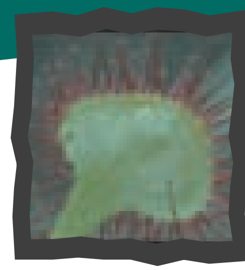
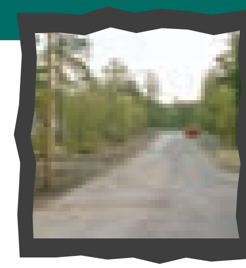


GEOLOGY HISTORY WATER BIODIVERSITY HUMAN IMPACTS & CONSERVATION

THE PINE BARRENS:

UP Close & Natural

INQUIRY BASED CURRICULUM

Geology

Introduction

Geology & Soils

The Pinelands National Reserve stretches from the western edge of New Jersey's Outer Coastal Plain, where the Pine Barrens begins, to Island Beach State Park, a barrier island on the Atlantic Coast. The life this region supports, both human and non-human, is shaped by the soils and waters arising from its geologic history. To understand the natural and human history of the region, the story of its geology and hydrology is a good place to begin.

The Pine Barrens is not barren at all, but is a complex mosaic of forests, wetlands, streams and ponds. Where you find truly barren land, it is the result of human actions, such as sand and gravel mining, not the "Barrens'" natural state.

East Plains

Why, then, the name Pine Barrens? The answer lies in a certain cultural bias that European settlers brought with them to America: that if land did not support the raising of their traditional farm crops, then it was "barren." The dominant soils of the Pine Barrens are porous, acidic and low in humus and nutrient content – poor conditions for row crop farming. Indeed, the Pine Barrens forests have only survived because their soils are so "poor." The irregular patterns of soils around the Pine Barrens edge can still be easily made out simply by the boundary where forest gives way to farmland and, increasingly, the housing subdivisions into which farmland is being converted.

Pine Barrens Geologic History

As elsewhere, the unique geologic history of the Pine Barrens has shaped its character today. Prior to the Cretaceous Period (about 145 million years ago), what is now the Outer Atlantic Coastal Plain consisted of metamorphic rock formations. Through the next 140 million years of the Cretaceous and Tertiary Periods, the coastal plain was repeatedly submerged as worldwide sea levels rose and fell during global cycles of glaciation and melting. When the coastal plain was under the sea, sediments were washed down from the coastal lands into the sea and settled on the sea floor. The seas deposited deep layers of sands, silt, and clays that dominate the formations beneath the Pine Barrens today.

The last layer of sediment to be laid down in this way was the sand we call Cohansey Sand, deposited during the Miocene epoch. This soil is composed of very coarse quartz-dominated ("quartzose") sand. Because of its large grain size and the fact that quartz does not weather or break down into clay-sized particles, the Cohansey Sand is very porous and does not hold organic matter and nutrients well. Such quartzose soil also tends to be very acidic, as explained below.

During periods of sea level retreat, new layers of sand and gravel were deposited across the coastal plain by rivers running down from higher land to the north. The Hudson River ran through what is now central New Jersey during periods when the sea had retreated. The soil we call Beacon Hill Gravel was a gravel bar created by the Hudson River about 6 million years ago. The Hudson River continued to migrate south, eventually following the path that later became the Delaware River. As the Hudson migrated across southern New Jersey, it deposited gravel across the coastal plain.

During the modern Quaternary period, the Pleistocene glaciation had a major impact on the shape of today's Pinelands. The last retreat of the seas at the end of the Tertiary Period left a coastal plain whose shore extended far to the east of today's coast. About 700,000 years ago, global temperatures dropped sufficiently to create massive glaciers that moved down into the temperate zones of North America and Europe in four major waves of glacial advance. These waves of glacial advance were separated by warmer periods during which melting ice sheets sent vast amounts of water and sediments flowing south across today's outer coastal plain of New Jersey. The most recent of the glacial waves is called the Wisconsin Ice Sheet, which reached as far south as modern New York City and began its final melting and retreat about 18,000 years ago.

While the Pine Barrens were not covered by glaciers, the climate was much colder, and run-off from the glaciers deposited sands and gravels along streams and deltas that carried melting glacier water to the sea. Intense wind erosion and deposition of soil is thought to have scoured large amounts of material from the region's surface and helped create the topography we see today. During this period, rivers running across the coastal plain also carried off most of the recent layers of sand and gravel sediments, leaving formations like the Beacon Hill Gravel only along higher ridges formed between shallow river valleys. When Beacon Hill Gravel weathers under the forces of wind, sun and rain it breaks down into clay soils. Some of these clays are still present as clay "lenses" embedded in the upper layers of earth as reddish-brown soils. This process of erosion once again exposed earlier deposits like the Cohansey Sands, which dominate the outer coastal plain of today.

The ecosystem of this period is thought to have been a sub-arctic tundra, similar to what is now found in Labrador. It appears that today's disjunct populations of northern plants, like Broom-Crowberry, arrived here during the final phases of the ice age. (Disjunct populations are those found in the Pine Barrens, but not in surrounding regions, so the Pine Barrens populations are separated from others of the same species by great distances.)

Through this geologic process, the coastal plain of New Jersey became a great wedge of unconsolidated soils in many layers of sand, silt, clay and gravel. The thin edge of the wedge is at the Delaware River, and the thick end at the Atlantic seaboard, where the wedge is about 6,500 feet thick. Today, these layers of sand and gravel are impregnated with fresh water, forming aquifers. Layers of silt and clay – soil types that can hold far less water and are more impermeable than sand and gravel – form the so-called "confining units" separating the various aquifers from one another.

The result of these processes is a region marked by a very flat terrain, very sandy soils, unique plant communities, and extensive wetlands, marshes and stream systems fed by the shallow aquifer system. The highest point in the Pine Barrens is said to be Apple Pie Hill at 205 feet above sea level.

Soils and Pine Barrens Ecology

What makes the Pine Barrens so different? Walk through the Pine Barrens and compare the landscape to images you have of other forests. The Pine Barrens is obviously different from what we might call a "typical" northeastern forest. Why is that?

The distinctive look of the Pine Barrens ultimately arises from its soils. Pine Barrens soil is largely sand. From this fact all else follows. The predominance of sand means Pine Barrens soils are highly porous to water, do not retain nutrients and organic matter very well, and are highly acidic.

