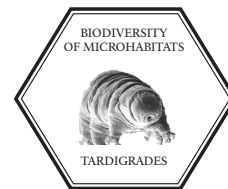


TARDIGRADES



THEME: Biodiversity in Microorganisms
BEST TIME TO PLAN TRIP: Fall or Spring

UNIT RATIONALE

When most students imagine national parks and nature in general they probably think of large animals such as bear and deer. Although bear, deer, and other visible animals are important parts of the ecosystem, there are other important pieces that we often overlook. Tardigrades and other microorganisms are some of the most numerous and most biodiverse organisms on Earth. This unit explores the biodiversity of these microscopic organisms. During this study students will be introduced to the process of collecting lichens and isolating resident tardigrades and other microscopic organisms.

NORTH CAROLINA CURRICULUM CORRELATIONS

EARTH/ENVIRONMENTAL SCIENCE GOALS AND OBJECTIVES

Essential Standard EEn.2.7 Explain how the lithosphere, hydrosphere, and atmosphere individually and collectively affect the biosphere.

- EEn.2.7.2 Explain why biodiversity is important to the biosphere.
- EEn.2.7.3 Explain how human activities impact the biosphere.

BIOLOGY GOALS AND OBJECTIVES

Essential Standards Bio.1.1 Understand the relationship between the structures and functions of cells and their organelles.

- Bio.1.1.2 Compare prokaryotic and eukaryotic cells in terms of their general structures (plasma membrane and genetic material) and degree of complexity.

Essential Standards Bio.2.2 Understand the impact of human activities on the environment (one generation affects the next).

- Bio.2.2.1 Infer how human activities may impact the environment.
- Bio.2.2.2 Explain how the use, protection and conservation of natural resources by humans impact the environment from one generation to the next.

AP BIOLOGY GOALS AND OBJECTIVES

Competency Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

- 1.01 The learner will identify questions and problems that can be answered through scientific investigations.
- 1.02 The learner will design and conduct scientific investigations to answer questions about the physical world.
- 1.03 The learner will formulate and revise scientific explanations and models using logic and evidence.
- 1.04 The learner will apply safety procedures in the laboratory and in field studies.

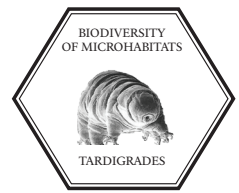
Competency Goal 6: The learner will develop an understanding of the unity and diversity of life.

- 6.02 The learner will survey the diversity of life.
- 6.03 The learner will analyze and apply current phylogenetic classification.
- 6.05 The learner will examine the structure and function of plants and animals.

Competency Goal 7: The learner will develop an understanding of basic ecological principles.

- 7.01 The learner will analyze population dynamics.
- 7.02 The learner will examine the actions and interactions of communities and ecosystems.





AP EARTH AND ENVIRONMENTAL SCIENCE (APES) GOALS AND OBJECTIVES

Competency Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

- 1.01 The learner will identify questions and problems in the earth and environmental sciences that can be answered through scientific investigations.
- 1.02 The learner will design and conduct scientific investigations to answer questions related to earth and environmental science.
- 1.03 The learner will formulate and revise scientific explanations and models using logic and evidence.
- 1.04 The learner will apply safety procedures in the laboratory and in field studies:

Competency Goal 2: The learner will build an understanding of the interdependence of Earth's systems.

- 2.05 The learner will investigate the biosphere.

Competency Goal 3: The learner will build an understanding of human population dynamics.

- 3.02 The learner will investigate local, regional and global carrying capacities.

Competency Goal 5: The learner will build an understanding of air, water, and soil quality.

- 5.01 The learner will analyze the sources of major pollutants.
- 5.02 The learner will investigate the effects of pollutants

Competency Goal 6: The learner will build an understanding of global changes and their consequences.

- 6.03 The learner will investigate effects and consequences on biota.

Competency Goal 7: The learner will build an understanding of environmental decision making.

- 7.04 The learner will develop an awareness of environmental options..

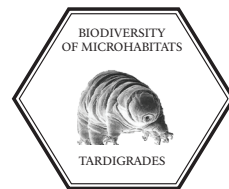
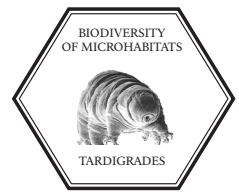


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PLANNING A SUCCESSFUL TRIP

SCHEDULE FOR A DAY OF ACTIVITIES IN GREAT SMOKY MOUNTAINS NATIONAL PARK AT PURCHASE KNOB

- Meet park ranger at Purchase Knob
- Use restrooms
- Large group introduction
- Break into two groups
- Participate in activities
- Lunch
- Switch groups
- Large group conclusion

• Check the weather before you go. Lunch will be eaten outside.

