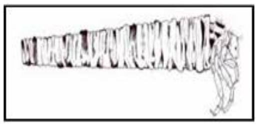
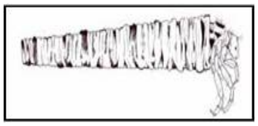
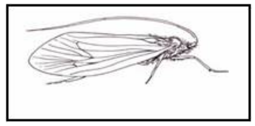
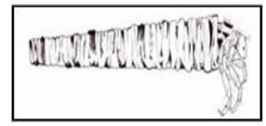
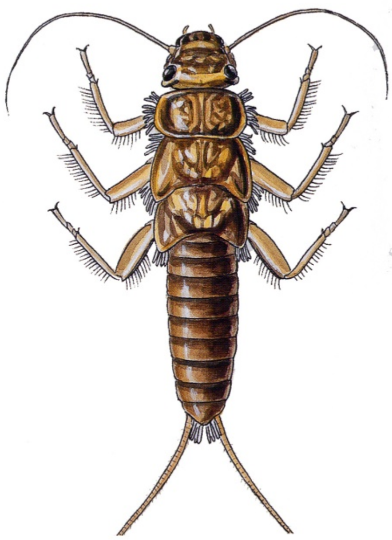
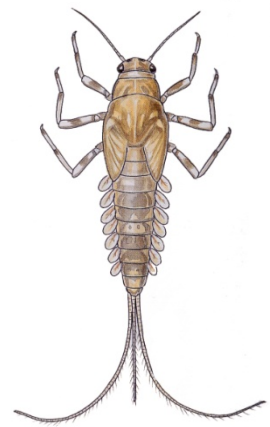
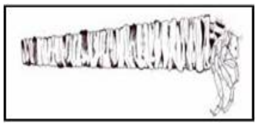
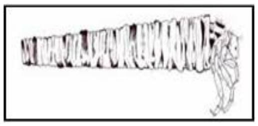
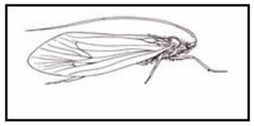
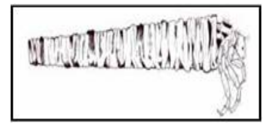
    

Bugs Don't Bug Me





Lessons plans and hands-on activities about aquatic macroinvertebrates and water quality for K-6 students

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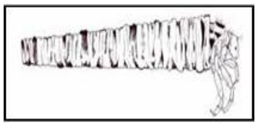
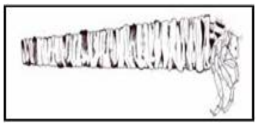
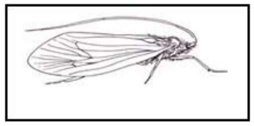
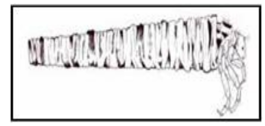
This publication is issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Noelle Cockett, Vice President for Extension and Agriculture, Utah State University.

UtahStateUniversity
WATER QUALITY EXTENSION

Introduction

Bugs Don't Bug Me is a series of lesson plans designed to assist teachers, 4-H leaders, scout leaders, and other educators in teaching about water quality and aquatic macroinvertebrates. Aquatic macroinvertebrates are small animals without backbones that live in water and are big enough to see with the naked eye. These animals include many types of insects as well as worms, mollusks, and crustaceans. Because aquatic macroinvertebrates are really fascinating for many students, they can be used to introduce concepts about adaptations, body structure, feeding habits, and aquatic ecology. Aquatic macroinvertebrates also provide a platform for introducing students to the impacts of pollution and the importance of good stewardship of our natural waters.

These lessons can be used to teach about adaptations, feeding habits, life history strategies, and body parts of aquatic macroinvertebrates (mostly aquatic insects), as well as how aquatic macroinvertebrates are linked to water quality. The lessons can be taught individually or as a series (see suggested sequences below). Each lesson has a recommended grade level but all can be modified for various ages and student knowledge levels. Some lessons include STEM discipline activities, such as graphing, data summary, or data interpretation. Each lesson is aligned to the Utah core curriculum. The lessons do not require expensive materials and most materials are easily available.

Appendices following the lesson plans include an alignment to Utah's core curriculum, additional resources, frequently asked questions, definitions, sample handouts, and more.

We hope you find these lessons useful. Please visit our website (http://extension.usu.edu/waterquality/) for updates and additional resources. We always welcome feedback or comments at:

Water Quality Extension
5210 Old Main Hill
Logan, UT 84322
(435)-797-2580
Nancy.Mesner@usu.edu

A word about outdoor classrooms

We encourage teachers to take their students to a stream or pond to explore aquatic macroinvertebrates in their natural habitat. This is the best place to learn about these organisms, their habits and adaptations. Students will benefit from the opportunity to investigate freely. Research shows that classroom experiences in conjunction with field experiences enhances student learning. It is best to conduct a field experience after students have some knowledge of what an aquatic macroinvertebrate is and their adaptations. Teachers should also plan at least one final lesson after the field experience to reinforce and revisit what students saw in the field.

Be aware that streams have higher flows during the spring season and may not be safe for young children. Collecting activities should be done in the late summer or fall if high flows are a concern.

Safety tips for macroinvertebrate sampling

Kids and water are a natural combination. To ensure the two mix well, consider the following guidelines before going to the stream site:

- If possible, have 1 adult supervisor per six students.
- If you choose to split up into groups, keep a good line of communication between groups at all times (e.g. stay within hearing distance).
- Be aware of medical considerations and have ready access to first aid.
- Know which students are allergic to bee stings and how to handle a reaction.
- Know the causes and early warning signs of hypothermia and heat exhaustion.

Be aware of these safety precautions in choosing a stream site:

- Avoid steep, slippery banks. Holes, vertical banks, and other hazards can be especially difficult to see when the banks are very heavily vegetated.
- Scout the area for dangerous trash such as broken glass, rusted wire, or metal scraps.
- Scout the area for poison ivy, poison oak, and stinging nettle.
- Moving water is deceptively dangerous. **Don't let students enter water over their knees or water that is moving very fast!**
- Never visit a stream during a lighting storm and beware of sudden storms that could produce flash floods.

> Do not let students enter the water without being prepared, i.e. waders, good wading shoes, and an available change of clothing.

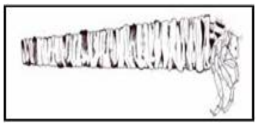
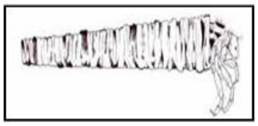
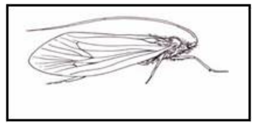
About aquatic macroinvertebrates

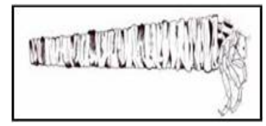
Aquatic macroinvertebrates are small animals that live in water, are big enough to see with the naked eye, and have no backbone. These animals include many types of insects as well as other animals such as worms, mollusks, and crustaceans.

Most aquatic macroinvertebrates make their homes in rocks, leaves, and the sediment of streambeds. These organisms have many special adaptations allowing them to live in demanding environments. Marcroinvertebrates that live in riffles and fast-moving water may have features that help them hold on to rocky or hard substrates such as hooked feet or suction cups; or flat, streamlined bodies that can handle rapid water velocities.

Macroinvertebrates that house themselves deep in muddy substrates may have different sets of adaptations for low oxygen environments such as air tubes or oxygen trapping red hemoglobin in their tissue. See the "Adaptations" column in Appendix C for more examples.

These bugs are important because they are an integral part of the food chain. They provide food for fish and other aquatic organisms. Many of them are also key indicator species. They can tell us about the quality of the water where they are found. Bugs that have a low tolerance to pollution tell us that the water they are found in is relatively healthy. If we do not find these bugs, then it could possibly be due to some sort of pollutant or other impairment to the water body.



Available resources

Websites:

USU Water Quality Extension: **http://extension.usu.edu/waterquality**
Utah Division of Water Resources Water Education: http://www.wateredcation.utah.gov/
Stroud Water Research Center: http://www.stroudcenter.org/education/MacroKeyPage1.htm

Video and photography:

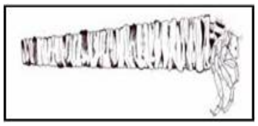
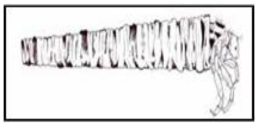
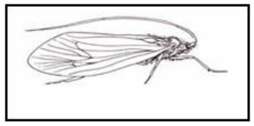
Bugs of the Underworld DVD showcases life cycles of many aquatic invertebrates, available for purchase at http://www.flyline.com (clips also available for viewing on www.youtube.com)
Freshwaters Illustrated: http://www.freshwatersillustrated.org
USU Bug Lab: http://www.usu.edu/buglab/Photos/bugPhotos.cfm

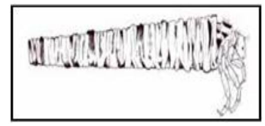
Manuals and field guides:

Voshell, J.Resse, Jr., 2002. A Guide to Common Freshwater Invertebrates of North America. The McDonald & Woodward Publishing Company. Blacksburg, Virginia, ISBN 0-939923-87-4
Utah Stream Team: available at **http://extension.usu.edu/waterquality**

Equipment and Supplies

Equipment and supplies used in the Bugs Don't Bug Me lessons are available for loan through USU Water Quality Extension. See Appendix G for more information.



Summary of each lesson plan

Build A Bug – Introduces students to aquatic macroinvertebrates and teaches about their unique adaptations. One student is selected to be dressed up in a bug costume. Through the help of the other students, each component is identified and added to the costume. This activity works well outdoors, or in a classroom setting.

Macroinvertebrate Simon Says – Teaches feeding habits and some adaptations for various aquatic macroinvertebrates. This is done by playing Simon Says using actions that depict the feeding habits for each bug. This activity can be done outdoors or in a classroom.

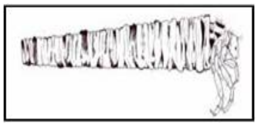
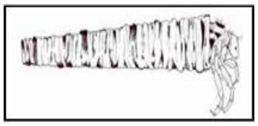
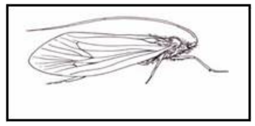
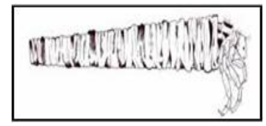
Macroinvertebrate Mix and Match – Introduces students to the 3 main body parts of a bug. Posters or pictures that show the adult macroinvertebrate are displayed and each body segment (head, thorax, and abdomen) of the corresponding larva or nymph are matched to the correct adult. This activity can be done outdoors or in a classroom.

Macroinvertebrate Graphing Activity – This activity helps students make the connection between aquatic life in a stream and water quality. Discussions include tolerant vs. intolerant species and why they are that way. Students are given a sample of "bugs" (represented by skittles) and required to sort them by "species" (color). Each student (or group) then discusses what their sample includes and what that may tell about water quality in that location. This lesson is easiest when done in a classroom setting.

Water Pollution Graphing – This activity introduces students to watersheds and the type of pollutants that can affect water quality. Discussions include the difference between point and non-point source pollution and how different land uses impact water quality. Students are given a water sample with some pollutants (represented by skittles) and required to graph the number of "pollutants" in their sample. The students then try to determine what type of land use activities are occurring in the watershed according to their water sample. This lesson is easiest when done in a classroom setting.

Macroinvertebrate Investigation – Introduces students to aquatic macroinvertebrates by allowing them to catch, observe, and identify them. This is best done in an outdoor setting near a stream, however, a teacher could also collect the invertebrates beforehand and bring them to the classroom.

If Bugs Could Talk – This lesson helps students understand the connection between land use activities, water quality, and aquatic macroinvertebrates. Two "samples" of aquatic macroinvertebrates are shown to the students, one representing a diverse sample of low tolerant species, and one representing a sample of less diverse, more tolerant species. The students then develop a hypothesis as to why the two are different. The students then learn about land use activities and pollutants; they graph the pollutants (represented by skittles) from each sample and compare the results. This can be done outdoors or in a classroom setting.

Suggested sequences

Although the lessons can be taught in any order, below are two suggested sequences, one that emphasizes animal adaptations, and another that emphasizes water quality. These sequences introduce important concepts and reinforce these concepts in a step-wise fashion.

Suggested sequence to teach about animal adaptation and diversity:

1. Build A Bug (introduction to aquatic macroinvertebrates and their adaptations)

2. Make a macroinvertebrate (an optional art project in the Build A Bug lesson)

3. Macroinvertebrate Simon Says (Simon Says game to demonstrate adaptations)

4. Macroinvertebrate Mix and Match (uses posters to illustrate the life stages and three major body parts)

5. Macroinvertebrate Investigation (allows students an opportunity to observe live macroinvertebrates)

Suggested sequence to teach how aquatic invertebrates are linked to water quality

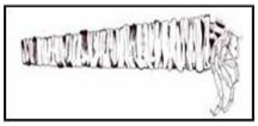
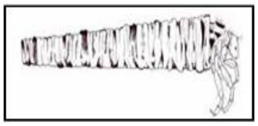
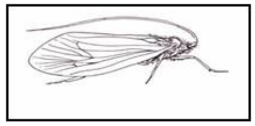
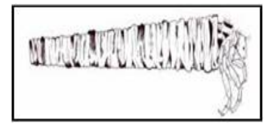
1. Build A Bug **–** (introduction to aquatic macro invertebrates and their adaptations)

2. Macroinvertebrate Mix and Match **–** (uses posters to illustrate the life stages and three major body parts)

3. Macroinvertebrate Graphing **–** (teaches which invertebrates are sensitive to pollution and which are tolerant)

4. Macroinvertebrate Investigation **–** (allows students an opportunity to observe live macroinvertebrates)

5. If Bugs Could Talk **–** (requires students to synthesize information from the previous lessons to determine why their sample of macroinvertebrates changed over time)

Enhancing the experience

There are several ways you can enhance these lessons to meet a specific objective. The following are just a few examples:

Objective – introduce students to natural settings or local water bodies:

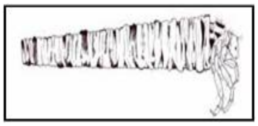
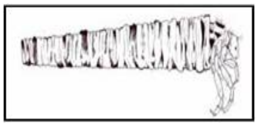
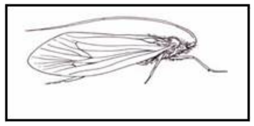
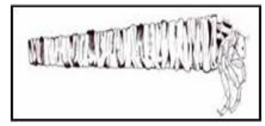
- A field trip to a local stream or river

Objective – allow students to explore living organisms:

- Catch aquatic invertebrates from a river or stream beforehand and bring them into the classroom
- Field trip to a local stream or river where students can collect invertebrates (please read safety tips on page #4).
- Creative writing about what life would be like as an aquatic macroinvertebrate.

Objective – demonstrate how macroinvertebrates function in the wild:

- Show DVD or photos of live aquatic macroinvertebrates (see available resources on page #5)
- Have students do independent/group research and create a poster/presentation to display or share with other students
- Have students write a poem/story about aquatic macroinvertebrates
- Integrate these lessons with other lesson plans found on the Utah State University Water Quality Extension website at [Water Quality - extension.usu.edu]



Build A Bug

PURPOSE: To introduce students to aquatic macroinvertebrates and their unique adaptations.

SUMMARY: By watching a presentation where one of their classmates is dressed up in a bug costume, students learn what adaptations macroinvertebrates have in order to live in an aquatic environment.

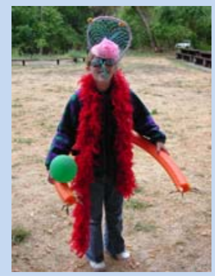
BACKGROUND: The small animals that live in water are called aquatic macroinvertebrates. These macroinvertebrates include many types of insects as well as other animals such as worms, mollusks, and crustaceans.

