From Frozen to Fascinating

Can tiny aquatic organisms survive Minnesota's frosty winters? Watch them emerge from a scoop of frozen muck!

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Please note: Academic Standards are updated regularly and our alignments will be updated on the DNR Academic Standards Website at: www.mndnr.gov/education/teachers/edstandards_intro.html

From Frozen to Fascinating

Minnesota Academic Standards

◔ Lesson *introduces* this Benchmark.
◑ Lesson *partially* addresses this Benchmark.
● Lesson *fully* addresses this Benchmark.

Language Arts

Grade 3
I. Reading and Literature
C. Comprehension:
Benchmark 4—The student will retell, restate or summarize information orally, in writing, and through graphic organizers. ●
III. Speaking, Listening, and Viewing
A. Speaking and Listening:
Benchmark 1—The student will participate in and follow agreed-upon rules for conversation and formal discussions in large and small groups. ◑
Benchmark 2—The student will demonstrate active listening and comprehension. ◑
Benchmark 3—The student will follow multi-step oral directions. ◑
Benchmark 4—The student will give oral presentations to different audiences for different purposes. ◑
Benchmark 5—The student will organize and express ideas sequentially or according to major points. ◑

Grade 4
I. Reading and Literature
C. Comprehension:
Benchmark 6—The student will distinguish fact from opinion, determine cause and effect, and draw conclusions. ●
III. Speaking, Listening, and Viewing
A. Speaking and Listening:
Benchmark 1—The student will participate in and follow agreed-upon rules for conversation and formal discussions in large and small groups. ●
Benchmark 2—The student will demonstrate active listening and comprehension. ●
Benchmark 3—The student will give oral presentations to different audiences for different purposes. ●
Benchmark 4—The student will organize and summarize ideas, using evidence to support opinions or main ideas. ●

Grade 5
I. Reading and Literature
C. Comprehension:
Benchmark 9—The student will determine cause and effect and draw conclusions. ●
III. Speaking, Listening, and Viewing
A. Speaking and Listening:
Benchmark 1—The student will participate in and follow agreed-upon rules for conversation and formal discussions in large and small groups. ●
Benchmark 2—The student will demonstrate active listening and comprehension. ●
Benchmark 4—The student will give oral presentations to various audiences for different purposes. ●
Benchmark 5—The student will restate or summarize and organize ideas sequentially using evidence to support opinions and main ideas. ●

History and Social Studies

Grades K—3
IV. History Skills
A. Concepts of Time:
Benchmark 1—Students will define and use terms for concepts of historic time. ◔ (Present, future, weeks, seasons)

Math

Grades 3, 4, 5
I. Mathematical Reasoning:
Benchmark 1—The student will communicate, reason and represent situations mathematically.

Grade 3
IV. Data Analysis, Statistics, and Probability
A. Data and Statistics:
Benchmark 2—The student will collect data using observations or surveys and represent the data with pictographs and line plots with appropriate title and key.
V. Spatial Sense, Geometry, and Measurement
C. Measurement:
Benchmark 1—The student will select an appropriate tool and identify the appropriate unit to measure time, length, weight and temperature.

Grade 4
IV. Data Analysis, Statistics, and Probability
A. Data and Statistics:
Benchmark 1—The student will collect data using observations or surveys and represent the data with tables and graphs with labeling.
Benchmark 2—Use mathematical language to describe a set of data.

Grade 5
IV. Data Analysis, Statistics, and Probability
A. Data and Statistics:
Benchmark 3—The student will collect data using measurements, surveys or experiments and represent the data with tables and graphs with labeling.

Science

Grade 3
I. History and Nature of Science
A. Scientific World View:
Benchmark 1—The student will explore the use of science as a tool that can help investigate and answer questions about the environment.
I. History and Nature of Science
B. Scientific Inquiry:
Benchmark 1—The student will ask questions about the natural world that can be investigated scientifically.
Benchmark 2—The student will participate in a scientific investigation using appropriate tools.
III. Earth and Space Science
B. The Water Cycle, Weather and Climate:
Benchmark 1—The student will measure, record, and describe weather conditions using common instruments.
III. Earth and Space Science
C. The Universe:
Benchmark 3—The student will observe that the sun supplies heat and light to the Earth.
B. Diversity of Organisms:
Benchmark 1—The student will describe the structures that serve different functions in growth, survival and reproduction for plants and animals.
Benchmark 2—The student will know that plants have different structures from animals that serve the same necessary functions in growth, survival and reproduction.
IV. Life Science
C. Interdependence of Life:
Benchmark 2—The student will know that changes in a habitat can be beneficial or harmful to an organism.

Grade 4
I. History and Nature of Science
B. Scientific Inquiry:
Benchmark 1—The student will recognize when comparisons might not be fair because some conditions are not kept the same.
Benchmark 2—The student will collect, organize, analyze and present data from a controlled experiment.
Benchmark 3—The student will recognize that evidence and logic are necessary to support scientific understandings.
II. Physical Science
A. Structure of Matter:
Benchmark 1—The student will observe that heating and cooling can cause changes in state.
IV. Life Science
A. Cells:
Benchmark 1—The student will recognize that cells are very small, and that all living things consist of one or more cells.
Benchmark 2—The student will recognize that cells need: food, water and air, a way to dispose of waste, and an environment in which they can live.

Grade 5

I. History and Nature of Science

A. Scientific World View:

Benchmark 2—The student will recognize that clear communication of methods, findings and critical review is an essential part of doing science.

I. History and Nature of Science

B. Scientific Inquiry:

Benchmark 1—The student will perform a controlled experiment using a specific step-by-step procedure and present conclusions supported by the evidence.

Benchmark 2—The student will observe that when a science investigation or experiment is repeated, a similar result is expected.

Environmental Literacy Scope and Sequence

Benchmarks

- Social and natural systems are made of parts. (PreK-2)
- Social and natural systems may not continue to function if some of their parts are missing. (PreK-2)
- When the parts of social and natural systems are put together, they can do things they couldn't do by themselves. (PreK-2)
- In social and natural systems that consist of many parts, the parts usually influence one another. (3-5)
- Social and natural systems may not function as well if parts are missing, damaged, mismatched or misconnected. (3-5)

For the full Environmental Literacy Scope and Sequence, see:
www.seek.state.mn.us/eemn_c.cfm

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Chapter 1 • Lesson 6

From Frozen to Fascinating

Grade Level: 3-5
Activity Duration: 30 minutes once a week for at least four weeks
Group Size: any
Subject Areas: Science, Expressive Arts, Health and Safety, Language Arts, Math
Academic Skills: communication, comparison, description, drawing, drawing conclusions, estimation, experimentation, identification, inquiry, measuring, observation, organization, prediction, presentation skills, recording data, reporting, small group work
Setting: Preparation: pond or stream
Parts 1-4: indoor gathering area
Vocabulary: adaptation, algae, aquatic organism, dormant, emerge, over-winter, phytoplankton, plankton, sediment, zooplankton
Internet Search Words: algae photos, aquatic invertebrate photos, aquatic plant photos, bottom sediment, daphnia, daphnia photos, dormancy, freshwater zooplankton photos, seasons, submergent aquatic plant photos, winter adaptations, zooplankton

Summary

In this activity, students investigate how spring-like conditions trigger plankton and algae from bottom sediments to emerge and resume activity after winter dormancy. Students add scoops of bottom sediment (liquid or frozen, and collected in winter) from an icy-cold lake, pond, or wetland to large containers of water to make "mini-ponds."