Sandy soils are made up of large mineral particles, much larger than those in soils we call silt and clay. The large gaps between sand particles mean this soil is very porous - water drains easily through it. As rainwater and melting snow drain rapidly through Pine Barrens soils, they carry with them the organic matter - the particles of decomposed pine needles, leaves and animal bodies - that have the nutrients plants need. Thus, even though the Pinelands may receive the same amount of rainfall as land along the Delaware River or in northern New Jersey, the water moves so rapidly through the sandy soil that little moisture and few nutrients are kept. The sandy soil acts more like a coarse sieve than a sponge. This makes Pine Barrens soils very low in nutrients compared to most other soil types.

The sandiness of Pine Barrens soils also makes them highly acidic. *Here are some examples of the pH of typical Pine Barrens soils and stream water, compared with some common liquids:*

Pine Barrens pH level comparison to common liquids

Substance	pH
Stomach juices	1.5
Pine Barrens soils	3.6 to 5.0
Oswego River water	3.99 to 4.52
Pure water	7.0
Milk of magnesia	10
Household bleach	12.5
Oven cleaner	13.5

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

acidic *neutral* *basic*

Why are Pine Barrens soil and water so acidic? There are a couple of reasons. One is that even unpolluted rainwater is somewhat acidic, and "acid rain" can be very acidic. Most soils have the ability to buffer, or neutralize, this acidity. The Pine Barrens' sandy soils do not have this ability, because they do not hold the minerals and organic matter that do this buffering in richer soils. Another reason is that Pine Barrens soils have relatively high proportions of aluminum, which tends to break down water molecules (H_2O) into an H^+ and an OH^- ion, keep hold of the OH^- ion and release the H^+ ion into its surroundings.

Nutrient Cycles

Nutrients in soil are derived from the weathering of underlying “parent” rocks, recycling of nutrients taken up by organisms and returned to the soil through the decomposition of their dead bodies or plant materials, and the capture of nutrients from the atmosphere. In the Pine Barrens, each of these processes is influenced by the special characteristics of the soils and water, making them a little different in the Pine Barrens from other nearby ecosystems.

Shamong farm

Weathered rock makes up the mineral component of soil and takes many forms, depending on the type of parent rock and the weathering process it has endured. These soil minerals include numerous nutrients essential to the lives of plants and soil organisms, particularly phosphorous, potassium and calcium. In the Pine Barrens, the principle mineral component of the soil is silicaceous sand. This sand provides little or no nutrient benefit. The nutrients in Pine Barrens soils, therefore, derive more or less entirely from the decay of plant and animal bodies and atmospheric contributions.

The rate of decomposition of plant and animal material in the Pine Barrens is relatively slow by comparison with most other temperate forests. Organisms that carry out decomposition, such as bacteria and fungi, “mineralize” the large organic molecules making up plant and animal bodies, thereby incorporating essential nutrients into inorganic molecules which plants can absorb for metabolism, growth and reproduction. For example, saprophytic bacteria and fungi in the soil break down the amino acids incorporated into plant and animal tissues into ammonia (NH_3) or ammonium (NH_4^+). Nitrifying bacteria in turn convert ammonia and ammonium into nitrate (NO_3^-) through oxidation reactions. Plants absorb nitrate, as well as ammonium and ammonia, and use the nitrogen to build the amino acids that make up proteins, DNA and other critical molecules.

In the Pine Barrens, the acidity of the soil and plant materials suppress bacterial decomposition, so the dominant saprophytes are fungi. The acidity and droughtiness of Pine Barrens soils also exclude earthworms, which in many other ecosystems play an important role in fostering decomposition by mixing and aerating soil. In Pine Barrens forests, ants flourish and play the role that earthworms have elsewhere in carrying out “bioturbation” of the soil and litter layers.

The fixation of nitrogen from the air and from precipitation is an important source of nitrogen for living things. Atmospheric nitrogen (N_2) is converted into forms plants can use by two means: by a reaction with oxygen in the atmosphere at high temperatures (as by lightning) to form nitrate, which comes to earth dissolved in rain drops; and by nitrogen-fixing microorganisms, particularly blue-green algae and bacteria that live in the soil or in symbiotic relationships with certain plants, to form ammonium.

In the Pine Barrens, the porous soils mean that water percolates rapidly down through the soil to the water table, carrying nutrients with it and away from plants’ feeder roots in the upper organic soil horizons. To deal with this situation, Pine Barrens ecosystems have evolved an efficient nutrient cycling system that relies heavily on mycorrhizal associations between fungi and plants. In these associations, fungi and plant roots combine to create mycorrhizi. In some cases, fungal tissue actually enters and becomes part of the plant root cells; in others, fungal strands grow in between the cells of plant roots. The mycorrhizi greatly increase the roots’ surface area, thus enabling the plant to absorb nutrients from the soil more efficiently as the nutrients are mineralized by bacteria and other, saprophytic fungi. In exchange, the fungi get carbon from the photosynthesis carried out by the plant. The mycorrhizi can also carry out decomposition of organic material directly, thus bypassing the mineralization process.

Barnegat Bay

Barnegat Bay, Manahawkin Bay and Little Egg Harbor form a single, connected estuary nearly 70 km long. Barrier islands create the Bay, trapping the ever-changing mixture of fresh water flowing into the Bay from the west and the sea water flowing in through gaps in the barrier islands from the east. As an estuary, a place where fresh and salt water mix, Barnegat Bay is a biologically very productive ecosystem.

Barnegat Bay is created by the barrier islands. These islands are very large sand banks which have risen above the high tide mark. The sand bars were created, are maintained, and are constantly being changed by waves and storms that wash sand onto, and away from, the islands. As the islands grew high enough to separate the ocean from the bay, rivers and ground water continued to feed fresh water into the bay. The salinity of the bay water dropped and estuarine environments arose.

Barnegat Bay is a shallow estuary. It is so shallow that scientists often call it a "lagoon." The Bay ranges in depth from less than 1 meter to 6 meters, where the Bay is dredged for the Intracoastal Waterway. Its average depth is about 1.5 meters, with much of the Bay being shallower than that. The volume of water in the Bay is about 238,000,000 m^3. Its total surface area is about 279 km^2. The water in Barnegat Bay is an ever-changing mixture of sea water from the ocean to its east and freshwater from the streams and aquifers to its west.