Most aquatic macroinvertebrates make their home in rocks, leaves, and the sediment of streambeds. These organisms have many special adaptations that allow them to live in demanding environments. Macroinvertebrates that live in riffles and fast-moving water may have features that help them hold on to rocky or hard substrates such as hooked feet or suction cups; or flat, streamlined bodies that can handle high water velocity. Macroinvertebrates that house themselves deep in muddy substrates may have different sets of adaptations for low oxygen environments, such as air tubes or oxygen trapping red hemoglobin in their tissue. See the "Adaptations" column in Appendix C for more examples.

Suggested grade level: K-6

Duration:
15 minutes

Setting:
Classroom
Outdoors

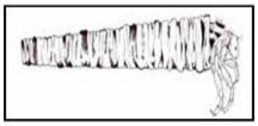
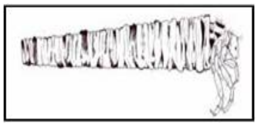
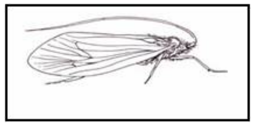
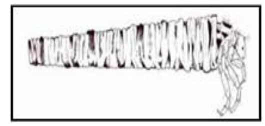


MATERIALS: Items contained in the "Items Representing Adaptations for Build A Bug" column in Appendix C. Use your imagination! Bright colors and silly items work well.

PROCEDURE:

1. Ask the students to brainstorm different adaptations a bug would need to live in an aquatic environment. (For younger students you may want to start with what an adaptation is.)
2. As students give you ideas, show pictures of invertebrates with these adaptations (see Appendix B).
3. Choose a volunteer from the class. Explain that you will be preparing the student to live as an aquatic macroinvertebrate.
4. Ask the students to recall adaptations the volunteer needs in order to live in water.
5. As students give you ideas, dress the volunteer in the items from the table in Appendix C that represent the adaptations.

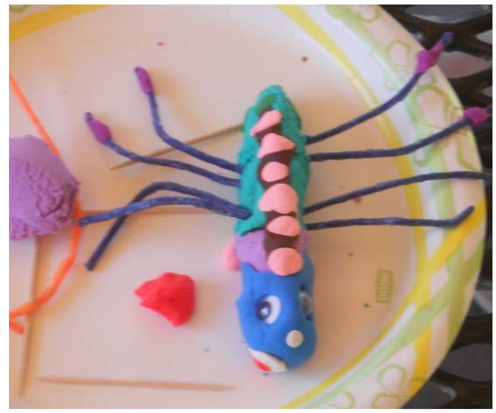
NOTE: An individual macroinvertebrate may not have all of the adaptations listed on the table. Your volunteer "bug" will have features found on many different types of macroinvertebrates.

6. Discuss the adaptations as you go along. Why would a macroinvertebrate need them? How do they help the macroinvertebrate survive?

7. A good way to end this activity is with a photo. "Does our volunteer need anything else? I think he/she needs his/her picture taken!"

OPTIONAL ART ACTIVITY:



You can enhance this lesson with the following art activity (use the materials listed in the table in Appendix C).

1. Tell your students that they will be making an aquatic macroinvertebrate of their own.

2. Show the students the materials listed in the adaptations table of Appendix C, (or substitute other materials to represent adaptations as you see fit).

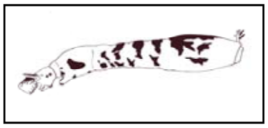
3. Ask them to recall adaptations they saw during the lesson and show them what materials might represent that adaptation (a feather might represent gills, bendaroos might represent legs and/or tails, etc.).

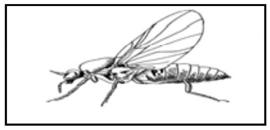
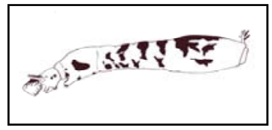
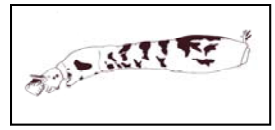
4. Have students use the materials to create their own macroinvertebrate

5. Have each student share his or her macroinvertebrate with the class and explain the adaptations.

CONTINUED LEARNING:

This lesson can be followed with Macroinvertebrate Simon Says to teach about specific feeding adaptations. You can also follow this lesson with Macroinvertebrate Mix and Match to teach the three parts of a bug.



Macroinvertebrate Simon Says

Suggested grade level: K-6

Duration:
30 minutes

Setting:
Classroom
Outdoors

PURPOSE: To introduce students to the feeding adaptations found in aquatic macroinvertebrates.

SUMMARY: After a short introduction to macroinvertebrate feeding habits, students will play a Simon Says game.

BACKGROUND: The macroinvertebrates we will cover can be classified into four groups, called functional feeding groups, depending on their feeding habits. They are shredders, collectors, scrapers (or grazers), and predators.

Shredders are those organisms that chew on intact or large pieces of material. Leaves, needles, flowers, and twigs that fall from trees and shrubs on the shore into the water are the most common food for shredders.

Collectors acquire and ingest very small particles of organic matter. They eat the organic matter suspended in the water by catching it with net-like features or other adaptations. Often they eat fine organic matter that has fallen out of suspension onto the streambed (substrate).

Scrapers (also called grazers) remove and eat the algae growing on rocks in shallow water.

Predators are organisms that prey on other organisms. They have special mouthparts called mandibles which they use to pierce prey and hold it while they eat.

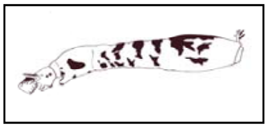
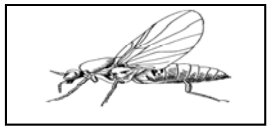
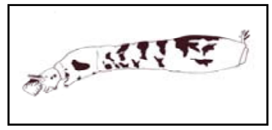
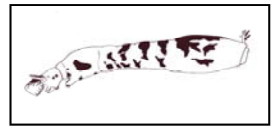
MATERIALS: None needed; however, pictures of the macroinvertebrates can be helpful (see Appendix B or http://www.extension.usu.edu/waterquality).

PROCEDURE:

1. Divide the students into six groups: Dragonflies, Craneflies, Blackflies, Mayflies, Stoneflies, and Caddisflies.

2. Explain the different feeding habits of each group, and assign them an action.

    a. DRAGONFLIES are predators. They have long mouthparts that extend and unfold to catch prey. For their action, have the students put their hands to their mouths with their elbows tucked down in front of them. To mimic eating, have the students straighten their elbows and make an upward scooping action. Students can also hold hands out with one up high and one down low and clap them together in a large “chomping” motion.

b. CRANEFLIES are collectors. They wiggle around until they find a place to feed. The action should be a wiggly walk.

c. BLACKFLIES are also collectors, but they collect with a large net-like feature on their head, which they use to gather food. They can lower it down to their mouths to eat. The action should be placing your hands above your head, and lowering them down to your mouth.

d. STONEFLIES are shredders. They wait for leaves or other debris to fall into the water and then they tear off small pieces to eat. The action should be similar to tearing up a piece of paper.

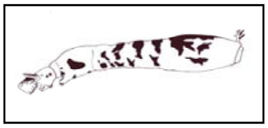
e. CADDISFLIES AND MAYFLIES are scrapers. They scrape algae off rocks and sticks. This action should be similar to scratching someone’s back.

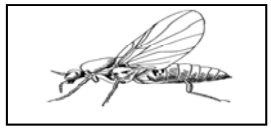
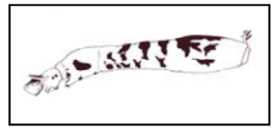
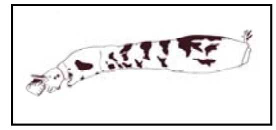
3. After groups have learned their actions, have them act out their part at the same time for one minute.

4. Then test the students on all of the feeding habits by playing “Simon Says” with the actions. (Example: Simon says act like a blackfly. Everyone should have their hands above their head.)

CONTINUED LEARNING:

Now that students have been introduced to aquatic macroinvertebrates, follow this lesson with Macroinvertebrate Mix and Match to introduce their body parts and life cycles.



Macroinvertebrate Mix and Match

Suggested grade level: K-6

Duration:
30 minutes

Setting:
Classroom
Outdoors

PURPOSE: To introduce students to aquatic macroinvertebrates (primarily insects) and the major segments (the head, thorax and abdomen) and the differences between larval, nymph and adult stages.

SUMMARY: The class will learn about the head, thorax and abdomen of insects by mixing and matching pictures of bugs. They will also match the larva/nymph stage of each species to the adult.

BACKGROUND: Macroinvertebrates have three body segments--the head, thorax and abdomen. The head contains the head and antennae. The midsection of the body is called the thorax. It bears the jointed legs and wings. The lower section of the body is the abdomen.

All aquatic macroinvertebrates start life as eggs. Some animals, such as water boatmen (Hemiptera) and leeches, do not change much as they grow – like humans, they get bigger but look basically the same. Some insects, however, change (metamorphose) quite dramatically as they grow. After hatching, the insect may go through several stages before reaching adulthood. Depending on the species, it may go through a larval stage, a nymph stage, or both.

Larva do not show wing buds and usually look quite different than adults.

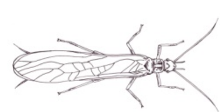
Black Fly Larvae

Black Fly Adult

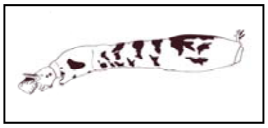
Nymphs usually resemble adults, but are smaller and have no wings.

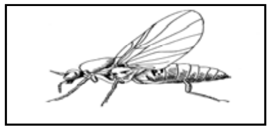
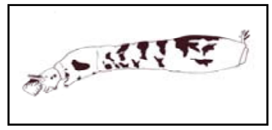
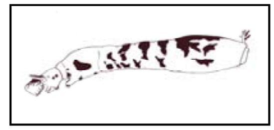
Stonefly Nymph

Stonefly Adult



MATERIALS: Macroinvertebrate posters (available on loan or for sale through USU Water Quality Extension 435-797-2580, see Appendix G for price list). You can also use your own pictures of macroinvertebrate adults and larvae. Cut the pictures of larvae into three sections (head, thorax and abdomen; use whole pictures of adults).



PROCEDURE:

1. Ask the students if they know what the words "aquatic macroinvertebrate" mean. Break down the different words…

   Aquatic = water, Macro = big enough to see with the naked eye, Invertebrate = no backbone.

2. Ask the students if they can name the three segments of an aquatic macroinvertebrate. You can have a volunteer show where the segments would be on a human.

3. Show the students pictures of larvae and nymphs you have cut into three segments. Ask them to repeat what the three segments are (head, thorax, and abdomen).

4. Tell the students the larvae and nymphs in the pictures live in water. Ask them how they can tell the difference between larvae, nymphs, and adults (*the adults have wings*).

5. Talk about the differences between larval and nymph stages of macroinvertebrates and adults. Reaffirm to the students that the pictures on the posters (or the whole pictures) are the adults, and the pictures cut into three segments are the larvae or nymphs.

6. Explain to the students that they will each receive one segment of a bug. Their first task is to mingle with each other and match their entire macroinvertebrate. The person with the abdomen needs to find a matching head and thorax, etc.

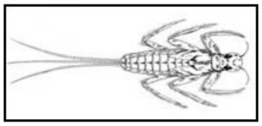
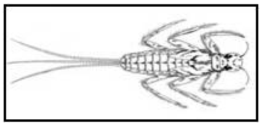
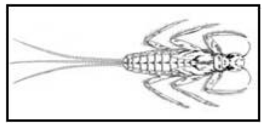
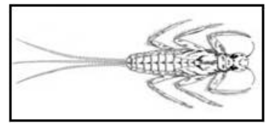
7. Pass out the pictures which are cut into three pieces. Each student should get one segment, unless there are extra, and then some students will get more than one.

8. After they have found the entire macroinvertebrate picture, they need to find the poster of the adult it matches.

9. Once they have matched all the pictures, have them sit down. Review all of the posters to make sure they are correct and discuss the information and facts about each macroinvertebrate in the posters.

CONTINUED LEARNING:

Now that the students know about macroinvertebrates, their adaptations, feeding habits, and body parts; follow with Macroinvertebrate Graphing or Macroinvertebrate Investigation.

Macroinvertebrate Graphing Activity

Suggested grade level: K-6
Duration:
30 - 45minutes

Setting:
Classroom

PURPOSE: To describe and identify the quality of a stream site by analyzing the aquatic macroinvertebrates that live there.

SUMMARY: Students will learn about water quality indicators through the use of candy representing a “macroinvertebrate sample.” Sorting the candy and evaluating what is found will tell the students about the quality of the water.

BACKGROUND: Sometimes it is easy to tell if a stream is polluted. Strange colors and dead fish are often indicators of poor water quality, but biologists need to know about water quality problems long before they reach this point. Some of their most effective partners in detecting declining trends in water quality are aquatic macroinvertebrates because they respond rapidly to changes in water quality.

To evaluate the health and productivity of a stream, biologists look at the types of macroinvertebrate species who live there. Different species have different tolerance levels to pollution. If many pollution-intolerant organisms, such as stonefly or caddisfly nymphs, are present, the water quality is probably good. Although the presence of certain species indicates good water quality, the absence of these species does not necessarily indicate bad water quality. Other factors besides pollution may account for their absence.

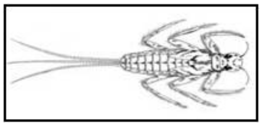
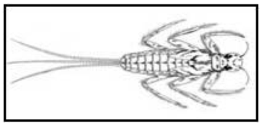
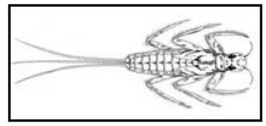
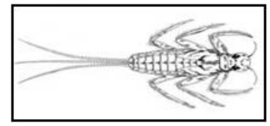
Sensitive or Intolerant Species:
Organisms easily killed, impaired, or driven off by bad water quality; includes many types of stonefly, dobsonfly, and mayfly nymphs and caddisfly larvae.

Somewhat Tolerant Species:
Organisms with the ability to live under varying conditions may be found in good or poor quality water; includes amphipods, scuds, beetle and cranefly larvae, crayfish, and dragonfly nymphs.

Tolerant Species:
Organisms capable of withstanding poor water quality; includes most leeches, aquatic worms, midge larvae, and sow bugs.

MATERIALS:

- Small coated candies (i.e. Skittles or M&M’s)
- Small plastic bags (1 per group of students)
- Graph paper (See Appendix D)
- Colored pencils
- Pictures of macroinvertebrates (see Appendix D)

PROCEDURE:

1. Divide the candy into the bags. You may have one bag per student, or one bag per group of students. You should have about 30 pieces of candy per bag. Each bag represents aquatic macroinvertebrates collected from a study site.

2. Have the class assign an aquatic macroinvertebrate to each color of candy (or do this beforehand if you have visual displays). For example, red = stonefly nymphs, yellow = cranefly larvae, green = leeches. See chart below for an example.

3. Distribute graph paper to each student (or group). Have students set up a bar graph for the aquatic macroinvertebrate sample. Label the x-axis with the names of the candy colors that correlate to the macroinvertebrates. Label the y-axis with the number of macroinvertebrates. You can also make copies of the graph below to hand out to the students.

4. Give each student or group a bag of candy. Have the students separate and count the number of candies they have in each color group and graph them on the paper. Use the colored pencils or crayons to fill in the bars. Have the students try to determine the quality of the water in their sample.

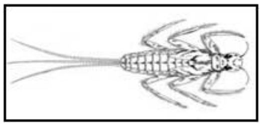
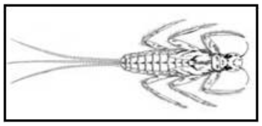
COLOR	MACROINVERTEBRATE (and tolerance to pollution)
Red	Stonefly Nymph (Intolerant)
Orange	Caddisfly Larva (Intolerant)
Dark Brown	Beetle (Somewhat Tolerant)
Blue	Cranefly Larva (Somewhat Tolerant)
Yellow	Midge Larva (Tolerant)
Green	Leeche (Tolerant)

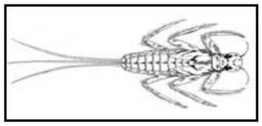
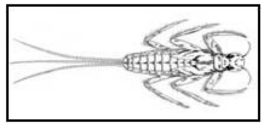
CONTINUED LEARNING:

Discuss how each sample site is different. While some sites may indicate poor water quality there may be other factors involved. Have the students hypothesize possible pollutants. Follow this lesson with Pollution Graphing and Macroinvertebrate Research

For older students, have them do research at the library or on the internet on different pollutants and macroinvertebrates to help them determine the water quality of their sample. They can also research what other factors might lead to no pollution in the water.

