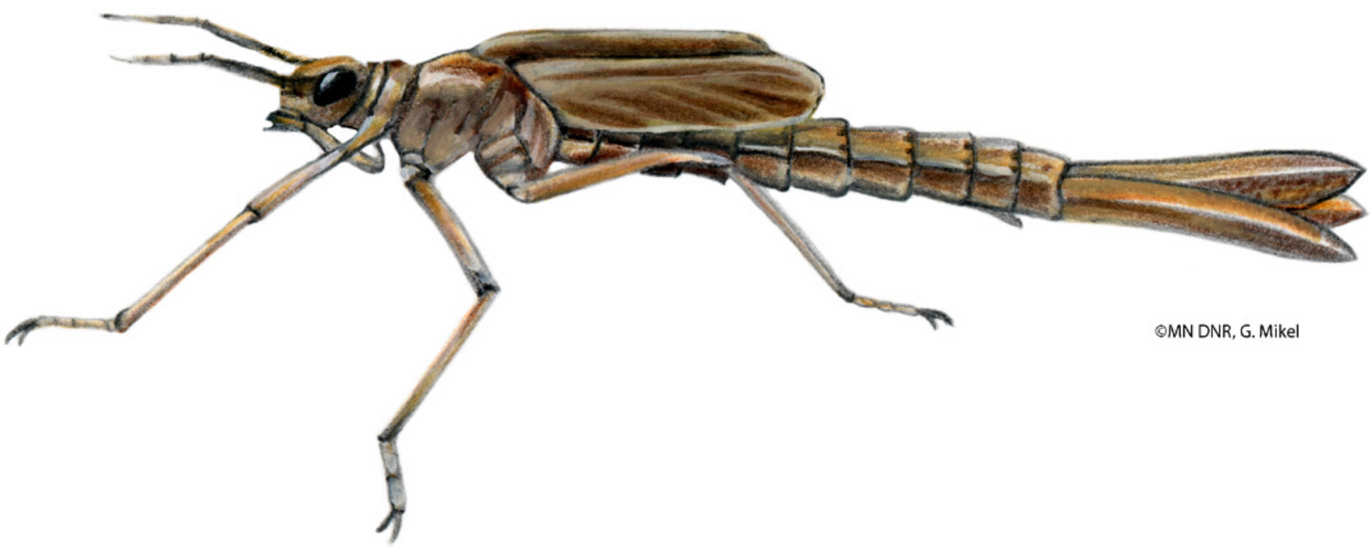
Macroinvertebrate Mayhem

How does the saying "appearances can be deceiving" apply to the water quality of a sparkling, crystal-blue stream?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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

Macroinvertebrate Mayhem

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
B. Vocabulary Expansion:
Benchmark 1—The student will acquire, understand and use new vocabulary through explicit instruction and independent reading.
C. Comprehension:
Benchmark 7—The student will follow three-step written directions.
II. Writing
A. Types of Writing
Benchmark 1—The student will write in a variety of modes to express meaning, including:
a. descriptive
b. narrative
c. informative
d. friendly letter
e. poetic
D. Research:
Benchmark 1—The student will use grade-level appropriate reference materials to obtain information from dictionaries, glossaries, encyclopedias, and the Internet.
III. Speaking, Listening, and Viewing
A. Speaking and Listening;
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.

Grade 4
I. Reading and Literature
B. Vocabulary Expansion:
Benchmark 1—The student will acquire, understand, and use new vocabulary through explicit instruction and independent reading.
II. Writing
A. Types of Writing
Benchmark 1—The student will write in a variety of styles to express meaning, including
a. descriptive
b. narrative
c. informative
d. friendly letter
e. poetic
f. persuasive
g. thank you note
D. Research:
Benchmark 1—The student will locate information in various reference materials including dictionaries, online dictionaries, glossaries, encyclopedias, and the Internet.
III. Speaking, Listening, and Viewing
A. Speaking and Listening
Benchmark 2—The student will demonstrate active listening and comprehension.
Benchmark 3—The student will give oral presentations to different audiences for different purposes.

Grade 5
I. Reading and Literature
B. Vocabulary Expansion:
Benchmark 1—The student will acquire, understand and use new vocabulary through explicit instruction as well as independent reading.
II. Writing
A. Types of Writing:
Benchmark 1—The student will write in a variety of modes to express meaning, including:
a. descriptive
b. narrative
c. informative
d. formal letter

e. poetry
f. persuasive
g. thank you notes
h. reports

III. Speaking, Listening, and Viewing
A. Speaking and Listening:
Benchmark 2—The student will demonstrate active listening and comprehension.
Benchmark 4—The student will give oral presentations to various audiences for different purposes.

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.
IV. Life Science
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.
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
A. Scientific World View:
Benchmark 1—The student will explore the use and effects of science in our interaction with the natural world.
IV. Life Science
B. Diversity of Organisms
Benchmark 1—The student will classify plants and animals according to their physical characteristics.
Benchmark 2—The student will learn that the characteristics used for grouping depend on the purpose for the grouping.

Grade 5
I. History and Nature of Science
A. Scientific World View:
Benchmark 1—The student will know that current scientific knowledge and understanding guide scientific investigation.
C. Scientific Enterprise:
Benchmark 1—The student will describe different kinds of work done in science and technology.