Inlets from the sea (or, depending on the tide, outlets to the sea) are found only at Barnegat Inlet and Little Egg Inlet, which are natural breaks in the barrier islands, and Manasquan Inlet/Point Pleasant Canal, an artificial canal. If not for human engineering, the natural inlets would migrate as sand bars shift with storms and tides. In 1939-40, jetties were constructed at Barnegat Inlet, which prevents the natural movement of the inlet, and the jetty on the south side of the inlet had to be reconstructed in 1987-91 to stop the formation of sandbars between the jetties. Little Egg Inlet is broader and does not have permanent structures to keep it open.

The bottom of Barnegat Bay is a mosaic of sand, silt, clay, shells, and organic matter. The size of the grains of sand tends to get larger as you move from west to east. The sediment entering the Bay in stream waters flowing into the estuary's western edge tends to contain more silt and clay (smaller grains), since these grains are lighter and more easily swept along in the stream flow. The sediments on the eastern side are more heavily influenced by beach sand being deposited by tides, waves and wind. The coarsest sands come from the ocean and tend to accumulate in the mouths of the two inlets, creating shoals or sand bars inside and near the inlets. As you move away from the inlets, the size of sand grains tends to get smaller, as these grains are carried more easily by the incoming tide deeper into the Bay.

Salt water flows into the Bay through the channels to the sea, primarily through Little Egg Inlet and Barnegat Inlet. Water flows in and out with the tides. Tides within the Bay range over about 1.5 m in height, but the height and velocity of the tides vary across the Bay. The many islands, sand bars and mudflats within the Bay alter and reduce the size of tidal changes, so high and low tides are delayed and may be reduced to very small swings the farther one is from the inlets.

Fresh water flows into the Bay from the rivers and streams that flow in from the Pine Barrens and from groundwater that seeps in from the Kirkwood-Cohansey aquifer system. Most of Barnegat Bay's watershed, about 70%, drains into the Bay north of Barnegat Inlet, and most of that 70% lies in the Toms River drainage area. The largest streams feeding Barnegat Bay by volume of water are Toms River (7.8 m^3/sec), Metedeconk River (4.2 m^3/sec) and Cedar Creek (3.8 m^3/sec). The total amount of fresh water flowing into the Bay from rivers and streams is estimated to be about 22.5 m^3/sec. Freshwater also seeps into the Bay directly from the Kirkwood-Cohansey aquifer. The volume of freshwater entering the Bay directly through the aquifer is hard to estimate, but is thought to be about 3m^3/sec. These figures are annual means, or the rate in an average second in an average year.

It is important to remember that the amount of water in these rivers and streams varies over the course of a year and from one year to the next. It is estimated that in periods of drought, the volume of water entering the Bay from rivers and streams can fall to about 1/3 or even 1/2 of the mean annual volume. Summer flows have been measured in some years to be about 1/2 of the annual average flow.

Drought is not the only factor that may reduce fresh water flows into the estuary. The Kirkwood-Cohansey aquifer system supplies about 90% of the water in the rivers and streams feeding Barnegat Bay, in addition to the fresh water the aquifer supplies directly to the Bay. Depleting the Kirkwood-Cohansey, therefore, means depleting the rivers and streams that sustain the estuary. Studies show that human exploitation of the aquifer for drinking water, irrigation and household uses has lowered the water table, so there is less fresh water in the aquifer. This depletion of the aquifer also reduces the amount of water flowing in the rivers and streams, because the aquifer is the source of water for these rivers and streams. The exact scale of these changes is currently unclear. Right now, no one has a good handle on how much water people are removing from the system through wells in the Kirkwood-Cohansey aquifer. Government and academic scientists have begun a major study of how much we humans can take for our own uses without harming the environment, a threshold we may or may not have already exceeded.

Much more salt water flows into the Bay than fresh water. Because of the many islands, channels, sand bars and other obstacles throughout the Bay, tidal effects and currents are complex, and can be very confusing. In shallower parts of the Bay, local currents may be governed more by winds than the tide.

All the water in Barnegat Bay changes as sea tides bring in new water and take old water out to sea. The rate of exchange is relatively slow in the case of Barnegat Bay, due to the length of the Bay and its small number of outlets to the sea. One researcher calculated the typical flushing time for the Bay as 27 days in January and 71 days in June/July 1995, suggesting a significant seasonal variation. This means that pollution and contaminants stay relatively long in the Bay. So we cannot count on everything we put in being washed out to sea before it can do any harm.

Cedar Creek

GEOLOGY | Title: Geologic History of the Pines

LENGTH: 45 MIN. | GRADE: 9-12

OBJECTIVES

Students will be able to…

- Distinguish between Total time, Planet time and Human time.
- State key geologic events that shaped the Pine Barrens.

OVERVIEW

Thought the use of time ropes the students will visual see the time lengths and key events on four (4) different time scales. The student will view Total time, Planet time, Human time and Pine Barrens time.

PROCEDURE

Pre – Lesson Set up

❍ Total Time Rope

14 feet long
Scale: 60 Billion Years = 120 inches
2 inches = 1 billion years

a) Tie first twist tie two feet in from the end – Beginning of Time
b) Tie the second tie 9 inches (4.5 billion years) alone the rope – Formation of the Earth
c) Tie the next tie 9.5 inches (5 billion years) along the rope – Life on Earth
d) Tie the next tie 27 inches (13.5 billion years) along the rope – Present Time
e) Tie the last tie 120 inches (60 billion years) from the first tie on the rope – The End of Time

14-foot rope (total time)

❍ Planet Time

10 feet long
Scale: 4.5 billion years = 90 inches
2 inches = 1 million year

a) Tie first twist tie two feet in from the end – Formation of Earth
b) Tie the next tie 10 inches (.5 billion years) alone the rope – Life Appears
c) Tie the next tie 64 inches (1,300 million years ago) alone the rope – Plants Appear
d) Tie the next tie 78 inches (670 million years ago) alone the rope – Animals Appear
e) Tie the next tie 86 inches (2 million years ago) alone the rope – Humans Appear
f) Tie the last tie 90 inches (4.5 billion years) alone the rope – Now

10-foot rope (planet time)