***** This activity is adapted from Activity S-2: Use Your Head, Protect Your Watershed! By Dr. Kitt Farrell – Poe, with information also taken from the Utah Stream Team Manual by USU Extension.

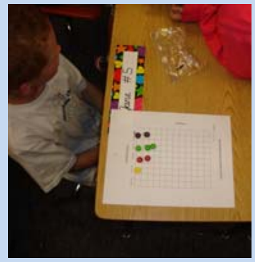



Water Pollution Graphing

Suggested grade level: K-6

Duration:
45 minutes

Setting:
Classroom
Outdoors



PURPOSE: To describe and identify the link between land use activities within a watershed and water quality.

SUMMARY: Students will evaluate the quality of a "water sample" (a bag of skittles), graph their results, and form a hypothesis about the land use near the location their "sample" was collected.

BACKGROUND: A watershed is an area of land from which all the water drains to the same location, such as a stream, pond, lake, river, wetland, or estuary (see figure below). A watershed can be large, like the Colorado River drainage basin, or very small, such as all the water that drains to a small farm pond. Large watersheds are often called basins and contain many small watersheds.

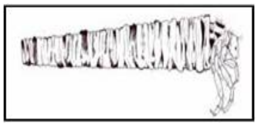
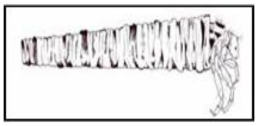
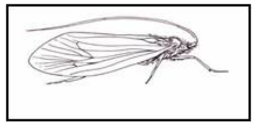
Watersheds can transport non-point source pollution. Non-point source pollution is associated with rainfall and snowmelt moving over or through the ground, carrying natural and human made pollutants into water sources. Examples of non-point source pollutants are fertilizers, pesticides, sediment, gas, and oil. Pollutants accumulate in watersheds as a result of various human and natural activities. These pollutants, while sometimes inevitable, drastically alter the state of the ecosystem. If we can determine the type of pollutant and its cause, then we can classify the source of the pollutant and take preventative measures to reduce any further contamination.

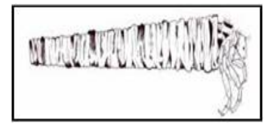
The table below outlines some examples of land uses and their potential problems.

See Appendix D for pictures of land use activities.

Land Use	Activities	Potential Pollution Problems
Agriculture	tillage, cultivation, pest control, fertilization, animal waste	sediment, nitrate, ammonia, phosphate, pesticides, bacteria
Construction	land clearing and grading	sediment
Forestry	timber harvesting, road construction, fire control, weed control	sediment, pesticides, gas and oil
Land Disposal	septic system, land fills	bacteria, nitrate, phosphate, gas and oil, toxic waste, hazardous materials
Recreation	ATV's, boating, hiking, camping, fishing	sediment, gas and oil, garbage
Roads	clearing trees, soil compaction, dirt excavation	Sediment, gas and oil
Surface Mining	dirt, gravel, and mineral excavation	sediment, heavy metals, acid drainage, nutrient
Urban Storm Runoff	lack of automobile maintenance, lawn and garden care, painting	oil, gas, antifreeze, nutrients, pesticides, paints

NOTE: Proper management can reduce the effect of the potential problems.



MATERIALS:

Candy (skittles)
Plastic sandwich bags
Graph paper (see Appendix D)
Colored pencils or crayons
Pollutant labels (see Appendix D)
Pictures of land uses (see Appendix D)

PROCEDURE:

1. Divide the candy into the sandwich bags (you may want to manipulate the bags so that the assortment of candy represents a particular land use area by adding more of a certain type of pollutant, rather than relying on a random mix). You may either have one bag per student or one bag per group of students. You should have about 30 pieces of candy per bag. Each bag represents a water sample from a watershed.

2. Ask the class to define the word pollutant. Tell them that each color of skittles represents a different kind of pollutant. You can use the visual aids provided in Appendix D to hang up in the classroom.

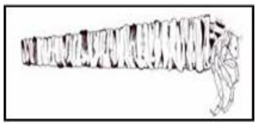
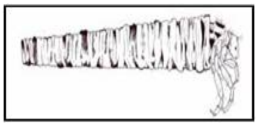
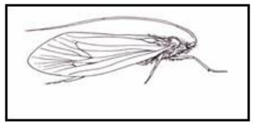
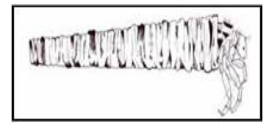
   PURPLE = Sediment
   RED = Pesticides
   GREEN = Fertilizers
   YELLOW = Oil and Gas
   ORANGE = Toxic Waste

   Discuss each of these pollutants with the students. Ask them where they come from, what they are used for, how they can be beneficial, and how they may be harmful. Refer to the Land Use Chart on the previous page for more information. Discuss what land-use means, and what kind of land use may cause the different kinds of pollution.

3. Distribute the graph paper to each student or group. Tell the students that they will be drawing a bar graph to show the number of pollutants found in their “water sample.” Show them the sample graph provided. Have the students label the x-axis with the pollutant types and the y-axis with the amount of pollutants.

4. Give each group a “water sample.” Tell the students to separate and count the number of each pollutant and graph them on the paper. Remind the students that they cannot eat the skittles until they are finished with their graph!

5. Ask the students to try and determine what land use activities are occurring in their watershed according to the “water sample.” For example, a water sample from an area with a lot of agricultural use may have more sediment, fertilizer, and pesticides. Refer to the Land Use Chart on the previous page for more information.

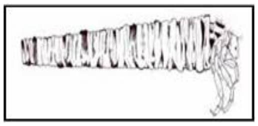
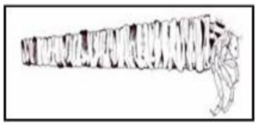
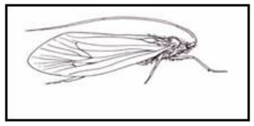
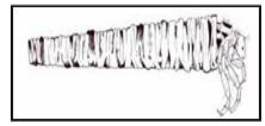
    

6. Discuss how each water sample is different. While some samples might contain an abundance of one type of pollution, almost all types of pollutants can be found in every sample (even if they are small amounts). Discuss strategies to reduce pollution. How can the students do this on a large scale (in their community) or small scale (in their own home)?

   In the community:
   - Encourage friends and neighbors to recycle
   - Plan a science fair project about water quality and reducing pollution
   - Talk to friends and neighbors about what they have learned
   - Pick up trash in your neighborhood

   In the home
   - Encourage parents to fix leaky cars
   - Talk to parents about using less fertilizers and pesticides
   - Recycle items at home
   - Do not dump oil, gas, or other pollutants in the storm drains

NOTE: Be sure the students understand that the factors (materials) we consider non-point source pollutants only become a problem when they are used incorrectly. For example, oil and gas become a problem when they are leaking onto the ground and washing into a water body. Fertilizers and pesticides become a problem when too many are applied and they run off into a water body.

Macroinvertebrate Investigation

Suggested Grade level: K-6

Duration:
30 minutes

Setting:
Outdoors

PURPOSE: To introduce students to living aquatic macroinvertebrates in a field setting.

SUMMARY: Students will collect live macroinvertebrates from a river or stream. They will then classify and count the invertebrates and use that data to determine the EPT index (explained below).

BACKGROUND: Many macroinvertebrates make their homes in riffles and pools of gravel-bed streams. By turning over stones and examining the underside, you may find aquatic macroinvertebrates. Aquatic macroinvertebrates are often used as an indicator of water quality. The orders of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies) are generally sensitive to pollution. Water Quality Biologists use these three orders to calculate an EPT index to determine the quality of a water body. If we find families from these three orders of invertebrates living in a stream or river the water is most likely not impacted from pollution. However, it is important to remember that the absence of these families does not always mean the quality is poor. There could be other reasons these families are not present (please see Appendix F – Discussion Questions for more information).

MATERIALS:

Kick nets* (see Appendix G for instructions on building your own kicknet)
Plastic tubs (1 per 5 students) *
Large transfer pipettes (1 per student)*
Plastic petri dishes (1 per student)*
Magnifying glasses (1 per student)*
Dichotomous keys
Buckets (2)
Waders

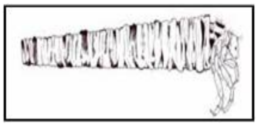
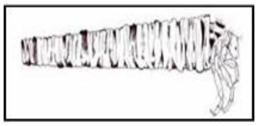
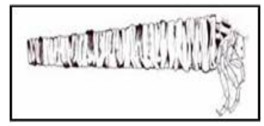
* Available for loan at USU Water Quality Extension or through your local Extension office. Please contact USU Water Quality Extension for details 435-797-2580 or http://extension.usu.edu/waterquality

PROCEDURE:

1. Choose your sample site. Be sure to take into account the safety of your students (see safety tips on page #4).

2. Explain to your students how to collect a macroinvertebrate sample.

    a. One student will wade into the stream and place the net so the mouth of the net is perpendicular to and facing the flow of water.

b. Another student will stand upstream from the net and disturb the stream bottom with his/her feet and hands.
c. Students can carefully pick up and rub stones directly in front of the net to remove attached animals. The stream bottom materials and organisms will be carried into the net by the current.
d. Tell the students to continue this process until they see no more organisms being washed into the net.

3. Have the students hold the sample over a plastic tub, and use a bucket of stream water to wash the organisms into the tub.

4. Have students sort and identify the macroinvertebrates using the transfer pipettes, magnifying glasses, petri dishes, and dichotomous keys. List the number of different families on the table below and calculate an EPT index.

A different "**family**" refers to animals that are related (e.g., all mayflies) but have enough different physical characteristics that they can easily be divided into separate groups. (See dichotomous key).

5. Discuss the different invertebrates the students found and what types of land uses might be impacting the site (see Background from "Water Pollution Graphing" lesson).

Aquatic Invertebrate Group (Orders)	**Number of different found**
Mayfies (Order Ephemeroptera)	
Stoneflies (Order Plecoptera)	
Caddisflies (Order Tricoptera)	
TOTAL	

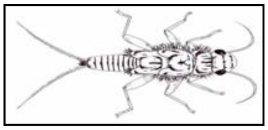
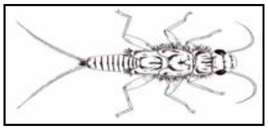
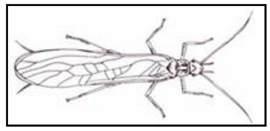
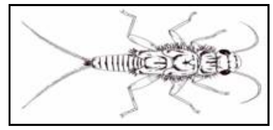
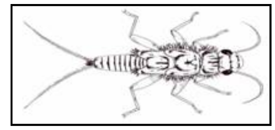
Total "families" equals EPT Value:

> 10 Not affected (excellent water quality)
6-10 Slightly affected (good water quality)
2-5 Moderately affected (fair water quality)
<2 Severely affected (poor water quality)

NOTE: A low EPT value does not always mean poor water quality. Factors other than pollution, such as physical characteristics of the stream or river, may cause the absence of some invertebrates.

CONTINUED LEARNING:

Have students rate the quality of the water using the EPT Value found above (or Water Quality Rating Index found in the Utah Stream Team Manual) found above. Have students sample other sites along the same stream or from two different types of water bodies (stream and lake) for comparison. Discuss what is different or similar between sites. You can also keep a yearly record and have students compare their sites over time.

If Bugs Could Talk

Suggested Grade level: K-6
Duration:
30 minutes

Setting:
Classroom

PURPOSE: To describe and identify the link between land use activities within a watershed and water quality. Students will also understand the link between aquatic macroinvertebrates and water pollution.

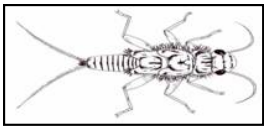
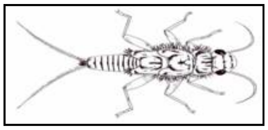
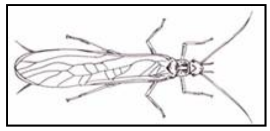
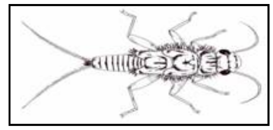
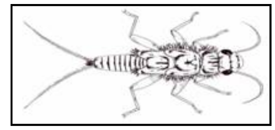
SUMMARY: Students will evaluate the quality of a "water sample" (using a bag of skittles to represent pollution and pictures of aquatic macroinvertebrates to represent invertebrates found in their sample), graph their results, and form a hypothesis about the land use near the location their "water sample" was collected.

BACKGROUND: A watershed is an area of land from which all the water drains to the same location such as a stream, pond, lake, river, wetland, or estuary. A watershed can be large, like the Colorado River drainage basin, or very small, such as all the water that drains to a small farm pond. Large watersheds are often called basins and contain many small watersheds.

Watersheds can transport non-point source pollution. Non-point source pollution is associated with rainfall and snowmelt runoff moving over and through the ground, carrying natural and human made pollutants into water sources. Examples of non-point source pollutants are fertilizers, pesticides, sediment, gas, and oil. Pollutants accumulate in watersheds as a result of various human driven and natural events. These pollutants, while sometimes inevitable, drastically alter the state of the ecosystem. If we can determine the type of pollutant and its cause, then we can classify the source of the pollutant and take preventative measures to reduce any further contaminants. Below are some examples of land use and their potential problems:

NOTE: These problems only occur because of a lack of proper management.

Land Use	Activities	Potential Pollution Problems
Agriculture	tillage, cultivation, pest control, fertilization, animal waste	sediment, nitrate, ammonia, phosphate, pesticides, bacteria
Construction	land clearing and grading	sediment
Forestry	timber harvesting, road construction, fire control, weed control	sediment, pesticides
Land Disposal	septic system	bacteria, nitrate, phosphate
Surface Mining	dirt, gravel, and mineral excavation	sediment, heavy metals, acid drainage, nutrient
Urban Storm Runoff	lack of automobile maintenance, lawn and garden care, painting	oil, gas, antifreeze, nutrients, pesticides, paints

Aquatic macroinvertebrates can indicate the level of water quality. Stoneflies, mayflies, and caddisflies (called indicator species) are not well adapted to living in water with high levels of pollution. They are pollution intolerant. Often, when these species are limited or absent in a river or stream where they typically should be found, that can be indicative of poor water quality. Aquatic macroinvertebrates can be classified by their level of tolerance to pollution.

Sensitive or Intolerant Species:
Organisms easily killed, impaired, or driven off by bad water quality; includes many types of stonefly, dobsonfly, and mayfly nymphs, caddisfly larvae, and water pennies.

Somewhat Tolerant Species:
Organisms with the ability to live under varying conditions may be found in good or poor quality water; includes amphipods, scuds, beetle and cranefly larvae, crayfish, and dragonfly nymphs.

Tolerant Species:
Organisms capable of withstanding poor water quality; includes most leeches, aquatic worms, midge larvae, and sow bugs.

MATERIALS:

Candy (skittles)
Plastic sandwich bags
Graph paper (graphs can be found in Appendix D)
Colored pencils
Pollutant labels (see Appendix D)
Macroinvertebrate pictures (see Appendix D)

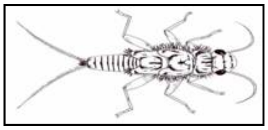
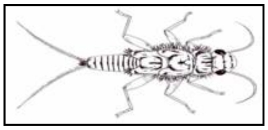
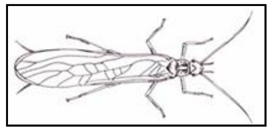
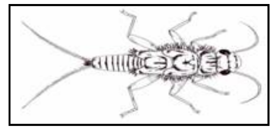
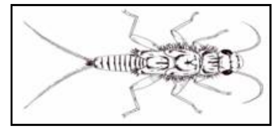
PROCEDURE:

1. Before the lesson, divide the candy up into the sandwich bags so that each student or group of students has two “water samples”. Make sure each set is the same: one with fewer pollutants and one with more pollutants.