Working in groups, students design their own experiments and place their mini-ponds in various environments within the classroom to encourage dormant organisms to emerge. Groups make predictions, decide where—and in which conditions—in the room to place their mini-ponds, record observations over a four-week period, and draw conclusions. They also use identification keys and pond field guides to identify and sketch organisms in the developing mini-pond. Each group prepares a final presentation that communicates their results to the class.

Instructor's Background Information

Seasons bring dramatic weather changes in Minnesota. How do people survive winter conditions here in the northern latitudes? We dress in layers of warm clothing, spend more time indoors, store food, and wear waterproof shoes and insulated boots. But what happens to plants and animals that live in the water during the cold, freezing months of winter? How do aquatic organisms survive dramatic seasonal changes?

An **aquatic organism** is a living thing that spends all or most of its life cycle in water. Some examples include water lilies, duckweed, Canada geese, fish, dragonflies, frogs, turtles, and beavers. Let's look at a few of the winter survival strategies of some of Minnesota's smallest aquatic organisms.

Small Aquatic Organisms

Many types of aquatic organisms are very small. But, despite their size, they impact aquatic ecosystems in big ways. **Plankton** are extremely small and microscopic organisms that live suspended in the water.

Extremely small and microscopic plants and bacteria are called **phytoplankton**. *Phyto* refers to plant, and like other plants, phytoplankton make their own food energy directly from sunlight through the process of photosynthesis. Animals eat plants or other animals to get their food energy. Because phytoplankton can produce food energy that supports other organisms, they're called producers.

Student Objectives

The students will:

1. Carry out an experiment studying the effects of varying amounts of natural or artificial light and various temperature conditions on over-wintering aquatic organisms.
2. Predict what will occur in the mini-pond over a four-week period and decide which indoor conditions to provide and where to place the mini-ponds to test their predictions.
3. Observe the mini-pond one to three times a week for four weeks and record observations.
4. Draw conclusions about varying amounts of sunlight and temperatures on over-wintering organisms within the mini-pond and communicate their results.
5. Discuss the relationship of sunlight, temperature, and seasonal cycles.
6. List some basic adaptations (including seeds, eggs, and dormancy) that enable aquatic organisms to survive cold winters in Minnesota.

Materials

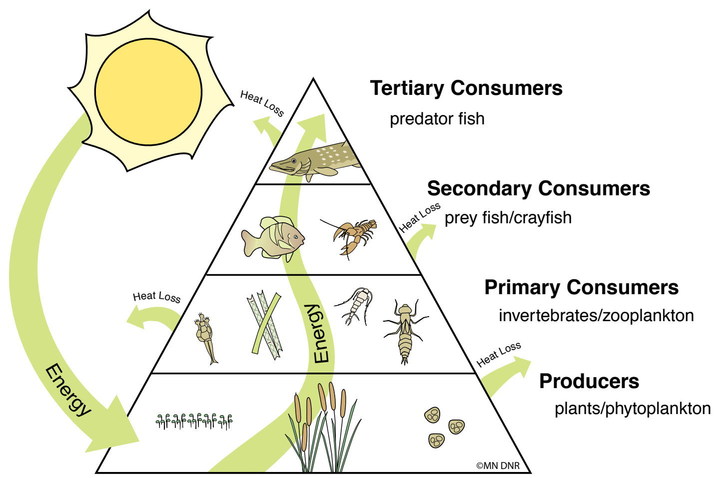
- Distilled water, well water, or melted ice and snow from the schoolyard (avoid ice and snow with heavy concentrations of road salt)
- *Or, if using tap water*, water dechlorinator drops, available at pet stores
- Ice auger or chisel (if necessary)
- Bottom sediment from a pond or wetland

continued

Some species of bacteria are capable of photosynthesis, so they're also classified as phytoplankton.

Organisms that can't photosynthesize depend on producers to make food energy. Some organisms consume plants to get food energy to carry out functions such as growth, reproduction, and finding food. Organisms that eat plants are called primary consumers. Organisms that eat primary consumers to get their food energy are called secondary consumers. These trophic levels (or levels of consumption) can also be considered in terms of a pyramid of life. Phytoplankton and larger aquatic plants compose the vast supporting food base of the aquatic pyramid of life.

An aquatic food pyramid



This fish food pyramid illustrates energy transfer and relative biomass in an aquatic ecosystem. Producers make up the greatest biomass in the system, and support all other life forms. All energy originates from the sun and is converted into food energy by producers. Food energy is transferred through the levels of the food pyramid as one organism consumes another. At each level in the food pyramid, energy is lost to the surrounding environment as heat as organisms use food energy to find food, respire, grow, and reproduce.

Food energy is not the only product of photosynthesis. Phytoplankton and larger aquatic plants release oxygen into the water as they photosynthesize, increasing the quantity of dissolved oxygen that aquatic animals (including fish) need for respiration.

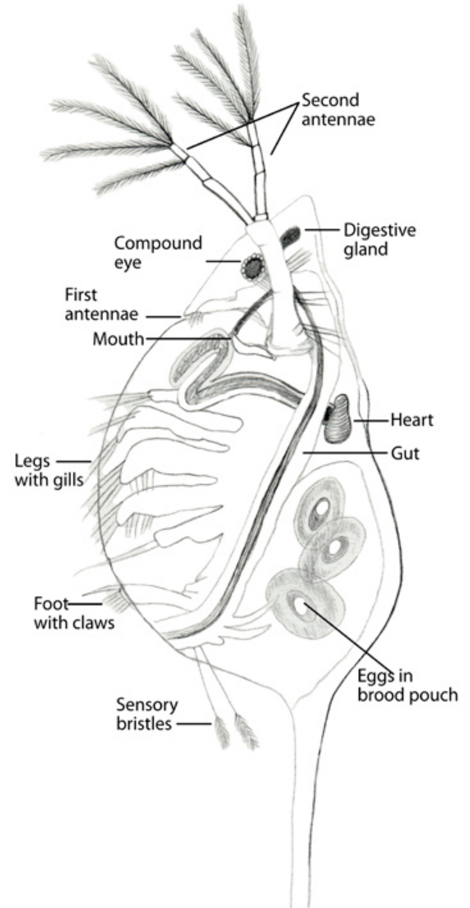
Like larger plants, phytoplankton recycle nutrients (basic materials such as carbon and sulfur). Producers take in these nutrients from their environments and combine them to make the materials needed to grow and function. Primary consumers eat producers to get the building block materials for their growth and structure, but they don't take up nutrients directly from the environment. Nutrients from the producers are passed through the food pyramid as one organism consumes another. When a plant or animal dies, bacteria decompose it, breaking its form or structure back into basic nutrients.