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

Chapter 3 • Lesson 6

Macroinvertebrate Mayhem

Adapted from Project WET MacroInvertebrate Mayhem Activity *Copyright International Project WET*, *© International Project WET*

Grade Level: 3-5
Activity Duration: Part 1: 50 minutes
Part 2: 50 minutes
Group Size: 20 or more
Subject Areas: Language Arts, Math, Physical Education, Science
Academic Skills: drawing conclusions, interpretation, kinesthetic concept development, large group skills, organization, simulation
Setting: large indoor or outdoor open space
Vocabulary: benthic, biodiversity, facultative, indicator species, intolerant, larva, larvae, macroinvertebrate, monitor, nymph, sensitive, tolerant
Internet Search Words: benthic macroinvertebrate, indicators of biological integrity, stream monitoring

Instructor's Background Information

Macroinvertebrates, those organisms that lack an internal skeleton and are large enough to be seen with the unaided eye, are an integral part of wetland and stream ecosystems. Examples of macroinvertebrates include aquatic insects (such as mayflies, stoneflies, dragonflies, and rat-tailed maggots), mollusks (such as snails); freshwater crustaceans (crayfish and scuds), annelids (worms and leeches), and microscopic water-dwelling animals, or zooplankton. These organisms spend all or part of their lives in water.

A variety of environmental stressors affect macroinvertebrate populations. Urban and agricultural runoff can produce intolerable conditions for some macroinvertebrates. Sewage and fertilizers present in streams promote the growth of algae and, eventually, bacteria that consume oxygen needed by macroinvertebrates. Land uses, such as poorly-protected construction sites or croplands, disturb or destroy natural vegetation and allow sediment to flow into the water. Sedimentation destroys stream habitats by smothering the rocky areas of macroinvertebrate habitat. The removal of trees along the banks, as well as changes in stream velocity or speed can alter normal water temperature patterns in the stream. Some organisms depend on temperature patterns to regulate changes in their life cycles. Other stressors include stream channelization and the introduction of non-native (invasive) species.

Summary

Students play a game of tag in a roleplaying activity that simulates the effects of environmental stressors on macroinvertebrate populations. Like the canaries once used in coal mines, macroinvertebrates can indicate water quality in their habitats.

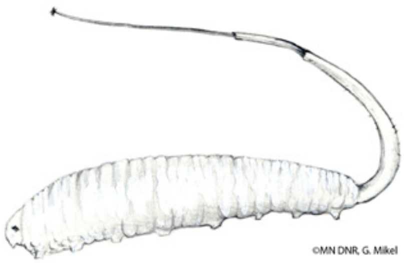
Student Objectives

The students will:

1. Illustrate how tolerance to water quality conditions varies among macroinvertebrate organisms.
2. Explain how macroinvertebrate population diversity provides insight into an aquatic ecosystem's health and water quality.

Materials

- Macroinvertebrate samples (optional)
- Field guides and other information resources
- **Macroinvertebrate Identification Tags**, one per student
- **Macroinvertebrate Mayhem Data Table**, one copy per game
- Pillowcases or burlap bags, one for each student in the caddisfly group
- Chart paper or whiteboard
- Pencil or board marker for instructor's use in keeping records on a chart



Some fly larvae are referred to as maggots. This rat-tailed maggot is the larva of a drone fly. The long, tail-like rear end protrudes from the water like a snorkel, enabling the maggot to breathe air from the surface as it feeds beneath the surface.

Some macroinvertebrates, such as the mayfly, stonefly, and caddisfly larvae, are **sensitive** or **intolerant**, to toxins and to changes in stream conditions that make survival difficult or impossible. These changes, caused by pollution, include water temperature and decreased concentrations of dissolved oxygen. Some organisms can move to more favorable habitats. Others die, or become unable to reproduce.

Macroinvertebrates that can survive in polluted conditions, such as rat-tailed maggots and midge larvae, are known as **tolerant** organisms. An organism is considered tolerant if it can survive in polluted conditions. Other **facultative**, or **semi-tolerant**, organisms (such as dragonfly and damselfly larvae), prefer good stream quality but can survive semi-polluted conditions.

Water quality researchers often sample macroinvertebrate populations to **monitor** (observe, check, and test) changes in stream conditions over time, and to assess the cumulative effects of environmental stressors such as increased sedimentation and changes in water temperature, dissolved oxygen levels, and pollutants. Environmental degradation can decrease the **biodiversity**, the variety of species in a community of macroinvertebrates, by eliminating intolerant organisms. Biodiversity is the total number of species of organisms living in a given area. The number of tolerant organisms may increase, but the diversity of species in the community may decrease. If the environmental stress is severe enough, species of intolerant macroinvertebrates may completely disappear. For example, if a sample of macroinvertebrates in a stream consists mainly of rat-tailed maggots, snails, and dragonfly larvae, the water quality of that stream is probably poor: it probably has low oxygen levels, increased sediment, contaminants, or all three. On the other hand, if the sample contains a diversity of organisms (including some intolerant species), the stream conditions are likely to be good. Acquiring baseline data for comparison is essential, however, because some healthy streams may, as a matter of course, contain very few macroinvertebrate species. A variety of food sources, adequate oxygen levels, and temperatures conducive to growth are all conditions that characterize a healthy stream.

