Macroinvertebrate Educational Trunk Overview

Benthic macroinvertebrates are animals without a backbone that can be seen with the naked eye and have the ability to cling to aquatic bottom surfaces such as rocks, leaves, or roots. They include crustaceans, mollusks, and annelids, but in many aquatic environments, most of the macroinvertebrate communities are the larvae of aquatic insects. These communities are important links in the food web between producers (leaves, algae) and higher consumers such as fish, and are key indicators of water health in streams, rivers, and wetlands. This educational trunk created in collaboration between the Gallatin Conservation District and Montana Conservation Corps provides tools and lessons to connect Gallatin County students to Montana's waters and aquatic macroinvertebrate populations in a stimulating and tangible format. This trunk will be used throughout Gallatin County for youth & community outreach and educational opportunities. This cooperative project has been funded in part by the Soil and Water Conservation Districts of Montana, the MT Department of Environmental Quality, and the United States Environmental Protection Agency.

Lessons from the trunk:

Macroinvertebrate Adaptations: This lesson plan was adapted from the Utah State Water Quality Extension and coloring pages were copied from "Bugs Don't Bug Me!" coloring book from the Utah State Water Quality Extension. Students will learn about what macroinvertebrates are and will gain a better understanding of macroinvertebrate adaptations that allow them to live in our waters in a hands-on way by crafting and coloring macroinvertebrates and dressing up as them.

Macroinvertebrates: Indicators for Water Health: This lesson plan was adapted from Project Wet. Students will learn about healthy water systems, how macroinvertebrates act as indicators of water health, and about the environmental stressors that can impact our waters by playing a tagging game.

Macroinvertebrates: investigating Your Waters Health: This lesson was adapted from Project Wet. Students will identify and learn about macroinvertebrates in their local watery system by observing and identifying them using dichotomous keys.

**All lesson plans are adaptable and can be paired with one another. All supplies and complete lesson plans are provided within the trunk.*

Macroinvertebrate Educational Trunk

What's Inside?

Macroinvertebrate Educational Trunk

Trunk Supply List

Macroinvertebrate Adaptations

- Wings
- Antenna
- Spider Legs
- Big Play Glasses
- Feather Boas
- Fishing Net
- Googly Eyes
- Modeling Clay/ Play Dough
- Yarn
- Macro Coloring Sheets
- Crayons

Macroinvertebrate Indicators for Water Health

- Stack of field cones
- Large bag of clothespins
- Macro Laminate Cards
- Pollutant Laminate Cards
- Burlap Sacks
- Balls

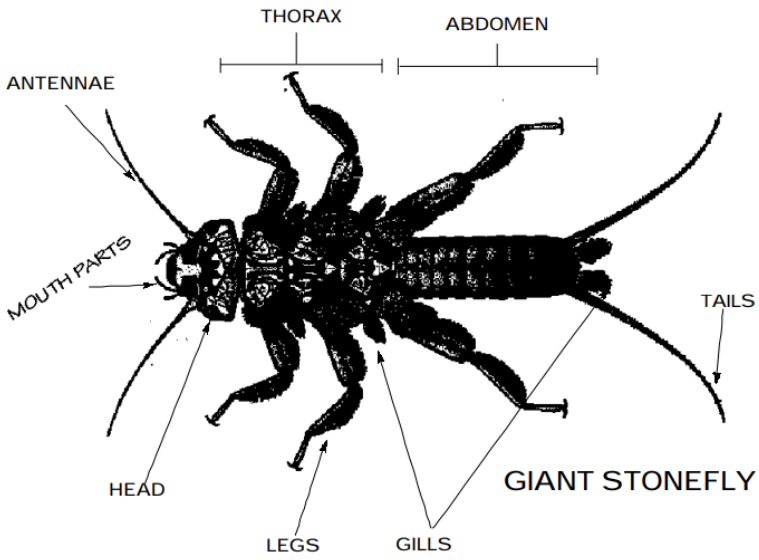
Investigating Your Waters Health

- 5-Gallon Buckets
- Dip Nets
- Ice Cube Trays
- Spoons
- Cups
- Laminated Dichotomous Keys
- Laminated Pollution Tolerance Keys
- Collection Tubs
- Mini hand lenses
- Small dry erase boards
- Dry erase markers
- Aerator pump

