive age than other individuals (Because the offspring also carry the genes for these traits, this process causes the genes for advantageous traits to become more common in populations and the genes for disadvantageous traits to become less common in populations.)

Offspring - the product of reproduction by an organism or organisms

Population - a group of organisms of the same species that live in the same area at the same time

Sexual reproduction - mode of reproduction involving two parents, usually involving meiosis, gamete formation, and fertilization

Species - organisms whose members are alike and successfully reproduce among themselves

Trait - a characteristic which is passed on to offspring through heredity

Genes are the Key to Bay Biodiversity
In-school Lesson Plan

This lesson is broken into eight parts. This lesson takes place in the students' classroom.

Part 1. Introduction - 1 minute

Part 2. Discuss Asexual Versus Sexual Reproduction - 4 minutes

Part 3. Natural Selection Discussion - 5 minutes

Part 4. Oyster Selection Activity - 18 minutes

Part 5. Climate and Evolution Discussion - 10 minutes

Part 6. Mutation Demonstration - 10 minutes

Part 7. Evolution Demonstration - 10 minutes

Part 8. Review - 2 minutes

Part 1. Introduction

- Introduce yourself.
- Tell the students that we will learn how organisms living in the Chesapeake Bay area adapt to changes in the environment.
- Explain to the students that organisms have to survive in different habitats and climates, and over time, they adapt to the conditions of their environment.
- Tell the students that we will learn that genetics plays an important role in **adaptation** because as populations of organisms adapt over time, the genes in the population change.
- Discuss how the students will observe or already observed plant and animal adaptations on the field trip. This lesson may be used as an introduction to the field trip experience or a review of the field trip experience.

Part 2. Asexual and Sexual Reproduction Discussion

For this section you will need samples of plants that reproduce both sexually and asexually.

- Tell the students that in order to understand how plants and animals adapt, we need to understand genes and how they are passed from one generation to the next.
- Remind the students of what they might remember from 7th grade (see 7th grade lesson, *Biodiversity Makes the Bay Better*). Review the following information with students:

- Tell them that **genes** contain information about an organism from one generation to another through **sexual reproduction** and **asexual reproduction**.
- Tell the students some organisms reproduce asexually. When organisms reproduce asexually, they make exact copies of themselves.
- Organisms that reproduce sexually mix the genes of two parents and produce **offspring** that are not exact copies of either parent. Remind students that combining genes from two different organisms (a "mother" and a "father") leads to a greater **biodiversity**, or a greater variety of living organisms.

- Show students examples of plants that reproduce asexually as well as sexually (see *Plant sample suggestions* in Teaching Aids).
- Give the students information about the plant samples and involve them in discussions about the plants.

Part 3. Natural Selection Discussion

For this section you will not need any special materials.

- Ask the students if they have heard of **natural selection**. If they have, ask them if they can explain it.
- Explain that some organisms have traits that help them survive better in a certain environment than other organisms that do not possess the same **traits**. The organisms with better traits will then be more likely to survive and pass on their genes through reproduction. Over time, more organisms in the **population** will have the **adaptation** or beneficial trait. This is the process of **natural selection**. Natural selections leads to a population of organisms that is better adapted to its environment.
- Ask the students if they think certain environmental factors, such as temperature, rainfall, soil type and neighboring organisms all play an important part in the selection process. Later, we will discuss how **climate** plays an important role in natural selection.
- Tell the students that even though this selection process happens in nature without human involvement, humans can also select organisms with certain traits.
- Ask the students, *"Do you know of a way humans selectively breed certain organisms for our advantage?"* Humans selectively breed many organisms such as dogs, farm animals, and agricultural crops.
- Tell the students that research around the Chesapeake Bay is occurring right now to selectively breed healthy oysters.
- Tell the students we will do an activity that will help us learn how genetics helps oysters adapt.

Part 4. Oyster Selection Activity

For this section you will need 3-4 decks of playing cards (see *Oyster selection activity set-up* and *Background information on the oyster diseases MSX and Dermo* in Teaching Aids).

- Tell the students that there are fewer populations of oysters in the Chesapeake Bay compared to the past. There are many reasons there are fewer oysters in the Bay. Over-harvesting of oysters, lack of quality oyster habitat, and disease have all contributed to the decline of oyster populations. Many of the oysters in the Chesapeake Bay have one of two diseases, either Dermo or MSX. These diseases do not affect humans who eat the oysters but the diseases do significantly decrease the size of the wild oyster populations. Dermo and MSX are caused by parasites but there is evidence to suggest that some oysters are resistant to the negative effects of the diseases. Scientists have determined this resistance is carried on genes.

- Ask the students, *"If oysters only reproduced asexually, how could humans increase the number of disease resistant oysters in an oyster population?"* (We could select the disease resistant oysters and let them reproduce asexually, and essentially, make more copies of themselves.)

- Tell the students that oysters reproduce sexually so it is more complicated than that, and scientists do not completely understand how the disease resistance is carried on genes. We do know that some oysters are resistant to dying from the disease, and scientists can successfully breed un-affected oysters to increase the percentage of disease resistant oysters in the popualtion.
- Tell the students that we are now going to be oyster breeders and breed healthy oysters for future placement back in the Chesapeake Bay.
- Ask the students, *"Why do think we would breed healthy oysters in laboratories and put them back in Chesapeake Bay?"* The goal is to increase the number of healthy oysters in the Chesapeake Bay by increasing the number of disease-resistant oysters that exist in the wild population.

A. Round 1

- Tell the students that these cards represent a wild population of oysters taken from the Chesapeake Bay. Give each student two cards and explain that each card represents an oyster in the Bay. Each pair represents a mating pair.
- Ask the students to look at their two oyster cards. Explain that the two black suits represent unaffected oysters, hearts represent oysters with MSX, and diamonds represent oysters with Dermo. (Make a key on the board so students can remember for subsequent rounds.)
- Explain that if either of the parents have a disease (MSX or Dermo), we will assume that their offspring will not be resistant to either disease. However, if both parents are unaffected there is a chance that their offspring will be resistant to Dermo and MSX. Tell the students we only want healthy oysters for our breeding program.
- On the chalkboard, tally how many pairs of unaffected pairs of oysters (both black) were formed, and tell the students that these are the healthy oysters we will continue to use for breeding.
- Also, tally up the number of pairs containing at least one diseased oyster (all the other pairs).

B. Round 2

- Collect all of the pairs of unaffected pairs and keep them in one pile.
- Next, collect all of the pairs that have at least one diseased oyster and set these aside.
- Shuffle the second deck of cards and randomly remove cards to equal the number of cards in your unaffected pile. Put these cards aside. Then, put the unaffected oyster cards from Round 1 into the deck and re-shuffle.
- Explain that in round 2, we will continue to select unaffected oysters to breed and improve the health of the overall oyster population in the Chesapeake Bay. Again, pass out two cards to each student and ask them not to look at their cards. Before the students look at their cards, ask the students, *"Do you think the results will be different this time? How?"* (Yes, we expect to see more double unaffected pairs)
- Again, tally the number of healthy and unhealthy pairs on the chalkboard and compare this to Round 1.
- Show the students that after human selection, the number of unaffected oysters increases, and the number of diseased oysters decreases.
- This activity can be done for several generations if time permits. Make sure to use a new and distinct deck of cards for each round so you can separate your cards at the end.
- When you are finished, discuss with students that through selective breeding we were able to increase the number of unaffected oysters while decreasing the diseased ones.
- Ask the students if they know of another example of scientists breeding disease resistant organisms. In agriculture, many crops are bred to be disease resistant, and in nurseries, many trees are bred to be disease resistant.

Part 5. Climate and Evolution

For this section you will need the climate data sheets (1 per student).

A. Looking at how climate affects living organisms

- Tell the students that things like soil type and **climate**, affect adaptations plants and animals have.
- Discuss with the students what might happen when the same kind of plant (i.e. Phragmites) lives in two different climates, such as Colorado and Maryland? The plant population will most likely have different adaptations to survive in each unique habitat. (This may be thicker leaves to store water, or a decreased need for water.)
- Tell the students that climate is determined using yearly average rainfall and yearly average temperature over 30 years. Hand out the data sheets to the students.
- Have the students compare the climate of two different locations. Ask, *"What differences do you see?"* (Answers will vary based on the two locations chosen but may include differences in monthly average temperature and rainfall.)
- Briefly discuss the climate of your local area so that students can begin to understand the factors affecting the organisms living in their area.

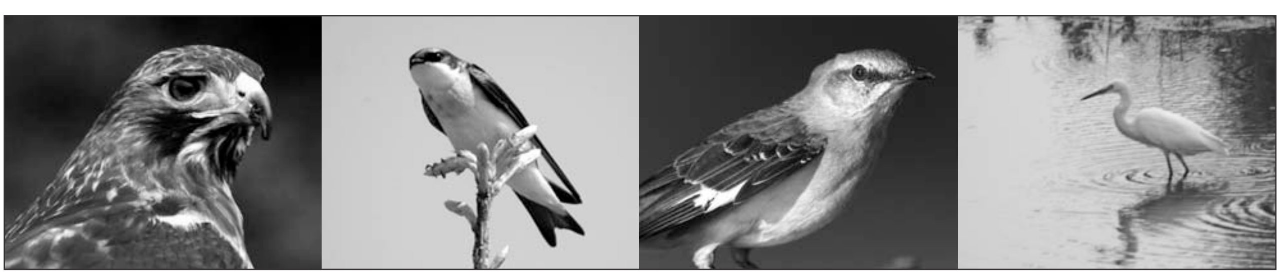
- Tell the students, a changing climate can force a population of species to change over time. A changing climate can be one way nature selects for certain organisms. Organisms that possess adaptations and survive are said to have adapted to the new climate.
- Ask the students, *"Do the organisms change in response to a change in climate or did they already have the beneficial trait and they simply survived?"* (The organisms already had the beneficial trait or adaptation, and because they survived, they reproduced and pass on the adaptation to future generations.)

B. Brief discussion on evolution

In order to be prepared for this discussion, read *Evolution Simply Explained* in the Teaching Aids section of this lesson.

Ask the classroom teacher if you can discuss macroevolution and the evolution of new species of plants and birds from a common ancestor. If not, skip to the Mutation Demonstration and skip all further discussion of macroevolution.

