Cornell Institute for Biology Teachers

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Title: **Lichens and Mosses and Water Bears…Oh my!**

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Appropriate Level: Middle School Science: Grades 6-8

NYS Standards: See pages 6-7.

Abstract: Students will explore the microscopic world found living on lichens and mosses. Using a simple collection and extraction process, students will observe extremophiles called tardigrades. This lab includes a reading activity with questions as well as an anticipation guide handout for use with a YouTube video.

Time Required: This activity will take approximately 2 standard periods to complete depending on student level and class size.

Materials Needed: Ziplock bags, water, plastic liquid transfer pipettes, compound light microscopes, moss and/or lichens, student handouts.

Teacher Section Contents

Background Information

Tardigrades

Goldstein Lab
UNC Chapel Hill

Quick guide

Tardigrades

Bob Goldstein[1] and Mark Blaxter[2]

Tardi-what? Tardigrades, also known as water bears, are a little-studied phylum of animals. First discovered 230 years ago, there are at least 700 different species living on land, in fresh water and in the sea. The tardigrades represent a successful group of animals — in flourishing existence after about 600 million years of evolution — that could hold keys to the patterns and mechanisms by which animal body plans evolve.

What do they look like? Tardigrades look like chubby, microscopic bears. Many species are transparent, and they are tiny — about a quarter to a half of a millimeter long. Under a microscope, a tardigrade looks a lot like a *Caenorhabditis elegans* in which someone has deviously expressed *Drosophila* leg genes, as they have a simple body plan and a pharynx that resembles a *C. elegans* pharynx, but they have four pairs of legs.

Where would I find one? Pick up a piece of moss and rinse it in some bottled water in a petri dish (soak the moss for a few hours if it's dry). Remove the moss and you can often find tardigrades in the water using a dissecting scope. They are also common in beach sediments.

Who cares about them? Almost everyone who has ever seen one, as their clumsy crawling is about as adorable as can be. Search for 'tardigrade' on the web and you'll find a peculiar culture of amateur microscopists who appear to be obsessed with tardigrades. In the 1960s, tardigrades were briefly in line to be groomed as biology's next big stars: when Sydney Brenner was looking for a new model organism for applying genetics to study development and neurobiology, he stopped briefly at tardigrades, but decided

Figure 1: Scanning electron micrograph of a tardigrade, by Diane Nelson.

they had too many neurons, before moving on to nematodes and eventually choosing the then little-known *C. elegans*.

What are they famous for? Terrestrial tardigrades have been studied for their fascinating ability to perform cryptobiosis: a dried-up tardigrade — known as a tun — can survive for years without water, and can be spread around the world by the wind. The tun is resistant to extreme pressures, high temperatures and freezing. On re-exposure to water, the tardigrade rehydrates and comes back to life — a process that takes only a few minutes. They are common components of the moss faunas of the Arctic, where their abilities to be freeze-dried, deep frozen and resurrected make them suited to life in the brief polar summers.

What are they related to? Their position in the tree of life has been debated for many years, but recently a consensus has emerged that tardigrades are part of a great group of molting animals that includes *C. elegans* and *Drosophila*. This phylogenetic position is, of course, ideal for studying how development evolves, as one can take advantage of the vast amount of developmental information in both *C. elegans* and *Drosophila*.

What's known about how they develop? Very little is known about their development, in fact less than just about any other animal phylum. The three most important papers about tardigrade development were published between 1895 and 1929. These studies give us some detail about what the embryos look like at various stages. For example, early cleavages appear to be complete, unlike *Drosophila*. There have been some recent transmission electron microscopy studies of embryos, but so far we have very little embryological information based on live embryos. This gap is currently being filled by generating a fate map and tracing cell lineages, and by working on methods, such as laser-ablation of specific cells, for studying how cell fates are specified (B. Goldstein, unpublished).

How about developmental genes? Very little is known at the molecular level about tardigrades: sequences from only six genes have been deposited in GenBank, and most of these are housekeeping genes sequenced for phylogenetic studies. Molecular information will be vital to link developmental processes in tardigrades with those in flies and worms. Most of the Hox genes from a freshwater species were recently sequenced (A. Aboobaker and M. Blaxter, unpublished), and a program is underway to sample additional sequence.