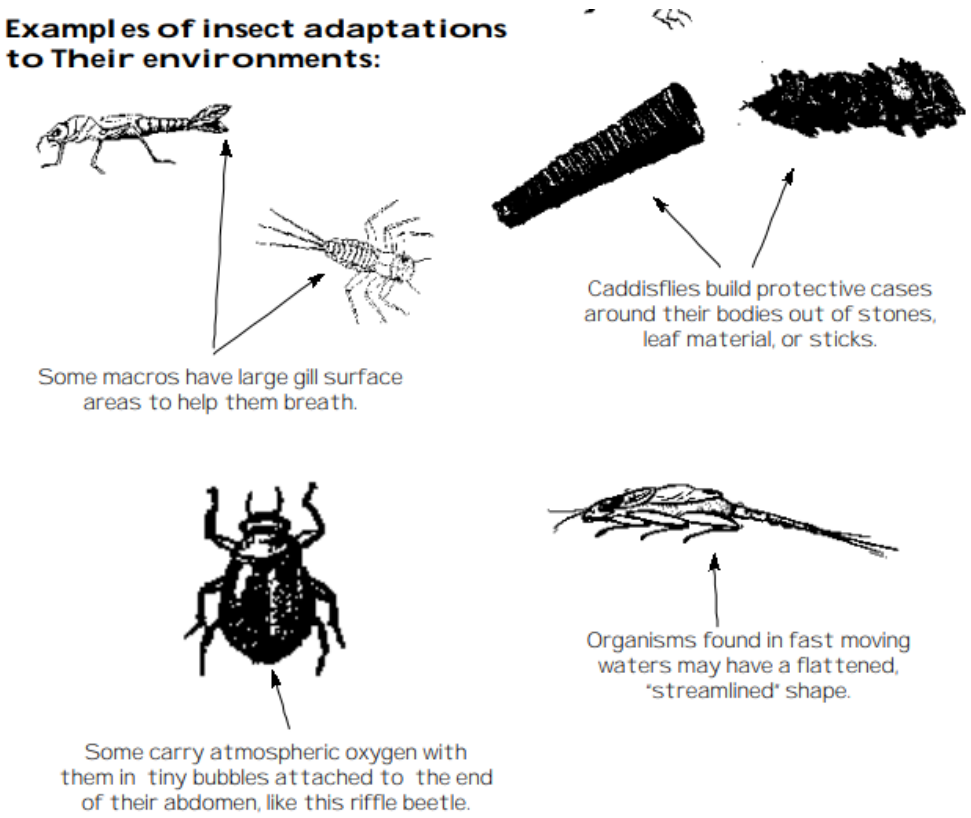
Macroinvertebrate Educational Trunk

Macroinvertebrate Resources Pages

Macroinvertebrates are organisms that lack an internal skeleton (no spine) and are large enough to be seen with the naked eye. Aquatic macroinvertebrates are often described as “Benthic” which means they have the ability to cling to bottom aquatic surfaces such as rocks, leaves, or roots. Examples of macroinvertebrates include mayflies, stoneflies, dragonflies, rat-tailed maggots, scuds, snails, mollusks, and leeches. These organisms may spend all or part of their lives in water; usually, their immature phases (larvae and nymphs) are spent entirely in water. Many aquatic insects you see are nymphs or larvae (juveniles). Some of the body parts of these creatures are similar to terrestrial insects. They have three body parts (head, thorax, and abdomen), three pairs of legs, and a set of antennae. Some larvae will have unique structures, like gills, tails, and distinct mouthparts. These structures can help you distinguish different groups of insects. For instance, most stoneflies have two tails and gills at the base of the legs and between the tails, while most mayflies have three tails and gills on the abdominal segments.