Zooplankton are extremely small or microscopic animals such as copepods, daphnia, and rotifers. Zooplankton and larger invertebrates, such as caddisfly and mayfly larvae, are primary consumers. They eat phytoplankton to get their food energy. They form the second tier or trophic level of the aquatic pyramid of life. Despite their abundance, zooplankton and invertebrates combined comprise a small fraction of a lake's total biomass.

The Natural History of Daphnia

Daphnia is a group of zooplankton commonly found in Minnesota waters. They're very small crustaceans, and are an important food source for many invertebrates and small fish. Although many types of zooplankton are microscopic, daphnia are large enough to see with the unaided eye. During most of the year, daphnia reproduce through parthenogenesis, producing only cloned females, which they incubate inside their bodies beneath their exoskeletons. The young daphnia are released when the female sheds her exoskeleton during molting cycles. Just prior to winter, however, daphnia produce freeze-resistant eggs. Environmental cues, such as limited food or shorter day length, stimulate production of the freeze resistant eggs that can survive the winter. Many of the eggs drop from the water into the top few inches of bottom sediment (muck) of a pond, lake, or wetland. In the spring, warmer temperatures and longer days trigger hatching of these eggs. The young daphnia then emerge from the sediment and begin to swim within the water column.

As filter feeders, daphnia eat minute organisms in the water. A single daphnia can filter almost a liter of water every day. Without healthy populations of daphnia and other filter-feeding crustaceans, our lakes would be green with excessive quantities of algae!



Anatomy of Daphnia

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Materials (continued)

- Bucket and shovel for collecting sediment
- Fluorescent "grow light," to increase day length (optional)
- **Guide to What to Expect in the Mini-ponds**
- For each group of two to five students:
  - Paper cup
  - One clear gallon container
  - Nylon knee-high stocking, or mosquito netting to cover container tops
- **Predictions and Summary Sheet**
- **From Frozen to Fascinating Data Sheet**, *twelve copies per student* (This number depends on the number of observations students are to record each week—changes will be more dramatic with fewer observations.)
- Pencil
- Clipboards, if working without tables
- Thermometer
- Disposable pipettes
- Study plate (shallow white food storage containers or white plastic plates with rims work well)
- Magnifying glass, one per student
- Identification sheets and keys from **Lesson 1:4—Water Habitat Site Study**
- Pond field guides (such as *Pond Life Book: Golden Pocket Guide* and *Through the Looking Glass: A Field Guide to Aquatic Plants*, by Susan Borman, et al)
- Microscope, hand microscope, or projection microscope
- Internet access (optional)

Anabaena
planktonic

Spirogyra
filamentous

Chara
plant-like

Common types of Minnesota algae.

Algae

Algae encompass several types of organisms that aren't really plants, animals, or fungi. Many types of algae resemble simple plants, but algae don't have leaves, roots, or flowers. Examples of algae include red algae and green algae. (Blue-green algae are actually bacteria.) Some species of algae are terrestrial (they live on land) and some are aquatic (these live in water). Like plants, almost all algae use the process of photosynthesis to turn light energy into chemical energy or food energy. They also release oxygen into the water as a by-product of photosynthesis. Many algae are one-celled organisms, but some types are multi-cellular.

Some forms of free-floating aquatic algae photosynthesize, and are included in the phytoplankton group that forms the basis of aquatic food chains. Some green algae are multi-cellular. If you've seen "pond scum" or the green filamentous growths found on dock posts, rocks, and other underwater objects, you're familiar with green algae.

Large numbers of algae in great densities are called algal blooms. Algal blooms are a result of excessive nutrients (particularly phosphorus and nitrogen) entering the water as pollution from the land. Algal blooms can make the water green, produce noxious odors, and even produce toxins that harm or kill other organisms. In large densities, algae can outcompete other organisms, using much of the available light, food, and space.

Algal blooms have a major impact on water bodies in another way, too. When the algae die, they sink to the bottom of the water body and, like any other deceased organism, are decomposed by bacteria. The bacterial decomposers use oxygen during this process. When large densities of algae from an algal bloom die, bacteria reproduce quickly as they decompose such large quantities. The bacteria use dissolved oxygen during respiration. Greater numbers of bacteria consume greater amounts of oxygen, leaving less available oxygen for fish and other aquatic organisms. **Summerkill** refers to an event where fish die from oxygen shortages triggered by the decomposition of an algal bloom.

Winter Adaptations

Aquatic organisms have **adaptations** that help them survive extreme winter temperatures and conditions in the water. An adaptation is an evolved physical characteristic or behavior that equips an organism for life in its environment, enabling it to survive specific conditions and characteristics of that environment.

Like daphnia's freeze-resistant eggs, other Minnesota plants and animals have a variety of strategies or adaptations that help them survive winter conditions. Various species exhibit different types of winter adaptations. For example, flat-stemmed pondweed produces seeds resistant to the effects of freezing. The seeds of this aquatic plant have a tough protective coat with a waxy covering that prevents the living tissue inside the seed from freezing and drying. When the seeds sprout in the spring, the new plants grow during the milder weather conditions of spring, summer, and fall. The plant then produces another generation of seeds that can survive winter.

Similarly, a species of zooplankton known as fairy shrimp lay eggs that don't freeze in winter. During egg formation, some cell water is replaced with sugar, which has a lower freezing point than water. The sugar acts as antifreeze, preventing ice crystals from forming in the fluids of the cells. Fairy shrimp eggs also have a tough protective covering that prevents them from drying and freezing. In the spring, the eggs hatch—and the species has survived another winter.

Over-winter is a term referring to how an organism addresses the challenges of winter survival. While many species over-winter as seeds or eggs, other species become dormant. **Dormancy** is a survival strategy of inactivity or rest exhibited by various plants and animals in temperate climates. In a state of dormancy, an organism slows down or stops growing and reduces its metabolic rate so it needs less food. It can then conserve energy until more favorable environmental conditions allow it to resume activities such as eating more food, growing, and reproducing.

Daphnia

As winter approaches, many organisms, eggs, and seeds settle into bottom sediment. **Sediment** is the accumulation of erosion from the watershed (silt, sand, and organic and inorganic material) and organic material produced within the body of water that accumulates on lake, river, and stream bottoms. It is in the sediment that organisms slow down and become dormant for the winter as temperatures drop. The warmer temperatures and longer daylight hours of spring signal them to **emerge,** or break dormancy, and return to a fully active state. As ice and snow cover melt from the water's surface and days become longer, aquatic plants and phytoplankton resume photosynthesis, producing more food energy and oxygen for themselves and other aquatic organisms.