2. Tell the students you have taken two macroinvertebrate samples from similar streams (or one taken years previous in the same location) and show them pictures of the aquatic macroinvertebrates from each sample. One sample should have pollution intolerant invertebrates; the second sample should have more tolerant invertebrates). Show them the pictures and ask them why they think the insects are different in each sample.

3. Tell the students that you also have a water sample that may help them decide why the bugs are different. Pass out the bags of skittles to each student or group of students.

4. Ask the class to define the word pollutant. Tell them that each color of skittles represents a different kind of pollutant. You can use the visual aids provided in Appendix D to hang up in the classroom.

PURPLE = Sediment
RED = Pesticides
GREEN = Fertilizers
YELLOW = Oil and Gas
ORANGE = Toxic Waste

5. Discuss each of these pollutants with the students. Ask them where they come from, what they are used for, how they can be beneficial, and how they may be harmful. Refer back to the Land Use Chart, on page 25 of the manual, for more information. Discuss what “land use” means, and what kind of land uses may produce the different kinds of pollution.

6. Distribute the graph paper to each student or group. Tell the students that they will be completing a bar graph to show the number of pollutants found in their “water sample”. Show them the sample graph provided. Have the students label the x-axis with the pollutant types and the y-axis with the amount of pollutants.

7. Tell the students to separate and count the number of each pollutant and graph them on the paper. Remind the students that they cannot eat the skittles until they are finished with their graph!

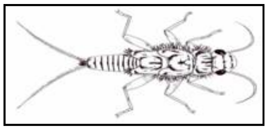
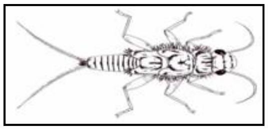
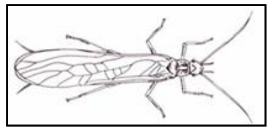
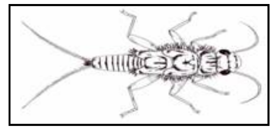
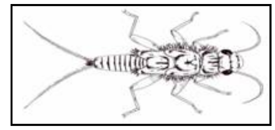
8. Go over the graphs as a class by creating a master graph in front of the classroom. Talk about what land use activities may be happening near the high pollution sample. Refer to the land use chart at the beginning of the lesson (page 25).

9. Review the pictures and ask students again why they believe the macroinvertebrates are different in each sample.

10. Discuss ways students can help reduce water pollution.

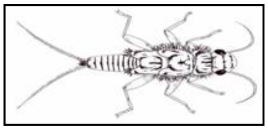
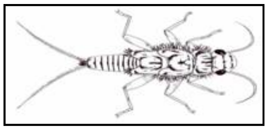
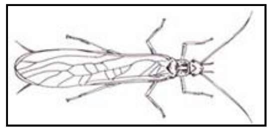
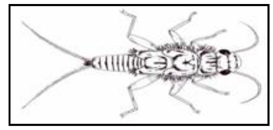
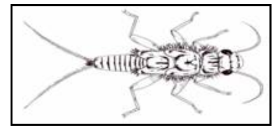
- *Don’t use excessive amounts of fertilizers or pesticides around your house. They can wash into the storm drains and end up in a stream.*
- *Never put anything but water down a storm drain.*
- *Don’t be a litterbug. Always dispose of trash in a proper container, not in the water.*
- *Make sure that your family car doesn’t leak oil or antifreeze. This can wash into the water and be dangerous for fish, birds, even cats and dogs.*
- *Walk only on existing trails when near the water to help reduce erosion.*

NOTE: Be sure the students understand that the factors (materials) we consider non-point source pollutants only become a problem when they are used incorrectly. For example, oil and gas become a problem when they are leaking onto the ground and washing into a water body. Fertilizers and pesticides become a problem when too many are applied and they run off into a water body.

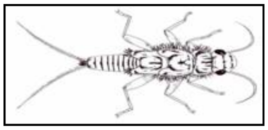
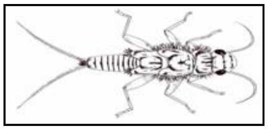
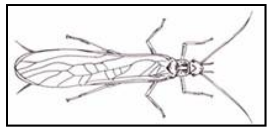
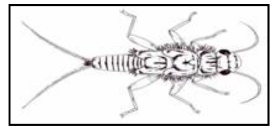
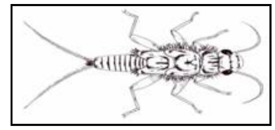


CONTINUED LEARNING:

- Make each sample different to compare different land uses (see land use table in Appendix E).
- Talk about how pollutants or contaminants affect our water supply.
- Discuss the adaptations of different aquatic macroinvertebrates and why some are more tolerant to pollution.
- Talk about how pollutants or contaminants might affect the food chain.
- Prepare the second group of macroinvertebrates with fewer bugs or no bugs rather than just different bugs
- For older students, have them do research on different pollutants and macroinvertebrates at the library or on the internet to help them determine the water quality of their sample. They can also research what other factors might affect there being no pollution in the water.
- See Stream Side Science manual for more lesson ideas on watersheds and water quality.

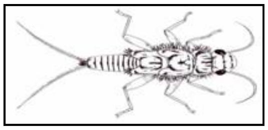
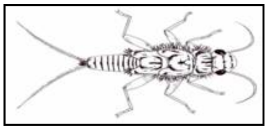
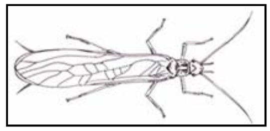
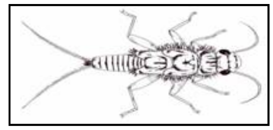
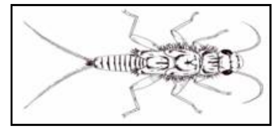
Appendices

Appendix A: Links to the Utah Core Curriculum for Grades K-6

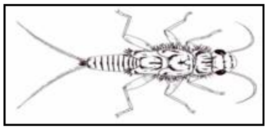
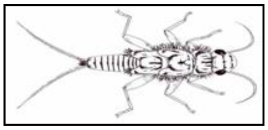
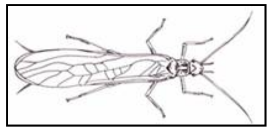
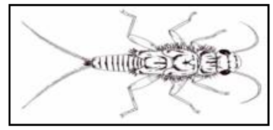
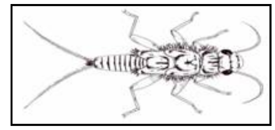
State of Utah Core Curriculum Standards for Kindergarten

			Build A Bug	Simon Says	Macroinvertebrate Mix and Match	Macroinvertebrate Graphing	Water Pollution Graphing	Macroinvertebrate Research	If Bugs Could Talk
Science	**Standard 1: ILO**	Objective 1	x	x		x	x	x	x
		Objective 2	x		x	x	x	x	x
		Objective 3	x		x	x	x		x
	Standard 2: Earth and Space	No Correlation							
	Standard 3: Physical Science	No Correlation							
	Standard 4: Life Science	Objective 1	x	x	x	x		x	x
		Objective 2	x	x	x	x		x	x
Math	**Counting and Cardinality**	Know number names and the count sequence				x	x	x	x
		Count to tell the number of objects				x	x	x	x
		Compare numbers				x	x	x	x
	Measurement & Data	Describe and compare measurable attributes						x	
		Classify objects and count the number of objects in each category				x	x	x	x

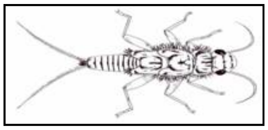
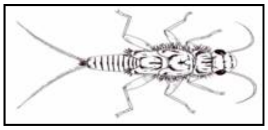
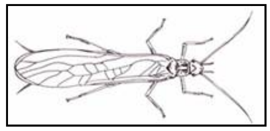
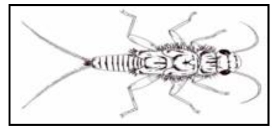
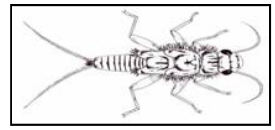
State of Utah Core Curriculum Standards for First Grade

			Build A Bug	Macroinvertebrate Simon Says	Macroinvertebrate Mix and Match	Macroinvertebrate Graphing	Water Pollution Graphing	Macroinvertebrate Research	If Bugs Could Talk
Science	**Standard 1: ILO**	Objective 1	x	x		x		x	x
		Objective 2	x		x	x		x	x
		Objective 3	x		x	x			x
	Standard 2: Earth and Space	No Correlation							
	Standard 3: Physical Science	Objective 1							
		Objective 2					x		
	Standard 4: Life Science	Objective 1	x	x	x	x		x	x
		Objective 2	x	x	x	x		x	x
Math	**Operations & Algebraic Thinking**	Represent and solve problems involving addition and subtraction						x	
		Add and subtract within 20						x	
	Number and Operations in Base Ten	Extend the counting sequence						x	
	Measurement & Data	Represent and interpret data				x	x		x

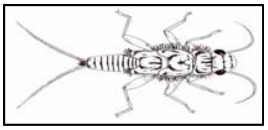
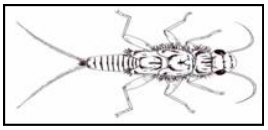
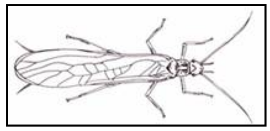
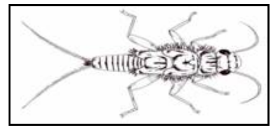
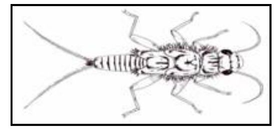
State of Utah Core Curriculum Standards for Second Grade

			Build A Bug	Macroinvertebrate Simon Says	Macroinvertebrate Mix and Match	Macroinvertebrate Graphing	Water Pollution Graphing	Macroinvertebrate Research	If Bugs Could Talk
Science	**Standard 1: ILO**	Objective 1	x	x		x		x	
		Objective 2	x		x	x		x	
		Objective 3	x		x	x			
	Standard 2: Earth and Space	No Correlation							
	Standard 3: Physical Science	No Correlation							
	Standard 4: Life Science	Objective 1	x	x	x	x		x	x
		Objective 2	x	x	x	x		x	x
Math	**Operations & Algebraic Thinking**	Add and subtract within 20						x	
	Measurement & Data	Represent and Interpret Data				x	x		x

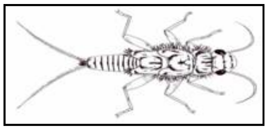
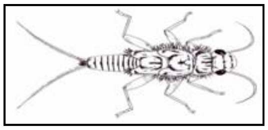
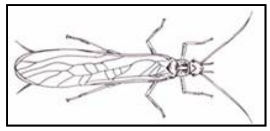
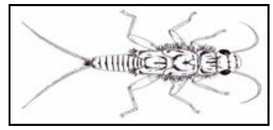
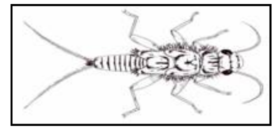
State of Utah Core Curriculum Standards for Third Grade

				Build A Bug	Macroinvertebrate Simon Says	Macroinvertebrate Mix and Match	Macroinvertebrate Graphing	Water Pollution Graphing	Macroinvertebrate Research	If Bugs Could Talk
Science	**Standard 2:**	Objective 1		x	x	x	x		x	x
		Objective 2					x	x		x
	ILO	Use science process and thinking skills	a	x	x	x	x	x	x	x
			b				x	x	x	x
			c				x	x	x	x
			d			x	x	x	x	x
			e				x	x		x
			f				x	x	x	x
			g						x	
			h						x	x
		Manifest scientific attitudes and interests	a	x		x	x	x	x	x
			b							
			c	x	x	x	x	x	x	x
		Understand science concepts and principles	a	x	x	x	x	x	x	x
			b							
			c	x	x	x	x	x	x	x
		Communicate effectively using science language and reasoning	a			x	x	x	x	x
			b	x			x	x		x
			c	x	x	x	x	x	x	x
			d				x	x	x	x
Math	**Number & Operations - Fractions**	Develop understanding of fractions as numbers							x	
	Measurement & Data	Represent & interpret data					x	x	x	x

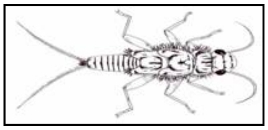
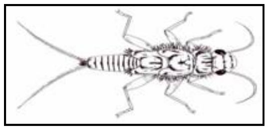
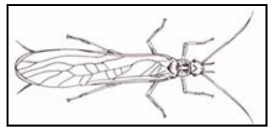
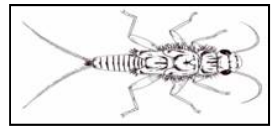
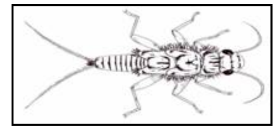
State of Utah Core Curriculum Standards for Fourth Grade

			Build A Bug	Simon Says	Macroinvertebrate Mix and Match	Macroinvertebrate Graphing	Water Pollution Graphing	Macroinvertebrate Research	If Bugs Could Talk
Science	**Standard 1**	No Correlation							
	Standard 2	No Correlation							
	Standard 3	No Correlation							
	Standard 4	No Correlation							
	Standard 5	Objective 1							
		Objective 2		x	x	x		x	x
		Objective 3							
		Objective 4						x	
	ILO	Use Science Process and Thinking Skills	x	x	x	x	x	x	x
		Manifest Scientific Attitudes and Interests	x		x	x	x	x	x
		Understand Science Concepts and Principles	x	x	x	x	x	x	x
		Communicate Effectively Using Science Language and Reasoning	x		x	x	x	x	x
Math	**Measurement & Data**	Represent and Interpret Data				x	x	x	x



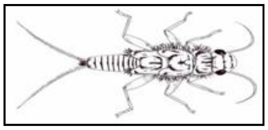
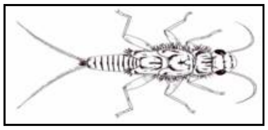
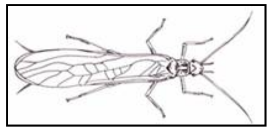
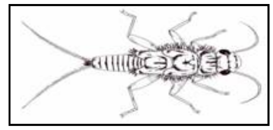
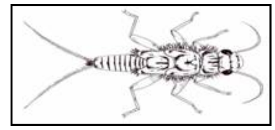
State of Utah Core Curriculum Standards for Fifth Grade

			Build A Bug	Simon Says	Macroinvertebrate Mix and Match	Macroinvertebrate Research	Macroinvertebrate Graphing	Water Pollution Graphing	If Bugs Could Talk
Science	**Standard 1**	No Correlation							
Science	**Standard 2**	No Correlation							
Science	**Standard 3**	No Correlation							
Science	**Standard 4**	No Correlation							
Science	**Standard 5**	Objective 1	x		x				
Science	**Standard 5**	Objective 2	x	x	x	x	x	x	x
Science	**ILO**	Use Science Process and Thinking Skills	x	x	x	x	x	x	x
Science	**ILO**	Manifest Scientific Attitudes and Interests	x		x	x	x	x	x
Science	**ILO**	Understand Science Concepts and Principles	x		x	x	x	x	x
Science	**ILO**	Communicate Effectively Using Science Language and Reasoning	x		x	x	x	x	x
Science	**ILO**	Demonstrate Awareness of Social and Historical Aspects of Science				x	x		x
Science	**ILO**	Understand the Nature of Science				x	x		x
Math	**Measurement & Data**	Represent and Interpret Data				x	x		x

State of Utah Core Curriculum Standards for Sixth Grade

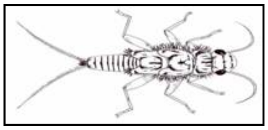
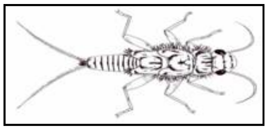
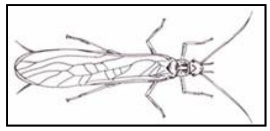
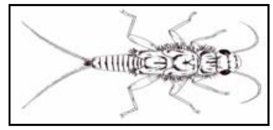
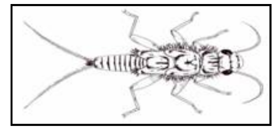
			Build A Bug	Simon Says	Macroinvertebrate Mix and Match	Macroinvertebrate Research	Macroinvertebrate Graphing	Water Pollution Graphing	If Bugs Could Talk
Science	**Standard 1**	No Correlation							
	Standard 2	No Correlation							
	Standard 3	No Correlation							
	Standard 4	No Correlation							
	Standard 5	No Correlation							
	ILO	Use Science Process and Thinking Skills	x	x	x	x	x	x	x
		Manifest Scientific Attitudes and Interests	x		x	x	x	x	x
		Understand Science Concepts and Principles			x	x	x	x	x
		Communicate Effectively Using Science Language and Reasoning	x		x	x	x	x	x
		Demonstrate Awareness of Social and Historical Aspects of Science				x	x		x
		Understand the Nature of Science				x	x		x

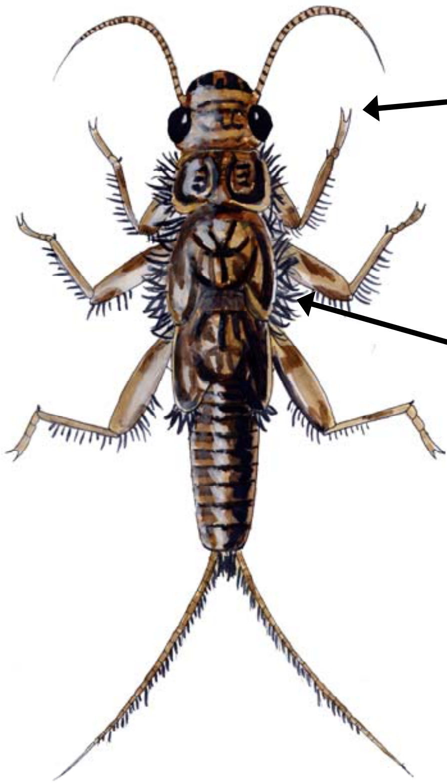






Appendix B: Examples of aquatic macroinvertebrate adaptations

The **Blackfly larva** has a net on its head for collecting food.