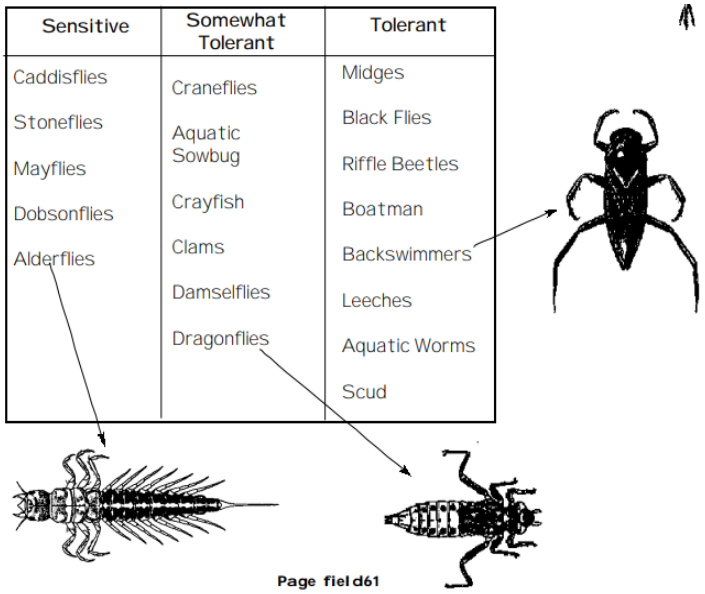
As was mentioned above, many macroinvertebrates live in aquatic environments, and to do so they must be able to navigate moving water as well as the substrate on the stream bottom. Many macroinvertebrates found in riffles (fast, white water areas of the stream) stick to rocks with suction devices. Organisms found in glides (smooth, flowing water) may have a flat shape to prevent being swept downstream. In slow-moving pools, many organisms have adapted to burrow in the sediments or developed bulky cases to provide protection from predators. Macroinvertebrates also need to be able to take in oxygen from the water. Some have gills to breathe oxygen dissolved in the water, others rise to the water's surface to break oxygen from the atmosphere.



Macroinvertebrates must also get food in its underwater environment in order to survive. They can be separated into four **feeding groups**. Each group has specific adaptations for obtaining and eating food. What a macroinvertebrate eats may determine its role in the food web. For instance, plant life is eaten by a herbivorous mayfly, who is eaten by a predacious stonefly. A fish then consumes the stonefly and an osprey consumes the fish.

FEEDING GROUPS	HOW THEY EAT	WHAT THEY EAT	HABITAT
Collectors (caddisflies, mayflies)	Physically gather food, or construct net-like structures to catch food.	Dissolved organics, algae, bacteria, feces, and plants.	Stream bottom
Shredders (mayflies, stoneflies, caddisflies)	Use chewing mouthparts designed to shred, cut, bite, or bore.	Leaves and vegetation that have fallen into the water.	Areas in the stream with lots of tree canopy cover.
Scrapers (caddisflies, mayflies)	Use special razor-like mouthparts to scape.	Scrape algae off of rocks.	Areas in the stream with enough light to make algae grow.
Predators (Stoneflies, beetles, dragonflies, alder-flies)	Bodies designed to chase, capture and kill their prey.	Catch and eat live organisms.	All habitat types.

Aquatic macroinvertebrates are an integral part of wetland, spring, lake, and stream ecosystems. They play a key role in nutrient cycling because they are the primary processors of organic materials, and they play a key role in indicating water health in a given aquatic ecosystem. A variety of environmental stressors can negatively impact water health, which in turn negatively impact macroinvertebrate populations. Urban and/or agricultural runoff can produce conditions that some macroinvertebrates cannot tolerate. Sewage and fertilizers added to streams induce the growth of algae and bacteria that consume oxygen and make it unavailable for macroinvertebrates. Changes in land use from natural vegetation to a construction site or poorly protected cropland may add sediment to the water. Sedimentation destroys habitats by smothering the rocky areas of the stream where macroinvertebrates live. The removal of trees, alteration along the banks of a river, and alteration of stream path, width, and depth can change normal water temperature patterns in the stream. Some organisms depend on certain temperature patterns to regulate changes in their life cycles. Other stressors include the introduction of alien species and stream channelization.