A large variety of small organisms, including zooplankton, aquatic macroinvertebrates, larval organisms, phytoplankton, algae, and other plants over-winter in the frozen sediments of ponds, lakes, and streams.

A scoop of frozen bottom muck collected from a lake, stream, river, pond, or wetland in winter—exposed to warmer temperatures and sunlight—allows you to discover the life that lies under the winter ice, and to watch it emerge from dormancy.

Algal blooms are a result of excessive nutrients (particularly phosphorus and nitrogen) entering the water as pollution from the land.

Sediments from wetlands and small ponds will have more organisms than lakes due to the absence of fish, which prey on invertebrates.

Procedure

Preparation

1 Collect the sediment. Sediment is best collected after there is safe ice on the lake, pond, or wetland. Drill or chisel a hole near the shoreline and vegetated areas, but away from beaches. This is the area in which invertebrate eggs have been concentrated by wind and wave action. The east side of the water body is often the best location due to prevailing westerly winds in the fall. Collect enough bottom sediment to fill one small paper cup for each group. You may wish to collect an additional sample for the instructor. Collect only the top inch of sediment: over-wintering seeds and eggs will be present on the surface of the sediment. You can collect the sediment the day before or even a week before class use. Store the filled paper cups in the refrigerator until you're ready to begin the activity. Thawed or frozen sediments yield similar results.

Precautions to Take While Collecting Sediment

Due to the increase in the number of harmful invasive species that have entered Minnesota waters, it's important to follow a few guidelines and the laws that protect aquatic resources. Refer to A Field Guide to Aquatic Exotic Plants and Animals, a brochure available from the Minnesota DNR, for additional information and assistance with invasive species identification.

- Avoid collecting sediment or organisms from a lake, pond, or wetland that has been posted "Infested Waters" by the Minnesota DNR. It's illegal to transport water from these sites. A list of infested waters is posted on the DNR website.
- Wetlands are not usually posted for invasive species. But if you know that an area contains purple loosestrife, don't collect sediment there—it's illegal to transport purple loosestrife seeds or parts.

Purple loosestrife.

- Properly dispose of materials at the end of the experiment by either returning the material to its original site or drying the material and placing it in a trash container.
- Never move or return water, plants, animals, or sediment from one aquatic system into another.
- Clean and dry sediment-collecting equipment before using it again.
- Refer to *MN Rules Chapter 6280 Item G,* and the *Minnesota Exotic Species Statutes Chapter 84D.* These guidelines also help prevent the spread of diseases to native aquatic organisms.

STOP AQUATIC HITCHHIKERS!
Prevent the transport of nuisance species. Clean all recreational equipment.

Minnesota law also prohibits the removal of aquatic vegetation from posted fish-spawning areas and Scientific and Natural Areas. Obtain all required permits. Refer to the current Minnesota fishing regulations booklet or check with MinnAqua staff, your local conservation officer, or a DNR resource biologist for proper procedures concerning the transportation, collection, and disposal of water and aquatic organisms.

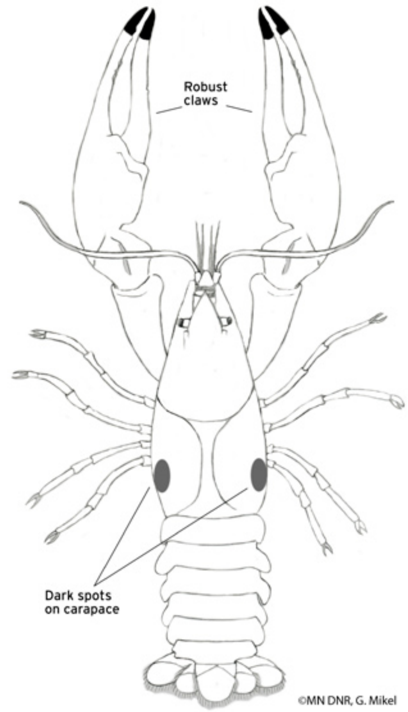
When choosing a site for collecting frozen muck it's important to remember that you will be disturbing bottom sediment, which can release any settled contaminants into the water. Avoid discharge areas and toxic spill locations.

- If this activity will be repeated throughout the season, or from year to year, don't repeatedly collect from the same area. Rotate sites to avoid disturbing a good study area.

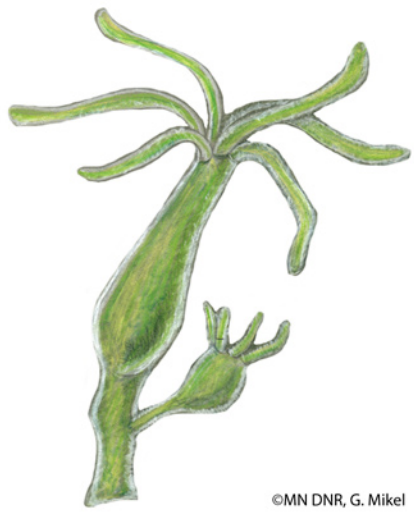
2 Clean the clear gallon containers thoroughly with a mild soap solution. Make sure to rinse all soap residues from the containers before use.

3 If you plan to use chlorinated tap water in the gallon containers, dechlorinate it with dechlorinator drops available at pet stores. You could also purchase distilled water, let the chlorinated tap water sit overnight in open containers, use well water, or use melted ice and snow. Avoid using snow from areas with heavy concentrations of road salt.

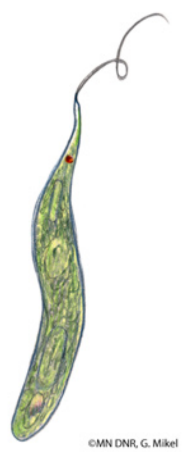
STOP AQUATIC HITCHHIKERS!
Prevent the transport of nuisance species. Clean all recreational equipment.



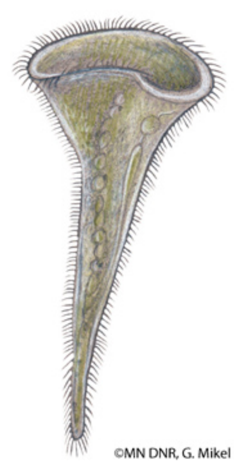
The rusty crayfish is an example of an invasive species that has spread through Minnesota waters, at least in part, by schools that have ordered them from biological supply businesses, studied them, and released them into ponds and lakes. Adult rusty crayfish have relatively large claws with black bands at their claw tips. They usually have dark, rusty colored spots on each side of their carapace at mid-body. For more information, request publication number X34 from Minnesota Sea Grant, University of Minnesota, Duluth at 218-726-8106.



Hydra



Euglena



Stentor

Activity

Warm-up

1 Conduct a questioning and brainstorming session. Discuss dramatic seasonal changes in Minnesota. Ask the students what makes life challenging in winter. List their responses on the whiteboard, interactive whiteboard, or overhead. The list should include:
- snow
- cold temperatures
- less light for photosynthesis
- and less available food.