• School buses can park at the program site.

• The pre-visit activities included in this packet are specific to the theme of your program and should be presented prior to your scheduled visit. The post-visit activities are designed to reinforce and build upon the park experience.

• A map to the Appalachian Highlands Science Learning Center Purchase Knob can be found on page 6

• All students, teachers, and chaperones will meet the park rangers at the Appalachian Highlands Science Learning Center at Purchase Knob.

• The maximum number of students for this trip is 30. We require an adult or teacher for every ten students to create a positive and rewarding experience. The on-site instruction is conducted by a park ranger. However, your assistance is needed with discussion and discipline. Please feel free to contact the park at (828) 926-6251 if you have any further questions.

•Dressing for the Weather

Please remind your students to wear appropriate footwear and clothing for an extended outdoor program. Short pants, flip flops, or sandals are not recommended. Temperatures in the mountains can be 10-15 degrees colder than at your school. You may wish to alter portions of the program should inclement weather appear.

•Restrooms and Water

Restrooms and water fountains will be available at the program site.

•Lunch

Lunches will be eaten picnic style on the grounds of the Learning Center. Lunches should be put in a box for storage and kept on the bus until needed. Lunches, snacks, and drinks should be provided by the students. There are no concessions at Purchase Knob.

•Safety

Purchase Knob is a remote location, far from any medical facilities. Students will spend most of their time away from buildings, so please bring a cellular phone. Notify the park ranger of any special concerns or medical conditions including students with allergies, asthma or other medical conditions.

•Cancellation

Should anything unforeseen occur preventing you from keeping your appointment, please contact the park at (828) 926-6251 to notify us of your late arrival or cancellation.





BACKGROUND INFORMATION

Park Description:

The National Park Service is charged with the management and preservation of the nation's most precious natural and cultural resources. These resources are woven into our natural heritage, and they provide opportunities for recreation, appreciation of beauty, historical reflection, cultural enrichment, and education.

Great Smoky Mountains National Park is one of the largest protected land areas east of the Rocky Mountains. With over 500,000 acres (800 square miles) of forest, the Smokies contain an enormous variety of plants and animals. In terms of biological diversity, a walk from a mountain's foot to its peak is comparable to the 2,000 mile hike on the Appalachian Trail from Georgia to Maine.

Because the National Park Service is charged with protecting resources and natural systems, the park engages in comprehensive research programs, such as air quality monitoring, to foster an understanding of park resources and to show how they are affected by local, regional, and global influences. Since the Smokies are so biologically diverse, the park is designated as an International Biosphere Reserve by the United Nations. The international system contains over 320 reserves in over 80 countries with the primary objectives of conserving genetic diversity and coordinating environmental education, research, and monitoring.