Some macroinvertebrates, such as mayfly and stonefly nymphs, and caddisfly larvae, are sensitive (**intolerant**) to changes in stream conditions brought about by pollutants. Some of these organisms will leave to find more favorable habitats, but others will be killed or will be unable to reproduce. Macroinvertebrates that can thrive in polluted conditions (e.g. rat-tailed maggots and midge larvae) are called **tolerant** organisms. Other organisms, called **facultative** organisms or somewhat tolerant (e.g. dragonfly and damselfly nymphs), prefer good stream quality but can survive under polluted conditions.

Scientists often sample macroinvertebrate populations to monitor changes in stream conditions over time and to assess the cumulative effects of environmental stressors. This means aquatic macroinvertebrates serve as good **indicators** of water health. Environmental degradation from environmental stressors will likely decrease the biodiversity of a community by eliminating intolerant organisms and increasing the number of tolerant organisms. If the environmental stress is severe enough, species of intolerant macroinvertebrates may disappear altogether. For example, if a sample of macroinvertebrates in a stream consists of midges, leeches, snails, and dragonfly nymphs, the water quality conditions of that stream are probably poor (e.g. low oxygen level, increased sediment, contaminants). If the sample contains a diversity of organisms, including organisms such as stoneflies or mayflies, the stream conditions are likely good. However, baseline data is essential because some healthy streams may contain only a few macroinvertebrate species. A variety of food sources, adequate oxygen levels, and temperatures conducive to growth all characterize a healthy stream.

Examples of Aquatic Macroinvertebrate Adaptations

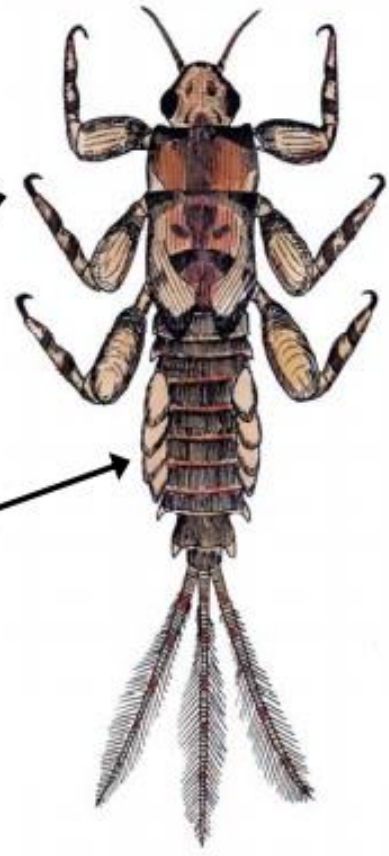
The **Blackfly larva** has a <u>net</u> on its head for collecting food.

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

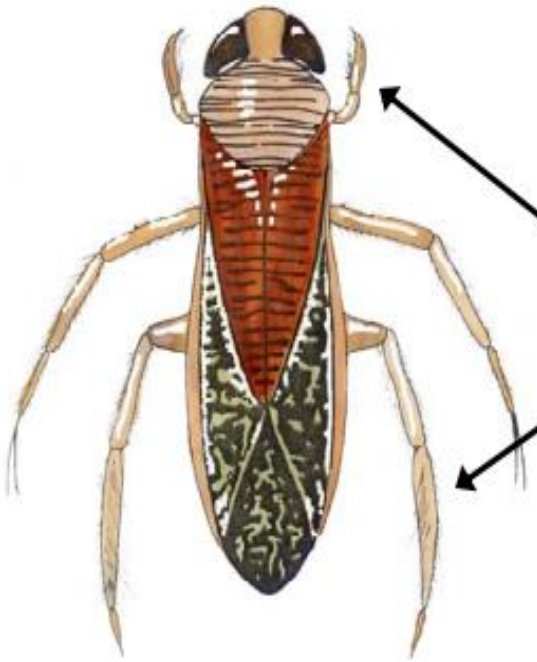
The **Stonefly** nymph has <u>claws</u> for capturing prey and holding on tight to rocky substrates.