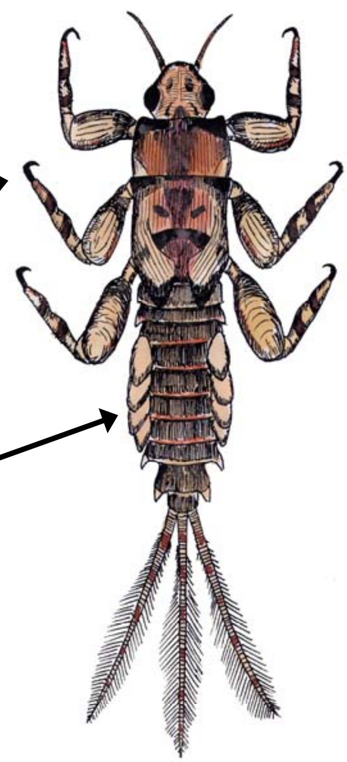
The **Cranefly larva** has tiny hairs and suction cups along its body so it can hold on to rocks and hard substrates in fast flowing water.



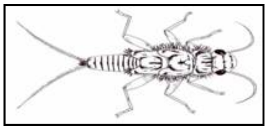
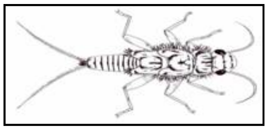
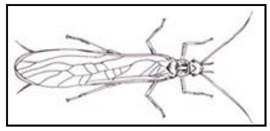
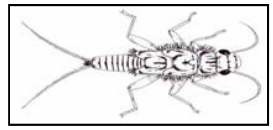
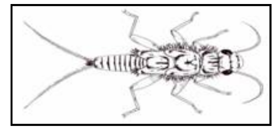
The **Stonefly** nymph has claws for capturing prey and holding on tight to rocky substrates.

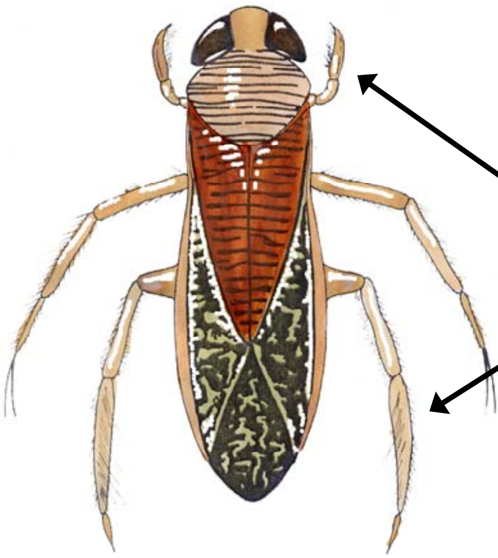
The **Stonefly** nymph has gills in its “armpits” for breathing dissolved oxygen in fast flowing streams.



The **Mayfly** nymph has hooks for holding on tight to rocky substrates.

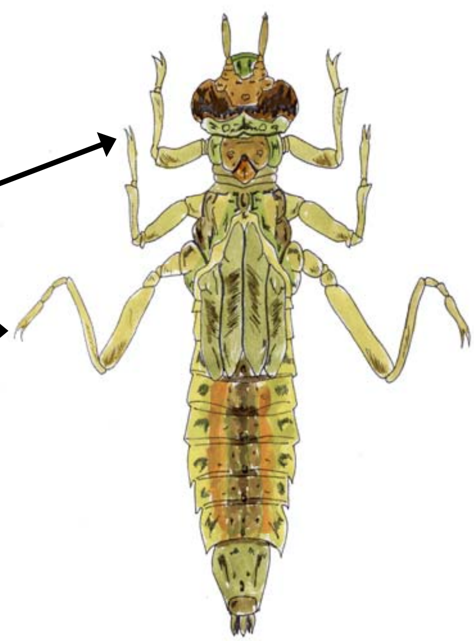
The **Mayfly** nymph has gills on its abdomen for breathing dissolved oxygen in fast flowing streams.

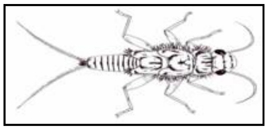
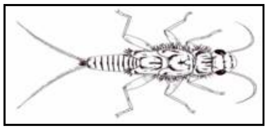
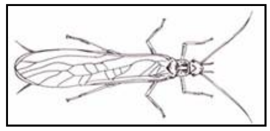
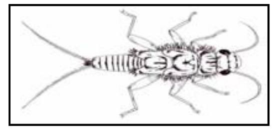
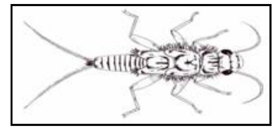
    



The **Water boatman** has paddle-like legs for swimming in slow moving water.

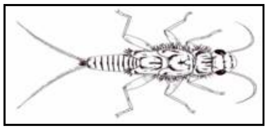
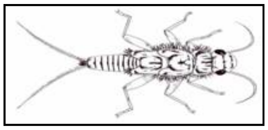
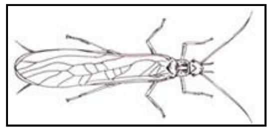
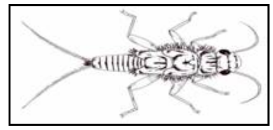
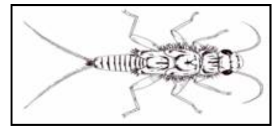
The **Dragonfly nymph** has claws on its legs for capturing prey and for climbing emergent vegetation.



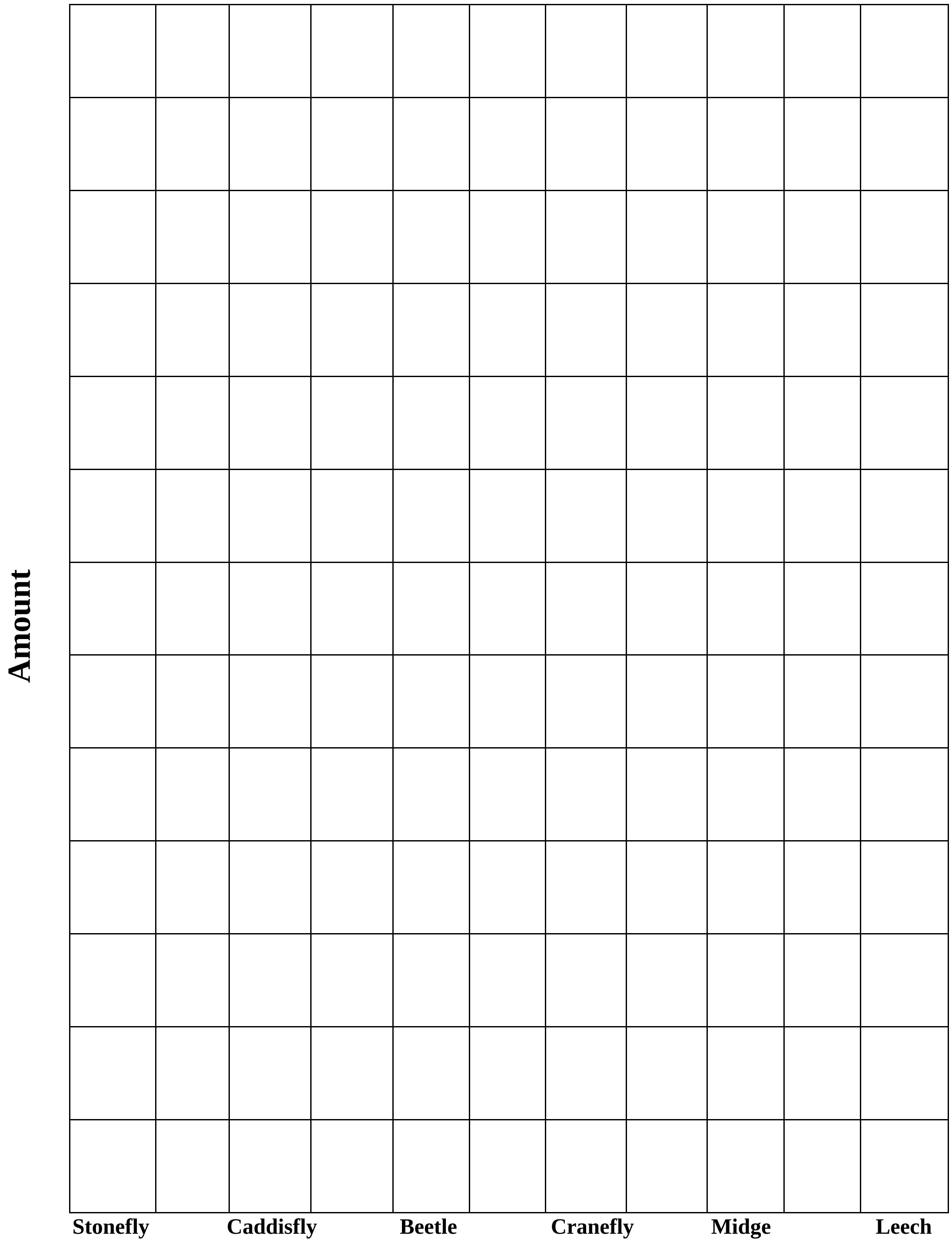
Appendix C: Suggested props for macroinvertebrate adaptations

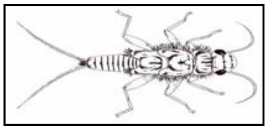
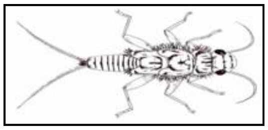
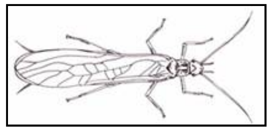
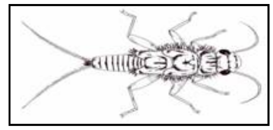
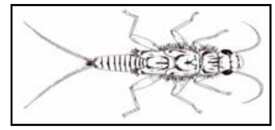
Adaptations	**Use**	**Items Representing Adaptations for Build A Bug**	**Items Representing Adaptations for Make A Macroinvertebrate**
Legs, claws, hooked feet, suction cups, hairs on legs	Holding on to rocks and hard substrate, scraping algae off rocks, attacking prey	Water noodle with hooks on the end	Bendaroos®, pipe cleaners
Tails	Swimming and maneuvering	Garland or rope	Bendaroos®, pipe cleaners
Compound Eyes	Help insect detect motion	Sunglasses with googly eyes glued on	Googly eyes (various sizes)
Hairs on head or body	Help detect movement or chemical changes in water	Wig or furry hat	Puff balls, feathers
Antennae	Sensing food, water, surroundings	Store bought or homemade antennae	Bendaroos®, pipe cleaners
Gills	Breathing dissolved oxygen in the water	Feather boa	Bendaroos®, feathers
Air bubble	Breathing oxygen from the surface air	Balloon	Plastic necklace pop-beads, bouncy ball, beads
Breathing tube	Breathing oxygen from the surface air	Straw	Straws
Specialized mouth parts	For scraping, piercing, shredding, etc. The mouth parts reflect food choices of the insect	Vampire teeth	Toothpicks
Device for catching food, i.e. net (made by the insect or part of their body structure) or special hairs	Catching food in the current	Fishing net	Fabric netting and toothpicks, feathers

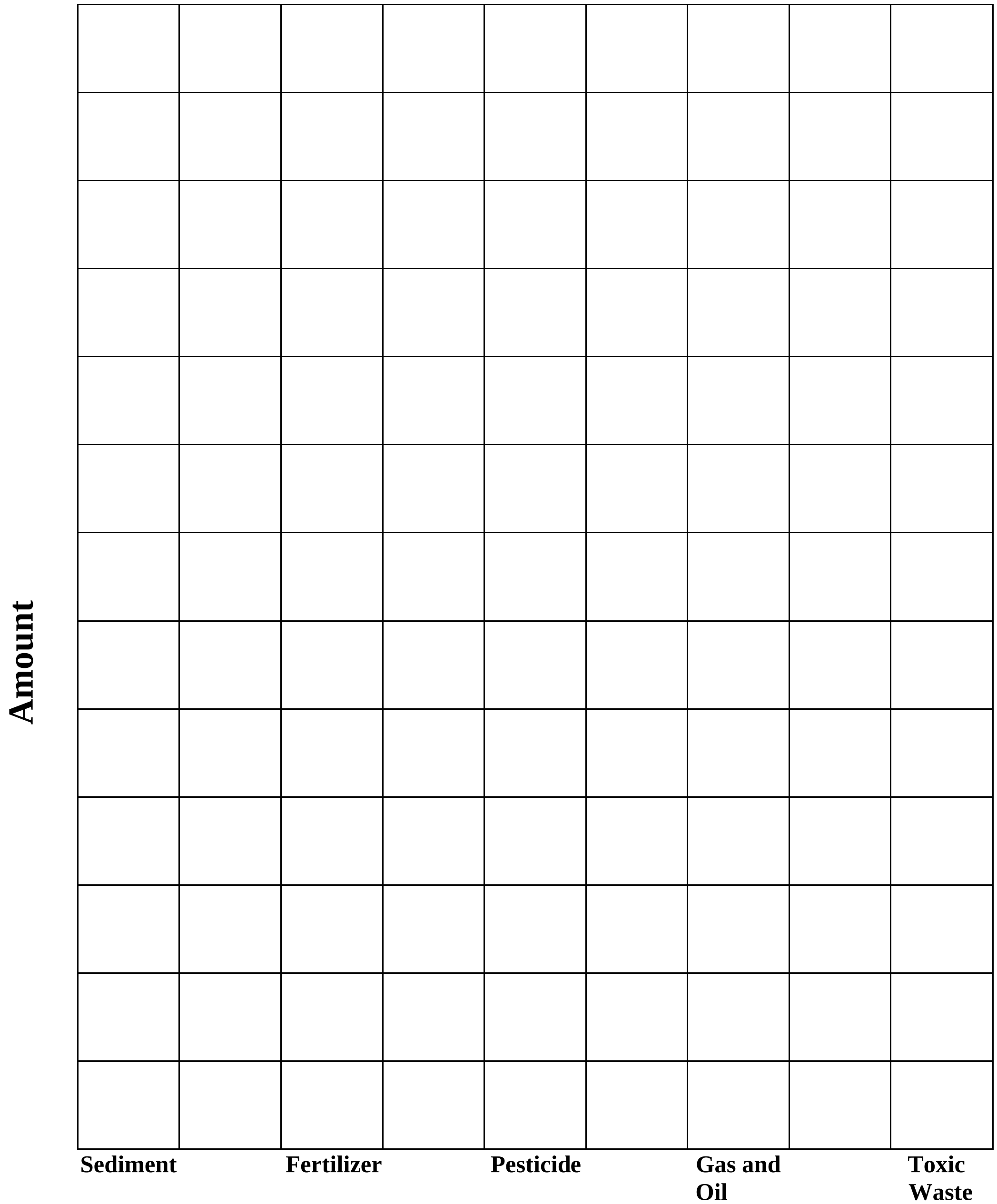
Appendix D: Visual aids and handouts for graphing lessons