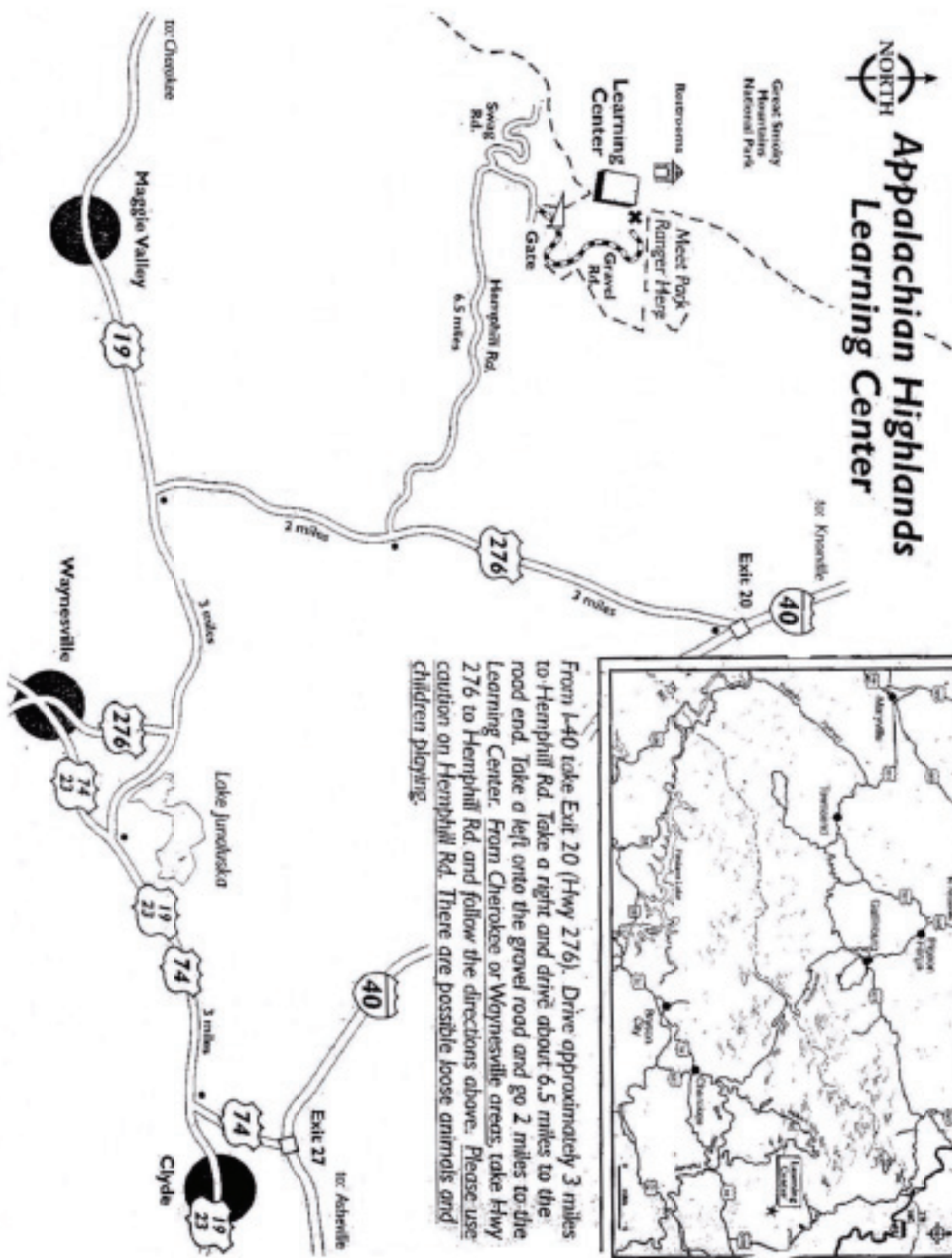
The Smokies also have a rich cultural history. Native Americans have lived in this area for thousands of years, and permanent white settlement began around 1800. The coming of commercial logging around 1900 stripped trees from two-thirds of what is now park land. Established in 1934, the park was created from more than 6,000 tracts of private and commercial land that was bought mostly with money raised and privately donated. Centrally located within a two-day's drive for half of the nation's population, Great Smoky Mountains National Park has the highest visitation of all the national parks in the country.

Purchase Knob Description:

The Purchase Knob property, over 530 acres in size, was donated to Great Smoky Mountains National Park by Katherine McNeil and Voit Gilmore in January 2001. Situated at an elevation of over 5,000 feet, the area contains old-growth forests, mountain meadows and high elevation wetlands. It also rests on geological formations that aren't found anywhere else in the park, lending to a unique and diverse habitat for the study of plants and animals. The house is the location of the Appalachian Highlands Science Learning Center, whose mission is to provide a space for researchers to perform biological inventory and monitoring while offering education programs for students and teachers on these same subjects.

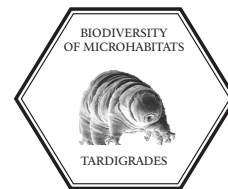


MAP TO PURCHASE KNOB



PRE-SITE ACTIVITY

TARDIGRADE INFORMATION



Grade Level: High School

Subject Area: Science

Activity time: 30 minutes

Setting: Classroom

Skills: Analyzing, Categorizing, Collecting information, Communicating, Connecting,

Vocabulary:

• **Bilateral symmetry:** symmetrical arrangement, as of an organism or a body part, along a central axis, so that the body is divided into equivalent halves.

• **Cryptobiosis:** the metabolic state some organisms enter in response to adverse environmental conditions such as freezing, drying, or oxygen deficiency. In this state, all metabolic processes stop, preventing reproduction, development, and repair until environmental conditions return to being hospitable. When this occurs, the organism will return to its metabolic state of life as it was prior to cryptobiosis.