Where can I find out more?

http://www.nematodes.org/tardigrades.html
Kinchin, IM: The Biology of Tardigrades. Portland Press, London, 1994.

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Required Time

This lesson takes two 40–minute periods.
Day 1- Collect Mosses and/or lichens, and let the samples set for at least 24 hours.
Day 2- Students can observe the samples under the microscopes.

Equipment and Supplies

- Ziplock bags
- Water
- Plastic liquid transfer pipettes
- Compound Light Microscopes
- Moss and/or Lichens
- Student handouts

Notes/Recommendations

- We had better success using the lichens to observe Tardigrades after a 12 hour period. We would recommend soaking the samples longer for more success in finding Tardigrades (at least 24 hours).
- Tardigrades may need to be purchased if students are unable to find them from their samples. Carolina Biological Supply Company sells them for $11.75 (this includes a living culture for a class of 30) (http://www.carolina.com/tardigrades/water-bear-tardigrade-living/133960.pr).
- Students or teacher may need a scraping tool to obtain the lichen samples.
- Students can take pictures of where they obtained their samples and while observing Tardigrades under the microscope.

Answers to Student Lab Questions

Answers to Pre-Lab Questions

Answers will vary based on student creativity.

Answers to Post-Lab Questions

1. Fill in the chart:

Name of Organism	Tardigrade
Size	Will vary.
Characteristics of Habitat	Could include mosses, lichens, damp soil, etc.
Adaptations for Survival	Exoskeleton, legs, claws, anhydrobiosis, etc.

2. Compare and contrast your original drawing of the organism to what the Tardigrades look like. Will vary. Students should state that tardigrades are microscopic and appear to have a simple body plan.

3. Tardigrades have been given the common name as “water bears”. What evidence from your micrscope observation would support using this name ? They rehydrate so water is necessary for them to resume activity. They have claws, a big body compared to the size of their little legs, and they tough, strong organisms that are resistant to a harsh environment.

Tardigrade Reading Answer Key:

1.) C
2.) False
3.) B
Short answer response- students’ answers will vary.

Anticipation Guide for Tardigrade Science Friday YouTube Video: “Behold the Mighty Water Bear”

1.) True
2.) False
3.) True
4.) True
5.) True
6.) False

Other Resources

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

*Vocabulary terms acquired from Parks as Class rooms Great Smoky Mountains National Park

Videos:

- Animal Planet YouTube Video: "The water bear (tardigrade), the most extreme animal on our planet" https://www.youtube.com/watch?v=SUC0_HjNFBs
- "Behold the Mighty Water Bear" Science Friday Video (See anticipation guide handout.) https://www.youtube.com/watch?v=PVNpSeutk2I
- Hunting for Tardigrades! Unusual Creatures; PBS Studios (shows lichen collection in action) https://www.youtube.com/watch?v=_yIuN2XL31w
- Tardigrades and Bonus Leeuwenhoek: Bite Sci-zed (first half of video; watch up to 3:25) https://www.youtube.com/watch?v=EiaQTFJxIqY
- Water Bear Don't Care! – SciTunes #14 (catchy song with lyrics) https://www.youtube.com/watch?v=z9Mw44u0UBw
- Tardigrades: Adorable Extremophiles Sci ShowYouTube Video https://www.youtube.com/watch?v=6H0E77TdYnY

Other Links:

- Tardigrades: The Living Gummy Bears (10-question interactive quiz) http://www.funtrivia.com/playquiz/quiz96910b1a798.html
- Species Distribution Project: Key to Tardigrade Genera (Interactive Dichotomous Key) http://sun.iwu.edu/~tardisdp/keypage1.html
- Microbial Life Educational Resources: Tardigrade Collection (Extensive list of resources) http://serc.carleton.edu/microbelife/topics/tardigrade/resources.html

References:

- Chris Wilson: "Bdelloid Rotifer Protocol for Teachers CGW 2010b" CIBT MS Word file
- Goldstein Lab Article; UNC Chapel Hill: Quick Guide: Tardigrades (See Background Information.)
- Planet Earth Online Article: "New water bear found in Antarctica" (June 2014) http://planetearth.nerc.ac.uk/news/story.aspx?id=1704
- Parks as Classrooms Great Smoky Mountains National Park: Pre-Site Activity; Tardigrade Information http://www.nps.gov/grsm/forteachers/classrooms/upload/NCMS_TardigradeResearchPreparation.pdf

New York State Learning Standards

Standard 2: Information Systems
Students will access, generate, process, and transfer information, using appropriate technologies.