- Tell the students, "As nature keeps selecting for different traits over a long period of time, new species can develop. This development of a new species is **evolution**."
- Ask the students, *"What do you think happens to the species who are not adapted to a new climate?"* (These individuals die and their genes are not passed onto the next generation.)
- Tell the students, *"Remember, the species that are able to adapt to the change in climate possess genetic traits which help them survive and reproduce. After many generations of natural selection, a new species could arise with genes very different from its ancestor."*
- Tell the students, *"Let's think of how different species of plants might evolve from a change in climate."*
- Ask the students, *"What kind of traits could a plant possess that would help it survive a new wetter climate?"* Think about the traits the wetland plants had when you learned about them back in elementary school." (There are multiple answers such as: large cells to hold air when the plant is submerged under water, a waxy waterproof coating on its leaves, hollow stems to allow air to reach the plants' roots, roots that grow or float to the surface to get air, leaves that float to the surface to capture more sunlight, etc. You may choose to write the traits on the classroom chalkboard.)
- After the students have thought of multiple traits the plants could have, tell the students, "A species could have multiple traits that help them survive a change in their environment. These traits may not be all in the same individual plant. For example, one plant in a species might have the ability to float on water, but another plant in the same species might have the ability to stay under water for a long time. Both plants could survive and after multiple generations, and possibly many years, two very different plants could exist that were once from the same species."
- Tell the students, "This example shows how two different species of plants could evolve from a single common ancestor."



Part 6. Mutation Demonstration

For this section you do not need any special materials. The example below uses 15 students. You should adjust the activity to the number of students in your class so that all students can participate.

- Tell the students that genes can change due to mutation. Mutation of genes can create more diversity within a species. Sometimes a mutation is beneficial and it helps an organism adapt and sometimes a mutation does not benefit the organism at all.
- Tell the students we will now do an activity that will demonstrate how new traits arise in a single species due to mutation.
- Form a pyramid of students by having some students stand up and face the rest of the class. For example, if you have 15 students in your group, tell five students to form a line facing the class and stand shoulder-to-shoulder.
- Tell 4 more students to line up in the same way but stand in front of the five students already lined up.
- Now have three students line up in front of the 4 students. Next, have two students line up in front of the three, and then have one student stand in front of those two. The students should have formed a pyramid symbolizing many generations of a population of the same species of birds. Each student represents multiple birds.
- Remind the students genes of an organism are passed onto its offspring.
- Tell the students, the student at the head of the pyramid will be the common parent of everyone else in the pyramid. Tell this single student to think of at least four genetic bird traits they would like to pass onto two offspring. (Example: a long beak, a bird call that sounds like cherup-cherup-cherup, blue feathers, and short legs that can grasp tree branches.) Encourage the student to make a bird call more challenging than a simple cheep-cheep-cheep. Make sure the student tells you the traits. Have the student take two offspring aside and whisper the traits to them separately.
- Tell this student, "You aged and died, so you can no longer talk in this activity. It is up to your offspring to pass on the traits to the next generation."
- The two 'offspring' will then whisper this information to their 'offspring'. They will then die and it will be up to the next generation to pass on the traits.
- At the end of the pyramid, compare the traits of the 5 birds to one another by having the remaining students tell their traits to the rest of the class. Each of the 5 students may have ended up with slightly different traits.
- Ask the students how the traits changed from the first bird. (The traits should have changed just as mutation changes genes.)
- Tell students this activity did not demonstrate evolution because no natural selection has occurred. These birds could still be members of the same species and capable of reproducing with one another.

Part 7. Evolution Demonstration

For this section you do not need any special materials.
If time and the classroom teacher permit, you may choose to do this activity. This activity repeats the Mutation Demonstration Activity in a different way to demonstrate how evolution occurs.

- Tell the students, to think about what happened in the Mutation Demonstration Activity. When natural selection starts occurring and some population of birds are selected over others, two populations of birds can become so different that they can no longer reproduce with one another. The two bird populations are now two different species and evolution has occurred. Remember that when two birds can no longer reproduce offspring together, they are considered two separate species.
- Start with the five students that ended the Mutation Demonstration Activity, and have them repeat their traits.
- Tell the students that the climate where they live changed and their _____ (insert trait) did not help them adapt. (For example, a certain beak length may be necessary to obtain food and since this bird was unable to eat, it was unable to adapt. All the birds with this trait died and this trait was removed from this population.) Remove this student from the population of birds by asking this student to stand aside.
- Tell the students, "At the same time, one population of birds had a trait that helped them adapt to the new climate, so they had more surviving offspring than the birds without this trait."
- Have the student who has the beneficial trait step aside and take one offspring plus the bird that previously died as an additional offspring. Tell these students that together they should be creative and come up with one more trait that will allow them to successfully adapt to their environment. The trait should make them very different from the other group of birds.
- Repeat this scenario until you reach the last row of students. (One bird will die and one bird will separate from the original group and form a new population with a new trait.)
- Tell the students that hundreds of years are passing and these separate bird populations continue breeding with one another but could not breed with the other bird populations. (One common reason bird populations are not be able to breed with one another is because they become geographically separated.)
- At the end of this activity, discuss with the students how traits were lost and multiplied over time. Discuss how different the final groups of birds are from one another. Tell the students that in real life, much time would have passed in order for all these things to happen and for these groups of birds to have evolved into different species. Since these groups of birds evolved into different species, they can no longer reproduce with one another.

Part 8. Review

- Briefly review the main point of the lesson with students.
- Ask the students, *"What are the major differences between sexual and asexual reproduction?"* (Asexual reproduction produces an exact copy; Sexual reproduction involves combining parental genes to form a unique offspring, and therefore leads to greater diversity)
- Ask the students, *"Why is it beneficial to humans to be able to select certain traits in organisms?"* (We do this in order to breed disease resistance in oysters and other animals, breed crops with better yields, or breed animals with better milk or meat.)
- Review how natural selection works by causing organisms' with adaptations to have more surviving offspring than those without beneficial traits.
- Review how evolution occurs over time and results in multiple different populations of organisms with different adaptations. The different populations of organisms can no longer reproduce with one another.

Teaching Aids

Source for climate data

The National Climatic Data Center website has free climate data available. The 'climate normals' section gives 30-year averages for temperature and rainfall, broken down by month. Specific information for cities and regions is listed under each state.
Website: http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl

Plant Sample Suggestions

- Find some live plants currently exhibiting signs of asexual or sexual reproduction. For example, vegetative propagation can be observed in many plants. Vegetative propagation is a type of asexual reproduction by which a plant forms new individual plants without production of seeds or spores. Examples of vegetative propagation include rhizomes, runners, adventitious buds on cut tree stumps, adventitious roots on stems, and bulbs. Signs of sexual reproduction in plants would include flowers, seeds, and fruits. Some easily obtainable live plant samples are suggested below:
    Asexual reproduction - ivy, strawberry, raspberry, phragmites, cattails, violets
    Sexual reproduction- plants that produce nuts, fruit, pine cones, true flowers, etc. (bring the nut, berry, flower, etc. with the plant)

Oyster selection activity set-up

- Each deck of cards represents 1 round of oyster breeding. You will need to do at least 2-3 rounds to show the increase in healthy "oysters". Set up each round's card deck as follows:
- A normal deck has 52 cards with 13 of each suit (remove any jokers and extra cards). For a class of 26 students use the whole deck. For each student less than 26 remove 2 cards (1 red and 1 black). For larger classes you can use the extra cards and designate them either red or black. Add two cards (1 red and 1 black) for each student above 26.

Background information on the oyster diseases MSX and Dermo

Information taken from Ewart and Ford, 1993.

MSX and Dermo are both caused by waterborne parasitic protozoans. Because oysters are filter feeders, they ingest the parasites. These parasites affect the gills before spreading throughout the oyster's tissue. In an area infected with the parasites all oysters will be exposed. Some oysters however, seem to be resistant to the negative effects of the diseases. Scientists have determined the disease resistance is carried on genes. The resistant oysters do not die although they most likely carry the parasites. Scientists test for the diseases by taking oyster tissue samples and studying them under a microscope. This method allows for testing of living oysters. It is also possible to see the effect of the diseases when a shell has been opened. There are no documented negative effects to humans who consume diseased oysters, but the parasites has devastating effects on natural oyster populations.

For pictures of healthy and diseased oysters to share with your class check the following sources:

Fisheries and Oceans Canada. Backgrounder – MSX Disease of American (Eastern) Oysters. http://www.dfo-mpo.gc.ca/science/images/msx_e%5B1%5D.jpg. Accessed November 2006.

Harbor Branch Oceanographic. Harbor Branch Aquaculture Division - Bivavle Aquaculture. www.hboi.edu/aqua/bivalvesub2.html. Accessed November 2006.

Hayes, Pauli and Merrill Leffler, eds. Oyster Research and Restoration in U.S. Coastal Waters: Strategies for the Future. June 2004. Annapolis, MD. www.mdsg.umd.edu/oysters/meeting/summary.html. Accessed November 2006.

University of Maryland Center for Environmental Science Chesapeake Biological Laboratory. Molecular, Cellular, and Biochemical Toxicology. www.cbl.umces.edu/.../Toxicology/molecular.htm. Accessed November 2006.

Evolution simply explained

Evolution is the result of natural selection acting upon variation within a population. Organisms that have traits favored under a given set of environmental circumstances are said to have a selective advantage over individuals without those different traits. The action of natural selection on available genetic variation leads to the development of different species. It is important to remember favored traits are only advantageous in a particular situation and may not help the organism survive under different circumstances.

Evolution can be broken down into microevolution and macroevolution. At the 8th grade level, understanding the concept of evolution can be difficult. This lesson chose to focus on macroevolution and simply call it evolution. Macroevolution is when new populations of species are formed as a population diverges. Microevolution occurs within a species or population. Some schools choose to focus only on microevolution. Understanding the difference between microevolution and natural selection can be challenging. An example of microevolution is when there is an increase in a particular gene's frequency in a population due to natural selection. If macroevolution is occurring, microevolution must be occurring as well. Because evolution happens over time, and it is hard to say when enough time has passed. You can safely say two organisms evolved differently when the two organisms are so different from one another that they can no longer produce offspring together (University of California Museum of Paleontology and the National Center for Science Education).

Extension Activities

Pre in-school activity for classroom teacher:

Review lesson vocabulary with students and relate the terms to concepts that students have learned or are currently learning in the classroom.

Post in-school activities for classroom teacher:

Teacher-led adaptation search

- After the lesson, you can take students to search for adaptations of plants and animals within the schoolyard or nearby park. There are functional and reproductive adaptations in all living organisms.
- You can show your students evidence reproductive adaptations (sexual and asexual reproduction are reproductive adaptations). For example, plants such as ivy, strawberries, raspberries and other plants with runners and rhizomes are great examples of common organisms that exhibit asexual reproduction.
- Fruits, seeds, nuts and flowers are all evidence of plants exhibiting sexual reproduction.
- Insects are pollinators that facilitate sexual reproduction in many flowering plants by transporting male pollen grains to the female parts of a flower.
- Immature animals and evidence (such as broken eggshells or nests) indicate sexual reproduction has occurred.
- Also look for signs of adaptation in plants and animals. Almost any function or method of reproduction that helps an organism survive in its environment can be considered an adaptation. Camouflage is a great sign of a functional adaptation in the animal kingdom.