❍ Human Time

10 feet long
Scale: 2 million years = 100 inches
1 inch = 25,000 years

(a) Tie first twist tie two feet in from the end (2 million years ago) – Humans appear
(b) Tie the next tie 4 inches (1.9 million years ago) alone the rope - Hunting
(c) Tie the next tie 25 inches (1.4 billion years ago) alone the rope – Fire Making
(d) Tie the next tie 96 inches (100 thousand years ago) alone the rope – Ritual Burial
(e) Tie the next tie 98 inches (45 thousand years ago) alone the rope - Speech
(f) Tie the next tie 99 2/5 inches (10 thousand years ago) alone the rope - Agriculture
(g) Tie the next tie 99 4/5 inches (5 thousand years ago) alone the rope - Writing
(h) Tie the last tie 100 inches alone the rope – Now

10-foot rope (human time)

❍ **Pine Barrens Time**

14 feet long
Scale: 140 million years = 140 inches
1 inches = 1 million year

a) Tie first twist tie one foot in from the end – Atlantic coast physiographic provinces formed
b) Tie the next tie 40 inches (100 million years ago) alone the rope – Sea intrusions begin
c) Tie the next tie 135 inches (5 million years ago) alone the rope – Last Sea Intrusion deposits Cohancy Sand
d) Tie the next tie 139 9/10 inches (100,000 years ago) alone the rope – Wisconsin Glaciation
e) Tie the next two ties next to each other at 140 inches - Humans appear approximately 10,000 years ago (first tie). Today second tie.

14-foot rope (pine barrens time)

❍ Set the time ropes aside where they can be easily reached.

Procedure

❍ Show the students the Total Time Rope. Explain that the rope is a visual representation of total time. It represents 60 billion years in which 2 inches equals 1 billion years.

❍ Describe and explain the event that happened at each tie.

a) The first twist tie two feet in from the end represents the beginning of time. Scientists refer to this event as the "Big Bang". It represents the beginning of time; there was no before that can be known.
b) The second tie 9 inches (4.5 billion years) alone the rope represents the formation of the Earth. There was no life on the Earth at the time.
c) The next tie 9.5 inches (5 billion years) along the rope, a mere half an inch further down the rope, represents the beginning of life on Earth
d) The next tie 27 inches (13.5 billion years) along the rope, a span of 8.75 billion years, that represents Present Time. The scale of this rope does not allow us to show the space from the first humans to the present time. It is only 1/250 of an inch (2million years).
e) The last tie 120 inches (60 billion years) from the first tie on the rope represents the end of time. Our current understanding is that the universe is expanding and might be open closed. It will continue to expand until the space between the smallest of particles will be great enough so that they no longer interact. If nothing interacts than there is no behavior to observe so no time. Another possibility is that the universe is expanding and might be closed. It will expand as far as it can and then begin to contact at the end of which time will have no meaning.

❍ Show the students the Planet Time rope. Explain that the rope is a visual representation of the time of the Earth. It represents 4.5 billion years in which 2 inches equals 1 million years.

❍ Describe and explain the event that happened at each tie.

a) The first twist tie two feet in from the end represents the formation of Earth 4.5 billion years ago.
b) The next tie 10 inches (.5 billion years) alone the rope represents the time when life first appears.
c) The next tie 64 inches (1,300 million years ago) alone the rope represents when plants first appear.
d) The next tie 78 inches (670 million years ago) alone the rope represents when animals first appear.
e) Tie the next tie 86 inches (2 million years ago) alone the rope represents when humans' first appear.
f) The last tie 90 inches (4.5 billion years) alone the rope represents the present time.

❍ Show the students the Human Time Rope. Explain that the rope is a visual representation of human time. It represents 2 million years in which 1 inch equals 25,000 years.

❍ Describe and explain the event that happened at each tie.

(a) The first twist tie two feet in from the end (2 million years ago) represents when Humans first appear.
(b) The next tie 4 inches (1.9 million years ago) alone the rope, Humans develop Hunting.
(c) The next tie 25 inches (1.4 billion years ago) alone the rope, Humans first develop fire making.
(d) The next tie 96 inches (100 thousand years ago) alone the rope, Humans first begin ritual burial.
(e) The next tie 98 inches (45 thousand years ago) alone the rope, speech is developed.
(f) The next tie 99 2/5 inches (10 thousand years ago) alone the rope, agriculture is developed.
(g) The next tie 99 4/5 inches (5 thousand years ago) alone the rope, writing is developed.
(h) The last tie 100 inches alone the rope represents present time.

❍ Show the students the Pine Barrens rope. Explain that the rope is a visual representation of Pine Barrens time. It represents 140 million years in which 1 inch equals 1 million years.

❍ Describe and explain the event that happened at each tie.

a) The first twist tie one foot in from the end – Atlantic coast physiographic provinces are formed.
b) The next tie 40 inches (100 million years ago) alone the rope represents the first of several sea intrusions. Each intrusion destroys all terrestrial plant cover.
c) The next tie 135 inches (5 million years ago) alone the rope represents the last sea intrusion and deposits the Cohancy Sand.
d) The next tie 139 9/10 inches (100,000 years ago) alone the rope represents the Wisconsin Glaciations. During the Wisconsin Glacuation the ice front of the glacier was 10 miles north of the Pine Barrens, closer than and other previous ice sheet. It is at this time that the Pine Barrens vegetation of today was established.
e) The next two ties next to each other at 140 inches represent the first human inhabitants, approximately 10,000 years ago (first tie), and the present.

❍ Explain to the students that modern people have only been in the Pine Barrens for a very short time. In that time people have created major change in that short time. As we study more about the Pine Barrens it will help to keep these ideas of time in mind.

Optional Activity

❍ Have the students create another set of events related to the Pine Barrens that could be represented on a time rope.

Extensions

- Why isn't there a tie for the appearance of humans on the first, Total Time, rope?
- What is the last major geologic event that helped create the Pine Barrens we see today?

Materials

❏ **Time Ropes**

- ❏ **(4) 10 - 14 ft of rope for each time rope**
- ❏ **30 twist ties (various colors if possible)**
- ❏ **Colored marking pens**
- ❏ **A yardstick or ruler**

New Jersey Core Curriculum Standards

3.5, 4.6, 5.11 & 5.12

Glossary:

Physiographic: The study of the natural features of the earth's surface, especially in its current aspects, including land formation, climate, currents, and distribution of flora and fauna. Also called physical geography.