Indicators of Biological Integrity

Water quality is monitored by collecting organisms from aquatic ecosystems and analyzing the number of types of organisms. Information on habitat quality, water level, and chemistry are also collected to support biological information. Biological information can be presented numerically as a value (or index) understandable and meaningful to scientists, civic leaders, and administrators. It can also be compared to reference conditions to determine the health of the water body. This process is called bioassessment.

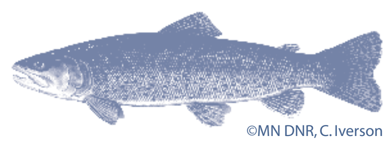
An organism that can provide information about the quality of its living environment is known as an **indicator species** or bioindicator.

Bioassessments are based on the premise that a water body's community of plants and animals will reflect the health of that water body. When a water body is damaged, the diversity of its animals and plants often decreases and the composition of its species changes.

Like the canaries that coal miners once used to monitor air quality in mines, the monitoring and assessing of macroinvertebrate populations—or other populations of organisms—can signal possible changes in water quality. Using bioindicators as an early warning of degradation in an aquatic ecosystem can alert scientists and resource managers to problems that must be addressed to sustain the water resources in a watershed. Typically, organisms that are intolerant to human disturbances, such as chemicals, sedimentation, changes in water temperature, removal of vegetation and habitat, will die or leave disturbed environments. The organisms that are more tolerant of disturbance will remain, comprising a larger proportion of the individuals. For example, a disturbed stream where erosion from a construction project has increased sedimentation will probably exhibit fewer kinds of plants and animals than a healthier, undisturbed stream. Numerical bioassessment results can reveal that a water body has been damaged, changed, or stressed in any way. These results are also used to assess current water quality and to track and predict future changes.

Aquatic macroinvertebrates, as well as other groups of aquatic organisms, are biological indicators for water quality. Examples include:

Fish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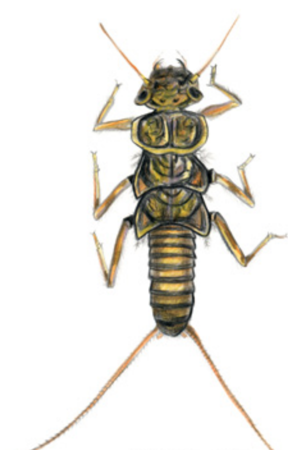
For many years, fish populations have been used to indicate whether or not waters are clean, polluted, improving, or declining. Merely knowing that fish live in the waters isn't revealing. Information on species, numbers, and the state of their health is important, too. Fish are excellent indicators of watershed health because they:

- live in the water all of their life
- differ in their tolerances of types and amounts of pollution
- are easily collected, with the right equipment
- live for several years
- are easily identified in the field

Fish are desirable components of biological assessment and monitoring programs and accurate indicators of environmental health because:

- Fish populations and individuals usually remain in the same area during summer seasons.
- Communities are persistent and recover rapidly from natural disturbances.
- Comparable results can be expected from an undisturbed site at various times.
- Fish have large ranges and are less affected by natural microhabitat differences than smaller organisms, making fish extremely useful for assessing regional and macrohabitat differences.

- Most fish species have long life spans (from two to more than ten years) and can reflect both current and long-term water resource quality.
- Fish continually inhabit the water, integrating the chemical, physical, and biological histories of the waters.
- Fish represent a broad spectrum of community tolerances, from very sensitive to highly tolerant, and respond to chemical, physical, and biological degradation in characteristic ways.
- From the human standpoint, fish are highly visible and valuable components of the aquatic community.
- Aquatic life uses and regulatory terms are usually characterized in terms of fish (such as the "fishable and swimmable" goal of the Clean Water Act).
- The sampling frequency for trend assessment is less than for short-lived organisms.
- The taxonomy of fishes is well established, enabling professional biologists to reduce laboratory time by identifying many specimens in the field.
- Many North American fish species' distributions, life histories, and tolerances to environmental stresses are documented in scientific literature.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Macroinvertebrates

Aquatic macroinvertebrates are referred to as **benthic** macroinvertebrates (derived from the Greek word *benthos*, meaning bottom). They live on the bottom—in sediments or attached to bottom rocks and plants. They're good indicators of watershed health and water quality because they:

- live in the water for most or all of their lives
- stay in areas suitable for their survival
- are easily collected
- differ in their tolerance to amount and types of pollution
- are easily identified in a laboratory
- often live for more than one year
- have limited mobility
- are integrators of environmental condition (meaning that, because they're always in the water, they take in the materials of their environments over time, and that these materials are eventually reflected in their tissues or in their overall health)

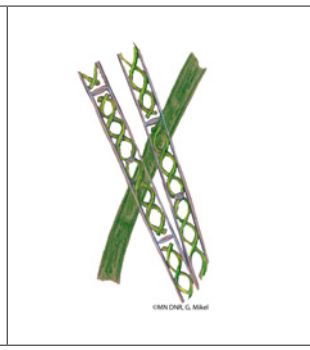
Periphyton

Periphyton are benthic algae that attach themselves to surfaces such as rocks or larger plants as they grow. Algae are primary producers—they can convert the sun's energy into food energy through photosynthesis. Algae are sensitive indicators of environmental change in waters because:

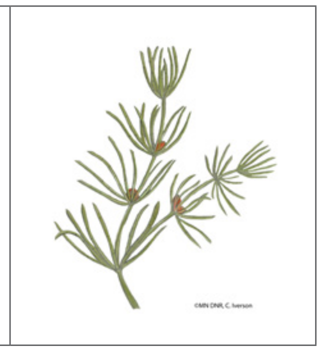
- they're found in all waters
- their number of species is naturally high
- they respond rapidly to both exposure and recovery
- experienced biologists can identify them to the species level
- sampling is easily performed, requiring few people
- for many species, the degree of tolerance or sensitivity to specific changes in environmental conditions is known

Common types of Minnesota algae.