Resources

Eastern Kentucky University. Vocal Communications. http://people.eku.edu/ritchison/birdocmmunication.html. Accessed October 20, 2006.

Ewart, John W. and Susan E. Ford. 1993. History and impact of MAS and Dermo diseases on oyster stocks in the Northeast Region. Northeastern Regional Aquaculture Center Fact Sheet No. 200.

Freeman, Scott and Herron, Jon C. Evolutionary Analysis 3rd edition. Pearson Prentice Hall, 2004.

Gill, Frank B. Ornithology. 2nd edition. W.H. Freeman and Company. 1994.

Krebs, Charles J. Ecology: The Experimental Analysis of Distribution and Abundance. 2nd edition. Harper & Row Publishers. 1978.

Maryland School System Voluntary State Curriculum. Teaching and Learning: Science. http://mdk12.org/instruction/curriculum/science/index.html. Accessed October 1, 2006.

University of California Museum of Paleontology and the National Center for Science Education. Understanding Evolution for Teachers. http://evolution.berkeley.edu/evosite/evohome.html. Accessed October 31, 2006.

Wikipedia. Vocabulary definitions. www.wikipedia.com Accessed September 27, 2006.

Genes are the Key to Bay Biodiversity
Field Trip Experience

Program length: 2 hours
Number of instructors needed: 1 for every 15 students

Synopsis

By participating in activities that illustrate the natural selection of birds, students will further understand the process of natural selection. Students will hike through different ecosystems and observe evidence of plant and animal adaptations. They will observe the benefits of the adaptations they encounter in the field and learn how genetics plays a key role in creating biodiversity in the Chesapeake Bay area.

Objectives

- Students will be able to identify and describe adaptations of animals and plants observed in their local environment.
- Students will be able to identify and describe evidence of sexual and asexual reproductive adaptations observed in their local environment.
- Students will be able to explain and provide examples of natural selection.
- Students will be able to explain the processes that lead to evolution.

Materials

See Teaching Aids for assistance preparing materials
- Camouflaged Critters Activity pieces
- Bird Trait Selection Activity cards (at least five sets for every 15 students)
- Adaptation Observation Hike Field Notebook sheets (1 for every student)
- Pencils (1 for every student)
- First Aid kit
- An audio player that plays various local birdcalls

Bird Evolution Game Materials
- One 50-foot rope
- Two 25-foot ropes
- Set of Climate Cards
- Set of Bird Cards
- Five food representations such as nuts or pictures of nuts
- Four bird house representations such as pictures of bird nests
- Three hula-hoops
- One bucket or other small container

Vocabulary

Adaptation - a characteristic, arising from natural selection, that that improves a population's chance of survival and reproduction

Biodiversity - the variety of life that can be found on Earth

Evolution - changes in species as a consequence of processes such as mutation and natural selection

Natural selection - a process in which some individuals with genetic traits that improve their survival or reproduction have more offspring surviving to reproductive age than other individuals (Because the offspring also carry the genes for these traits, this process causes the genes for advantageous traits to become more common in populations and the genes for disadvantageous traits to become less common in populations.)

Runoff - water from rain, snow melt, or irrigation that flows over the ground surface and can carry pollution or sediment into bodies of water

Trait - a characteristic which is passed on to offspring through heredity

Vegetative propagation - a type of asexual reproduction by which a plant forms new individual plants without production of seeds or spores

Genes are the Key to Bay Biodiversity
Field Trip Experience Lesson Plan

This lesson is broken into 5 parts. If more than 15 students are participating at one time, one group of 15 students can participate in parts 2 and 3 while the other 15 students participate in part 4. The groups can then switch parts.

Suggested locations include an open space, a place to sit down for a brief discussion, and various ecosystems or natural areas to include in the hike (ex. forest, forest-edge, wetland, field, stream edge, etc). If you are in a location with only one broad ecosystem (ex. forest), try to find areas with different terrain (a vernal pool, sloping ground, rotten logs, etc.). Times include travel between locations.

Part 1. Introduction - 5 minutes

Part 2. Natural Selection Activities - 45 minutes

Part 3. Evolution of Bird Calls - 10 minutes

Part 4. Adaptation Observation Hike - 55 minutes

Part 5. Review - 5 minutes

Part 1. Introduction

- Introduce yourself and welcome the students to your Center.
- Tell the students that we will learn about genetics, natural selection, and evolution by becoming birds and participating in some fun activities. When we go hiking, we will also have the opportunity to observe special adaptations of plants and animals found in the wild. From these observations, we will begin to understand how organisms evolve.
- Tell the students genetics is key to evolution and provides the wide diversity of life we will see today.
- If the students had participated in the 7th grade lesson, they should have a good understanding of biodiversity. Ask a student to describe or define **biodiversity**.
- Ask the students, *"Why is biodiversity important to the Bay?"*
- Ask the students, *"What if there was only one species of bird? What do you think might happen?"* (Ex. Birds help transport many seeds from one place to another, but a single type of bird might not be able to transport the seeds of all plants. Therefore, a variety of birds is needed.)
- Ask the students, *"If a landscape full of plants is destroyed, how can it be recreated?"* (seeds from nearby plants can be transported to the site by animals, wind, water, etc.)

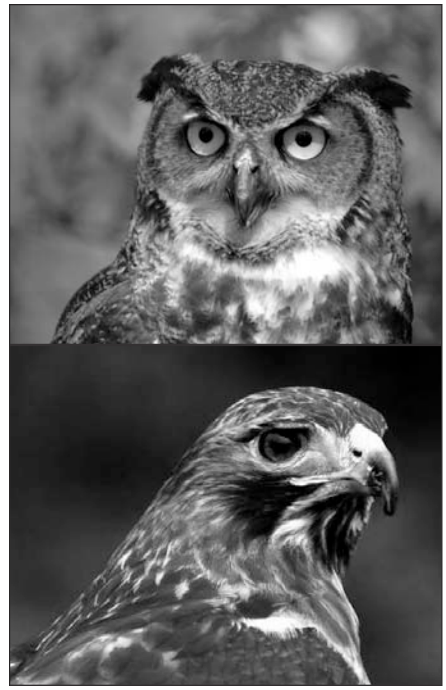
- Ask the students, *"If that landscape was full of the same type of plant, do you think it would be as good at filtering water before it flows into the Chesapeake Bay as a landscape with a variety of plants? Why?"* (A variety of plants would filter the water before it flows into the Bay in many different ways. Therefore, it is better to have a variety of plants filtering water before it flows in the Bay.)
- Tell the students, *"If a species becomes extinct what could be an effect?"* (Once a species becomes extinct, it can no longer benefit the ecosystem it was once a part of. Also, people use plants and organisms like Horseshoe Crabs for many purposes, including for medicine, so a cure for a disease might be lost.)
- Ask the students, *"Do you think humans are part of the diversity of the earth? Are there reasons for humans to care what happens to plants and animals we may never see?"* (We are part of the diversity on earth, and it is very important for us to care what happens to plants and animals around the Chesapeake Bay for all the reasons we just discussed.)
- Tell the students all of the diverse plants we will see today help the Chesapeake Bay in some way. For example,
    - Some of the plants hold soil in place and keep it from washing into the Bay.
    - Some of the plants filter and clean **runoff** before it flows into the Bay.
    - Many animals transport seeds and help plants reproduce in different locations.

Part 2. Natural Selection Activities

A. Explanation of Natural Selection

- Ask the students if they remember the difference between asexual and sexual reproduction. Asexual reproduction produces clones, and sexual combines genes from two parents.
- Ask the students if one type of reproduction produces more biodiversity, or more variation between living organisms. Sexual reproduction creates more biodiversity because genes from two different organisms are combined.
- Tell the students that as a result of genetic variation, organisms possess many **traits** that may or may not benefit them and help them adapt to their environment.
- Tell the students, "Some individuals have genetic traits that improve survival or reproduction. These animals have more offspring that survive to reproduce as compared to animals without these traits. Because the offspring also carry the genes for these traits, the process that causes the genes for beneficial traits to become more common in the population and causes the genes for the non-beneficial traits to become less common in a population is called **natural selection**."
- Tell the students, traits that improves a population's chance of survival and reproduction are called **adaptations**.
- Tell the students that the definition of natural selection includes the whole process that selects which traits will become more common in a population over time. Natural selection is not easy to define in one sentence. Therefore, we are going to do some fun activities to help you understand how natural selection works.

B. Camouflaged Critters

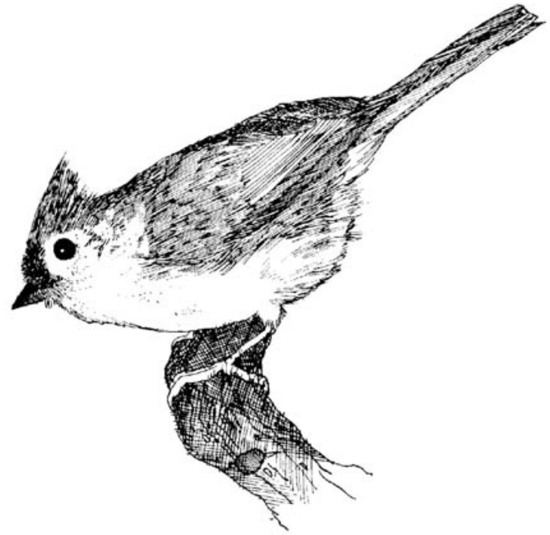


For this activity you will need a large open space and forty-five Camouflaged Critters for every fifteen students participating (see *Camouflaged Critters* in Teaching Aids). This activity is a tried and true activity that is not original to this lesson. There are many variations of this activity available in a variety of resources. Below is one variation of this activity.