Key Idea 1:
Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

Performance Indicator 1.4: Collect data from probes to measure events and phenomena.

Major Understandings
1.4a. collect the data, using the appropriate, available tool
1.4b. organize the data
1.4c. use the collected data to communicate a scientific concept

Standard 4: The Living Environment
Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 1:
Living things are both similar to and different from each other and from nonliving things.

Performance Indicator 1.1: Compare and contrast the parts of plants, animals, and one-celled organisms.

Major Understandings
1.1a. Living things are composed of cells. Cells provide structure and carry on major functions to sustain life. Cells are usually microscopic in size.
1.1d. Some organisms are single cells; others, including humans, are multicellular.
1.1h. Living things are classified by shared characteristics on the cellular and organism level. In classifying organisms, biologists consider details of internal and external structures. Biological classification systems are arranged from general (kingdom) to specific (species).

Key Idea 3:
Individual organisms and species change over time.
Performance Indicator 3.1: Describe sources of variation in organisms and their structures and relate the variations to survival.

Major Understandings
3.1b Changes in environmental conditions can affect the survival of individual organisms with a particular trait. Small differences between parents and offspring can accumulate in successive generations so that descendants are very different from their ancestors. Individual organisms with certain traits are more likely to survive and have offspring than individuals without those traits.

Key Idea 5:
Organisms maintain a dynamic equilibrium that sustains life.
Performance Indicator 5.1: Compare the way a variety of living specimens carry out basic life functions and maintain dynamic equilibrium.

Major Understandings
5.1a Animals and plants have a great variety of body plans and internal structures that contribute to their ability to maintain a balanced condition.
5.1b An organisms overall body plan and its environment determine the way that the organism carries out the life processes.
5.1g The survival of an organism depends on its ability to sense and respond to its external environment.

Name: _____ Date: _____ Class: _____

Lichens and Mosses and Water Bears… Oh My!

Introduction

You will explore the microscopic world found living on lichens and mosses. Using a simple collection and extraction process, you'll observe extremophiles called tardigrades.

Pre-Lab Activity

Draw an illustration and fill in the chart about an organism based on the information listed below.

Information about the Organism:

1.) Toughest organism on the planet.
2.) Can survive very low temperatures.
3.) Can survive very high temperatures.
4.) Can survive through radioactive materials.
5.) Can survive without water.
6.) Can live on land or in water.
7.) Can survive in space.

Drawing Based on Information

Name of Organism	
Size	
Characteristics of Habitat	
Adaptations for Survival	

Procedure

Collecting and Viewing Tardigrades

You will need:

- Ziplock bags
- Water
- Plastic liquid transfer pipette
- Compound Light Microscope

1. Go outside (you needn't go far!). Look on trees, stones, or walls for patches of moss and lichens. Almost any moss will work, even if dry or dead.
2. Place about 2g (1 tsp) into the plastic bag and return to the lab/classroom.
3. Add about 10mL of water to the bag and re-seal it.
4. Shake gently to wet the moss and/or lichens, then wait at least 24 hours (longer is better, even several days).

Next Class:

5. Shake bag vigorously to crumble the moss and/or lichens and mix it thoroughly into the water.
6. Using a plastic pipette, take up approximately 2-3 drops of the moss and/or lichens water mixture from the bag.
7. Place this onto the middle of a depression slide or microscope slide and locate the tardigrades.
8. Once you locate a tardigrade, observe and draw the organism in the box below.