Anabaena
(planktonic)



Spirogyra
(filamentous)

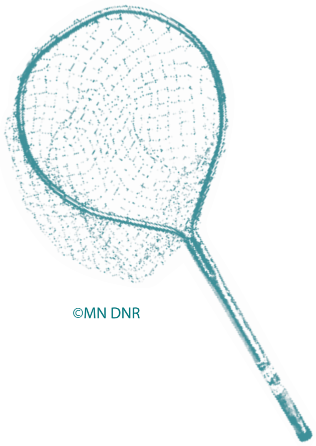


Chara
(plant-like)

Scientists combine information about changes in algae populations with data on macroinvertebrates and fish to form an even clearer picture of water quality. In assessing the health of periphyton populations, scientists typically measure biomass, species composition or diversity, and the organisms' biological condition.

Macrophytes

Macrophytes are aquatic plants large enough to be seen by the unaided eye (without a magnifying lens or microscope). These plants are emergent, submergent, or floating types. (**See Lesson 3:2—The Function of Aquatic Plants.**) Aquatic plants benefit lakes because they provide cover for fish and substrate habitat for aquatic invertebrates. They produce oxygen that aquatic organisms breathe and provide food for some fish and other wildlife. Some studies indicate that reduced populations of sport and forage fish and waterfowl are linked to the lack of macrophytes in local systems. An absence of macrophytes may also indicate water quality problems arising from excessive turbidity and herbicides and salt carried in runoff. Conversely, an overabundance of macrophytes can result from high nutrient levels, diminishing the water's aesthetic appeal and interfering with lake function and recreational activities (such as swimming, fishing, and boating).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Aquatic plants are excellent indicators of the health of an aquatic ecosystem because they:

- respond to nutrients, light, toxic contaminants, metals, herbicides, turbidity, water level change, and salt
- are easily sampled using transects or aerial photography
- don't require laboratory analysis
- are easily used in calculating simple abundance metrics or indices
- are integrators of environmental condition

Volunteer Stream Monitoring

Across the nation, volunteer stream monitoring has proved an engaging and effective way to evaluate the health of water resources. Monitoring involves repeated visits to sites, where measurements are taken for comparison over time. Monitoring activities vary widely, depending on volunteers' interests and skill levels. A monitoring program may include the following:

- physical habitat monitoring, such as stream width or stream flow
- biological monitoring, such as collecting and identifying bottom-dwelling water insects and other benthic macroinvertebrates
- chemical monitoring, for such measures as pH, dissolved oxygen, or nutrients

Procedure

Preparation

1. Use the **Macroinvertebrate Identification Tags** to make game identification tags for the students. Divide the number of students by seven. Make that number of copies of each of the macroinvertebrate tags and environmental stressor tags, and cut them apart.
2. Copy enough "additional" copies of the rat-tailed maggot cards and midge larva cards to equal the number of students in your class (make half of these rat-tailed maggots and the other half midge larva.)
3. To assemble the identification tags:
   One side of each macroinvertebrate tag should have a picture of one of the seven macroinvertebrates. Using glue or clear contact paper, attach one of the "additional" rat-tailed maggot or midge larva pictures to the back side of each macroinvertebrate tag (but not to the original midge larva, rat-tailed maggot and environmental stressor tags—the back sides of these tags should be blank).
4. For durability, the tags may be laminated.
5. Use clothespins, tape or paper clips to attach the tags to students' clothing during the activity.
6. Copy the **Macroinvertebrate Mayhem Data Table.**

Activity

Warm-up

1. Review the conditions of a healthy ecosystem. (Enough of the right kinds of food, shelter, cover, and space.) Ask students to describe what could happen to an ecosystem if these conditions were altered, damaged, or eliminated. What clues would investigate to determine whether an ecosystem is healthy or unhealthy?
2. Remind students that a stream is a type of ecosystem. Organisms need healthy ecosystems to survive. Ask them how they would assess the health of a stream. Students may suggest conducting a visual survey of the surrounding area, considering the following questions: What are the area's land use practices and activities? How might these affect the stream? Does plant cover grow on the banks of the stream? Are the banks eroded? What color is the water? Is pollution entering the water? What kinds of organisms live in the stream?
3. Identify several environmental stressors (such as urban and agricultural runoff, erosion/sedimentation, or the introduction of exotic species). Discuss how environmental stressors impact a stream's health. Review the many types of plants and animals, including macroinvertebrates that live in streams. How might environmental stressors affect these organisms? Would all types of organisms be impacted in the same way? Why or why not?
4. Students should be familiar with the words *macroinvertebrate* and *biodiversity*. They should understand that, sometimes, it is possible to accurately assess the water quality of a stream by its appearance and odor. But polluted streams can also look and smell clean. Students should understand that there are different ways to test water quality, including water chemistry testing and macroinvertebrate sampling.