Ask students what happens to these winter conditions in the spring. Answers should include:
- longer days
- warmer temperatures
- more sunlight
- plants turn green and can photosynthesize
- and there is more food available.

2 Introduce the definition of **adaptation**, a characteristic or feature that helps an organism survive in the environmental conditions where it lives. Write the definition above the list of winter conditions. Ask students how people adapt to winter conditions in Minnesota. For as long as people have lived in cold climates, they've needed strategies for surviving extreme weather conditions. Plants and animals have strategies or adaptations, developed over very long periods of time, for surviving extreme weather conditions where they live.

3 Ask students to list adaptations that plants and animals have that help them survive Minnesota winter conditions. List the responses on the whiteboard, interactive whiteboard, or overhead. The list should include:
(for plants)
- some trees slow their metabolic rates
- stop photosynthesizing
- and drop their leaves and seeds;

(for animals such as insects and frogs)
- by becoming dormant (the students may say hibernation). Ask students if they've ever wondered how plants and animals in the nearby lake or pond survive the winter under the ice and snow?

4 Discuss how Minnesota waters have tiny plants and animals called plankton that form the base of aquatic food chains. Tell students that plankton are very tiny, and that many types of plankton are too small to see without a microscope. Many are single-celled organisms. Plankton and larger plants make up most of the weight of living things in a water body. Like larger plants and animals, these tiny microscopic plants and animals have strategies or adaptations for surviving in winter.

5 Tell students they will be working in groups and that each group will have a mini-pond to observe. Each group will get a small cup of refrigerated or frozen sediment from a local water body to place

in a large jar of water. Explain that this jar of water with the very cold sediment on the bottom represents a pond in the winter.

6. Divide the students into groups of two to five students.
7. Tell students that, now that the mini-ponds are indoors, we are simulating the end of winter and the beginning of spring. What weather conditions change as winter gives way to spring? Tell students that each group will make their own predictions about what will happen in their mini-ponds as the spring conditions continue.

Prior to beginning this activity, you may wish to set up a florescent grow light in one location. A student group may choose this spot to observe any differences that the grow light (sunlight) might make in the mini-ponds.

Lesson

Part 1: Making Mini-ponds

1. Have each student group gather materials and prepare their mini-ponds:
   - Fill the gallon containers three-quarters full of distilled water, well water, melted ice or snow, or dechlorinated tap water. You may have to add additional water to the jars over the course of the experiment due to evaporation.
   - Distribute one paper cup of sediment to each student work group. Holding the sides of the cup in the hands for two minutes will thaw and loosen the sediment from the sides of the cup if it's frozen solid.
   - Add the muck from the paper cup to the gallon container.
   - Stretch a nylon knee-high stocking or some mosquito netting over the opening of the container. (*This prevents winged insects from emerging from the mini-ponds later in the experiment.*)
2. Ask the students if they think any plant or animal life exists in their mini-ponds.

Part 2: Making Predictions

1. Pass out one **Predictions and Summary Sheet** to each group.
2. Prompt the students with these questions:
   - What do you think might happen in the mini-pond in the future as conditions change from winter to spring (from cold sediment from the refrigerator to indoor conditions in the classroom)?
   - Which springtime seasonal conditions do you think will have the greatest impact on the wintertime mini-pond?
3. Ask the groups to write down two predictions regarding what they think might happen to their mini-ponds as springtime conditions continue.

Before students begin making observations, you may want to review the proper way to use a thermometer and record temperatures, as well as instruct students on the use of magnifying lenses or microscopes.

Part 3: Beginning the Experiment

1. Give each student a **From Frozen to Fascinating Data Sheet**. Tell students that the groups are now going to test their predictions with an experiment. To design their experiment, each group must decide on the springtime conditions to which they will expose their mini-ponds in the classroom. These conditions should be the ones that will best test their predictions. You may need to remind them that some corners of the room are darker, some spots in the room

Students will notice more dramatic changes in their mini-ponds if they make fewer observations each week.

Mini-ponds in dark, cool areas tend to show fewer changes than those in lighter or warmer spots. You may wish to make your own mini-pond, put it in a dark, cool spot, and record observations. Or, if a group has nothing happening in their mini-pond after a week, you may wish to allow them to move it to a different spot. Although this strays from the scientific method by changing variables mid-experiment, it may help hold the students' interest. Make sure they record any changes in their mini-pond location on their **From Frozen to Fascinating Data Sheet**. A group may wish to collaborate with other student groups to compare 24 hours of artificial light vs. the effects of natural daylight exposure vs. placing the container in a darkened corner of the room.

are noisier, some places might be draftier, and so forth.

2 Have the student groups place the mini-ponds in the classroom locations they have chosen to test. Appropriate locations in the room may include spots that receive different amounts of sunlight. Some students may place their mini-ponds on the window ledge to get sunlight during the day.

3 When the groups have determined the spots in which to place their mini-ponds, have students fill out the top portion of their **From Frozen to Fascinating Data Sheets** and record initial observations.

Part 4: Recording Observations

1 Students should record their observations one to three times per week at a set time of day for at least four weeks. They will use thermometers to measure water temperatures in the mini-ponds during each observation. Provide students with a new **From Frozen to Fascinating Data Sheet** for each day they collect and record observations.

2 Refer to the **Guide to What to Expect in the Mini-ponds** for an explanation of the organisms that the students may find emerging in their mini-ponds. Because this experiment may produce mostly extremely small and microscopic organisms (such as plankton, daphnia, or algae), have students move some water from the mini-ponds into a small dish or onto a slide. They can then look at the water using a hand lens or microscope during observations. What do they see now that they weren't able to see without the hand lens or microscope?

3 Have groups use pond field guides, websites, or the identification keys and sheets in **Lesson 1:4—Water Habitat Site Study** to identify organisms. (See Internet Search Words on the first page of this lesson for keywords to use to search for images of aquatic organisms.) Have student groups draw any organisms observed and label the drawings.

4 At the end of the four weeks, each group should fill out the summary portion of their **Predictions and Summary Sheet**. In their summaries of observations, they should describe the actual changes they've observed in their mini-ponds.

5 Have students create line graphs illustrating the change in number of organisms observed over the course of the four weeks.

6 As students complete the conclusion section of the **From Frozen to Fascinating Data Sheet**, you may wish to prompt them to answer the following types of questions: Were your predictions supported by the results of your experiment? Why or why not? How did the location of your mini-pond within the room influence your results? Which environmental conditions did you test in your experiment? Was your location warmer or cooler than those of the other groups? Did your location have more or less light than other spots in the room? How do springtime light and temperature conditions differ from winter light and temperature conditions? How might these seasonal differences impact aquatic organisms?

Wrap-up

1 So students can communicate their results and compare their predictions and experimental results with those of the other groups, have each group prepare and present an oral report to the class. Ask groups to display data in graphs, tables, posters, drawings, or dramatic interpretation. Allow time for questions and answers after presentations.