Glaciations: 1: the condition of being covered with glaciers or masses of ice; the result of glacial action; "Agassiz recognized marks of glaciation all over northern Europe" 2: the process of covering the earth with glaciers or masses of ice.

Million: The cardinal number equal to 10^6.

Billion: The cardinal number equal to 10^9.

GEOLOGY | Title: Hunting for the Elusive Amoeba in the Pine Barrens

Length: One class period may be required to prepare, pour and label Petri dishes. One class period may be required to collect samples. One week may be required to make observations on a daily basis.

Grade: 9-12

Objectives

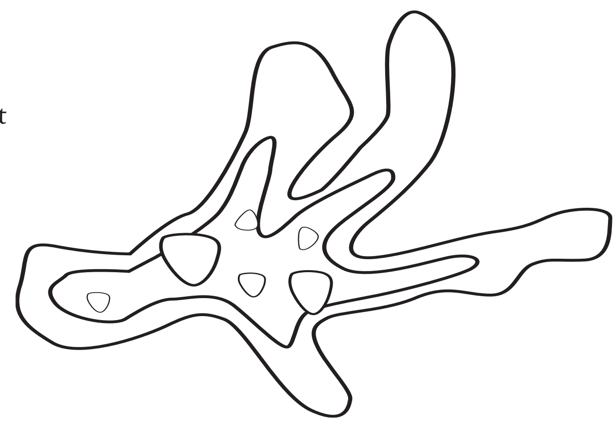
Students will be able to…

- Examine soil samples from different Pine Barrens habitats to isolate amoebae.
- Illustrate biodiversity in a microenvironment in the Pine Barrens.
- Utilize collection and plating procedures.
- Utilize inquiry as a process to generate hypotheses about environments that would produce the greatest diversity.
- Construct an experimental design.

Overview

Program Background:

The soil is home to the largest biodiversity on this planet, the most common being the bacteria, fungi and algae. However, they are not the only soil organisms of biological and ecological significance. Of equal importance are protozoans, earthworms, nematodes and insects. This lab will focus on a method of locating *Amoebae*, members of the Protozoa.



Amoeba

Protozoa are unicellular, eukaryotic microorganisms. The *Amoebae* move by means of pseudopodia. Many of them obtain their food by holozoic nutrition characterized by direct feeding on microbial cells such as bacteria. It has been estimated that one species of *Amoeba* requires 40,000 bacteria per cell division; consequently bacteria must reproduce at a rapid rate to keep pace with their predators. This information suggests that the protozoa populations are important in limiting the bacteria population maintaining a balance in this highly populated soil habitat.

Amoeba are usually found near the surface in the upper six inches of the soil that are warm, moist, and rich in organic matter, as these conditions encourage a high bacteria population. Amoeba tolerate a range of pH with a preference for acidity. Acidity is characteristic of the Pine Barrens. Since soil is a complex habitat, with a rich biodiversity component, collecting amoebae will also show other organisms coming out of the soil. This activity may lead to other investigations of the soil ecosystem. It can be noted that the *Amoebae* survive unfavorable conditions by forming cysts.

Program Description

Samples of soil from different Pine Barrens habitats will be utilized to isolate amoebae. Small samples of soil are placed on an agar gel surface in the center of a Petri dish. A ring of food bacteria, *Enterobacter aerogenes*, is swabbed around the soil samples. Under low power, amoeba can be seen coming from the soil, as well as nematodes, fungi, and other protozoans. This lab illustrates biodiversity in a microenvironment and can be done as a parallel investigation with the biodiversity found in the macroenvironment of leaf litter.

Procedure

❍ Pour and label six sterile Petri dishes with 20 ml of prepared agar that is nutrient deficient (no added nutrients). Agar prep is 20 grams of agar/1liter of distilled water.

❍ Have containers and tools to collect soil samples. Plastic bags to retain moisture work well.

❍ Have sterile swabs and/or inoculating loops, along with plastic wrap/parafilm to prevent agar plates from drying out.

❍ Have a culture of a suitable food bacterium, *Enterobacter aerogenes*.

❍ Select six microenvironments of varying decomposition. The five experimental sites are soil under pine needle dead fall, soil around a decaying log, mud from the edge of a stream, soil around the knee of a living tree, and soil under a decaying animal, or choices specified by students based upon your location. The sixth microenvironment is sand that is the control. Additional microenvironments can include clay soil, loamy soil, dry areas, soil moist from a human source, soil naturally moist or the middle/bottom of a water source. Students can be creative in their suggestions.

❍ Inoculate each Petri dish in the center with a pea size sample of each of the 6 soil types using a scoopula.

❍ Using a sterile swab, carefully make a ring one centimeter in diameter around the bit of soil. Between the soil and the surrounding bacterial ring there should be a bare agar surface.

❍ Incubate the plates upright and at room temperature for forty-eight hours. Observations are recorded at intervals of two, four, and seven days. Observations are qualitative in nature, using the microscope, digital camera images and written descriptions.

Part II

❍ It is possible to question the amount and kind of bacteria found in each of the soil samples. So as to isolate just bacteria, obtain Petri dishes that are made with nutrient agar containing cyclohexane (a fungicide).

❍ Make a series of dilutions resulting in 1 gram of soil/1000 ml distilled water.

❍ Streak the soil dilutions on to the agar plates and incubate them for seventy two hours at room temperature.

❍ Make qualitative observations.

Optional Activity

The Woodrow Wilson Foundation Leadership Program for Teachers 1999 Summer Biology Institute Biodiversity “The Search for Microbial Biodiversity: Using a Winogradsky Column to Isolate Bacteria from Aquatic Sediment” http://www.woodrow.org/teachers/bi/1999/.