Lesson
Part 1

1. Introduce the practice of sampling macroinvertebrate populations to monitor stream quality. Show students pictures or specimens of macroinvertebrates used to monitor stream quality.
2. Divide the class into seven groups and assign a macroinvertebarte to each group:

   Macroinvertebrate Groups
   - Caddisfly Larva
   - Mayfly Larva
   - Stonefly Larva
   - Dragonfly Larva
   - Damselfly Larva
   - Midge Larva
   - Rat-tailed Maggot

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Try to have at least four students in each group. For smaller classes, reduce the number of macroinvertebrate groups.

3 Have group members conduct library or internet research on their organism and prepare a report for the class. The group's report should include conditions (such as clean water, cool water, abundant oxygen, rocky bottoms, and vegetation) required for the survival of their assigned macroinvertebrate.

4 Have students present their reports to the class. Compare the types of conditions that each macroinvertebrate species requires. What would happen if one of these conditions were damaged or polluted by an environmental stressor? Did they find information that could tell them if their macroinvertebrate would be tolerant or sensitive to degraded or polluted stream conditions?

Part 2

1 Tell students that they're going to play a game that simulates the changes that happen in a stream when an environmental stressor, such as a pollutant, is introduced. Show students the playing field and indicate the boundaries.

2 Have one student volunteer to be an environmental stressor (such as sedimentation, sewage, or a toxic substance like mercury). Discuss the ways in which a stream becomes become polluted, and how pollution alters stream conditions. For a large class or a large playing field, you'll need more stressors.

3 To play the game, divide the rest of the class into seven groups. Each group represents a macroinvertebrate listed in the Macroinvertebrate Group list in Step 2.

4 On the **Macroinvertebrate Mayhem Data Table**, record the number of students in each macroinvertebrate group in the Start column.

5 Distribute the appropriate **Macroinvertebrate Identification Tags** to all group members. The tags have images on both sides, but the picture of each group's macroinvertebrate should face outward when students begin to play the game.

6 Inform students that they'll encounter hindrances as they try to cross the field. These obstacles in the following chart represent the sensitive organisms' tolerances to pollutants. Have the students practice these motions.

Intolerant Macroinvertebrates and Hindrances		
Organism	**Hindrance**	**Reason for Hindrance**
Caddisfly	Must place both feet in a bag and hop across field, stopping to gasp for breath every five hops.	Many types of caddisflies build cases of tiny sticks or stones and attach themselves to rocks for protection and stability. But they're intolerant of low oxygen levels in the water.
Stonefly	Must do a push-up every ten steps.	Stoneflies require high oxygen levels. When oxygen levels drop, stoneflies actually do push-ups to increase the flow of water over their gills. (Their gills lie underneath the thorax, where their legs attach to their bodies!)
Mayfly	Must flap arms and spin in circles when crossing field.	Mayflies often increase oxygen absorption by undulating their abdomens to increase the flow of water over their gills (Their gills are on their abdomens).

7 Assemble the macroinvertebrate groups at one end of the playing field and place the environmental stressor(s) midfield. When a round starts, the macroinvertebrates move toward the opposite end of the field and the stressor will try to tag them. To "survive," the macroinvertebrates must reach the opposite end of the field without being tagged by the environmental stressor. The environmental stressor can try to tag any of the macroinvertebrates, but will find it much easier to catch those with hindered movements. This mirrors life in a real stream—if the environment changes drastically enough—and a species lacks the adaptive characteristics necessary to survive changed conditions—that species will die and disappear from that environment.

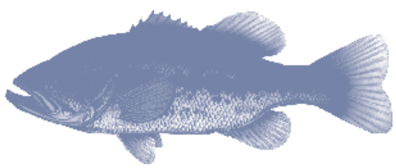
8 Begin the first round of the game. Tagged macroinvertebrates must go to the sideline and flip their identification tags to display the more tolerant species (such as the rat-tailed maggot or midge larva). Tagged players who are already in a tolerant species group do not flip their labels.

9 The round ends when all the macroinvertebrates have been tagged or have reached the opposite end of the playing field. Record the new number of members of each species on the **Macroinvertebrate Mayhem Data Table**.

10 In the next rounds, the "new" rat-tailed maggots and midge larvae no longer have hindrances. Complete two more rounds, with all tagged players rejoining the macroinvertebrates who successfully survived the previous round. Record the number of members of each species on the data table at the end of each round. Because some players will have flipped their identification tags, there will be a larger number of tolerant species in each successive round.

Wrap-up

1 The game is completed after three rounds. Discuss the outcome with the students.
2 Emphasize the changes in the distribution of organisms among groups. Have students compare the population sizes of groups at the beginning and at the end of the game, providing reasons for the changes.
3 Review why some organisms are more tolerant of poor environmental conditions than others.
4 Have students compare the stream environment at the beginning of the game to the environment at the end of the game.
5 What would happen if we added more environmental stressors to the stream? (Fewer sensitive macroinvertebrates would survive each round until there were only tolerant species left in the stream, or until there were no macroinvertebrates left in the stream.) What would happen if there were fewer environmental stressors? (More tolerant species would survive.)
6 Ask students how monitoring a stream to track macroinvertebrate diversity would provide information about water quality.