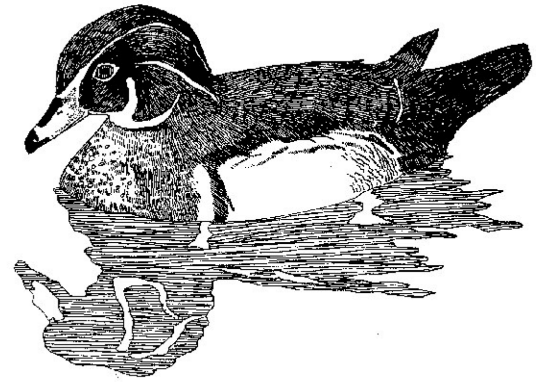
- Have the students split into two teams and line up in two parallel lines at a starting line some distance from where you will place the Camouflage Critters. Point out the starting line for the students.
- Ask the students if they can think of some animals that would be camouflaged, and therefore hard for us to see right now.
- Go over to where the critters will be placed and as you're spreading them out on the ground, tell the students that you are placing _____ (insert name of object-ex. Pieces of paper) all over this area and they will represent different colored insects. Some of the insects will be more camouflaged than others.
- Go back over to the students and ask them, *"Do you think camouflage is an important adaptation?"* (Yes, camouflage is a great example of an adaptation that helps an animal survive.)
- Throughout this activity, students will get the opportunity to see how natural selection selects for individuals with beneficial traits such as camouflage.
- Tell the students that they will be birds who eat insects. Each team is a different flock of birds, but they are all after the same insects.
- Tell the students that when you say go, one student bird from each flock should fly over the area where the insects are and pick up one insect. They must bring the insect back to the flock and cross the starting line before another bird from their flock can go.
- The first team to finish wins because it means their flock ate well and survived!
- After one round of the game, bring all the students together to look at the insects collected.
- Ask the students, *"Which colored insect was the easiest to find? Why? Which insect was the hardest? Why? Which insects can pass on traits like color to offspring because they survived?"* (The camouflaged ones. Color is a trait that could be passed on to the next generation.)
- Ask the students, *"What do think will happen to the population of insects over time?"* (Soon the camouflaged colors will become more prevalent in the population as the non-camouflaged organisms are eaten and therefore unable to reproduce.)
- Tell the students observing this change in the population is how you know natural selection is occurring.
- Depending on how much time and supplies remain, you can repeat the activity. It may be helpful to repeat the activity one more time so the students can experience the challenge of being a bird and finding camouflaged insects to eat.

C. Bird Trait Selection Activity

For this activity, you will need one set of the "Bird Trait Cards" for every fifteen students participating (see *Bird Trait Selection Activity Cards* in Teaching Aids).

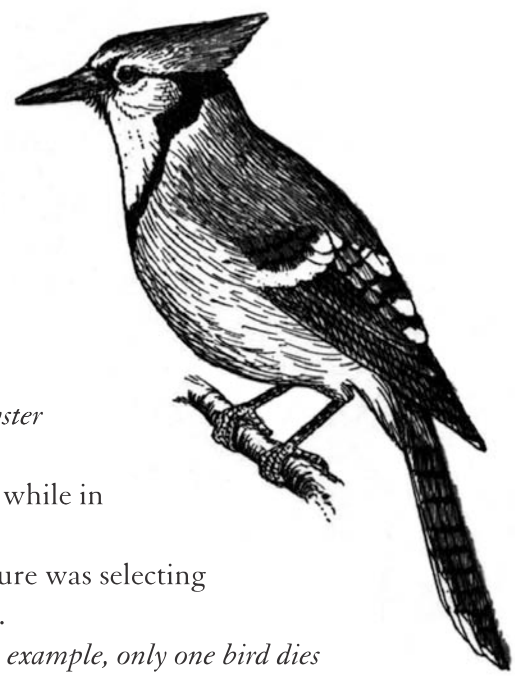


- Make sure you adjust your sets of trait cards for the number of students participating.
- Tell the students that bird calls and other traits such as tail size can help male birds attract mates. A louder call, for example, indicates that a male has a large amount of testosterone and can produce strong, healthy young. If a male bird does attract and mate with a female, he will not have offspring, and he cannot pass his genes to future generations.
- Tell the students they are going to do an activity that illustrates natural selection, which is a significant part of evolution. We are only going to look at what happens to one small population of birds that is on an island isolated from other populations of birds.
- Form a pyramid in an open area (similar to the pyramid made in the 8th grade in-school lesson Mutation Demonstration Activity).
- Tell the students they might represent more than one bird and each row represents a couple of generations. This is because natural selection happens over time or many generations.
- Give each of the five students in the back row a set of trait cards. The cards will describe the type of call they (as birds) make, their courtship dance, the length of their tail, and the length of their beak. The instructor needs to keep track of the traits that will be selected against. Do not tell the students in advance if they possess traits that will not be passed onto future offspring.
- Tell the students to act out all their bird call trait. The students may need some encouragement, but having them act out the traits will make the game more fun.
- Tell the one student in the bottom row with the quiet birdcall they do not have a loud enough birdcall to attract mates. If birds do not mate, they do not pass their genes on. Have the student with the 'quiet bird call' card give you all his or her cards.
- Have the four remaining students with the selected trait cards (the successful breeding birds with loud birdcalls) give their cards to a student in the next row.
  Tell the students, the students in the next row represent future generations of birds. (Each student offspring gets one set of trait cards.)



- Have the students act out their tail length trait.
  Tell the students long tail feathers attract mates.
  One of the students should have a "short tail length card". Tell the student his or her tail feathers were not long enough to attract mates. Therefore, these birds do not mate, and they are unable to pass their traits onto the next generation.

- Have the student with the 'short tail length' trait give you his or her cards.
- Have the three remaining students (birds) pass his or her trait cards onto the next row.
- Have the students act out their beak length trait. Tell the students the climate has changed slightly and the plants have adapted by growing longer seedpods. The birds with the short beaks couldn't reach the seeds in the seedpod, and couldn't find another source of food to eat. Therefore, these birds did not find enough food to eat and they died. These birds were unable to pass their traits onto future generations represented by the next row. One of the students should have a 'short beak card'.
- Have the student with the 'short beak' trait give you his or her cards, and have the other two students give their selected trait cards to student offspring (birds) in the next row.
- Have the students act out their courtship dance trait. Tell the students that fancy courtship dances attract mates. One of the students should have a 'lame bird dance card'. Tell this student their dance did not attract mates. Therefore, they are unable to pass their traits onto the next generation.
- Have the student with the 'lame bird dance' trait on it give you his or her cards.
- Have the remaining students (birds), with the naturally selected traits pass their trait cards onto the student offspring (birds) in the fifth row.
- Tell the students we now have a population of birds with traits that helped the birds survive in their environment and attract mates. Have the last student(s) read (or act out if they don't mind the attention) the traits that were selected for on this island. Compare how different this bird is from the five birds in the beginning.
- Have the students act out their cards. One of the students should have a "short beak card". Tell this bird (and the rest of the students) that now the climate has changed slightly and the plants have adapted by growing longer seedpods. The bird with the short beak couldn't reach the seeds in the seedpod, and couldn't find another source of food to eat. Therefore, these birds did not find enough food to eat and they died. These birds were unable to pass their traits onto future generations represented by the next row.



- If the students already had the 8th grade in-school lesson, ask the students, *"What was different between this activity and the oyster selection activity you did in your classroom? What was similar?"* (In the oyster activity, humans were selecting for certain traits while in this activity nature was selecting for certain traits.)
- It is important to remind the students that, in this activity, nature was selecting for certain traits. This activity demonstrated natural selection.

  NOTE: *This activity can be done in multiple ways. In this simple example, only one bird dies at each level and the surviving birds pass on only their beneficial genes. You can have multiple birds die as long as you add cards to the game or make sure you have enough to pass on to the next generation. As the instructor, you can change which traits are beneficial or non-beneficial and lead to impending death. You can also change the environmental examples by using examples of human disturbance. You do not have to end with one bird, because it is possible that multiple different subspecies of birds survived with different traits. When changing the game, please remain accurate with your examples and do not mislead students with unrealistic scenarios.*

Part 3. Evolution of Bird Calls

For this section, you will need the audio player with prerecorded birdcalls and a small open space.

- Have the students gather into a circle and, preferably, sit down to make sure they can listen and focus on you.
- Remind the students, evolution is t he long-term result of natural selection acting upon natural variation within a population.
- Some organisms within a population have traits (like camouflage or long beaks) that are favored under a given set of environmental circumstances. Therefore, these organisms have a selective advantage over individuals without those traits. When natural selection leads to the development of different species, evolution has occurred.
- Tell the students it is important to remember that favored traits were only advantageous in a particular situation and may not help the organism survive under different circumstances. For example, if the ground cover changed, insects that were once camouflaged may no longer be camouflaged. Then, a new color would be more advantageous trait to possess.
- Birds have evolved into many different species over time. In the Chesapeake Bay watershed, there are over 350 species of birds! Although, we will not get to see all the different species of birds today, we will most likely get to hear a variety of species calling or singing.
- Tell the students you are going to play some different recordings of local bird calls and songs for them. See if the students can guess some of the species of birds.
- When playing the bird calls, ask the students, *"Have you ever heard this bird before? Maybe in your backyard or at the park?"* (Yes)
- Tell the students the names of the birds making the calls. Tell the students about the bird making the call such a its coloring or behavior.
- Remind the students all these birds are different species and some of them evolved from a common ancestor. For example, all owls evolved from a common ancestral population of owls.
- Ask the students, *"If two different species of birds sound similar, do you think they evolved from a common ancestor?"* (No. The sound a bird makes is not indicative of its evolutionary history.) Tell the students, "In fact, even the way birds look or behave does not tell a lot about their evolutionary history."
- Scientists are always finding new evidence indicating which birds evolved from common ancestors. DNA analysis has helped scientists rearrange bird evolutionary tree diagrams so that they are more accurate. For example, recently, scientists agreed that vultures (like turkey vultures and black vultures) are more closely related to wood storks in Florida than to eagles (as they previously thought).
- Because evolution of species occurs over a long period of time, you can not see it happening. A lot of information about different species must be collected before you can make assumptions about which species share a common ancestor.

Part 4. Adaptation Observation Hike

For this section you will need one Adaptation Hike Field Notebook sheet and one pencil for each student (see *Adaptation Hike Field Notebook sheet* in Teaching Aids). You will direct the students to fold the worksheet into quarters to make a field notebook, so you will not need clipboards. You should take the backpacks and first aid kit on the hike. You will need to prepare ahead of time for your hike and be familiar with multiple plants and animals and their observable adaptations.

A. Preparing for the Hike

- The hike needs to be suited to your Center and highlight any great plant or animal adaptation specimens you have available. This is a great opportunity for these students to be outside, getting exercise, and exploring the grounds around your Center. It is not suggested that you let the students do this activity on their own without a Center guide. One goal of this activity is to provide these students the opportunity to explore and learn about nature in a safe and fun way.
- Find ways to have students touch, examine, and smell samples as much as possible.
    - It is suggested that you hike the students through different ecosystems such as: wetlands, creeks, forests, fields, and edges where fields and forests meet.
    - Stop frequently to show the students plant and animal traits and discuss how the traits help the plant or animal adapt to its environment.
    - Stop in at least three different ecosystems and have students make entries into their field notebooks. If your grounds are homogeneous, you can stop in three different sites with different microclimates. If you choose to discuss microclimates, make sure the students do not confuse microclimate with climate.
    - Remember that plants and animals have no control over their adaptations, because organisms do not choose their traits. Genes determine which traits an organism will possess and natural selection makes a trait become more common in a population over time. Traits that help an organism survive in a particular environment are called adaptations. Plants and animals are constantly under the pressure of natural selection, so traits are always being selected.
    - When showing an adaptation to the students, say that the plant or animal possesses an adaptation rather than saying that particular organism has adapted. If you say an individual organism adapted, the students may get confused and think that particular organism changed in some way.