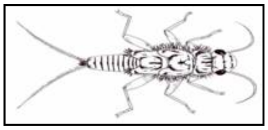
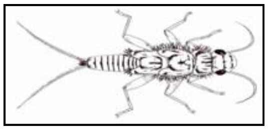
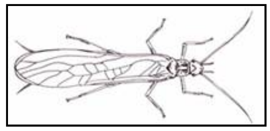
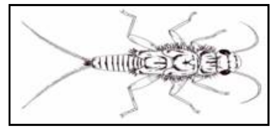
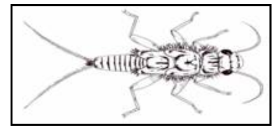
Macroinvertebrate Graphing Activity



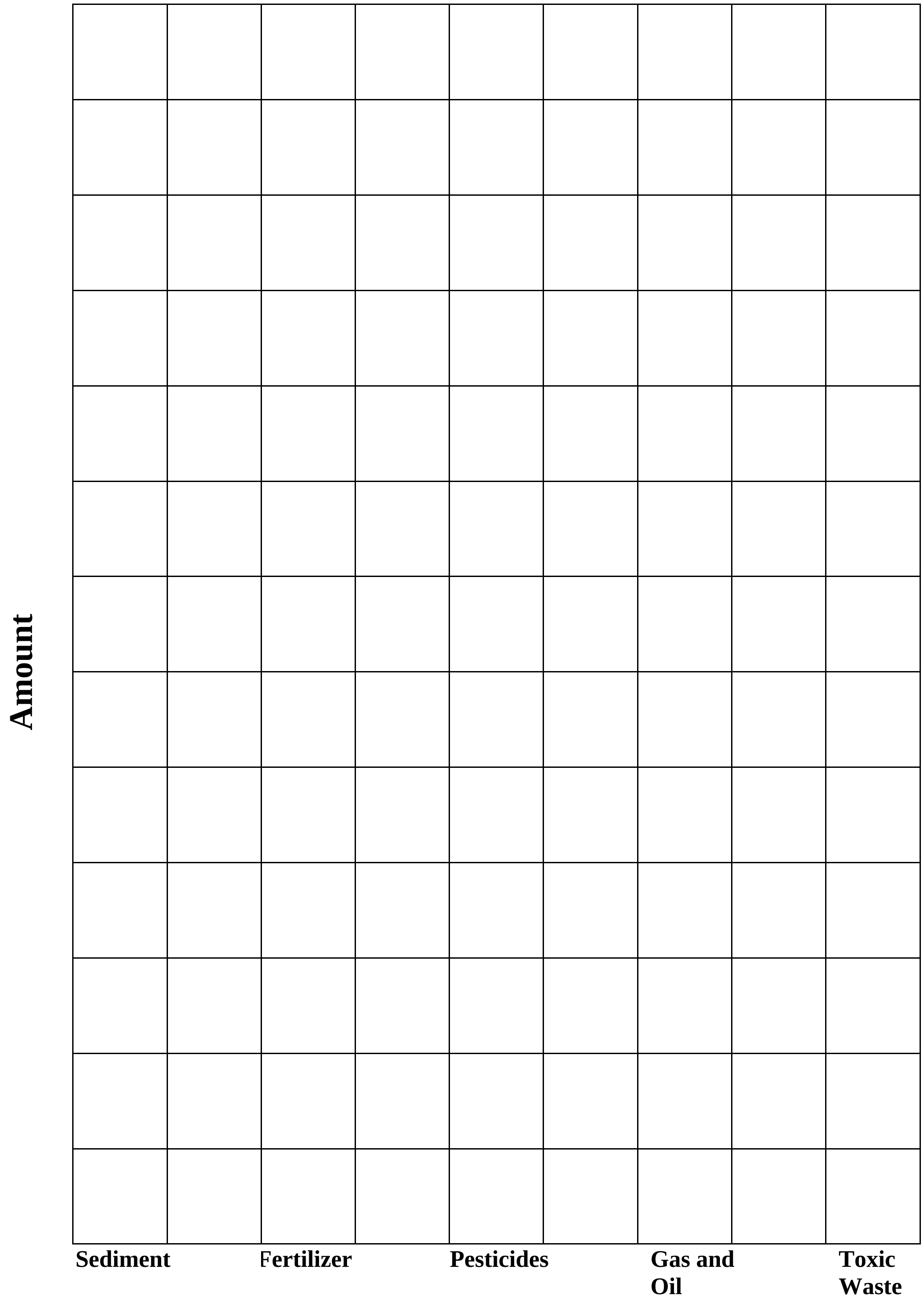
    

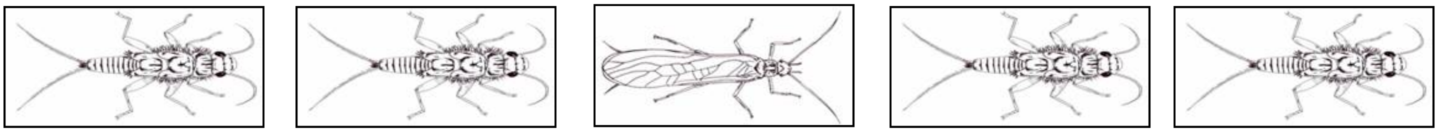
Water Pollution Graphing Activity



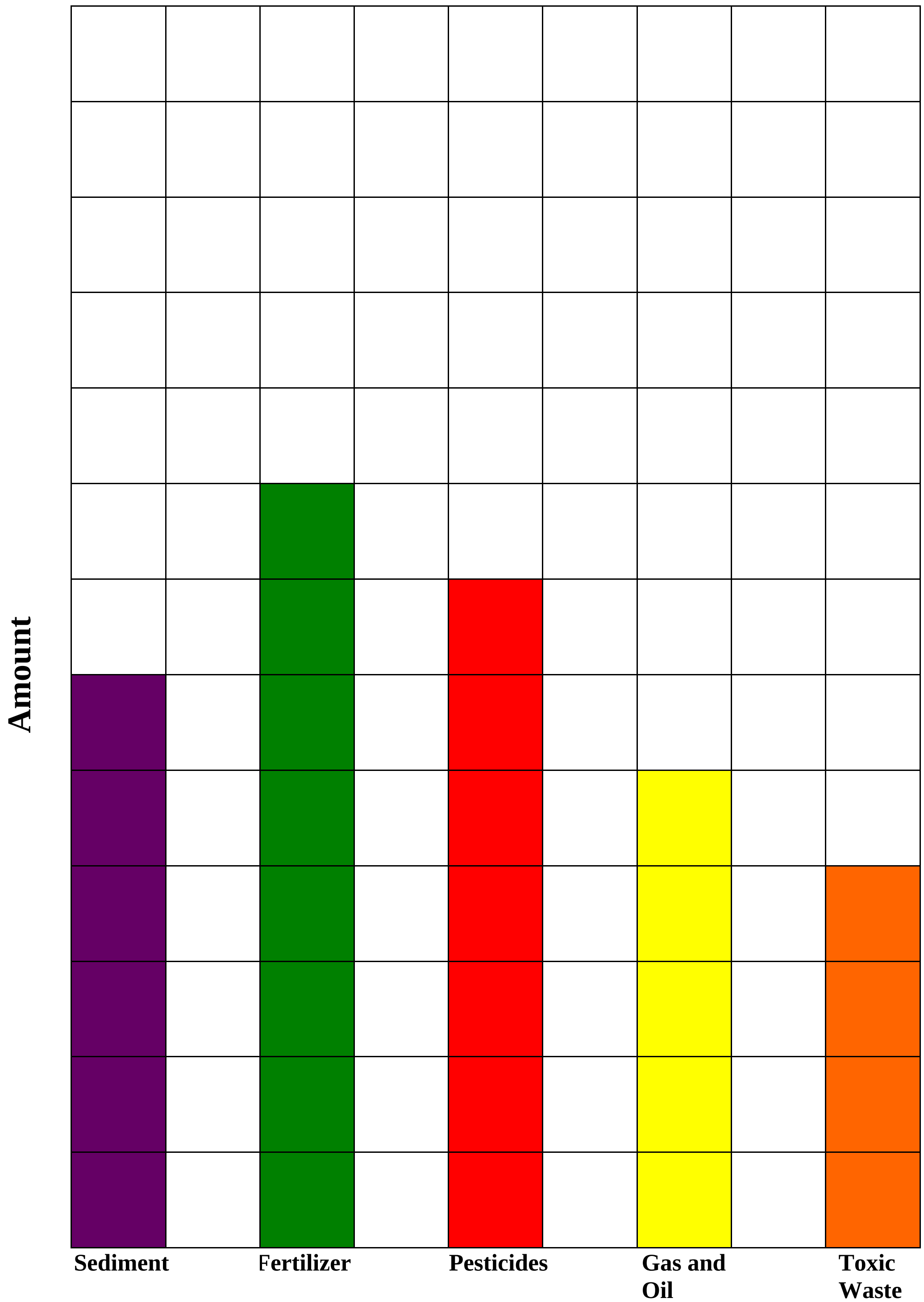
    

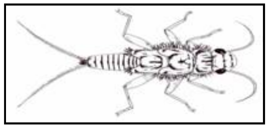
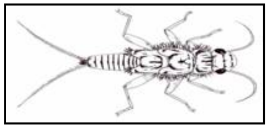
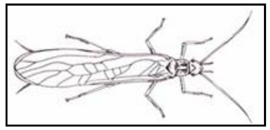
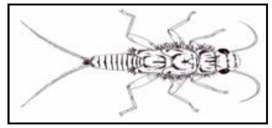
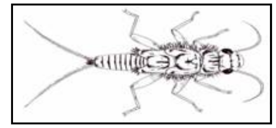
If Bugs Could Talk Graphing Activity



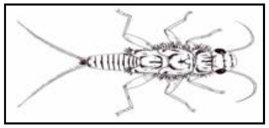
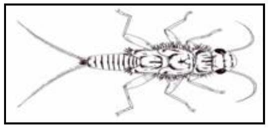
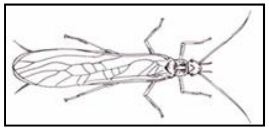
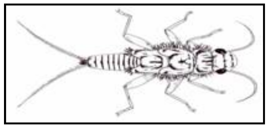
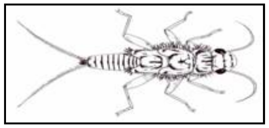


Sample graph



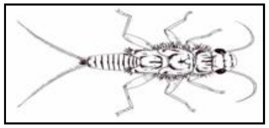
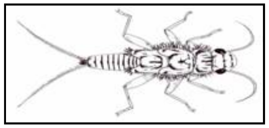
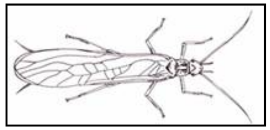
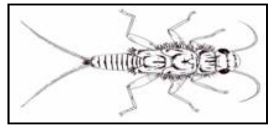
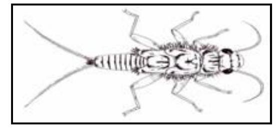
    

SEDIMENT

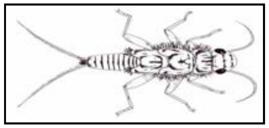
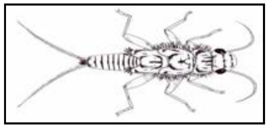
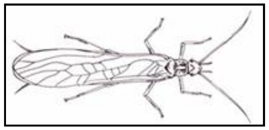
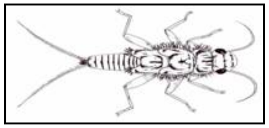
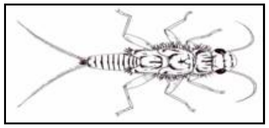








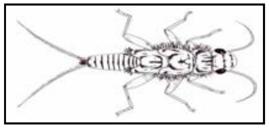
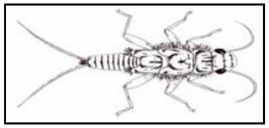
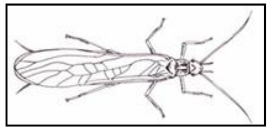
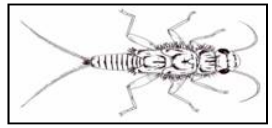
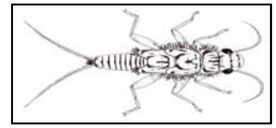
FERTILIZERS/ NUTRIENTS

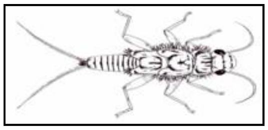
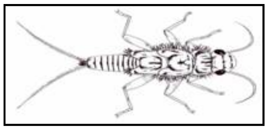
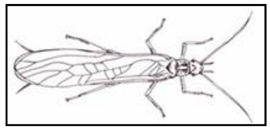
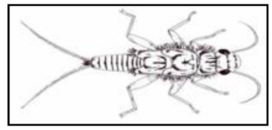
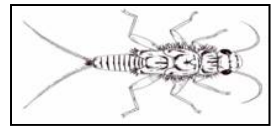
PESTICIDES