Materials

❏ Petri dishes containing a gel made from agar and water (no added nutrients)
❏ Containers and tools for collecting the soil samples
❏ Soil samples from six different microenvironments
❏ Sterile swabs and/or inoculating loops
❏ A culture of a suitable food bacgteriaum, *Enterobacter aerogenes*
❏ Microscope and/or stereoscope
❏ Optional equipment include flex cam and TV monitor or computer hook up, digital camera

New Jersey Core Curriculum Standards

5.1, 5.4 & 5.10

Glossary:

Biodiversity: The full range of biological organisms on Earth that includes plants, animals, fungi, bacteria, and viruses.
Biofilm: Layer of microorganisms and nutrients adhering to various surfaces.
Enterobacter aerogenes*:* a Gram Negative bacilli used as a food source for *Amoeba.*
Holozoic nutrition: Means "feeding like an animal" as in feeding on solid organic materials which are then digested internally to give smaller chemical fragments that are ready for absorption. Herbivores, carnivores and omnivores engage in holozoic nutrition and involves ingesting, digesting, absorbing, assimilating and egesting of nutrients.
Microenvironment: a specific set of physical, biological, and chemical factors immediately surrounding an organism.
Macro-environment: Large complex set of physical, chemical and biotic factors (as climate, soil and living things)that act upon an organism or an ecological community and ultimately determine its form and survival.
Pseudopodia: A method of cell movement utilized by Amoeba that when literally translated means "fake foot." Pseudopodia are not organelles or even structures but are extensions of the cytoplasm toward which the rest of the cytoplasm tends to flow.

Web Resources

The Woodrow Wilson Foundation Leadership Program for Teachers 1999 Summer Biology Institute Biodiversity http://www.woodrow.org/teachers/bi/1999/

The Woodrow Wilson Foundation Leadership Program for Teachers 1999 Commuter Institute Biodiversity http://www.woodrow.org/teachers/1999_Commuter_Institute/projects/Bacchi/

MicrobeWorld http://www.microbeworld.org/

Western Kentucky University Biology Home K-12 Resources
http://biodiversity.bio.wku.edu/

UBC Biodiversity Research Centre What is Biodiversity? Teachers Resources
http://www.zoology.ubc.ca/biodiversity

(This lesson plan is adapted from the Woodrow Wilson Foundation Leadership Program for Teachers 1999 Summer Biology Institute Biodiversity as created by Deborah Gatlin, Lynda Barraca, Marguerite Graham)

Student Activity

Inquiry

1. How would you characterize the soil environments that have the greatest diversity of microbes?
2. State a hypothesis that might allow you to predict which environment would have the greatest number /diversity.
3. How would you determine a control against which to test your hypothesis?
4. Which of the following items, on the list of possible materials, would be useful in your experiment?
   - ❏ Microscope and / or stereoscope.
   - ❏ Petri dishes containing a gel made from agar and water (no added nutrients).
   - ❏ Containers and tools to collect the soil samples.
   - ❏ Soil samples from different microenvironments.
   - ❏ Sterile swabs and /or inoculating loops.
   - ❏ Plastic wrap/Para film.
   - ❏ A culture of a suitable food bacterium, *Enterobacter aerogenes.*
   - ❏ Digital camera or camera to record each site.

5. Study the following collection and plating procedure:
   - ❏ From each environment collect a sample and place in a collection container.
   - ❏ Label the location on the bag.
   - ❏ Label the plate with name, habitat, date.
   - ❏ Place about a quarter of a teaspoon of soil sample in the center of the plate.
   - ❏ Using a swab, spread a circle of food bacteria provided about 2cm from the sample.
   - ❏ Cover the plate, wrap tightly, and place upright in a cool dark place for 48 hours
   - ❏ Make observations every 2, 4 and 6 days.

6. Design your experiment :
   - ❏ Write out your experimental design.
   - ❏ What method(s) are you going to use to analyze your data?
   - ❏ Draw/photograph all the organisms you observe on a separate sheet and indicate when they occurred.
   - ❏ Analyze your data.
   - ❏ What conclusion(s) did you draw.

GEOLOGY | Title: Porosity and Drainage Rate of Soils

LENGTH: 45-50 MINUTES | GRADES: 9-12

OBJECTIVES

Students will be able to…

- Identify the different physical components of soils.
- Predict the drainage rate of various soil types given soil composition.
- Describe how porosity is affected by soil size.
- Describe how porosity affects the ability of soil to hold water.

OVERVIEW

Soils are composed of different physical combinations of mineral particles and organic matter. Mineral particle size is a major factor that influences both aeration and water retention. Water tends to drain more rapidly through larger pore size than small pores. The speed at which the water passes through the soil determines how long water will remain in the soil to be used by organisms that live in the soil. In this lab, you will determine and compare the permeability of coarse gravel, fine gravel, sand, and soil by determining the permeability and porosity of each soil type. You will also observe the impacts of soil compaction on permeability and porosity.

PROCEDURE

PART 1: POROSITY

- ❍ Collect materials for your lab group.
- ❍ Measure 200 mL of sand with a graduated cylinder and place it in a 250-mL beaker.
- ❍ Fill a 250-mL graduated cylinder with water. Slowly pour water into the soil until the sample is saturated (water reaches the top of the soil).
- ❍ Determine the amount of water added to the sample by subtracting the amount left in the graduated cylinder from the original amount of water (200 mL) and record the amount in Data Table #1.
- ❍ Repeat steps for each soil sample (fine gravel, coarse gravel, and soil).

Sandy Road

Part 2: Permeability of Varied Soil Types

❍ Measure 500 mL of loosely packed soil in a graduated cylinder and place into the soda bottle.

❍ Place the soda bottle on top of a 500 mL beaker.

❍ Use the grease pencil to make a mark 2.5 cm above the bottom of the catch beaker.

❍ Slowly add 250 mL of water and begin timing on the stopwatch.

❍ Record the time it takes for the water to fill the catch beaker to the 2.5 cm line on the data sheet.

❍ Continue timing until water stops dripping from the bottom of the bottle, or it is dripping so slowly that it appears to have stopped flowing. Record the time it has taken from the time the water was added until this point in Data Table #2.

❍ Calculate the drainage rate in cm/hour.

❍ Measure how much water is in the catch beaker using a graduated cylinder and record the amount on the data table.

❍ You should notice that 250 mL of water has not drained through the soil sample. Subtract the amount of water that did drain out from 250 mL. This will be the volume of water that the soil retained.

❍ Repeat steps for each soil type.

Part 3: Compaction of Soil

❍ Place the 500 mL of soil into the soda bottle.

❍ Tightly pack the soils down, using a wooden dowel.

❍ Repeat steps from Part 2.

❍ Record your results in Data Table #2.