Have each group address the following questions in their presentations:

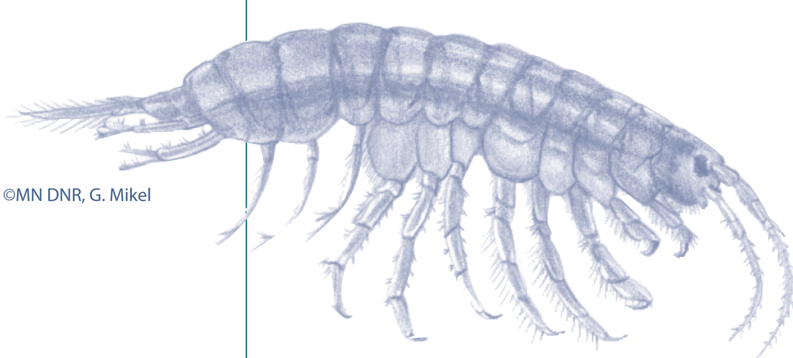
- What did you observe over the four weeks?
- Were your predictions shown to be correct?
- What conclusions did you reach?
- What interesting thing did your group learn from this lesson?
- What would your group do differently next time?
- Did you have other questions after you completed this activity?
- Were you surprised as organisms began to emerge in the mini-ponds?
- Why are organisms more active in the spring than in winter?
- Why didn't you notice organisms in the wintertime mini-ponds? Where were the organisms?

2 After the presentations, conclude with a class discussion. Facilitate the discussion by asking the following questions. Guide the student discussion to include the following:

- How were the organisms able to survive winter conditions? Were they frozen solid? (No, the organisms were not frozen solid, even though the muck may have been frozen. Many of the organisms were in dormancy or in an egg stage. Dormancy protects organisms because, as they slow down and use less energy, they need less food. Eggs are fertilized, but no cell division takes place until light and temperature conditions are more favorable in the spring. Resting or over-wintering eggs have adaptations, such as thick outside coverings or antifreeze-like substances, that prevent them from freezing by keeping ice crystals from forming in the cells.)
- What triggered the organisms to hatch from over-wintering eggs, sprout from seeds, or emerge from dormancy? (Longer hours of sunlight and warmer temperatures.)
- Where would you place your mini-pond in the room the next time you wanted to simulate spring conditions? (In a warmer spot with more light.) Why? (These spring conditions trigger over-wintering organisms to emerge, hatch, and sprout.)
- How might the community in your mini-pond differ from a real pond? (Mini-ponds have less biodiversity because they lack larger plants and animals such as fish, birds, beavers, and other animals. There are no larger predators to eat the small organisms.)
- What effect did the amount of light or the temperature have on the speed at which your mini-pond developed? (More light

and warmer temperatures speed the emergence of organisms.) Why might this be important to the organisms that live in a real ecosystem? (When temperatures are warmer in the spring, the daylight hours are longer. This triggers the organisms to emerge at the right time of year—when they can be more active and survive without freezing, and find enough food to produce energy for activities such as growing, feeding, and reproducing.)

- Why do you think the types of organisms and number of organisms changed during the duration of the experiment? (Some were better able to find food and survive conditions in the jar. Maybe some types didn't find the food they needed after they emerged. With more light and warmer temperatures, the algae could photosynthesize and grow. Over time, the surviving organisms reproduced and their numbers increased—if they had enough food. Some types of organisms ate other types of organisms in the jar.)
- How might the organisms have emerged or developed differently in a real pond? (They would have needed the right outdoor environmental conditions to emerge in spring. Predators that weren't in the mini-ponds, but would have been present in the wild might have eaten some organisms.)
- Which pollutants might enter the pond in the spring through stormwater or snowmelt runoff? How could these impact organisms living in the pond? (Road salt can be toxic to aquatic organisms. Motor oil from automobiles on the roads can enter ponds via stormwater and snowmelt in the spring. In winter, sulfuric and nitric acids from auto exhaust and coal burning power plants mix with water in the atmosphere to become acid snow. When the snow melts in the spring, these acids enter water bodies with the runoff, producing an acid shock. These and other pollutants harm aquatic organisms and ecosystems.)
- What are some basic adaptations that help organisms survive Minnesota winters? (Special seeds and eggs, dormancy.)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Assessment Options

1 Allow students to choose their own presentation method. They may create and present a poster, videotape a news report of their experimental results, prepare a written report of their results, or make a formal presentation. The groups may also choose to present their findings in a discussion, comparing similarities and differences and posing questions about their findings. They may think of other ways to present their results. Evaluate group presentations to ensure students address the questions from the Wrap-up. Presentations should also demonstrate the students' understanding of their experimental designs, including prediction, determining where to place the mini-pond to test the prediction, making observations, recording observations, drawing a conclusion from the class results, and reporting results.

2 Invite parents, caregivers, or other adults or another class to a winter scientific forum. Guests can view the organisms in the mini-ponds, listen to the group presentations, and learn what the students discovered about winter adaptations of aquatic organisms. Create forms so that the guests can evaluate each presentation.

3 Assessment Options include the Checklist and Rubric on the following pages.

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Checklists are tools for students and instructors. Checklists involve students in managing their own learning. They help students understand and set learning goals before the lesson begins, and help them monitor their progress during the lesson, ensuring that they meet learning goals and objectives by the end of the lesson. Students can also use checklists to discover areas that may need improvement. Checklists help instructors monitor each student's progress throughout the lesson, facilitating appropriate adjustment of instruction to ensure learning by the end of the lesson. The instructor may wish to have students add several of their own learning goals to the checklist to personalize it, and to accommodate varied learning needs and styles.

Grade

27-30 points = A
Excellent. Work is above expectations.

24-26 points = B
Good. Work meets expectations.

19-23 points = C
Work is generally good. Some areas are better developed than others.

14-18 points = D
Work does not meet expectations; it's not clear that student understands objectives.

0-13 points = F
Work is unacceptable.

From Frozen to Fascinating Checklist

Possible Points	Points Earned Student	Points Earned Instructor	
10	______	______	Student presentation includes predictions, study design, observations, and conclusion. Questions generated by the study included.
2	______	______	Student presentation explains how experiment demonstrates the role of temperature in causing dormant organisms to emerge in spring.
2	______	______	Student presentation explains how experiment demonstrates the role of light in causing dormant organisms to emerge in spring.
2	______	______	Data presented in easily read format.
4	______	______	Uses at least two types of visual aids.
2	______	______	All members of the group participate in presenting information.
2	______	______	Voices were loud enough to hear.
2	______	______	Presentation length equal to the time limit given.
2	______	______	Group members define *dormant*.
2	______	______	Group members define *adaptation*.