The **Stonefly** nymph has <u>gills</u> in its "armpits" for breathing dissolved oxygen in fast flowing streams.

The **Mayfly** nymph has <u>hooks</u> for holding on tight to rocky substrates.

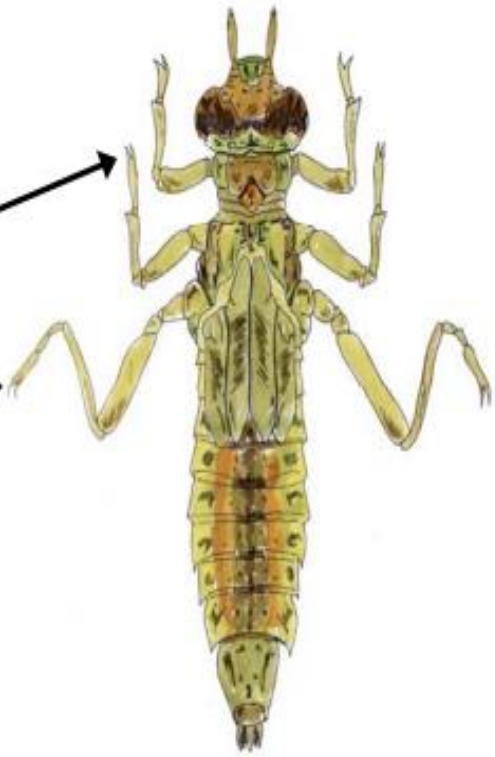


The **Mayfly** nymph has <u>gills</u> on its abdomen for breathing dissolved oxygen in fast flowing streams.



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

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



Macroinvertebrate Educational Trunk

Additional Resources Links

Utah State University Water Quality Extension Resources:
https://extension.usu.edu/waterquality/learnaboutsurfacewater/propertiesofwater/aquaticmacros

https://extension.usu.edu/waterquality/educator-resources/

https://extension.usu.edu/waterquality/educator-resources/lessonplans/macro

https://extension.usu.edu/waterquality/macrokey/

Water Education Foundation: Macroinvertebrate Mayhem Resources:
https://www.watereducation.org/general-information/macroinvertebrate-mayhem

West Virginia Department of Environmental Protection Macroinvertebrate Identification Guide:
http://dep.wv.gov/WWE/getinvolved/sos/Documents/Benthic/WVSOS_MacroIDGuide.pdf

Project WET Curriculum and Activity Guide 2.0:
https://www.projectwet.org/

Macroinvertebrate Educational Trunk

Lesson Plans

Macroinvertebrate Adaptations

A dress-up & Simone Says Activity

Grade Level: 2nd - 4th

Duration: Prep time = less than 5 minutes Activity = 15 min to 45 min

Students Will:

- Gain understandings of what lives in our waters;
- Learn about macroinvertebrates and their adaptations for living underwater and eating and;
- Practice what they've learned in a game of Simon Says.

Materials Needed

Macro Art box from the Gallatin Conservation District & MCC trunk which includes the following;

Dress-Up Supplies

1. Wings
2. Antenna
3. Spider Legs
4. Big Play Glasses
5. Feather Boas
6. Fishing Net

Craft/ Art Supply

1. Googly eyes
2. Modeling Clay/ Play-dough
3. Yarn
4. Macro coloring sheets
5. Crayons

Activity Procedure:

- Discuss with students what lives in our watershed & introduce them to macroinvertebrates. (Reference macroinvertebrate resource page for more information about macroinvertebrates to share with students.)
    - Ask students if they know what the words "aquatic macroinvertebrate" mean. Aquatic = water, macro = big enough to see with the naked eye, invertebrate = no backbone.
- Discuss how they look & live under water using dress up supplies and/or macro coloring pictures.
    - Ask students to brainstorm different adaptations a bug would need to live in an aquatic environment (or just start with asking what an adaptation is).
    - Ask for a volunteer or a few volunteers. Explain that you will be preparing

the student to live as an aquatic macroinvertebrate.
- Ask students to give you ideas, and using the "suggested props for macroinvertebrate adaptations" table, dress the volunteers in the items that represent the adaptations.
- Discuss each adaptation as you go. Why would a macroinvertebrate need them? How do they help the macroinvertebrate survive?