- Don't forget that an adaptation is only beneficial in a particular environment. If the environment changes, new adaptations will naturally be selected in a population (natural selection).

B. Introducing the Students to the Hike

- Tell the students that we will be hiking around your Center to observe various adaptations of plants and animals. Tell the students if you will hike them through different ecosystems, and periodically ask them to record observations in a field notebook.
- Remind the students the climate (as discussed in the in-school lesson) will remain the same for the whole area. If the students did not have the in-school lesson prior to the field trip or they do not understand climate, take time to explain it here.
- Tell the students we may encounter an area in an ecosystem where it is wetter or shadier compared to another location in the same ecosystem. The amount of water or shade in a particular area can affect what plants can grow there.
- Hand out the Adaptation Hike Field Notebook sheets and direct the students to fold them into quarters to make a field notebook.
- Tell the students they will be responsible for carrying their field notebook and pencil the whole time, and, as a group, we will stop and fill in our field notebooks throughout the hike.
- Go over the Adaptation Hike Field Notebook and explain how they will record observations of plant and animal adaptations we encounter in their own field notebook.
- Tell the students how long you will be hiking, and tell the students any rules they must follow throughout the hike.

C. Suggestions for Hike

- Many adaptations can be found in nature, below are some plant and animal adaptations you might find on your hike at your Center in the Chesapeake Bay watershed.

<u>Forests</u>

- Forests offer a place to observe many plant and animal adaptations.
- You can show your students forest plant adaptations. Forest plants are always in competition with one another for survival. As evidence of this you will see various plant reaching toward a small patch of sunlight, and you will see small trees that have been shaded out by larger trees. Differences in leaf size are an adaptive trait that is significant to the trees ability to make food for survival and growth (WU, 2006). Have the students look around an area for these adaptations.
- You can show your students tree bark adaptations. For example, fissured bark blocks sucking or burrowing insects. Examples of fissured bark can be found on oak trees (white oaks are deeply fissured). Pitch pines, black willows, and red maples have shallow fissured bark. Woody plants with green stems are almost always capable of capturing sunlight for photosynthesis. This means that these plants have stems adapted for producing food for the plant (UCLA, 2006) (Hardin et. Al, 2001). Have the students touch the bark, closely examine tree bark , and compare bark on different trees.

- You can show your students forest animal adaptations. In addition to reproductive adaptations given below, you can look for different colored birds and squirrels. Discuss with the students whether the colors provide any benefit and could be considered adaptations.

<u>Wetlands</u>

- You can show many adaptations to your students in wetland. Many wetland plants have adaptations allowing them to live in water or wet soil that has little oxygen (Ex. cattails, Phragmites, duck potato). You can show the students adaptations of plants in a wetland such as: hollow stems, larger cells, waxy coated leaves that feel like rubber, or trees with their roots sticking out above the water.
- Have the students touch plants, closely examine plants, and compare different plants.
- Bald cypress trees (*Taxodium distichum*) are found in parts of the Chesapeake Bay watershed, these trees are typically known for their prevalence in southern swamps. When bald cypress trees grow in water, they produce cone-shaped extensions of their root system called knees. These root extensions protrude above the ground and help the roots obtain oxygen in flooded conditions. They help stabilize the tree (University of Florida). If you encounter this adaptation, have the students touch and examine the trees' knees if possible.
- Chances are you will encounter phragmites or Common Reed in a wetland in the Chesapeake Bay watershed. This type of plant has many visible adaptations. Two varieties of phragmites exist in this area. *Phragmites australis* is not native to the U.S. Researchers believe that this variety is the more aggressive variety that it has replaced the native variety. The native variety of phragmites is Phragmites communis. This variety of phragmites spreads by rootstocks and leafy runners. *Phragmites communis* usually does not produce seeds. *Phragmites australis* produces asexually (like *Phragmites communis*) and reproduces sexually by producing seeds (Swearingen, et al) (Martin).
- Discuss with the students how *Phragmites australis* reproduces itself more effectively compared to Phragmites communis.

Fields

- Have your students look at the field grasses and other field plants. Discuss with the students whether these plants could grow in a shady area. If they are adapted to living in full sun, then they probably will not survive in a shady area. Field plants often have seeds that blow in the wind or hitchhike on animals. Discuss how these traits may have been beneficial to the survival of these plants and allowed these plants to adapt to living in a field.
- Show students evidence of how plants and animals reproduce. Discuss why the different methods of reproduction may be beneficial and help the animal adapt to its environment.
  - Show your students signs of asexual reproduction.
  - Show your students signs of **Vegetative propagation**. Vegetative propagation can be observed in many plants and even fungi. Vegetative propagation is a type of asexual reproduction by which a plant forms new individual plants without production of seeds or spores. Examples of vegetative propagation include rhizomes, runners, adventitious buds on cut tree stumps, adventitious roots on stems, and bulbs.
  - Consider digging up bulbs and showing them to your students.
  - Show your students beech tree sprouts (basal sprouts). American Beech Trees and other native trees often reproduce through the vegetative propagation of their roots. Vegetative propagation is a sign of asexual reproduction. These trees also often exhibit flowers and seeds (signs of sexual reproduction).

*Be careful not to mistake beech drops for beech sprouts. Beech drops are parasitic plants found only under beech trees. Beech drops lack chlorophyll so they can appear to be woody plants the same color as the beech trees (Evans).

- Show your students signs of sexual reproduction.
    - Have your students look for signs of sexual reproduction in plants. Have the students look closely at flowers, seeds, and fruits. Discuss how these things are evidence that the plant is reproducing sexually. Discuss why this method of reproduction could be beneficial and help the plant adapt to its environment. Remind the students this method of reproduction allows for mixing of genes and contributes to creating biodiversity.

    - Have your students look for signs of sexual reproduction in animals. You can have the students look for signs such as baby animals, eggshells, and nests. If you are so fortunate as to come across parents and offspring, you can try to see if all the offspring look like the parents. Even though the offspring may look just like the parents or one another, it is important to remind the students that the animals are not exact genetic copies of one another.
- Look for areas of obvious human disturbance and show them to your students.
    - In these areas, you can point out how we came in and rapidly changed the environment. For example, humans may have cut down a forest, drained a wetland and turned it into a field, flooded an area on purpose, or paved it over. In these examples, humans have not stopped plants and animals from adapting nor have they changed natural selection. Humans just manipulated the selection process. Nature continues to select traits, and this is different from the oyster selection activity we did in class. In class during the oyster selection activity, we were selecting individuals instead of nature.
    - In areas disturbed by humans, the area has been dramatically changed and different plant or animal traits will be selected by nature from now on. There are many plants and animals that have adapted to living in human disturbed areas.
    - Phragmites is an example of a plant adapted to living in human disturbed wetlands.
    - Deer are an example of animals adapted to living in agricultural or suburban landscapes.
    - Rodents and cockroaches have adapted to living in houses and urban landscapes.
- Show students animals with camouflage as evidence of adaptation.
- Show students plant and animal defense mechanisms as evidence of adaptation (the ability to defend themselves against predators).

Extra Activity – Bird Evolution Game

For this activity you will need one 50-foot rope, two 25-foot ropes, food representations, bird house representations, three hula-hoops, one bucket or other small container, Climate Cards and Bird Cards (see *Bird Evolution Game* in Teaching Aids).

This activity discusses evolution as macroevolution. Do this activity only if time and the classroom teacher permit. Otherwise, skip to Part 5.

Set up game

(For a complete diagram, see *Bird Evolution Game* in Teaching Aids)

- This set-up and explanation are based on the participation of 15 students. Adjust the number of cards and resources to the size of your group.
- Make three rope circles in a field (or other open area). These circles represent different geographic areas with different climates.
    - Place the 50-foot rope in a circle at one end of the field. Call this the Mainland.
    - Place a 25-foot rope in a circle about 30 feet away from the Mainland. Call this circle Island 1.
    - Place the second 25-foot rope in a circle about 30 feet away from Island 1. Call this area Island 2.
- Place the Arid Climate Card in the middle of the Mainland.
- Place the Tropical Climate Card in the middle of Island 1.
- Place the Tundra Climate Card in the middle of Island 2.
- In the Mainland, place five objects that represent food. Real nuts, cut-outs or plastic objects may be used.
- In Island 1, place four objects that represent bird housing. Bird houses, nests, or pictures may be used.
- In Island 2, place three hula-hoops that will be used to represent space.
- Place all Bird Cards in the middle of the Mainland.
- Place the bucket off to the side of the game area.

Playing the game

- Explain to the students they will play a game to learn how bird populations evolve.
- Tell the students the large circle they see in the field represents a large area of land. We will call this area of land the Mainland.
- Tell the students the closest circle to the Mainland represents an island. We will call this Island 1.
- Tell the students the second small circle in the field represents a second island. We will call this Island 2.
- Explain to the students these are small representations of very huge pieces of land with miles and miles of water (or another geographic barrier) between them.
- Tell the students they will each represent a small population of birds versus one bird.
- Have all the students stand in the Mainland.
- Have each student pick a Bird Card out of the pile and read the traits listed on the back. Do not let them read the Climate Card yet.
- Tell the students not all of them will be able to stay on the Mainland because some of the resources they need to live are limited. If they want to stay on the Mainland, they will first have to find some food.
- Tell the students when you say "go" they must scramble (nicely, no pushing) to grab a piece of food (show a representation of the food or point to the pile of food in the circle). Say "go" and stand back!