Total Points

30	______	______	**Score** ______

From Frozen to Fascinating Scoring Rubric

Presentation Criteria	4 Excellent	3 Good	2 Fair	1 Poor	0 Unacceptable
Content	Presentation includes predictions, study design, observations, and conclusion. Questions generated by the study included.	Presentation includes predictions, observations, and conclusion Questions generated by the study included.	Presentation includes prediction, observations, and conclusion.	Presentation focused solely on the observations and conclusion.	Made no effort to complete presentation.
Experimental variables	Presentation explains how experiment demonstrates the role of temperature and light in causing dormant organisms to emerge in spring.	Presentation addresses the role of temperature and light in causing dormant organisms to emerge in spring.	Presentation addresses the role of temperature *or* light in causing dormant organisms to emerge in spring.	Presentation addresses environmental variables, but not temperature or light.	Presentation didn't address environmental conditions that could impact spring emergence of dormant organisms.
Visuals	Data presented in easily-read format. At least two types of visual aids used.	Data presented in easily read format. One type of visual aid used.	Data presented in visual format, but information was hard to understand and read.	Attempted to use a visual aid, but it didn't support presentation.	No visual aid used for data.
Presentation style	All members of the group presented information. Voices were loud enough to hear. The presentation was equal to the time limit given.	All members of the group presented information. Voices were loud enough to hear. The presentation was shorter or longer than the time limit given.	All members of the group presented information. Some voices were too soft. The presentation was shorter or longer than the time limit given.	Only a few group members presented information. Voices were too soft to hear. The presentation was shorter or longer than the time limit given.	Didn't complete presentation.

Score ______ (Calculate score by dividing total points by number of criteria.)

In its elliptical orbit around the sun, the earth is actually closer to the sun during Minnesota's winter than it is in the summertime.

Diving Deeper

Extensions

1. Explore how organisms that don't have over-wintering eggs or seeds (such as fish, birds, mammals, reptiles, amphibians, and terrestrial plants) survive during the winter months.
2. Begin this lesson with a discussion of cycles in nature and seasons. Seasonal changes are an example of one type of nature cycle. In Minnesota, we enjoy the variety brought by four very distinct seasons.

   Why does it get so much colder in Minnesota in the winter than it does in Florida? This can be demonstrated very easily in a darkened classroom using a globe and a flashlight. Print the letter M on a piece of masking tape. Place the masking tape on the globe over the state of Minnesota. Ask for two student volunteers and have them stand in front of the class about three feet apart (you may adjust this distance depending on the strength of the flashlight beam you're using). One student should hold the globe, and one will hold the flashlight. The globe is the earth, and the flashlight represents the sun. The sun remains stationary, shining on the earth. Have the student holding the globe position it with the equator directly across from the straight-on or direct light of the flashlight.

   With the class observing, tell the class it is winter and ask the student holding the globe to slowly begin to tilt Minnesota back and away from the direct sunlight. Ask the students in the class to observe the area covered by the sun's rays on the surface of the earth. What has changed? What happens to the sunlight over Minnesota? The sun's rays that reach Minnesota spread across the surface of the earth.

   In the summer, the earth's equator tilts back towards the sun again. Ask the students to watch the area on the globe lit by the sun (flashlight). What happens to the area of sunlight on the earth's surface when the sun is directly over Minnesota? The sun's rays are more condensed, or direct.

   Ask students, what season it is when the sun is directly overhead. (Summer.) Why? (The sun's rays are closer together and more concentrated, so it's warmer.)

   Without changing the position of the globe, look at South America. What does the light look like there? The sun's rays are less direct (less concentrated and spread), so while Minnesota has warm summer temperatures, South America experiences its winter season.

3 Students may wish to examine Minnesota's other temperature extreme—heat! Try the experiment a second time, placing the mini-ponds on a heating pad (set to a low setting) to simulate a really hot summer. Consider how evaporation and rainfall might affect the system.

4 Ask students to bring in sediment samples collected from different streams and ponds in winter. Put the samples in identical containers of dechlorinated water and place them in the same place in the room, where exposure to light and temperature will be identical for all of the mini-ponds. Have students record observations over four weeks, then compare and contrast the results in the various mini-ponds. Explore why different sediment collection sites might produce different results with different emerging organisms in the mini-ponds—even when all other variables are identical.

5 The class may wish to keep a phenology calendar to document the "firsts" of spring in a local aquatic habitat or in the schoolyard. They can also record the date that the ice goes out on a local pond or lake. If you have your students keep this phenology calendar from year to year, subsequent classes can compare the "firsts" of spring from year to year.

STOP AQUATIC HITCHHIKERS!
Prevent the transport of nuisance species. Clean all recreational equipment.

Remember to dispose of these sediments in the trash. Do not transfer materials from one body of water to another.

For the Small Fry

K-2 Option

When working with younger children, you may find it easier to simplify the project by omitting the **From Frozen to Fascinating Data Sheets**. Observations can be made and recorded as a class. Do the whole project as a class, perhaps using an aquarium for class demonstration. Alter the concepts covered in the activity to include the following: Lakes have muck and sediment at the bottom. Small animals live in the sediment. Some of those animals sleep (become dormant) all winter and wake up (emerge) in the springtime when it gets warm and the days become longer. Do a roleplaying activity with students acting out what happens to the organisms as the conditions change and seasons progress and winter is followed by spring.

INSTRUCTOR COPY

Guide to What to Expect in the Mini-ponds

The organisms that will emerge from the frozen muck in the students' gallon jars will vary depending on the source of the sediment. You may want to collect sediment samples from different types of water bodies and compare the results.

Planktonic organisms occupy virtually every type of freshwater habitat, but sediments collected from wetland areas or ponds may produce a greater number and variety of organisms than those from large open lakes or the bottoms of fast-moving rivers. A wetland may have more vegetation, which provides cover and habitat for zooplankton and other tiny organisms. In a large lake, there may be more fish and other predators preying upon zooplankton and invertebrates. Water bodies with high nutrient levels resulting from agricultural and stormwater runoff containing nutrients (such as phosphates and nitrates) might produce more phytoplankton growth. Plants, algae, and phytoplankton are also abundant in areas receiving more sunlight for photosynthesis, which allows them to thrive as they convert the light energy to food energy.

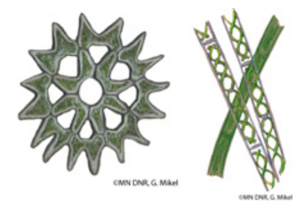
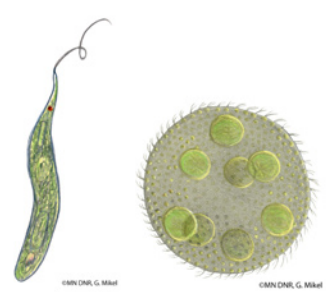
Mini-ponds placed in areas with more light, such as under a florescent grow light or windowsill, will demonstrate greater growth of plants and algae because light gives them an advantage in photosynthesis.

Mini-ponds placed in areas with warmer temperatures, such as under a grow light or next to a heating vent, will demonstrate increased growth and reproduction of both phytoplankton and zooplankton. Higher temperatures increase the metabolic rates of many of these organisms.