Suggested Props for Physical Macroinvertebrate Adaptations		
Adaptations	**Use**	**Props Representing Adaptations**
Tails	Swimming and maneuvering	Costume tail, could use rope or garland if available for extras
Legs	Help insect move around and hold onto rocks and hard substrate, scraping algae off rocks, attacking prey	Costume legs *could attach hooks to end of legs or use water noddle with hooks on end
Compound eyes	Help insect detect motion	Large sunglasses with googly eyes glued on
Antennae	Sensing food, water, surroundings	Antennae headbands
Wings	Typically only on adult insects used for traveling	Costume wings
Gills	Breathing dissolved oxygen in water	Feather boas
Device for catching food (i.e. net made by insect or part of their body structure or special hairs)	Catching food in the current	Fishing net
Other Adaptations to represent if supplies are available		
Hairs on head or body	Help insect detect movement or chemical changes in water	Wig or furry hat
Air bubble	Breathing oxygen from the surface air	Balloon
Breathing tube	Breathing oxygen from the surface air	Straw
Specialized mouth parts	For scraping, piercing, shredding, etc.	Vampire teeth

- Allow students to color or create a macroinvertebrate & discuss its adaptations further.
    - Utilize either the coloring sheets to color different macroinvertebrates OR utilize the other craft supplies for students to build their own macroinvertebrate.
    - Have each student share their macroinvertebrate with the class and explain the adaptations.
- Introduce students to the different types of macroinvertebrate feeding groups and the adaptations needed to feed differently.
    - The table below describes each feeding group and a movement to represent each.
    - Go through each of these groups with the students and practice the movements.
    - Once students have mastered the movement for each macroinvertebrate and their type of eating, begin your game of Simone Says referencing the learned macros and/or the learned type of eaters to get the correct movement from students. For example: Simone Says eat like a dragonfly (or like a predator). Every student should make large chomping motion with their hands. Some macroinvertebrates may be part of more than one feeding group so multiple movements are allowed if calling out a macro name vs a feeding group.

Macroinvertebrate Feeding Groups and Feeding Adaptations		
MACRO	**FEEDING GROUP**	**MOVEMENT**
Dragonfly	**PREDATORS:** Eat other organisms. Dragonflies have large, long mandible adaptations to their mouth that they use to pierce and hold prey while they eat.	**ACTION:** Chomping motion with arms extended, one above the other to signify their large mouths scooping up prey.
Blackfly	**COLLECTORS:** Eat small organic matter suspended in water caught with net-like features or other adaptations.	**ACTION:** Place hands above your head and lower them down to your mouth to signify a large, net-like feature collecting food.
Stonefly	**SHREDDERS:** Eat large intact materials such as, leaves, needles, flowers, and twigs by using chewing mouthpart adaptations to tear it apart and ingest the smaller pieces.	**ACTION:** Motion of tearing up a piece of paper (or leaves if there are fallen leaves around you) and eating the ripped off pieces.
Caddisfly, Mayfly	**SCRAPERS** Eat algae growing on rocks in shallow water by using special razor-like mouth adaptations to scrape it off and ingest it.	**ACTION:** Bringing hands to rest on shoulders and bringing bent arms together and back open as if bent arms the “razors” scraping rocks for algae.