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Assessment Options

1 Assess student participation in the game, and discussion in the Wrap-up. Can students articulate that tolerance to water quality conditions varies among different types of macroinvertebrate organisms? Can they explain how macroinvertebrate population diversity provides information about the health of an aquatic ecosystem and its water quality?
2 Have students research different aquatic macroinvertebrate organisms and identify the stream conditions they need for survival. Students can work in groups or individually. They can present their findings in a chart, poster, or written report. Offer students the option of presenting their findings in an exhibit or model form. Evaluate students' research, looking for detail in their descriptions of macroinvertebrate organisms and their ability to identify the stream conditions they need for survival.
3 Have each student make a model of a different type of macroinvertebrate and study its body parts. Ask them to investigate the physical adaptations that make the macroinvertebrate more sensitive or more tolerant to environmental stressors.
4 Have students explain why organisms like fish, algae, macroinvertebrates, and macrophytes could be good indicators of water quality. They can present their findings to a group of younger students as a written report, skit, mural, story, song, or demonstration.
5 Have students develop a match game in which pictures of streams of varying conditions or states of health are matched with organisms that might live there.
6 Assessment options include the Checklist and Rubric on the following pages.

Macroinvertebrate Mayhem Checklist

Possible Points	Points Earned	Points Earned	
	Student	**Instructor**	
6	______	______	Student can explain how aquatic macroinvertebrates (including tolerant and intolerant species) reflect the health of a stream.
6	______	______	Student accurately describes the key physical and behavioral features of macroinvertebrates in the game.
2	______	______	Student accurately defines environmental stressor.
3	______	______	Student can give three examples of stressors to water environments.
3	______	______	Student defines tolerant, semi-tolerant and sensitive.
4	______	______	Student follows step-by-step verbal instructions throughout the game.
Total Points			
24	______	______	**Score** ______

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
22-24 points = A
Excellent. Work is above expectations.

20-21 points = B
Good. Work meets expectations.

17-19 points = C
Work is generally good. Some areas are better developed than others.

13-16 points = D
Work does not meet expectations; it's not clear that student understands objectives.

0-12 points = F
Work is unacceptable.

Macroinvertebrate Mayhem Scoring Rubric

Aquatic Macroinvertebrates as Indicators of Water Quality Criteria	4 Excellent	3 Good	2 Fair	1 Poor	0 Unacceptable
Stream analysis	Makes the connection that aquatic macroinvertebrates can be tolerant or sensitive to stressors, and that this is why a stream's macroinvertebrate populations reflect the health of a stream.	Describes how macroinvertebrate species have different tolerances to stressors in the game.	Knows that different types of macroinvertebrate species live in various stream environments, but can't explain the reason.	Doesn't understand that different types of macroinvertebrate species exist in different numbers in streams with varied environmental conditions.	Doesn't understand that aquatic macroinvertebrates are animals without backbones that spend all or most of their life cycle in water, and that they're visible to the unaided eye.
Diversity	Accurately describes key physical and behavioral features of macroinvertebrates in the game.	Can describe key features of 75% of the macroinvertebrates in the game.	Can describe features of 50% of the macroinvertebrates in the game.	Can describe features of fewer than 50% of the macroinvertebrates in the game.	Can't describe features of macroinvertebrates in the game.
Stressors	Accurately defines environmental stressor; can give three examples of stressors to water environments.	Can define environmental stressor; can give two examples of stressors to water environments.	Can define environmental stressor and provide one example.	Can't accurately define environmental stressor.	Doesn't try to define environmental stressor.
Following verbal instructions	Follows step-by-step verbal instructions throughout the game.	Follows verbal instructions during 90% of the game.	Needs occasional reminders to follow instructions.	Needs repeated reminders to follow instructions.	Doesn't follow verbal instructions.

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

Diving Deeper

Extensions

1 Have students investigate a nearby stream. Take students to a nearby stream to sample and collect aquatic macroinvertebrates with dip nets. Place the organisms into shallow white trays. What types of macroinvertebrates live there? Use an identification key to identify the organisms. How would students describe the diversity of organisms? Do students' findings provide insight into the quality of the stream? What other observations can students make to determine stream quality? They may want to report their findings to local watershed managers or water quality inspectors.

2 Supplement the students' macroinvertebrate survey of the stream with chemical tests and water analyses. These can be purchased in kits to measure pH, temperature, oxygen, phosphates, sulfides, sulfates, nitrates, and nitrates.

3 You can repeat your stream surveys periodically during the school year, or from year to year with subsequent classes, and compare the results. Do you detect any changes from survey to survey? What could explain any changing results? If students discover water quality problems, they can develop an action plan or a service-learning project to address the issues they identified.

4 Have students design their own caddisfly case. They can use a computer graphics program, draw a design, or make a model using natural materials like sticks and stones, or craft items like tooth picks, popsicle sticks, pipe cleaners, pony beads, or modeling clay. Have students write a paragraph explaining how their case helps their caddisfly larva survive in its habitat.