Microscopes allow students to observe tiny organisms that they couldn't otherwise detect. Prompt the students to look for the "very tiny life forms" that will emerge from the bottom sediment. Provide them with hand lenses or microscopes during the experiment. Have students use plankton field guides to identify the organisms they observe. Zooplankton are typically larger than phytoplankton.

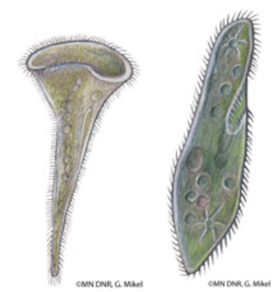
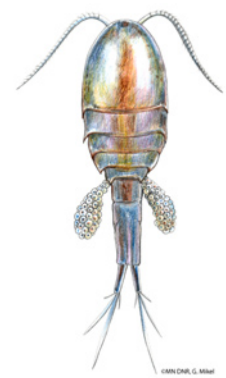
INSTRUCTOR COPY

Guide to What to Expect in the Mini-ponds

Common Aquatic Organisms That Could Emerge in the Mini-ponds			
Green Algae Pediastrum Spirogyra	Plant (Phytoplankton)	Green algae are the most common algae in ponds and lakes. They're a major component of the base of the aquatic food pyramid. They can be single-celled (Pediastrum) or filamentous (Spirogyra).	
Blue-Green Algae Anabaena	Bacteria	Blue-green algae are the "slimy stuff." Blue-green algal blooms often resemble pea soup or paint-like scum on beaches and shorelines. Blue-green algae aren't plants—they're actually bacteria that can photosynthesize their own food. They appear bluish-green under the microscope.	
Diatoms Cyclotella	Plant (Phytoplankton)	Diatoms are photosynthetic unicellular organisms. Found in almost all aquatic environments, they're an important part of the base of the aquatic food pyramid. Diatoms often have a crystalline structure and reflect light with a prism-like effect—their cell walls are made of silica, a material used to make glass.	
Mastigophora Euglena Volvox	Plant (Phytoplankton)	These protozoans (single-cell microscopic organisms) move with whip-like extensions (flagella) that beat or spin in the water. Some protozoans (Volvox) band together in colonies and beat their flagella in unison to move the colony through the water. Many have chloroplasts (green, disk-like structures), where photosynthesis takes place.	 *continued*

INSTRUCTOR COPY

Guide to What to Expect in the Mini-ponds (continued)

Common Aquatic Organisms That Could Emerge in the Mini-ponds			
Ciliophora Stentor Paramecium	Single-celled animals (Zooplankton)	These protozoans (single-cell microscopic organisms) are called ciliates (si-le-its) and have hundreds of tiny cilia (hairs) that beat in unison to propel them through the water. In addition to locomotion, cilia sweep food into their gullets (throats).	
Sarcodina Amoeba	Single-celled animals (Zooplankton)	Sarcodina are a blob of protoplasm (a complex of proteins and water) formed into a single cell. They move by flowing their protoplasm forward into a "foot," and slithering the rest of their body into the foot space.	
Copepods Cyclops	Many-celled animals (Zooplankton)	Cyclops are very small crustaceans, approximately two to three millimeters long, with one black or red eye in the middle of the head. They're named after the one-eyed monster of Greek legend. They can be seen without a microscope, and appear as yellowish flecks jerking through the water. The females carry the eggs (see picture) in little side sacs.	
Rotifers Bdelloidea	Many-celled animals (Zooplankton)	Rotifera is derived from the Latin word for wheel-bearer. This name refers to the tufts of cilia around the mouth that, when in motion, resembles a wheel. The cilia are used for locomotion and to create a current that sweeps food into the mouth.	

continued

INSTRUCTOR COPY

Guide to What to Expect in the Mini-ponds (continued)

Common Aquatic Organisms That Could Emerge in the Mini-ponds			
Hydra Pelmatohydra	Many-celled animals (Zooplankton)	Freshwater Hydra are quite common in ponds, lakes, and streams throughout the world. Hydra capture food with stinging tentacles and swallow it whole through a mouth located in the center of the tentacles. Hydra appear as little whitish or yellowish hair-like structures attached to the bottom or sides of the mini-pond.	
Cladocerans Daphnia	Many-celled animals (Zooplankton)	Cladocerans, or "water fleas," are crustaceans related to copepods, crayfish, and shrimp. They have a single compound eye and move by beating their antennae. Cladocerans are slightly heavier than water so, without active movement, they settle to the bottom. They feed on algae, protozoa, bacteria, and decaying organic material. Most are filter-feeders that consume phytoplankton. They can be seen with the unaided eye, and look like small dots swimming smoothly through the water.	
Ostracoda Cypridopsis	Many-celled animals (Zooplankton)	Ostracods, also known as seed shrimp, move and feed by extending their legs from between the two halves of their shell and moving them very rapidly. Usually, the legs move too fast to see. Ostracods can be seen without out a microscope, and are typically found close to the bottom of the mini-pond.	

STUDENT COPY

Name(s) ______________________________ Date ______________

Predictions and Summary Sheet

Where was your sediment collected? ______________________________

____

Predictions

What you think (predict) will happen in your mini-pond over the next four weeks?

____

____

____

____

____

Testing Your Predictions

Where in the classroom did you place your mini-pond? ______________________________

____

Describe the environmental conditions at the location where you placed your mini-pond.

____

____

____

Recording Observations

Observe and record what you see in the mini-pond over the next four weeks—use the **From Frozen to Fascinating Data Sheets**. Then complete the Summary and Conclusion below.

Summary

Review the observations you recorded on the **From Frozen to Fascinating Data Sheets.** What happened in your mini-pond over the four weeks?

____

____

____

____

STUDENT COPY

Name(s) ______________________________ Date ______________

Predictions and Summary Sheet (continued)

Conclusions

Did your results support your predictions? ______________________________

Why or why not? ______________________________

____

____

____

Was your location warmer or cooler than other locations in the room? ______________

Did your location get more light or less light than other locations in the room? ______________

Do you think the conditions in the location that you chose for your mini-pond influenced your results? ______________________________

If you did the experiment again, which location in the classroom would you choose for your mini-pond? ______________________________

Why? ______________________________

____

____

Why didn't you see any organisms in your winter mini-pond at the beginning of the experiment? ______________________________

____

____

____

How do you think these organisms survive through the winter in the lake or pond where they live? ______________________________

____

Do you have any other questions about what you observed in your mini-pond?

____

____

____

STUDENT COPY

Name(s) ______________________________ Date ______________

From Frozen to Fascinating Data Sheet

Location of mini-pond in classroom ______________________________

____

Week # ________ Date ________ Time ________ Do you see organisms?________

Do you see more or fewer organisms than you saw during your last observation time? ______

Water Temperature ________ Light Source (Circle one.)

Sun   Artificial Light   Little Light   No Light

Record Your Observations	Draw and Label Any Organisms You See in the Mini-pond
1.	
2.	
3.	
4.	