Materials

❏ Soil Samples (sand, small gravel, large gravel, soil)
❏ 250 mL graduated cylinder
❏ 250 mL beaker
❏ 500 mL beaker
❏ 2- 1 L empty soda bottle with holes poked through the bottom
❏ Wooden dowel
❏ Permanent marker
❏ Stopwatch
❏ Grease Marking Pencil

New Jersey Core Curriculum Standards

5.3.C.1 & 5.8.A.1

Glossary

Porosity: The volume of air and water that soil can hold.
Permeability: Selative ease in which water and air can move through soil.
Compaction: When pressure is applied to a soil surface.
Runoff: Water that is not absorbed by the soil and flows to lower ground, eventually draining into streams, lakes, rivers, and other bodies of water.

Soil Porosity

Student Activity

Student Record Sheet

Data Table 1: Soil Porosity

Soil Type	Original Amount of Water In Graduated Cylinder (mL)	Amount of Water Remaining in Graduated Cylinder (mL)	Pore Space Volume (mL)
Sand			
Fine Gravel			
Coarse Gravel			
Soil			

Data Table #2: Permeability

Soil Sample	Time Reached 2.5 cm	Percolation Rate (cm/hour)	Time until finished	Total Volume of Water Collected (mL)	Water Retained (mL)
Sand					
Fine Gravel					
Coarse Gravel					
Soil					
Compacted Soil					

1. Which soil sample has the most space to hold water? The least?
2. In what situations might it be useful to know the water-holding capacity a soil? Why?
3. What is the relationship between the permeability and the grain (particle) size of each soil sample?
4. How did the results you obtained for the porosity compared with the amount of water retained for each sample?
5. Which soil type tested in this activity would cause the most water runoff? The least?
6. What happened to the water that did not pass through your sample? Where is that water?
7. Below are the examples of drainage rates. How would you describe Pine Barrens soils in terms of drainage? How does this quality affect recharge of the aquifers in the Pine Barrens?

Description	Drainage Rate
Very Slow	Less than 0.5 cm/hour
Slow	0.5 to 1.6 cm/hour
Moderate	1.6 to 5.0 cm/hour
Rapid	5.1 to 16.0 cm/hour
Very Rapid	More than 16.1 cm/hour

8. Some people like to ride all terrain vehicles for recreation in the Pine Barrens. How would these vehicles affect the porosity of the soil as they drive back and forth over the Pine Barrens soils? What impact could this have on the soil organisms of the Pine Barrens?

GEOLOGY | Title: Soil Analysis

LENGTH: 2–3 CLASS PERIODS | GRADE: 9-12

OBJECTIVES

Students will be able to…

- Collect soil samples representing different soil types.
- Analyze samples for physical and chemical properties.
- Compare and contrast samples from different soil sources.

OVERVIEW

Program Description

Students collect soil samples from home and school and then test the samples for physical and chemical properties.

PROCEDURE

❍ Have students collect soil samples from different location recoding the location, time and general weather conditions.

❍ In groups, have students review Soil Analysis Directions worksheet.

❍ In groups, have students perform soil tests and record results.

❍ Compare sample results from various locations.

MATERIALS

❑ LaMott soil sample kits
❑ Soil sample tubes
❑ Several aluminum cans
❑ Electronic balance
❑ Earth colors guide book

NEW JERSEY CORE CURRICULUM STANDARDS

5.8A,C&D

GLOSSARY

Percolation rate: In chemistry and other physical sciences, percolation is a type of filtering.
Infiltration: The act or process of infiltrating; The state of being infiltrated; Something that infiltrates.
Sand: A sedimentary material, finer than a granule and coarser than silt, with grains between 0.06 and 2.0 millimeters in diameter.
Silt: A sedimentary material consisting of very fine particles intermediate in size between sand and clay.
Clay: A fine-grained, firm earthy material that is plastic when wet and hardens when heated, consisting primarily of hydrated silicates of aluminum and widely used in making bricks, tiles, and pottery.
Water holding capacity: The ability and quantity of water that soil can maintain.
Loam: Soil composed of a mixture of sand, clay, silt, and organic matter.
Soil nutrients: A source of nourishment and richness in soil.
Runoff: Rainfall not absorbed by soil.
Recharge: To replenish.

Soil Analysis

Student Activity

Inquiry

1. In what situations would knowing the water holding capacity of the soil be important or useful?
2. Why is it best that the water holding capacity be between 60% -80%?
3. Obtain and examine the class data for all tests. What conclusions can you draw about location and site description of each soil sample in relation to others?
4. Describe the optimum pH and mineral concentration of soil. Of what biological importance are these substances?
5. How does soil particle size affect the type of plants that can be successfully grown in that soil? Why?
6. Describe the benefits provided to an ecosystem by organic matter in soil.
7. What is the outer coastal plain of New Jersey? Describe the characteristics of its soils and the ecological and agricultural implication of these characteristics.
8. Choose one nation, not in North America, and research it's agricultural productivity. What are its major products? How does this relate to the state of the soil? Could this nation be self-sustaining with regards to food production? Why or why not? What are the population growth rate and the doubling time?

Soil Analysis Directions

Moisture Content of Soil

The amount of moisture found in soil varies based on climate, soil particle size and amount of organic material. This in turn impacts the biological components of the soil system.

1. Weigh a clean dry beaker and record in grams.
2. Add enough fresh soil to cover the beaker bottom to a depth of 1-2 cm.
3. Reweigh the beaker + soil and record.
4. Heat the sample at around 75C for 24 hours.
5. Reweigh and record weight.
6. Calculate % moisture in sample.

Water Holding Capacity

The water holding capacity of soil is mainly dependent on humus content and size of soil particles. Generally water content should be 60 -80% of the soil's capacity. If the soil contains less than 60%, cellular needs of organisms may not be met. At more than 80%, too little oxygen is available for many organisms.

1. With an aluminum can open at both ends, attach two sheets of filter paper with a rubber band to one open end.
2. Using a spray bottle, lightly moisten the filter paper, allow to drip for ten minutes, then weigh the can +paper.
3. Weigh enough dry soil so as to cover the bottom of the can. Record.
4. Place the soil in the can and immerse overnight in water.
5. Remove the can and place it on a drying rack for 30 minutes. Weigh the can and contents.
6. Calculate % moisture. Compare with moisture content.

Student Activity

PERCOLATION RATE -(MUST BE DONE AT SITE OF COLLECTION)

The ability of water to enter the soil affects the hydrologic cycle, particularly runoff and recharge of aquifers. Increased impervious surfaces (as found in our area) impede this cycle.