Optional Additions:

Utilizing the materials in the Macro Collection box from the Gallatin Conservation District & MCC macroinvertebrate educational trunk you could collect live macros for the students to examine. See activity instructions for more details

Resources

1. Simone Says game adapted from Utah State University Water Quality Extension https://extension.usu.edu/waterquality/educator-resources/lessonplans/macro
2. Build-A-Bug activity adapted from Utah State University Water Quality Extension https://streamsidescience.usu.edu/ou-files/pdfs/build-a-bug_2017.pdf
3. Coloring pages taken from "Bugs Don't Bug Me!" created by Utah State University Water Quality Extension https://extension.usu.edu/waterquality/kidspage/index

Macroinvertebrates: Indicators for Water Health

Grade Level: 3rd - 5th

Duration: Prep time = less than 5 minutes Activity = 30 min to 1hr+

Students Will:

- Discuss what makes a healthy water system and how we assess water health;
- Learn how macroinvertebrates provide insight into the health of our waters and;
- Share what environmental stressors may be impacting our waters.

Materials Needed:

Macro Mayhem box from the Gallatin Conservation District & MCC trunk which includes the following;

Macro Mayhem Game Basics

1. Stack of field cones
2. Large bag of clothespins
3. Macro laminate cards
4. Pollutant laminate cards

Macro Hindrance Props

1. Burlap sacks
2. Medium sized balls

Activity Summary

- Set up the play zone area by using 10 cones to establish boundaries for your stream. Ensure the area is wide enough students have space to run from end to end.
- Ask students what makes a water system healthy/clean and how scientists test for this. During this discussion with students work to introduce them to point source pollution & non-point source pollution.
    - Review conditions that are necessary for a healthy ecosystem (cold, clean water; variety of food sources; adequate oxygen levels) - What clues would students look for to determine if the water system was healthy or not?
    - Identify several environmental stressors and discuss how they can affect the health of a stream or other water body.
    - Define point source and nonpoint source pollution
        - Point source = pollution that comes from a specific source (like pollution coming from a pipe)
        - Nonpoint Source = pollution that comes from multiple sources (rainwater runoff over an agricultural field, cows in the stream, sedimentation from construction sites
    - Ask students for ideas on how scientists test to see if a water system is healthy or not.
- Ask students what lives in a healthy water system & introduce them to

macroinvertebrates (Reference macroinvertebrate resource page for more information about macroinvertebrates to share with students.)
    - How might environmental stressors affect macroinvertebrates
    - Define differences between tolerant, intolerant, and facultative macroinvertebrates and how they can be used as indicators for water system health.
- After discussion, introduce the Macro Mayhem game (a Project Wet activity).

Basics for activity:

1. Divide students into the seven different macroinvertebrates using the clothespins and macro laminate cards. Make sure all levels of tolerance are represented, but there may be more intolerant species represented in the beginning of the game. Keep track of how many of each you start with
    a. The three intolerant macros species cards all have two sides to their cards, make sure to have the intolerant macro facing out first (these will be switched to the tolerant species on the other side later in the game. Use the Facultative and tolerant species cards that have only one side at first to represent these species in the beginning of the game.
2. You'll need one to five volunteers (depending on the size of the class) to be the pollution (wear pollutant cards). Ask the students to decide what kind of pollutant (nonpoint or point source) they are. For example, one student might decide that they are run off from dog poop not disposed of properly & the other might decide they are oil run off from cars.
3. Have all the students line up at one edge of the play area (or "stream"). Ask them if they think their "stream" is healthy and why they think so. *Plug for biodiversity here if age/grade appropriate.
4. Explain that all the macroinvertebrates must make it across the stream without being impacted (tagged) by "pollution". But there's a catch. Not every macroinvertebrate is as tolerant to the pollution living in their water as others. To signify this the intolerant species will have some hindrance they have to act out while moving across the stream. See table below.
5. Line the pollutants somewhere in the middle of your stream and all at once have the macroinvertebrates race across to the other side while the pollutants tag as many as they can.
6. If a student representing an intolerant macro is impacted by pollution (tagged) on their journey across the stream, the player goes to the sideline to flip over their laminate card to become a tolerant species for the next round. Repeat 3- 5 times with students keeping their switched over card for each consecutive round.
7. After a few rounds, ask students again if their stream is healthy and why they think so. Take a look at what macros are represented, are there any intolerant species left? How does the population differ from the beginning of the game?
8. Discuss how scientists are able to use macroinvertebrate collections of water ways to gain a basic understanding of water health because of the known variable impacts pollution has on them.