- Explain that students who successfully grabbed a piece of food will be able to survive on the Mainland because they are good competitors.
- Tell the students we also have to consider the climate on the Mainland. Have the students that did not claim any food read the Climate Card. Tell the students the traits on the back of their Bird Cards may help them survive in this arid climate even though they may not have been good competitors for food. Tell the students which traits will help them survive:
    - Brown or tan feathers for camouflage
    - Wide foot span to walk on sand
    - Short wings for short-distance flying
- Students with cards that do not have beneficial traits will not survive well on the Mainland. Thus, these birds (students) will migrate to another piece of land where they may be able to survive. Have these students stand along the edge of the Mainland, facing Island 1, in preparation for migration.
- Ask these students, *"Why do you think you have to leave the Mainland?"* (Birds migrate for many reasons. One reason is a lack of adequate resources, and another is to reach a particular breeding ground. In this example, there is a lack of resources available on the Mainland.)
- Explain that they will now have to fly to Island 1. It will be a long flight, and they will be very tired when they get there. Tell them there is a pile of nesting sites (houses) on Island 1. They must look for a place to make a nest as soon as they get to the Island. After they claim a nesting site, they should wait for more directions. Tell them "go".
- Explain that students who successfully found a nesting site will be able to survive on the Island because they are good competitors.
- Ask the students who did not claim a nesting site, *"Why were you not able to find a place to make a nest?"* (Nesting sites (houses) were limited.) These students will have to see if they are adapted to the wet and hot climate on this Island. Have them read the Climate Card and the traits on the back of their Bird Cards. Tell the students which traits will help them survive:
    - Bright feathers to attract a mate
    - Loud calls to be heard from far distances throughout the forest
- Students with cards that do not have beneficial traits will not be able to adapt to life on Island 1. Thus, these birds (students) will migrate to another piece of land where they may be able to survive and reproduce. Have these students stand along the edge of Island 1, facing Island 2, in preparation for migration.
- Explain to these students they will now have to migrate to another island. Ask the students *"Why do you have to leave the island?"* (There weren't enough resources). This new island is much smaller than the Mainland or Island 1, so space is limited. As soon as they reach the island, they must quickly claim their own territory (a hula-hoop, one student per hula-hoop) then wait for more directions. Say "go".
- Explain that students who successfully found their own territory will be able to survive on Island 2 because they are good competitors.
- Students who did not claim a territory will have to see if they are adapted to the cold climate on this Island. Have them read the Climate Card and the traits on the back of their Bird Cards. Tell the students which traits will help them survive:
    - White or gray feathers for camouflage in snow
    - Long wings for long-distance migration

- Increased body fat for survival during times of scarce food supply
- At the end of the game all students should have migrated to a place where their ability to compete and/or other traits allow them to survive.

Conclusion

- Gather the students in one spot to discuss the game.
- Ask the students to remember the beginning of the game, when they were all together on the Mainland. At that point, they were one big population. All of the birds in the population were of the same species, even though they had different traits (short vs. long wings for example). However, the population was too big for the Mainland. There were too many birds and not enough resources. Only the birds that could successfully compete for resources and/or had other beneficial traits could survive on the Mainland.
- Discuss with the students how the populations have different traits. Some populations might have physical traits that help them survive in the specific climate, and others might be such good competitors that they do not need those helpful traits to survive and reproduce. Birds with these beneficial traits (specific traits like on the back of their cards or competitiveness) survive and may be able to reproduce better than others. They pass their traits on to their offspring, causing those traits to become more common in the population over time.
- Tell the students over a very long time (millions of years), the separate populations will have mated and changed so much that they will become different species.
- Ask the students, *"Once the birds have evolved into different species, will they be able to reproduce with birds from another population?"* (No, different species can not reproduce and produce offspring that can reproduce.)

Part 5. Review

- Review the major concepts covered in this lesson with the students.
- Ask the students to identify and describe adaptations of animals and plants they observed.
- Ask the students to identify and describe evidence of sexual and asexual reproductive adaptations they observed.
- Ask the students to explain and provide an example of natural selection they learned today.
- Ask the students to explain the processes that lead to evolution.
- You can use the following questions to determine if the students gained a further understanding of the concepts covered in this lesson.
- Ask the students, *"Can an individual plant suddenly change and respond to a change in its environment such as flooding or fire? Why or why not?"* (No. The plant must already possess a trait that helps them survive the sudden change in their environment.)
- Ask the students, *"If a population of plants survives multiple natural disasters such as repeated floods or*

repeated fires, have the plants adapted? Why or why not?" (Yes if multiple plants survived. Due to the genetic variation in the population, some of the plants possessed traits, which helped them survive. The traits that helped the plants survive are called adaptations. So, the plants that survived adapted to this particular change in their environment.)

- Ask the students, *"Think about the plants that survived the repeated floods or fires. Has natural selection occurred?"* (Most likely, if multiple plants survived. If multiple plants survived, this probably is not the first time these plants were exposed to a flood or a fire. However, we would have to look at the whole plant populations' genetics to determine if natural selection has taken place. Most likely the plants that survived all possess the same trait that helped them survive, so that trait is now more common in the population.)
- Ask the students *"Do you think this example is a case where asexual reproduction might be beneficial trait and help a plant reproduce? Why or why not?"* (Yes, asexual reproduction helps plants reproduce and quickly cover areas that have been recently disturbed. Asexual reproduction is fast and simple compared to sexual reproduction. Using asexual reproduction, a plant can reproduce quickly and recreate the population that was lost in the flood or fire. In this example, asexual reproduction would be an adaptation because it is a trait that could help this plant survive and reproduce more effectively compared to other plants.)
- Ask the students, *"If we compared the plants that grew in the area before it was flooded or burned with the ones that grew there after the disaster, can we say that the new population of plants evolved from the old one?"* (No. Evolution takes place over a long period of time. Most likely these plant populations are still the same species and they possess a trait that helped them survive. We can say this population of plants has adapted and natural selection is taking place.)

Teaching Aids

Bird Trait Selection Activity Cards

These cards can be as elaborate or as simple as you desire. They serve the purpose of reminding you and the students of the various traits.

For 15 students, make 5 sets of cards. A set contains 4 traits. You will most likely want extra cards or even extra sets of cards for alternative versions of the activity.

- You will need the following materials: 20 index cards preferably 4 different colors (5 of each color), marker
- Write on one side of 5 cards 'Bird Call', and on the other side of 4 of these cards write "loudly say cheeseburger, cheeseburger, cheeseburger". (This phrase sounds like the call of the Carolina wren; you may choose to use a different bird.) On the other side of the 5th card write 'quietly say cheeseburger, cheeseburger, cheeseburger'

  NOTE: *Birdcalls serve a different purpose than Bird songs. Birdcalls are simple vocalizations that are important in communicating information about predators, food, etc. but are not important in reproduction. Bird Songs are affected by hormones and are important in reproduction.*
- Write on one side of 5 cards 'Courtship Dance', and on the other side of 4 of these cards write "make up a cool bird dance". On the other side of the 5th card write 'make up a lame bird dance'
- Write on one side of 5 cards 'Tail Length', and on the other side of 4 of these cards write "long tail

length". On the other side of the 5th card write 'short tail length'

- Write on one side of 5 cards 'Beak Length', and on the other side of 4 of these cards write 'long beak length'. On the other side of the 5th card write 'short beak length'
- In preparation for the lesson, you will want to bundle your cards into 5 bundles. All the traits that will be selected against must be in different bundles in order for the game to work.

Creating Camouflage Critters

You will need 45 Camouflaged Critters for every 15 students participating

- Some suggestions for what you can use as critters are small colored scraps of paper, wooden toothpicks, or colored craft sticks.
- Consider whether your critters biodegrade easiliy. (For example, pipe cleaners do not biodegrade easily.) Remember that your critters may be so well hidden that you may not find them all at the end of the activity. Therefore, you want to make sure you do not pollute the environment.
- Depending on where you play the activity, you may want to vary the colors of the critters. Beige, black, and shades of brown or green are almost always hard to find. Red, blue, bright yellow and pink are usually easy to find. Make sure you have a mixture of easy-to-find critters and hard-to-find critters.

Background Information for the Instructor

Please read *Evolution Simply Explained* in the Teaching Aids section of the 8th grade in-school lesson before teaching this lesson.

Adaptation Hike Field Notebook sheet

See next page.

NOTE: *The worksheet will be folded into quarters and serve as a small field notebook for each student. Folding this worksheet into quarters will eliminate the need for the students to carry clipboards.*

Bird Evolution Game

How to Make the Bird Cards

- You will need one bird card for each student.
- The instructions below are based on 15 students. For a larger class add a card for each student while keeping approximately the same proportions of cards in each stack.
- The cards used in this game can be elaborate or as simple as you desire. Either write on both sides of 4"x6" index cards or print the cards out and use real pictures of birds.
- Create 7 cards that have the following traits and descriptions listed on the back:
    - Brown or tan feathers – for camouflage
    - Wide foot spread – to walk on sand
    - Short wings – for short-distance flying
- Create 5 cards that have the following traits and descriptions listed on the back:
    - Bright feathers – to attract a mate
    - Loud calls – to be heard from far distances throughout the forest

- Create 3 cards that have the following traits and descriptions listed on the back:
    - White or gray feathers – for camouflage in snow
    - Long wings – for long-distance migration
    - Increased body fat – for survival during times of scarce food supply

How to Make the Climate Cards

- The climate cards may be as elaborate or as simple as you desire. Either write on both sides of three 4”x6” index cards, or print the cards out double-sided.
- Create three cards.

First card:

- On the front write: Hot and Dry (Arid)
- On the back write: Brown or tan feathers - for camouflage
Wide foot spread – to walk on sand
Short wings – for short-distance flying

Second card:

- On the front write: Rainy and Hot (Tropical)
- On the back write: Bright feathers – to attract a mate

Loud calls – to be heard from far distances throughout the forest

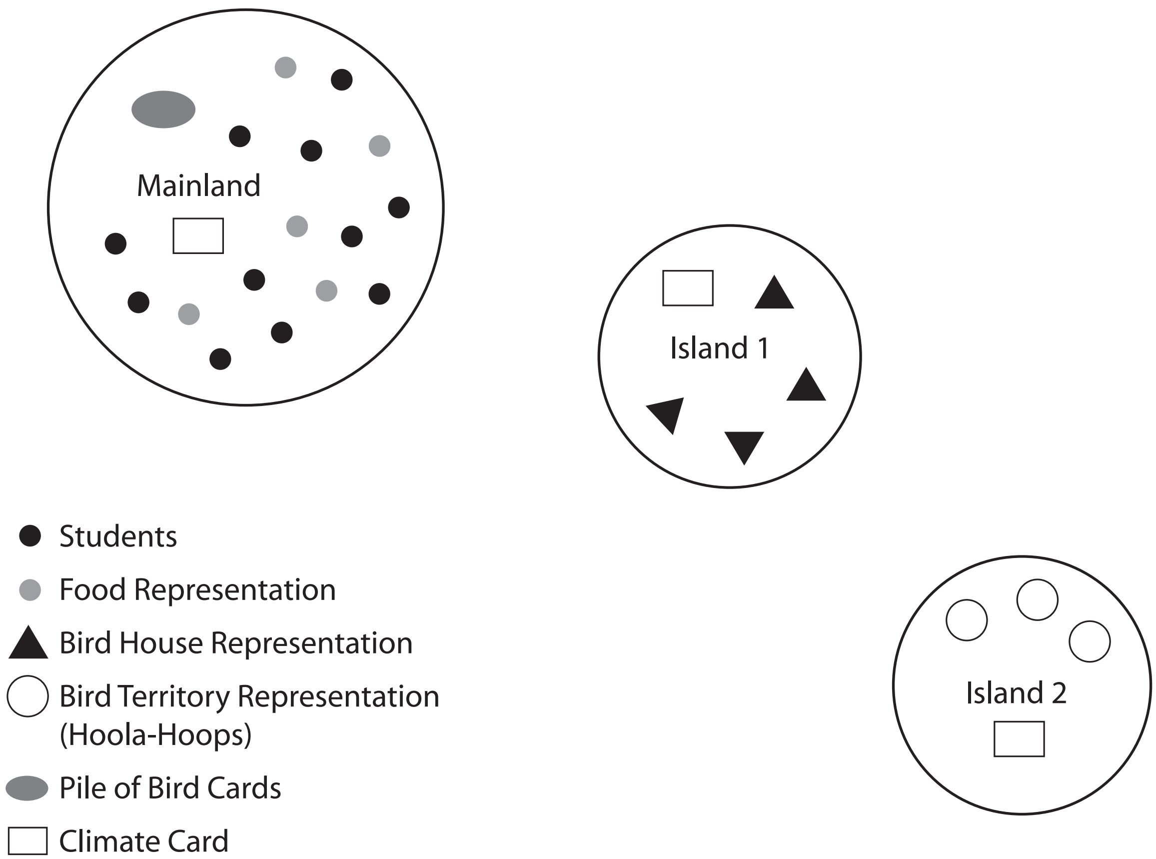
Third card:

- On the front write: Cold (Tundra)
- On the back write: White or gray feathers - for camouflage in snow
Long wings – for long-distance migration
Increased body fat – for survival during times of scarce food supply

Bird Evolution Game Diagram

Game Diagram

1. All students begin in the Mainland.



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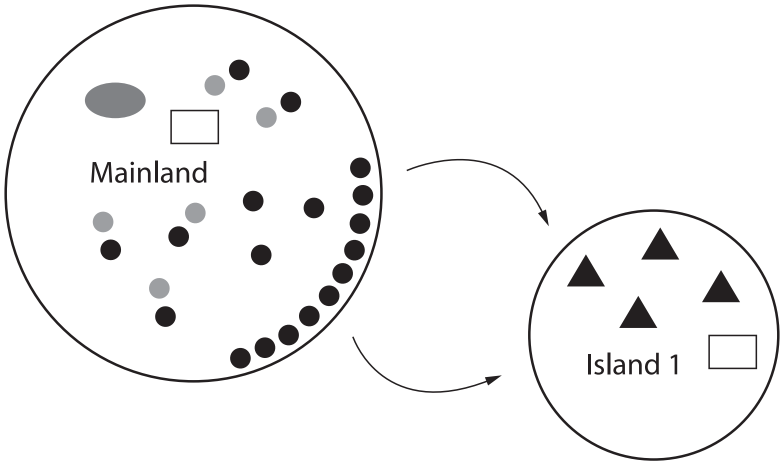
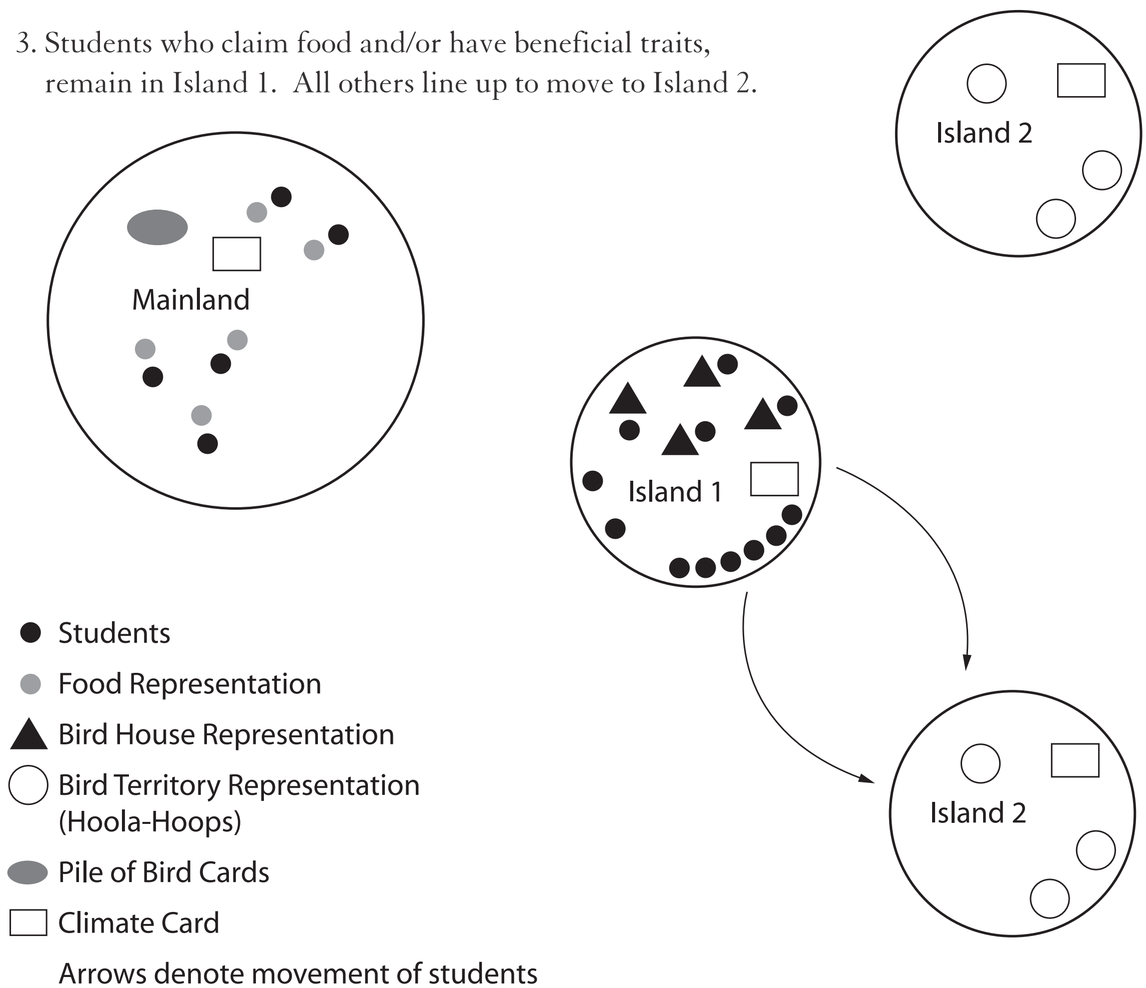
Bird Evolution Game Diagram

2. Students who claim food and/or have beneficial traits, remain in the Mainland. All others line up to move to Island 1.



3. Students who claim food and/or have beneficial traits, remain in Island 1. All others line up to move to Island 2.



Adaptation Hike Field Notebook

(use the back of this worksheet if you need more space)

Ecosystem 1 (name): ______________________

1a. Name of plant observed (species): ______________________

1b. Trait observed:

1c. How does this trait help this plant survive in its environment?

1d. Name of animal (species) and trait observed:

continue on next page

1e. How does this trait help this animal survive in its environment?:

Ecosystem 2 (name): ______________________

2a. Find a plant with an observable trait that helps it survive in its environment. Describe this plant and the observable trait.

2b. How does this trait help this plant survive in its environment?

Ecosystem 2 (continued):

2c. Find an animal or a sign of an animal. Describe an observable trait of this animal.

2d. How does this trait help this animal survive in its environment?

Ecosystem 3 (name): ______________________

3a. Find a group of plants that looks the same. Describe a trait that all of these plants have that might help them survive in this environment.

3b. Find a different group of plants. Describe traits these plants have that are different from the first group of plants.

3c. Do you think these two groups of plants evolved from a common ancestor? Why or why not?

Extension Activities

Pre Field trip activity for classroom teacher

- Review the vocabulary with your students.
- Discuss or review the following concepts with your students:
    - Review how asexual reproduction results in genetic clones or exact genetic copies of the parent organism.
    - Review how sexual reproduction mixes genetic information from two parents and results in offspring that are genetically different from either parent.
    - Review how sexual reproduction leads to mixing of genetic material from two parents and helps create greater biodiversity.
    - Discuss how it is important to have biodiversity.
    - Once the students understand that there is biodiversity in the natural world, they can begin to understand how natural selection will select organisms that are adapting to their environment. Natural selection over time can lead to the development of new species, which is called evolution. (see *Background Information for Classroom Teacher* below)

Post Field trip activities for classroom teacher

Focusing on the fundamentals of evolution

- Discuss with your students how the field-trip experience (and possibly the in-class lesson when the Center instructor came to your class) helped them understand the basic principles of evolution. The mechanism of evolution is based on four fundamentals: variation, inheritance (involving genes), selection, and time.

Reviewing what we learned on the field trip

- Ask the students the following questions and make a list of the answers on the board, or use the questions as a written assignment.

    1. What did we learn about the variation that exists in a population? Was every plant or animal exactly the same if they were the same species? What could have caused them to be different? (Students should refer to their field notebooks)
    Answer: They could have had different traits or genes from one another as a result of sexual reproduction or mutation. Remind the students that having variation in a population of organisms is necessary for evolution to occur.

    2. What did we learn about the way traits are inherited? Remind the students of the plant examples they saw.
    Answer: Traits are passed to offspring on genes that they receive from the parents. The basic difference between asexual and sexual reproduction is that asexual reproduction produces clones, and sexual reproduction combines genes from two parents. Sexual reproduction produces more biodiversity, or more variation between living organisms than asexual reproduction, because genes from two different organisms are combined.

3. What did we learn about natural selection? Remind the students of the games they played. *Answer:* Some individuals have genetic traits (such as camouflage) that improve survival or reproduction. These animals have more offspring that survive to reproduce as compared to animals without these traits. Because the offspring also carry the genes for these traits, the process that causes the genes for beneficial traits to become more common in the population and causes the genes for the non-beneficial traits to become less common in a population is called natural selection.

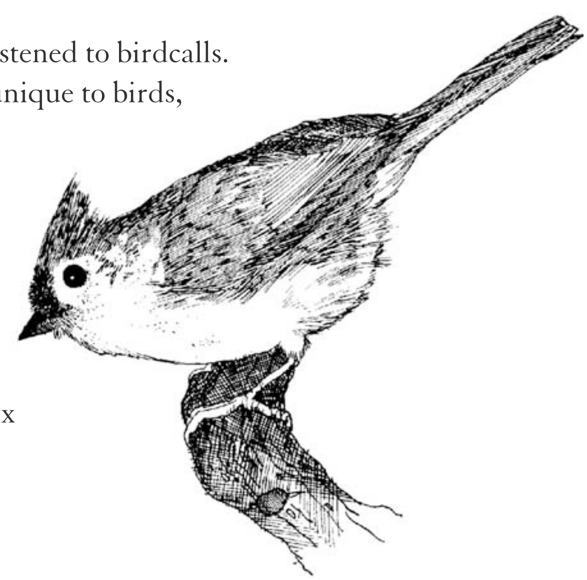
- Explain to the students how these three answers are all part of evolution. Evolution is the long-term result of natural selection acting upon natural variation within a population. When natural selection leads to the development of different species, evolution has occurred.
- Macroevolution takes place over a long period of time (such as millions of years). Scientists usually must look at fossils for evidence of evolution.