1. Work a can, open at both ends, into the ground to about 4 cm.
2. Pour 100ml of water into the can and determine the amount of time it takes for the water to percolate into the ground (use a stop watch for this).

SEPARATION OF SOIL BASED ON PARTICLE SIZE

Soil is made of an organic portion (humus and dissolved organics), an inorganic component (sand, silt and clay) and a living component (invertebrates, fungi, bacteria, etc.). The functioning of a soil community depends largely on particle size. Typically the best farm soils are a combination of silt and sand, with a bit of clay and good amount of organic material. We call these soils loams.

1. Weigh out approximately 20 grams of dry soil. Record the mass.
2. Place the sample in the top of the sieve tower. Replace the lid and agitate for 30 seconds by shaking.
3. From each chamber, carefully remove the portion of the sample found within and weigh and record that portion as % of the total.

SOIL COLOR

Soil color is based on mineral, organic and moisture composition. Knowing the color can thus allow one to make certain generalizations about location and functioning/activity.

1. Use the Earth Colors Guide and match your sample, wet and dry, to the appropriate color.
2. Document the color for both and compare to other samples.

SOIL NUTRIENTS

The elements N, P, K and Ca are essential to the growth and development of plants and animals. Except for N, the other three are released into the soil via weathering. Concentrations depend on type of soil, precipitation patterns and biological activity. Often humans add nutrients to the soil to enhance growth and/or productivity. A typical bag of fertilizer you might purchase has numbers such as 10-10-10. The numbers represent the % content of the bag in the order N-P-K.

1. Reference the LaMotte chemical test directions found at each lab bench.
2. For each chemical test, use soil that is fresh and relatively dry.
3. Document the value for each test.

SOIL PH

The pH of the soil will impact the biological activity of that system. For example, decomposition can be significantly retarded by low pH, (pinelands for example). In addition community composition can also be impacted by varied pH (recall range of tolerance). Inputs of acid (via acid deposition or natural organic acids) can change the pH. Humans sometimes add lime (CaO) so as to allow plants to grow that require some degree of neutralization.

1. Reference the LaMotte pH directions at the lab bench.
2. Follow the directions and complete the pH test.
3. Document the value.

GEOLOGY | Title: Mines in the Pines

Length: 2 –3 Class periods   Grade: 9-12

Objectives

Students will be able to…

• Review open pit mining and be able to explain the basics of the process.
• Represent a special interest group in a given case study at a mock town meeting.
• Investigate the interdisciplinary nature of environmental issues and be able to distinguish the difference between fact and opinion.

Overview

Program Description

Students participate in a Town Meeting to decide the fate of an open pit mine project.

Procedure

❍ Students review the case study.

❍ Students are divided into groups and research the role of one of the special interest groups.

❍ In their groups, students' investigate topographic maps and biological features.

❍ In their groups, students' plan a presentation for town meeting representing their interest group.

❍ Students' present at the town meeting.

❍ Students' discuss the town meeting and the interdisciplinary nature of environmental issues.

Optional Activity

❍ Visit an open pit mine

❍ Attend a Pinelands Commission meeting

Materials

❏ Topographic Map

New Jersey Core Curriculum Standards

5.1A, 5.5B, 5.8A, B&D, and 5.10A&B

Glossary

Open Pit Mining: An excavation or cut made at the surface of the ground for the purpose of extracting ore and which is open to the surface for the duration of the mine's life.
Endangered Species: A species present in such small numbers that it is at risk of extinction.
CMP: Comprehensive Management Plan.
Wetlands: A lowland area, such as a marsh or swamp, that is saturated with moisture, especially when regarded as the natural habitat of wildlife: *a program to preserve our state's wetlands*.
Aquifer: An underground bed or layer of earth, gravel, or porous stone that yields water.
Clean Water Act: Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. The Act established the basic structure for regulating discharges of pollutants into the waters of the United States. (www.epa.gov/region5/water/cwa.htm)
Mining Regulations: The laws and statutes used to monitor and license open pit mines.

GEOLOGY | Title: Mines in the Pines

Introduction:

Resources in the NJ Pinelands have provided income and, in some cases, a sustainable way of life to generations of Pineys and newer transplants to the area. The extraction and utilization of resources (timber, sphagnum, sand, water etc.) however, is not without impact. The sensitivity of wetlands, the fragmentation of forest, the introduction of non-native species and pollution have all taken an ecological toll.

Proposal:

The enclosed maps provide an environmental, geographic and regulatory reference for the proposed site for a series of open pit sand mines to be established by Cohansey Industries in Cumberland County, NJ. Several NGOs and local residents have voiced concerns for the project citing violations to the CMP and, possibly, state laws. In response to these concerns, Cohansey Industries maintains their practices will be careful and sensitive and, as a token of their genuine concern for the environment, has proposed the establishment of a wetland nature park adjacent to the mine site, to be utilized by local schools and residents.

The Town Meeting:

Final approval has not been granted for the project. As a matter of course, the town meeting has been established to allow several groups to establish their take on the issue and facilitate communication between the parties involved and affected by the plan.

Of special concern: The wetland located on or near the tract, the presence of a state listed threatened frog and a very rare orchid, pollution in the watershed leading to critical shorebird habitat on the Delaware Bay shores, and the questionable applicability of CMP regulations in this Pinelands border region.

The Groups:

Cohansey Industries: the Mining outfit that plans to develop the sand mines for this project. The purport to be environmentally sensitive and wish to work with the community.

NJ Wetland Coalition: an NGO made of citizen scientists that studies and advocates protection for wetlands in the state of New Jersey.

Cumberland County Development Committee: a group of local business people and politicians that wishes to bolster the depressed local economy and increase industry and commerce in the area.

Pinelands Protection: An NGO that looks to uphold the CMP and will, as necessary, bring legal action against violators to its integrity. This group supports the designation of Pinelands Management Areas.

Vineland and Millville Schools: The local school boards, PTAs and student governments that have used the proposed mine area for field trips and investigations.

NJDOT: State department of transportation, this group references new, sensitive methods for road construction and roadside buffers that can protect wetlands and other vulnerable habitats.

CUMBERLAND COUNTY PROPOSED OPEN SAND MINING PROJECT