• **Eutardigrada:** a class of Tardigrada without lateral appendices. These species are primarily found in lichens, mosses, and leaf litter, but many species are found in freshwater habitats such as lakes, rivers, and streams.

• **Extremophile:** an organism that thrives in and even may require physically or geochemically extreme conditions that are detrimental to the majority of life on Earth.

• **Heterotardigrada:** a class of tardigrades comprised of two orders: the armored terrestrial tardigrades and the marine tardigrades. Heterotardigrades have a lateral appendage between the head and the shoulder plate.

• **Meiofauna:** animals inhabiting the bottom of a river, lake, or sea that are nearly invisible to the naked eye with dimensions in the range 0.1 to 1 mm.

• **Micrometazoa:** extremely small multicellular animals.

• **Parthenogenesis:** form of reproduction in which an unfertilized egg develops into a new individual; no males are present in the population.

• **Polyextremophiles:** an organism which has several extremophilic features.

• **Tun:** cryptobiotic state of the tardigrade in which the appendages are drawn inward and metabolism stops.

Materials:

- Vocabulary (listed at left)
- ATBI and Tardigrades worksheet (page 8)
- Tardigrade information worksheet (page 9)
- Computer with internet connection

Objectives:

- 1) understand the biodiversity of the Great Smoky Mountains National Park
- 2) learn several characteristics of tardigrades
- 3) learn the vocabulary related to the tardigrade study

Procedure:

When students visit the Smokies on their field trip they will be collecting, isolating, and viewing tardigrades. This lesson will introduce tardigrades and their characteristics. Read aloud to the students the following information regarding the ATBI and Tardigrades (listed to the right). Students should read individually the vocabulary and definitions worksheet and tardigrade information worksheet. After the students have finished their reading, discuss the characteristics of tardigrades and what adaptations they have in order to live in extreme environments.

To view the Biodiversity podcast video go to

<http://www.thegreatsmoky-mountains.org/eft/10modules.html>

Turn the microscope knob that appears on the computer screen to Section 1, Understanding Biodiversity. Click "Watch Video" and view video.





ATBI AND TARDIGRADES

The All Taxa Biodiversity Inventory (ATBI) is a project of Discover Life in America (DLIA) that seeks to inventory the estimated 100,000 species of living organisms in Great Smoky Mountains National Park. The project has developed checklists, reports, maps, databases, and natural history profiles that describe the biology of this rich landscape to a wide audience. The species level of biological diversity is central to the ATBI, but the project is developed within an ecological and conservation context and encourages understanding at other levels of organization, including genetic variation within species and ecosystem descriptions. As of December 2009, discoveries include 907 species new to science and 6,582 species new to the Park.

The Great Smoky Mountains National Park is a 2,200 square kilometer (800 square mile) reserve that straddles the mountainous divide between the states of Tennessee and North Carolina. The park contains some of the highest peaks in eastern North America, and has very complex geology. The park is known for its temperate forest richness and extensive old-growth forests; however, the park is challenged with a number of threats to its ecological integrity. These threats include invasive, exotic organisms in both terrestrial and aquatic systems; very high depositions of nitrogen and sulfur, as well as high ozone levels; and increasing insularity as a result of human development and fragmentation of adjacent natural areas.

Prior to the ATBI project there were only 3 species of Tardigrades known in the park. Since the ATBI began there have been 55 species of tardigrades found new to the park and 18 new to science for a total of 76 known to be in the park as of December 2009.

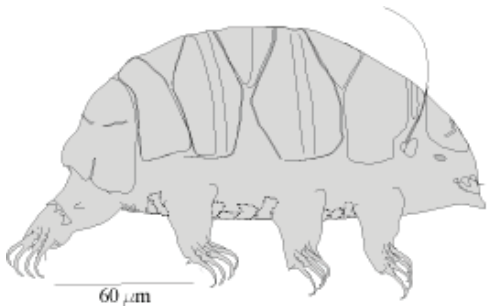


TARDIGRADE INFORMATION

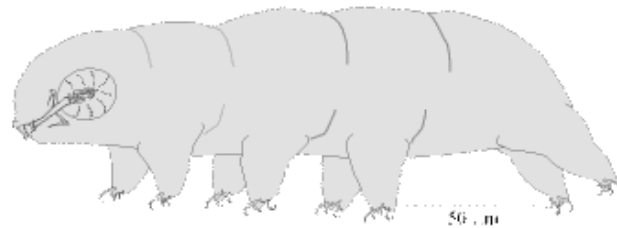
Tardigrades (“water bears”) are members of the phylum Tardigrada. They are microscopic segmented animals with eight legs. These tardigrades were first described by Johann August Ephraim Goeze in 1773 (Kleiner Wasserbär = little water bear). The name Tardigrada means “slow walker” and was given by Lazzaro Spallanzani in 1777. The name water bear comes from the way they walk, similar to a bear’s gait. The largest adults may reach a body length of 1.5 mm, the smallest below 0.1 mm. Freshly hatched juveniles may be smaller than 0.05 mm.