Drawing of Tardigrade
Total Magnification _____ x

9. The grid slide is a prepared slide of a tiny piece of graph paper. The lines of the graph paper are all spaced 1.0 mm apart.
10. Place the grid slide on the microscope stage and bring the graph paper into focus, using the lowest power.

11. When you look into the microscope, the whole area you see is called the "field of view." Knowing that the lines of the graph paper are 1.0 mm apart, estimate the diameter of the lowest power's field of view to the nearest 0.25 mm.
12. Estimated diameter of the lowest power's field of view: _____ mm
13. Return the grid slide to the table.
14. Place the Tardigrade slide on the microscope and bring it into focus under the lowest power. Look closely at the Tardigrade.
15. Based on the microscope field of view, determine the average length of the tardigrade to the nearest 0.1 mm. _____ mm/organism

Post-lab Questions

4. Fill in the chart:

Name of Organism	Tardigrade
Size	
Characteristics of Habitat	
Adaptations for Survival	

5. Compare and contrast your original drawing of the organism to what the Tardigrades look like. _____

_____

_____

6. Tardigrades have been given the common name as "water bears". What evidence from your micrscope observation would support using this name ? _____

_____

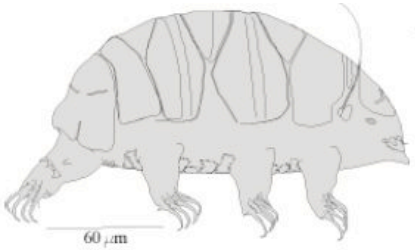
_____

Tardigrade Information

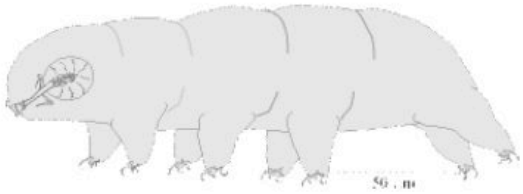
Tardigrades ("water bears") are members of the phylum Tardigrada. They are microscopic segmented animals with eight legs. These tardigrades were first described by Johann August Ephraim Goeze in 1773 (Kleiner Wasserbär = little water bear). The name Tardigrada means "slow walker" and was given by Lazzaro 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

Name: _____ Date: _____
Period: _____ Tardigrade Reading

Directions: *CIRCLE the choice that best completes the statement or answers the question.*

1. How many known species of tardigrades exist?
   A.) 75 species
   B.) 500 species
   C.) 1000 species
   D.) 1777 species

2. The sun's surface temperature reaches 5600°C. Tardigrades will be able to survive there.
   True or False

3. Commonly where are most tardigrades found?
   A.) Dry habitats
   B.) Mosses and lichens
   C.) The refrigerator
   D.) Atlantic Ocean

Directions: After reading the article, complete the following short response. Please write in complete sentences and be sure to include a claim and evidence from the text. You will be graded on content and correct use of grammar and mechanics. **Claim: Tardigrades are known as extremophiles. Extremophiles are organisms that can survive in extreme conditions.** Using details from the text, support your claim. You must use at least two details or evidence from the text.

Name: _____ Date: _____
Period: _____ Tardigrade Video Anticipation

Instructions:

1. Read the statements below **BEFORE viewing the YouTube video**. Decide whether you think each statement is true or false, and put an "X" in either the TRUE or FALSE box before the statement number.
2. **AS you are viewing the YouTube video**, place an "X" in the box of the correct answer, either TRUE or FALSE. The answers are chronological for this activity.

Anticipation Guide for Tardigrade Science Friday YouTube Video

"Behold the Mighty Water Bear"

http://www.sciencefriday.com/video/01/23/2009/behold-the-mighty-water-bear.html

BEFORE viewing		**Statement**	**AS you are viewing**	
TRUE	**FALSE**		**TRUE**	**FALSE**
		1 Tardigrades live in your backyard.		
		2 Tardigrades have six legs.		
		3 Tardigrades go through a stage where they can go into extreme hibernation.		
		4 Tardigrades can survive in the vacuum of space.		
		5 Tardigrades can be rehydrated after a decade.		
		6 Tardigrades' closest relatives are fruit flies and earthworms.		