5 Orient students to stream ecology prior to this lesson. Refer to the "Stream Sense" lesson in the **Project WET Activity Guide**, which activity provides a variety of streamside investigations. Students can learn how nonpoint source pollutants accumulate in a stream in the Project WET activity "Sum of the Parts." Treatment of polluted water is addressed in the Project WET activities "Sparkling Water" and "Reaching Your Limit." For information about Project WET, contact the Minnesota Project WET Coordinator, Minnesota DNR, at 651-296-6157, or toll free at 1-888-646-6367.

6 Have students study aspects of biodiversity by adding another round to the game. For example, add a fourth round in which all organisms are caddisflies. This added round demonstrates that, in an aquatic ecosystem with little biodiversity, a few intolerant species or a single species can quickly be eliminated.

Before conducting a macroinvertebrate survey or the chemical tests and water analyses, take students to the stream and ask them to do a visual assessment. Ask students to record their observations at the site. Does the water look clean? Is it cloudy, clear, milky, foamy, brown, oily, or green? What kind of human activities take place on the land near the stream? What types of plants and animals live nearby? Is the shoreline stable or does it show visible evidence of erosion? Does the water have an odor? If so, what does it smell like? Does the water feel cool or warm? How much shoreline vegetation exists? Are there emergent plants in the water such as cattails, reeds, and lily pads? Is the stream shaded, or does it receive direct sunlight? Do they see evidence of insects or animals in and around the stream? Are there other observations? After conducting either the macroinvertebrate survey from Extension 1 or the chemical testing and water analysis survey, compare your results with the visual survey of the stream. What can students conclude about the stream's water quality? What can you learn from a visual survey? What information does an aquatic macroinvertebrate survey supply? What can you learn from a chemical and water analysis survey?

For the Small Fry

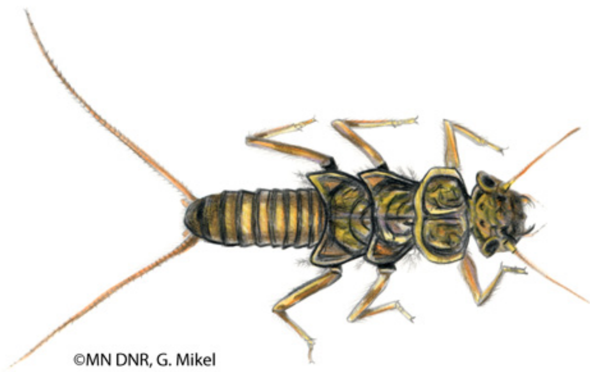
K-2 Option

Play the game using simplified vocabulary to help students understand that aquatic macroinvertebrates live in lakes and streams, that some are sensitive to pollution, and that others are more tolerant of contaminants in the water.

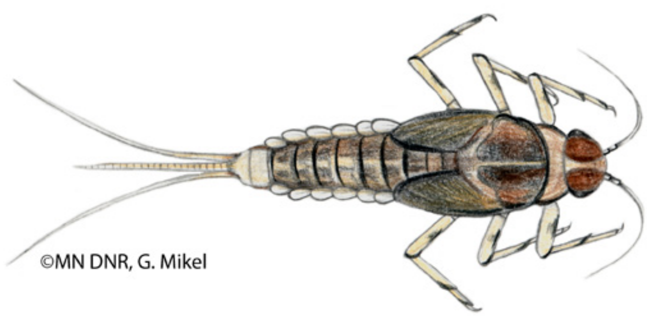
Macroinvertebrate Pollution Tolerance Level Chart

These macroinvertebrates are grouped according to their ability to tolerate pollution in their aquatic habitats. Some types of macroinvertebrates are very sensitive to water quality. Others are semi-tolerant of pollution. Some have adaptations that help them tolerate certain levels of pollution in the water.

Sensitive



Stonefly Larva
Stonefly larvae have two long tails, tubes of thread-like gills on their undersides in their "armpits," wing pads on their backs, antennae, and two claws on each foot. They live among stones or plants in clear, cool, well-oxygenated streams.

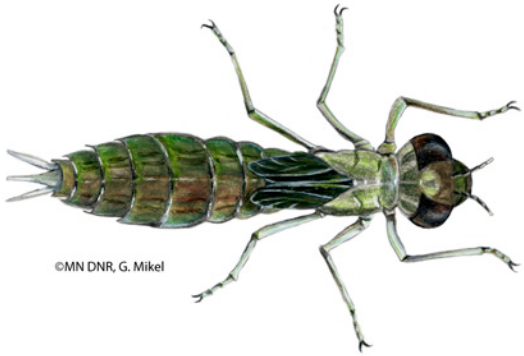


Mayfly Larva
Mayfly larvae have lateral gills along the abdomen, wing pads, and two or three long tail filaments. They have short antennae, and a single claw on each foot. They live under stones in fast-flowing water or among plants in slow-flowing water.