More than 1000 species of tardigrades have been described. Tardigrades occur over the entire world, from the high Himalayas (above 6,000 m) to the deep sea (below 4,000 m) and from the polar regions to the equator. They are polyextremophiles and are able to survive in extreme environments from temperatures of -273°C (close to absolute zero) to temperatures as high as 151°C (303°F). They can survive 1,000 times more radiation than other animals, including humans, a year without water, and even the vacuum of space.

The most common place to find tardigrades are in the sediment between lichen or moss and its substrate (tree, rock, etc.). Tardigrades are most common in moist environments, but can also be found in dry habitats that are periodically wet. The animals must have a film of water around the body in order to be active. Tardigrades are one of the few groups of species that are capable of reversibly suspending their metabolism and going into a state of cryptobiosis in response to drying, freezing, or low oxygen.



Heterotardigrada

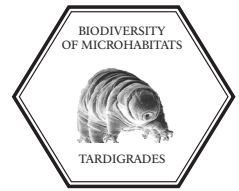


Eutardigrada

Water bear, oh water bear,
On the stones and on the stair,
I’m sorry I did not see you there.
Oh water bear, water bear,
Survival skills are beyond compare
Our tiny friends are everywhere.
--Frank Glubbah

ON-SITE ACTIVITY

TARDIGRADE STUDY



Grade Level: High School

Subject Area: Science

Activity time: 75 minutes

Setting: Outdoors in the park

Skills: Analyzing, Categorizing, Classifying, Estimating, Listing, Summarizing

Materials:

- Lichen samples
- Microscopes
- Sieve
- Erlenmeyer flask
- Pipette
- Deep well slides
- Water
- Funnel

Objectives:

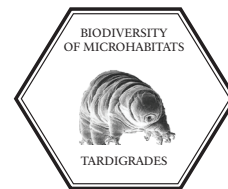
- 1) Collect lichens
- 2) Isolate microorganisms
- 3) View tardigrades and other microscopic organisms (such as rotifers, nematodes, and protozoans)

Background:

The ranger will explain the methods and techniques for collecting lichens and the three main types of lichens. The students will work in groups to collect lichen, isolate tardigrades and other microorganisms from the lichen sediment, and then observe them under the compound or dissecting microscope.

POST-SITE ACTIVITY

EXTREME CREATION



Grade Level: High School

Subject Area: Science

Activity time: 30 minutes

Setting: Classroom

Skills: Communicating, Connecting, Describing, Drawing

Vocabulary:

- **Extremophile:** an organism that thrives in and even may require physically or geochemically extreme conditions that are detrimental to the majority of life on Earth.

Materials:

- Computer with Internet connection
- Colored pencils, crayons, or colored markers
- Blank paper

Objectives:

- 1) understand the definition and classification of extremophiles
- 2) be able to list examples of earthly extremophiles
- 3) create their own extremophile creation

Background:

Students were able to experience one type of extremophile during their field trip in the Smokies, the tardigrade. In this lesson students are able to explore in more depth other examples and classifications of extremophiles. Additionally this lesson allows for discussion on how people must adapt to living in extreme environments and different time periods and how inventions have changed those living conditions.

Procedure:

Go to the following websites for information about extremophiles:

1. Examples of earthly extremophiles: http://nai.arc.nasa.gov/poster/poster_images/astrobioactivity1-studenthandout.pdf
2. Life in extreme environments: <http://www.spaceref.com/news/viewnews.html?id=463>

Either download the information from the websites for students or have the students themselves read it from the computer. Discuss what they have learned about extremophiles.

Ask students to imagine an extreme environment on earth and what you would need in order to survive in those conditions. After imagining these extreme conditions, create an imaginary animal with characteristics to withstand these extreme conditions. List the characteristics and the name of animal to the side of the imaginary animal drawing. Have students present their animal creations.