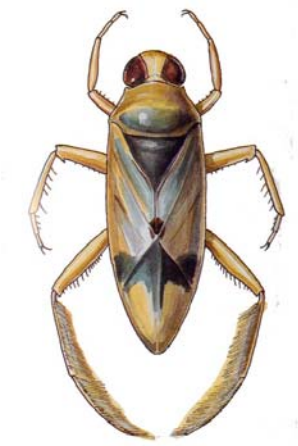

TOXIC WASTE

OIL AND GAS

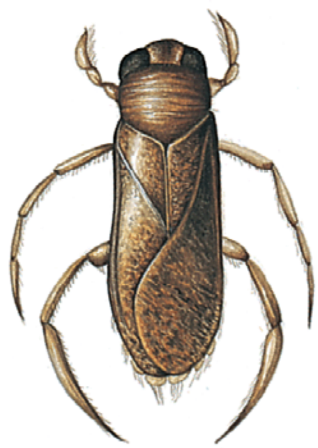






Aquatic Macroinvertebrates with high pollution tolerance



Back swimmer

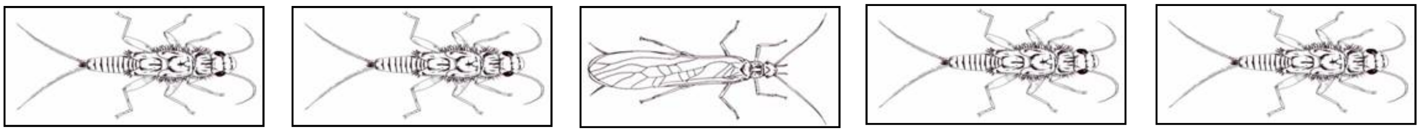
Diving Beetle



Water boatman

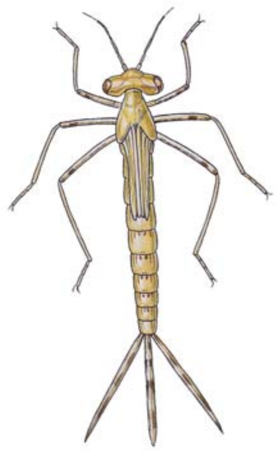
Water Strider

Rat-Tailed Maggot



Aquatic Macroinvertebrates with medium pollution tolerance

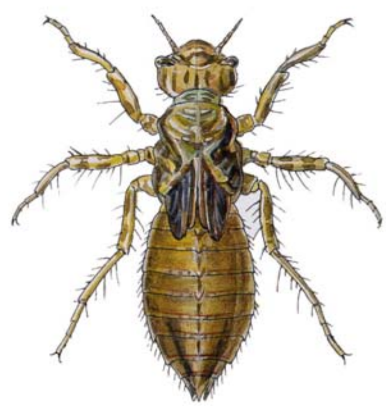
Blackfly



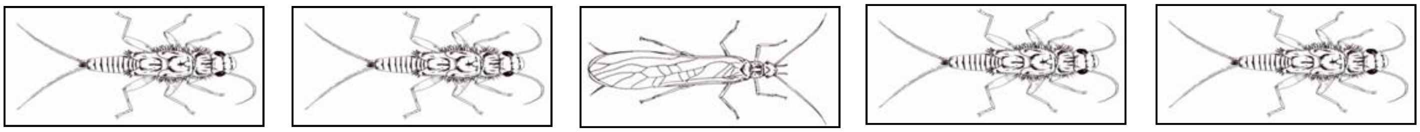
Damselfly

Cranefly

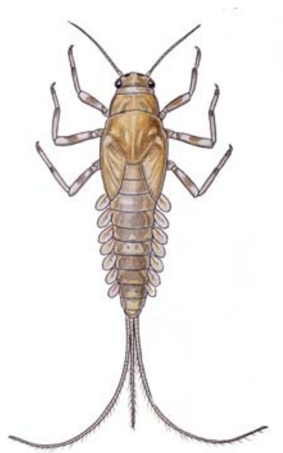
Flat worm



Dragonfly



Aquatic Macroinvertebrates with low pollution tolerance

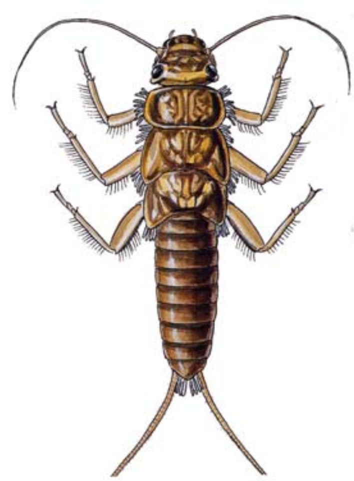


Mayfly

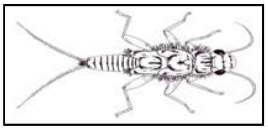
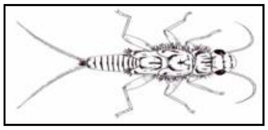
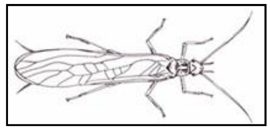
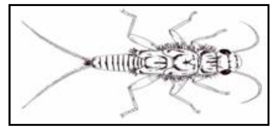
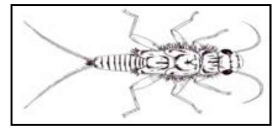
Caddisfly

Stonefly

Mayfly



Stonefly

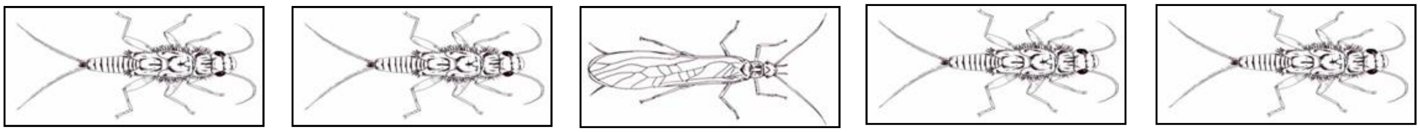
Suggested combinations of skittles for different land uses:

Land use	Purple	Red	Green	Yellow	Orange
Agriculture	8	5	5	2	0
Golf Course	5	5	8	2	0
Factory/Industrial	5	2	5	5	10
Construction	10	0	0	5	0
Neighborhood	2	5	8	5	0

Pictures of land uses:

Agriculture:

Pasture/grazing land
Poorly managed grazing and/or a concentration of animals near streams can cause a loss of riparian vegetation and an increase in erosion.

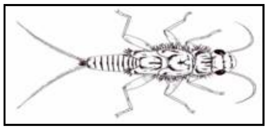
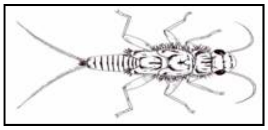
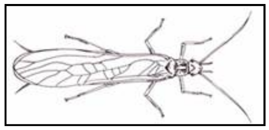
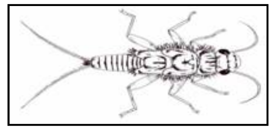
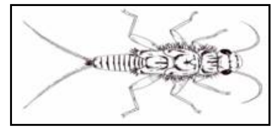


Fertilizer and pesticide application

When fertilizers and pesticides are applied in large quantities they can enter the groundwater or get washed away into nearby water bodies.

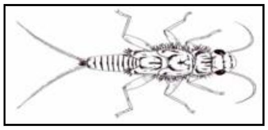
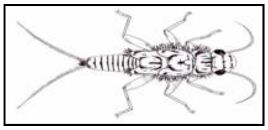
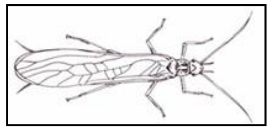
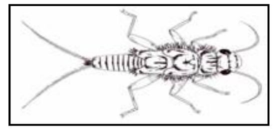
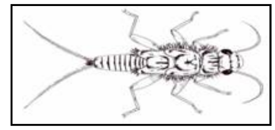
Harvesting crops

Fields left empty after harvesting can easily be eroded away. This soil often gets washed into nearby streams and rivers.

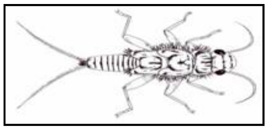
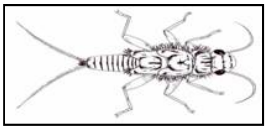
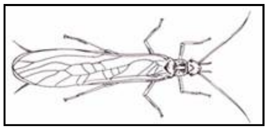
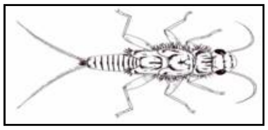
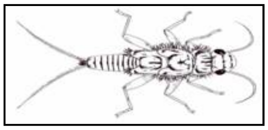
Construction:

Sediment runoff
Dirt and soil from construction sites is easily washed into storm drains during rain storms.

Forestry:

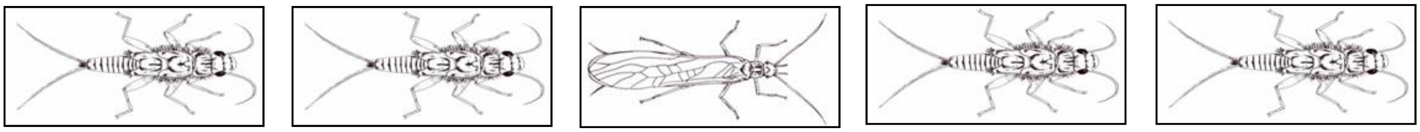
Deforestation
Removing trees and other vegetation causes an increase in erosion. More sediment is washed into streams and rivers.

Land Disposal:

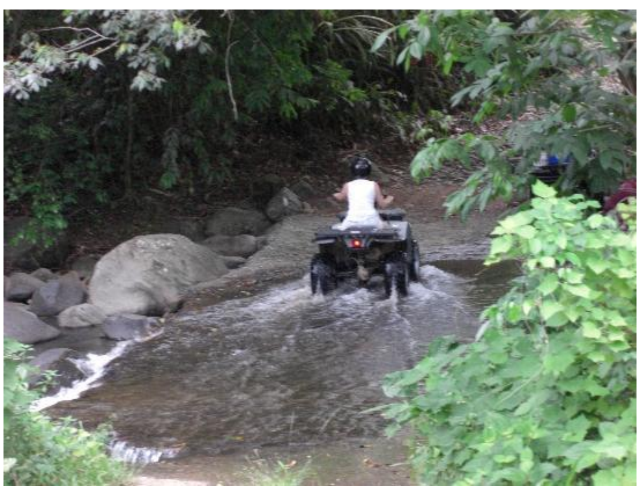
Landfills
Chemicals and other substances can sometimes leak into groundwater contaminating it and making it unsafe to drink and use for other purposes.

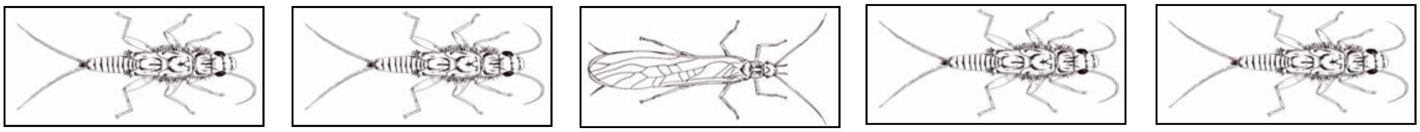
Waste Water Treatment Plants
The discharge of untreated or poorly treated water can cause serious health problems for humans and wildlife. Chemicals and pharmaceuticals from waste water treatment plants are sometimes put into rivers and streams.



Recreation:

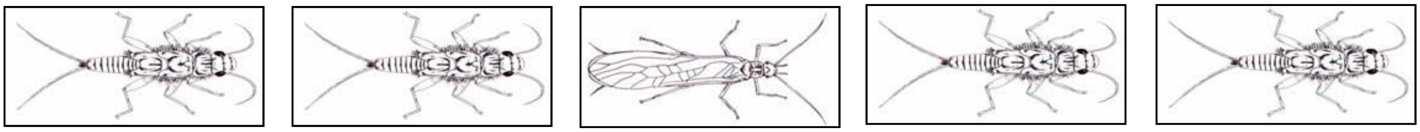
Oil and gas from motorized vehicles can pollute rivers and streams. Garbage and other litter left at campsites or other areas can also be washed into rivers or streams.



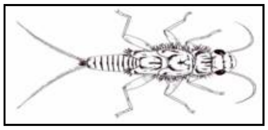
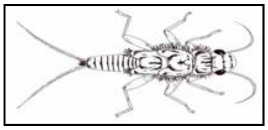
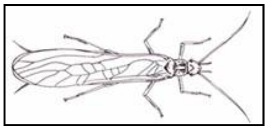
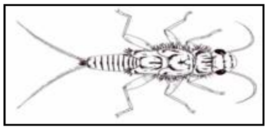
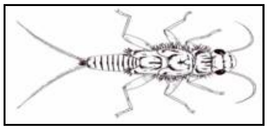


Roads:

Roads are often built in the valley or gulley of a watershed: Sediment and pollutants, like gasoline and oil, can easily be washed into rivers and streams during snow melting events, or when it rains.



Surface Mining:

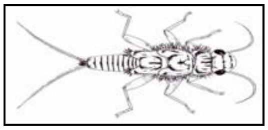
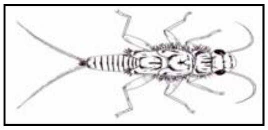
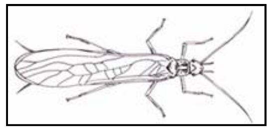
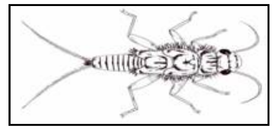
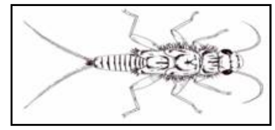
    

Urban runoff:

Channelization: Results in loss of habitat for wildlife, fish, and invertebrates. Loss of riparian vegetation and building concrete stream beds increase water temperature and exacerbate spring flooding.

Impervious surfaces: Parking lots, roads, and roofs all create an impervious surface that water cannot infiltrate. This leads to increased run off and more oil, sediment, and other pollutants washed into stream and rivers.

Storm drains: Storm drains most often direct water to rivers and streams. Any trash, oil, or other pollutant that enters the storm drain can end up in our rivers and streams.

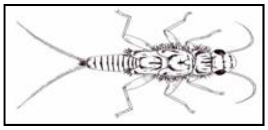
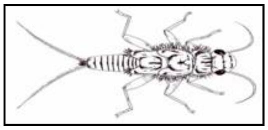
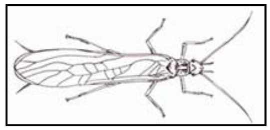
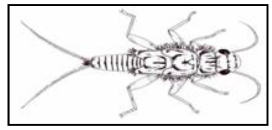
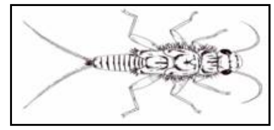
Good Management:

Buffer strips: Planting buffer strips (native riparian vegetation) along stream banks reduces erosion and traps sediments and fertilizer from entering the river.

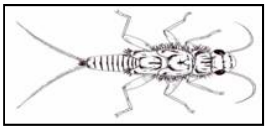
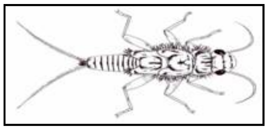
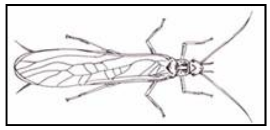
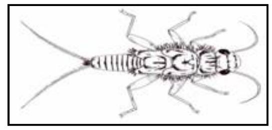
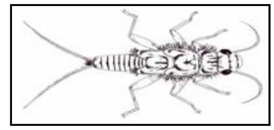
Off stream watering: Providing livestock with drinking water away from the stream can prevent the animals from trampling riparian vegetation which increases erosion.

Pet waste bags:
Using pet waste bags in the park or on trails keeps the waste from washing into rivers and streams.

Planting for water conservation:
Using plants that need less water helps us use less water.

Car washes:
Washing your car in a carwash helps keep extra dirt, oil, and soap from washing into a stream or soaking into the groundwater supply.

Appendix E: Suggestions for teaching about aquatic invertebrates

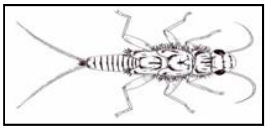
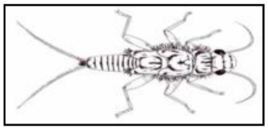
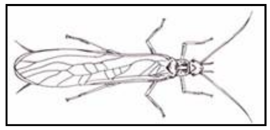
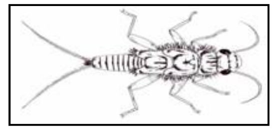
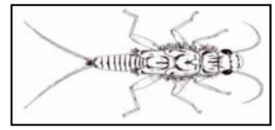
How to explain the term "aquatic macroinvertebrate"

When teaching students about aquatic macroinvertebrates for the first time, it is often helpful to break down the word. Ask students first what the word "aquatic" means. When the correct definition is given, do the same with the words "macro" and "invertebrate". Although the term invertebrate refers to any animal without a backbone, be sure to emphasize insects since these lessons deal mostly with insects. Explain to them that although the term "macro" means big (opposite of micro) these bugs are not huge, but large enough to see without a microscope. Have the kids put the words together, i.e. aquatic macroinvertebrate means 'big water bugs'.

Ideas to introduce adaptations

Explain to your students that aquatic macroinvertebrates need special adaptations to survive and live underwater. You can ask how the invertebrates might breathe underwater. A lot of students probably understand that fish breathe with gills, so you can say they breathe similar to fish. However, some invertebrates do not have gills, but instead use a breathing tube. You can relate this to kids using snorkels when they go swimming.

Stoneflies have gills in their armpits (the point where the legs attach to the thorax). If students have the opportunity to observe stoneflies in a tub of water the stoneflies may begin to do "push-ups". This is an excellent opportunity to discuss adaptations. Stoneflies live in fast flowing water where dissolved oxygen is abundant and easily acquired as water moves over their gills. Dissolved oxygen is less abundant in still water and the stoneflies have to do "push-ups" to force water over their gills. This is similar to students breathing hard after they have run across the playground.