Background Information for Classroom Teacher

Evolution can be broken down into microevolution and macroevolution. At the 8th grade level, understanding the concept of evolution can be difficult. Macroevolution is when new populations of species are formed as a population diverges. Microevolution occurs within a species or population. Understanding the difference between microevolution and natural selection can be challenging. An example of microevolution is when there is an increase in a particular gene's frequency in a population due to natural selection. If macroevolution is occurring, microevolution must be occurring as well. Because evolution happens over time, and it is hard to say when enough time has passed. You can safely say two organisms evolved differently when the two organisms are so different from one another that they can no longer produce offspring together. A valuable, free resource that can provide you more information on evolution, as well as pre-written lessons and activities, can be found on the Internet courtesy of the University of California Museum of Paleontology and the National Center for Science Education. Visit Understanding Evolution for Teachers on the Internet at http://evolution.berkeley.edu/evosite/evohome.html.

Demonstration of a bird syrinx

- On the field trip, we talked about birdcalls and the students listened to birdcalls. This activity helps illustrate the voice box of a bird, which is unique to birds, and important in making the sounds the students heard on the field trip.
- Tell the students that birds make noise in the same basic way that humans and many mammals do. Tell them that the part of the bird that makes this noise is called the **syrinx**. In humans, it is called the larynx (commonly called voice box). Because humans and birds evolved differently, they do not have the same type of voice boxes. You can define a syrinx as the physical part of a bird that produces sound.



- Explain that when air is forced to rub against a surface such as a flat muscle, a sound is produced. The volume and tone of the noise can be changed depending on the amount of air passing over the muscle and the tension of the muscle when air passes over it.
- Show the students a balloon and tell them it can behave like a syrinx. Blow up the balloon and stretch the mouth of the balloon as you let some air out. The noise that is produced is analogous to the noise birds produce.
- This demonstration shows how a bird uses its voice box that evolved over time.

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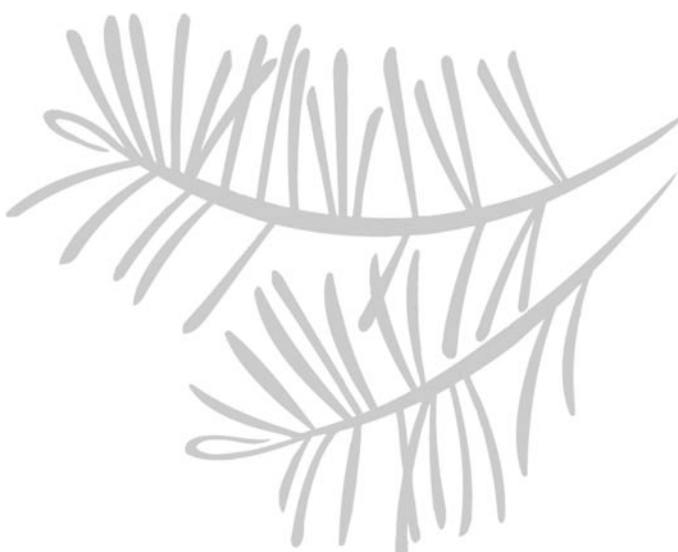

Pre and Post lesson assessment for Grade 6:
Erosion Exposes History of the Bay

These questions are intended to be administered both prior to and following the lessons in order to assess learning. Depending on student ability they can be done individually or as a group activity.

I. In-school lesson

- **What are some visible signs of erosion?**

  Coastal cliffs and creek-bed valleys where sediment layers have been exposed and paths worn into the soil from water flow.

- **What are the different types of fossils and how are they formed?**

  Molds and casts form when sediment fills a space that was once occupied by an organism. A mold is an impression left by a shell or bone while a cast forms when sediment has taken the shape of the ancient organism.

  Trace fossils are the remains of burrows, tracks and other animal signs left behind.

  Permineralization happens when water containing minerals drains through an organism and replaces the organic matter.

- **How can humans reduce the amount of sediment and pollution flowing into the Bay?**

  Plant trees, grasses and submerged aquatic vegetation (especially native ones) which hold the soil in place and filter pollution through their roots.

  Create and preserve wetlands.

  Reduce pavement and other impermeable surfaces near waterways that channel water away rather than absorbing it.

  Reduce the amount of man-made shorelines composed of rip-rap, bulkheads, seawalls, and breakwaters.

  Reduce the amount of waves caused by jet skis and speedboats by establishing No Wake Zones.

II. Field-trip experience

- **How does erosion affect the plants and animals living in the Chesapeake Bay?**

  Sediment washing into the bay reduces water clarity and therefore the amount of sunlight that reaches the submerged aquatic vegetation. Without enough sunlight to make food the submerged aquatic vegetation dies. Many bay animals need submerged aquatic vegetation for food and shelter.

- **How did the fossil layers get exposed around the Chesapeake Bay?**

  Through natural erosion caused by wind, water and ice.

- **Why is it important to study fossils?**

  We study fossils to learn about the organisms and climate of the past. By studying the past we can learn how different organisms adapted and evolved over geologic time. By studying the past, scientists can make better predictions about the future.

Pre and Post lesson assessment for Grade 7: Biodiversity Makes the Bay Better

These questions are intended to be administered both prior to and following the lessons in order to assess learning. Depending on student ability they can be done individually or as a group activity.

I. In-school lesson

- **What is the difference between asexual and sexual reproduction?**

  During asexual reproduction, a single parent makes an exact copy of its genetic material that is then transferred to its offspring.

  Sexual reproduction results in greater genetic variation because the offspring represents a mixture of the genes of two parents.

- **What is an example of an organism that reproduces asexually?**

  Lots of plants such as strawberries, potatoes and ivy reproduce asexually.

- **Which type of reproduction results in genetic variation and more biodiversity?**

  Sexual reproduction

- **Describe two animals that look similar but can't reproduce with one another because their genetic material is not similar enough.**

  Any two animals that are from the same genus may look similar but can not reproduce with one another because they are genetically very different. Examples of animals might include different genera of turtles, birds, lizards, and snakes.

II. Field-trip experience

- **What is an ecosystem and what characteristics might a scientist use to classify different ecosystems?**

  An ecosystem is a collection of living, non-living and dead things that function together within the environment. Climate, major plant types, soil type and geography are all used to classify an ecosystem as forest, wetland, field, etc.

- **What are two calculations scientists use to determine whether an ecosystem is diverse?**

  Species richness (The total number of different species present in a particular area)

  Relative abundance (The proportion of the total number of organisms living in a particular area represented by a single species.)

- **What are some reasons it is important to have biodiversity in the Chesapeake Bay area?**

  Different plants perform different functions in the ecosystem such as holding soil in place, filtering water before it flows into the Bay, and providing a variety of food and shelter for a variety of animals.

  Different animals perform different functions in the ecosystem such as transporting seeds and consuming dead animals to prevent the spread of disease.

  Once an organism becomes extinct, we lose all the benefits of that organism.

Pre and Post lesson assessment for Grade 8:
Genes are the Key to Bay Biodiversity

These questions should be administered both prior to and following the lessons in order to assess learning. Depending on student ability they can be done individually or as a group activity.

I. In-school lesson

- **What are the two main types of reproduction and which one leads to greater genetic diversity or biodiversity?**

  Asexual reproduction in which one parent makes an exact genetic copy of itself

  Sexual reproduction in which the genetic material from two parents combines, thus leading to greater genetic diversity

- **Briefly describe the process of natural selection.**

  Natural selection is the process in which organisms possessing adaptations (a physical or behavioral trait that helps a plant or animal survive in its habitat) are more likely to survive and pass on their traits through reproduction. This results in adaptations becoming more common in a population over time.

- **How can humans affect the process of natural selection? What are some examples of human-influenced selection?**

  Humans can artificially select organisms with traits that are desirable to us and have these organisms interbreed. The desired trait would then increase in the population.

  The selection of disease resistant organisms (such as oysters) is an example of how humans select organisms instead of nature. The variety of dog breeds is also due to human selection. Traits in farm animals and crops are another example of traits selected by humans to increase the amount of milk, meat, and grain produced.

II. Field-trip experience

- **What important role do genes play in creating biodiversity?**

  Genes are the basic physical unit of heredity carried on chromosomes and they are responsible for an organism's traits. Genes, and therefore traits, are passed from one generation to the next and they can create a diversity of organisms within a population.

- **Why is biodiversity important in the Chesapeake Bay area?**

  A diversity of plants and animals can help damaged landscapes recover by transporting a variety of seeds to the damaged landscape (such as a barren field).

  Different plants perform different functions in the Chesapeake Bay ecosystem such as holding soil in place, filtering water before it flows into the Bay, and providing a variety of food and shelter for a variety of animals.

Different animals perform different functions in the Chesapeake Bay ecosystem such as transporting seeds and consuming dead animals to prevent the spread of disease.

Once an organism becomes extinct, we lose all the benefits of that organism.

- **Describe an example of an adaptation you might be able to observe in a plant or animal in the Chesapeake Bay area.**

  Any evidence of a local plant's ability to grow in a particular area, reproduce, protect itself, or make food can be an example of an adaptation.

  Any evidence of a local animal's ability to survive in a particular area, reproduce, protect itself, or find food can be an example of an adaptation.

- **Describe an example of natural selection that could have occurred to a population of plants or animals that can be found in the Chesapeake Bay area. In your example, describe how certain traits were beneficial and became more common in the population.**

  Any scenario involving a population or group of local plants or animals that shows similar adaptations throughout the population. The assumption is that these adaptations were selected by nature over time and, therefore, became more common in the population.

  Examples:

  A group of milkweed plants all have the ability to produce seeds that are transported by wind. This helps the plants transport their seeds to other areas. Flowers with this trait were more successful at reproducing and passing this trait onto future generations, so this trait became more common in the population.

  All the females in a group of mallard ducks have brownish feathers. The females that were brown were able to hide and avoid predators. These females survived and were more successful at reproducing and passing this trait onto future generations. Therefore, brown colored females became more common in the population.

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PICKERING CREEK Audubon CENTER

11450 Audubon Lane • Easton, Maryland 21601
410-822-4903 • www.pickeringcreek.org • www.audubon.org
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