Caddisfly Larva
Caddisfly larvae are caterpillar-like insect larva with three pairs of legs on their first three body segments, and they breathe through the surface covering of their bodies. They usually live in protective cases that they make from rolled leaves, hollow twigs, or small stones. (*Caddis* means house or home.) Their head and legs protrude from these cases as they move.

continued

Semi-tolerant/Facultative

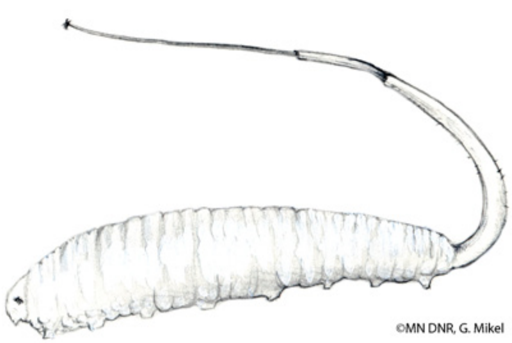


Dragonfly Larva
Dragonfly larvae are short, chunky predators with wing pads and internal gills. To breathe, they pump water in and out of the tip of their abdomen. They live on plants, among stones or leaf litter, and on the bottom.

Damselfly Larva
Damselfly larvae are more slender than dragonflies and have a distinct head section. They have three feather-like gills on the end of their abdomens. They live on plants, among stones and leaf litter, or on the bottom.

Tolerant

Midge Larva
Midge larvae are slender and wormlike. Some of them are red. They have no legs (or stumpy unjointed ones) and bristles. They live in all sorts of aquatic habitats: swimming along, on rocks, or on the bottom.

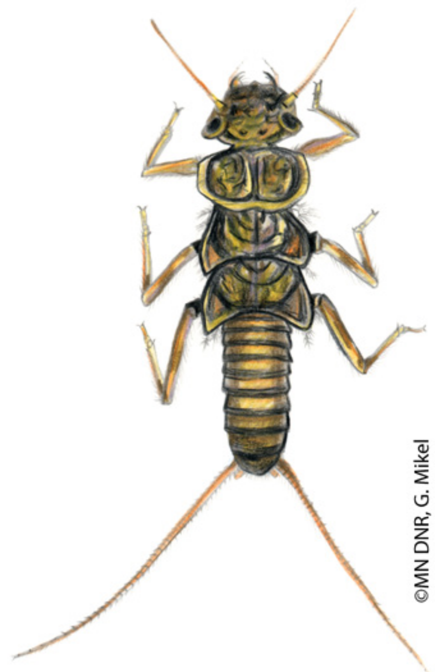


Rat-tailed Maggot
Rat-tailed maggots are semitransparent, soft-bodied fly larvae. Their ventral side ends in a single breathing tube that looks like a tail. These tail-like structures maintain contact with the air above the surface of the water. With this tail, the maggot breathes air from the surface, as it feeds and rests below the surface. Some species inhabit the water in tree holes. Some live in the shallow waters near the shores of pools, marshes, and ponds. They often live in organically rich (eutrophic) waters. Adults resemble honeybees.

Macroinvertebrate Identification Tags

See the Preparation section of this lesson for instructions on making identification tags and how to determine how many of each type of macroinvertebrate tag to make for your group.

Caddisfly Larva



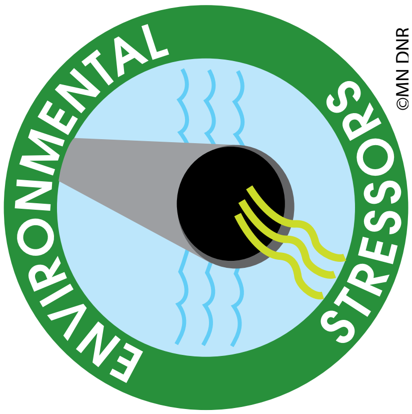
Stonefly Larva

Dragonfly Larva

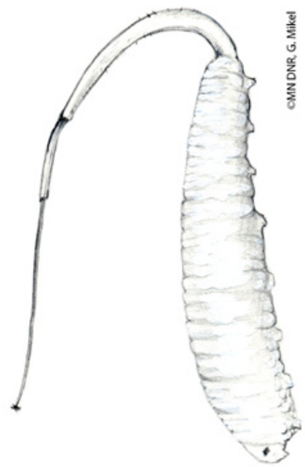
Damselfly Larva

continued

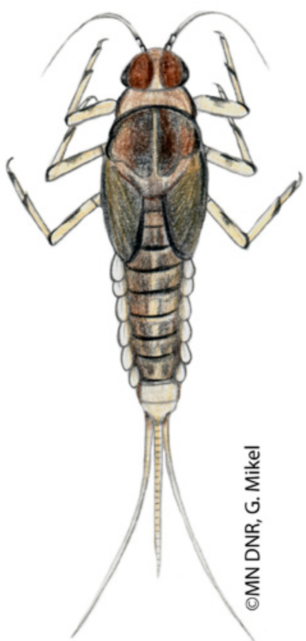
Macroinvertebrate Identification Tags



Environmental Stressor



Rat-tailed Maggot



Mayfly Larva

Midge Larva

Macroinvertebrate Mayhem Data Table

Macroinvertebrate	Tolerance Level	Numbers (at the start and end of each round)			
		Start	Round 1	Round 2	Round 3
Caddisfly Larva	Intolerant				
Mayfly Larva	Intolerant				
Stonefly Larva	Intolerant				
Dragonfly Larva	Semi-tolerant (facultative)				
Damselfly Larva	Semi-tolerant (facultative)				
Midge Larva	Tolerant				
Rat-tailed Maggot	Tolerant				
TOTAL					