Appendix F: Discussion Questions

1. Why are aquatic macroinvertebrates important in a stream, river, or lake?

   Aquatic macroinvertebrates are important for several reasons. First, they are an important part of the food chain. Many other organisms, such as fish, birds, and other invertebrates depend on them as a food source. Also, some macroinvertebrates play a role in breaking down plant matter that falls into and/or grows in the stream. These insects either rip apart and eat plants, or they graze on the algae that grows on the streambed.

   Invertebrates are also used as an indicator of water quality. Because some invertebrates are sensitive to pollution, their absence in a stream system may indicate a pollution problem. This is not always the case because other factors can influence the absence of certain invertebrates. For example, stoneflies, an indicator of good water quality, can only survive in cold, clear, running water. We may not find stoneflies in large, slow rivers low in the watershed because the water temperature is naturally too warm for stoneflies. This does not mean the water quality is poor, only the natural system cannot support stoneflies.

2. Why do some types of organisms seem to be more sensitive to pollutants than others?

   This question doesn't have one simple answer, but it's an interesting opportunity to discuss the differences in these organisms.

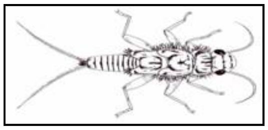
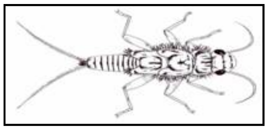
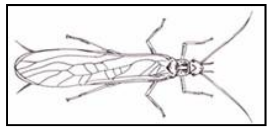
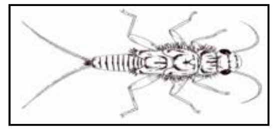
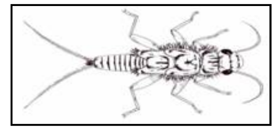
   More tolerant organisms may be those that evolved under more diverse conditions, and therefore are now able to handle a wider range of conditions. Animals that evolved under very unique or non-varying conditions may have very narrow ranges of tolerance to change.

3. What organisms depend on aquatic macroinvertebrates?

   Aquatic macroinvertebrates are an important part of the food chain. Other organisms such as fish, birds, some mammals and other invertebrates depend on them for their food supply. Some organisms, such as birds and fish depend directly on invertebrates because they eat them. However, other organisms such as large mammals depend on them indirectly because they eat the birds and fish that feed on invertebrates.

4. Do aquatic macroinvertebrates spend their whole life in the water?

   Some macroinvertebrates complete their life cycle in a few weeks; others may live for several years. Usually, just the larvae stage of an insect's life is spent in the water. These insects include mayflies, stoneflies, caddisflies, craneflies, and some water beetles. Most of them spend 1-2 years in the water as larvae and then only 1-14 days on land as adults. Some insects, such as the water boatmen and backswimmers, spend their whole lives in the water and do not undergo metamorphosis. Most non-insect macroinvertebrates, such as amphipods (scuds), gastropods (snails), and bivalves (clams and mussels) spend their entire life in the water.

5. What is metamorphosis?

   Metamorphosis is a process in which an animal physically develops and changes in two or more distinct stages during its life cycle. Complete metamorphosis consists of 4 stages - egg, larva, pupa and adult. Examples of complete metamorphosis include a butterfly, a caddisfly, or blackfly. For insects that go through complete metamorphosis the larva and adult stages look very different. The larva stage is often worm or caterpillar like. An incomplete metamorphosis consists of only three stages – egg, larva, and adult. Examples, of an incomplete metamorphosis include a grasshopper, a stonefly or a mayfly. The larva often looks similar to the adult and may be called a nymph.

6. How do macroinvertebrates breathe in the water?

   Different macroinvertebrates have developed several different adaptations for breathing. Invertebrates such as mayflies, stoneflies, and caddisflies have gills for obtaining dissolved oxygen directly from the water. Mosquito larva and some fly larva have slender breathing tubes that can extend past the water surface to obtain oxygen from the air. Other insects, like the waterboatmen, swim to the surface and trap an air bubble on the underside of their abdomen and obtain oxygen from this bubble. They must live in still or slow moving water in order to easily resurface for more air.

7. Why is it important for macroinvertebrates to have different feeding habits?

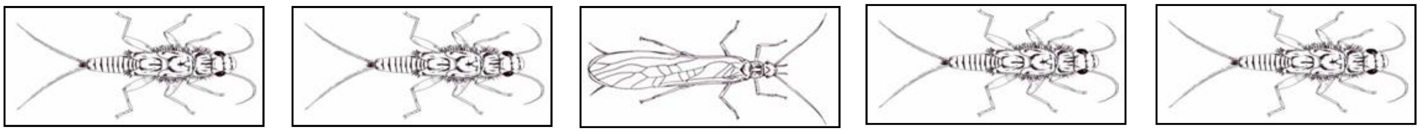
   It is important to have different feeding habits so that one river system can support a wide variety of organisms. If all invertebrates were scrapers, a river could not support a large community. Also, some feeding groups benefit from the action of other feeding groups. As stoneflies shred large leaves, some leaf particles float downstream and may be caught in a caddisfly's net.

   Invertebrates help break down and process plant and animal matter that fall into or grow in a stream. If there were no scrapers to eat algae, the streambed would become covered with algae and other water plants.

8. What are natural and human influences that cause changes in macroinvertebrate populations?

   Macroinvertebrate populations can change naturally with the seasons.

   Human influences that can cause changes include any type of development or land use in the watershed that impacts water quality. These activities can be logging, construction, agriculture, recreation, housing developments, or road building. It is important to remember that these activities are not always bad, however, when they are poorly managed they can have a negative impact the water quality.



9. Where do aquatic macroinvertebrates make their home in the water?

   Streams, rivers, and ponds are made up of different microhabitats. In a stream, these microhabitats include the substrate, the sediments below the substrate, the river channel, the top of large rocks in the river, the edge waters, and the emergent vegetation near the edge. Ponds have similar microhabitats. Different macroinvertebrates make their home in different microhabitats and have specific adaptations to live successfully in these microhabitats. Their specific habitats must have food available and offer places of refuge from predators. Mayflies are scrapers/grazers; they scrape algae off the top of rocks for their food source. They spend their time clinging to the tops of rocks to find food and crawling between rocks on the substrate for refuge. Caddisflies are filter feeders; they builts nets or use long hairs on their legs to filter food from the current. They also spend their time on top of and between rocks where they have access to flowing water. Dragonflies are predators and typically lie in wait to ambush their prey. They cling to the emergent vegetation and wait for smaller insects.

10. What is the difference between point source and non-point source pollution?

    Point source pollution is from a single source that can easily be identified or pinpointed as the source of pollution. Examples include an industrial factory, a feed lot, or a wastewater treatment plant. Non-point source pollution comes from a large area of land where there are many contributors to the same pollution. Examples include urban runoff, agricultural fields, and housing developments.

    Point source pollution is easy to regulate because it is easy to identify where the pollution is coming from and where it is entering the rivers or streams. It is also easy to measure the amount of pollution entering a waterbody from a point source. Non-point source, on the other hand, is very difficult to regulate.

11. What are functional feeding groups?

    Functional feeding groups refer to a characterization based on how an invertebrate obtains food. The functional feeding groups are:

    Shredders: These organisms eat large pieces of leaves and other vegetation by shredding them apart.

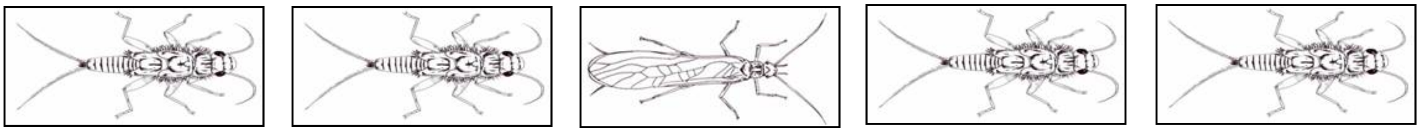
    Filter Feeders: These organisms filter small particles out of the current using nets or hairs on their legs.

    Grazers/scrapers: These organisms feed by scraping algae off of rocks.

    Collectors/gatherers: These organisms crawl around picking up small pieces of debris on the bottom of the stream.

    Piercers: These organisms pierce their food source (often large plant stems).

    Predators: These organisms eat other insects and /or animals.



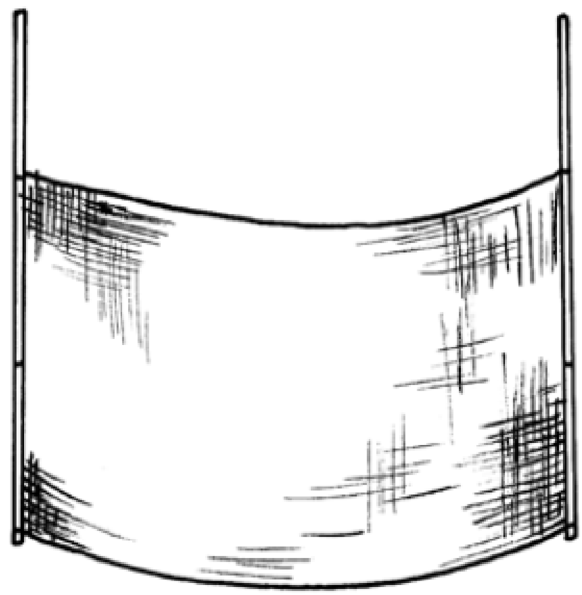
Appendix G: Equipment

All the equipment needed for these lessons is available for check out from USU Water Quality Extension. Macroinvertebrate collection equipment such as kicknets, magnifying glasses, pipettes, and petri dishes are also available at each county extension office throughout the state of Utah. Please visit our website for contact information for your county extension office:
Equipment and Supplies - Water Quality - extension.usu.edu

You can also purchase and/or make your own supplies for collecting macroinvertebrates.

Make your own Kicknet

Kick nets, which consist of screening material stretched between two poles, are used for sampling macroinvertebrates. Sampling is done by pushing the two poles into the substrate until the edge of the screen rests on the bottom. Organisms are dislodged by disrupting the substrate on the upstream side of the net, allowing them to be carried by the current into the screen.

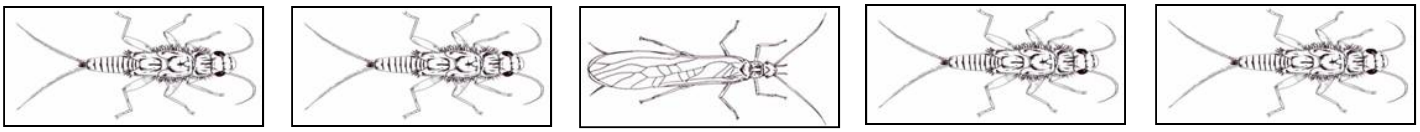


Materials
- two 3 ft x 5/8 in sections of wooden dowel
- one 3 ft x 2 ft section of fiberglass window screen
- staple gun
- duct tape (optional)

Directions

1. Stretch window screen length-wise between dowels

2. Wrap end of window screen around dowel once and staple along length of dowel. Wrap screen around the dowel a second time and staple again. You can repeat a third time if necessary and/or secure window screen to dowel with duct tape.

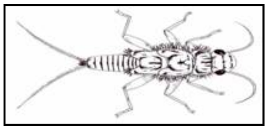
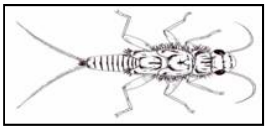
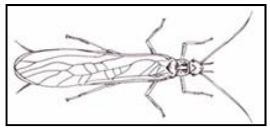
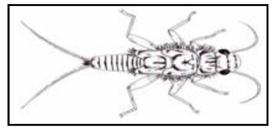
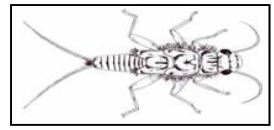


Purchasing supplies

The following is a table of suggested places to purchase equipment.

Item	Part number	Source	Cost	Quantity
Thin Stem Pipette	15 V 2091	Ward's Natural Science http://wardsci.com/	$20.95	100
Petri dish	18 V 7101	Ward's Natural Science http://wardsci.com/	$6.00	20
Dual magnifying glass	24 V 1112	Ward's Natural Science http://wardsci.com/	$2.79	1
Plastic tray		Buy locally	$4-10.00	1
Hip waders		Buy locally	$25-50.00	1
Professional kick-net	77676	Forestry Suppliers.com	$189.00	1
Macroinvertebrate ID book	ISBN 21	Borders or other bookstore	$34.95	1

For more equipment see our website:
http://extension.usu.edu/waterquality/htm/educator-resources/equip/list/

Appendix H: Glossary

Adaptation: The modification, over time, of the structure, function, or behavior of an organism, which enables it to be more suited to its environment.

Aquatic: Relating to or consisting of or being in water.

Collectors: Macroinvertebrates that collect bits of food from the water column.

Contaminant: Any substance that when added to water (or other substance) makes it impure and unfit for consumption or use.

Decomposition: The breakdown or decay of organic matter through the digestive processes of microorganisms, macroinvertebrates, and scavengers.

Dichotomous Key: A tool for identifying objects, such as macroinvertebrates. The key presents a series of “yes or no” questions to the observer; each question brings the observer closer to the identification.

Dissolved Oxygen (DO): Oxygen dissolved in water and available for living organisms to use for respiration.

Emergent vegetation: Plants rooted underwater, but with their tops extending above the water.

Engulfers: Macroinvertebrate predators that feed by swallowing their prey whole.

EPT Value: An index of water quality derived from the percent of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies) in a 100-individual sample of macroinvertebrates.

Functional Feeding Groups: Classification of macroinvertebrate groups according to their mode of feeding.

Habitat: The environment occupied by individuals of a particular species, population, or community.

Hypoxia: Depletion of dissolved oxygen in an aquatic system.

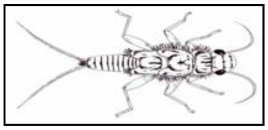
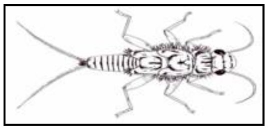
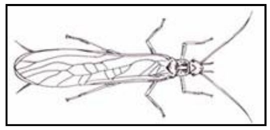
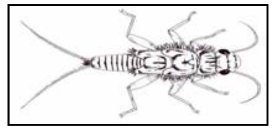
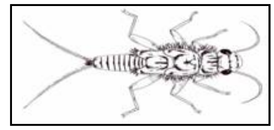
Indicator: A gauge of water pollution: not legal criteria, but rather a sign that there may be a problem. When an indicator level is exceeded, further studies are done.

Kick Net: A fine mesh net used to collect organisms. Kick nets vary in size and shape.

Larva: The immature, wingless, feeding stage of an insect that undergoes complete metamorphosis.

Macroinvertebrate: Organism that lacks a backbone and can be seen with the naked eye.

Niche: The role, or combination of functions, that an organism holds in the environment.

Nymph: The young of an insect that undergoes incomplete metamorphosis.

Piercers: Macroinvertebrate predators that feed by injecting a sharp mouth part into their prey and sucking out body fluids.

Predator: An animal, such as a macroinvertebrate, that feeds on other animals.

Riparian: The area of land next to a stream or river.

Riparian vegetation: The vegetation growing in the riparian area. Healthy riparian vegetation consists of native, hydrophilic (water loving) plants that help stabilize the stream banks and control flood waters from inundating adjacent lands.

Scrapers: Macroinvertebrates that feed by scraping algae and other material from the surface of plants, wood, and rocks. Also known as grazers.

Shredders: Macroinvertebrates that feed by cutting or tearing leaves and woody material that fall into the stream.

Substrate: Refers to a surface. This includes the material comprising the streambed or the surfaces which plants or animals may attach or live upon.

Tolerance: The ability to withstand a particular condition – e.g. pollution tolerance indicates an ability to live in polluted waters.

Water Quality: The chemical, physical, and biological characteristics of water with respect to its suitability for a particular use.

Water Quality Criteria: Maximum concentrations of pollutants that are acceptable, if those waters are to meet water quality standards. Listed in state water quality standards.

Water Quality Rating Index: An index of water quality derived from a 100-individual sample of macroinvertebrates. The more pollution-intolerant individuals found in the sample, the better the water quality.

Water Quality Standard: Recommended or enforceable maximum contaminant levels of chemicals or materials (e.g. nutrients).