MACRO	TOLERANCE	RESPONSE TO POLLUTION	MOVEMENT
Caddisfly	Intolerant of pollution	Caddisfly larvae build cases and attach themselves to rocks for stabilization and protection; they are intolerant to low oxygen levels.	**HINDRANCE**: Hop across field in burlap sack.
Stonefly	Intolerant of pollution	When oxygen levels drop, stoneflies undulate their abdomens to increase the flow of water over their bodies.	**HINDRANCE:** Must shake & wiggle body as they move in a zigg-zagg fashion in between cones across the field.
Mayfly	Intolerant of pollution	Mayflies often increase oxygen absorption by moving their gills.	**HINDRANCE**: carry soft ball in between knees, under chin or move from chin to hands continuously while running across field.
Dragonfly Nymph	Facultative (somewhat tolerant of pollution)	No response	**NO HINDRANCE**
Damselfly Nymph	Facultative (somewhat tolerant of pollution)	No response	**NO HINDRANCE**
Midge larva	Very tolerant of pollution	No response	**NO HINDRANCE**
Rat-tailed maggot	Very tolerant of pollution	No response	**NO HINDRANCE**

Optional Additions:

Utilizing the materials in the Macro Collection box from the Gallatin Conservation District & MCC traveling trunk you could collect live macros for the students to examine. See activity instructions for more details

Resources

1. Adapted from “Macroinvertebrate Mayhem” lesson from the Project Wet Curriculum and Activity Guide 2.0.

Macroinvertebrates: Investigating Your Waters Health

Grade Level: 5th - 8th

Duration: Prep time = 1-2 hours Activity = 30 min to 1hr+

Students Will:

- Identify and learn about macroinvertebrates in their local water system;
- Discuss what makes a healthy water system and how we assess water health;
- Learn how macroinvertebrates provide insight into the health of our waters and;
- Share what environmental stressors may be impacting our waters.

Materials Needed:

Macro Collection box from the Gallatin Conservation District & MCC trunk which includes the following;

Macro Collection:

1. 5-gallon buckets
2. Dip nets
3. Ice cube trays
4. Spoons & cups
5. Dichotomous Keys
6. Pollution Tolerance Keys
7. Collection tubs
8. Mini hands lenses
9. Small dry erase boards
10. Dry erase markers
11. Aerator pump

Activity Summary:

Set Up:

- Collect your macroinvertebrates prior to meeting with your students. Depending on your class size/age and the location of the lesson, you could have the students help collect macros by breaking them up into groups and taking turns with the dip nets.

  Collection basics:

  1. Select a local stream or river to collect from. *Macros can be found in flowing waters along shorelines, within roots, leafs, amongst the rocks and even in the sand of shallow flowing sandy bottoms systems.
  2. Fill your five gallon bucket with some water from your collection area to

place your collections in and keep it nearby.

3. Approach your collection site from down stream with your dip net.
4. Place the dip net downstream of yourself and begin to disturb the stream bottom with your foot, kicking up debris and allowing them to flow down toward your dip net.
5. Do this for roughly 1 min disturbing the stream bed by kicking and/or even picking up rocks and rubbing them clean underwater in front of your net.
6. Carefully swoop the net up out of the stream and place contents in the reserved five gallon bucket.
7. Repeat as many times as needed in different locations to collect the quantity of macroinvertebrates desired.
8. Once collected, keep macros in a shaded cool location to help keep them alive, using the aerator if some time will pass before student observation occurs or if using macros for a long event.

- Divide your collection into the desired number of collection tubs for student examination.
- Each student examination station should contain a collection tub, hand lenses, laminated dichotomous key, ice cube tray, spoons, dry erase boards, and dry erase markers.

Implementation:

- Ask students what makes a water system healthy/clean and how scientists test for this.
- Ask students what lives in a healthy water system & introduce them to macroinvertebrates (Reference macroinvertebrate resource page for more information about macroinvertebrates to share with students.)
- Break students into groups for each station set up.
- Introduce students to the dichotomous key and explain how to use one.
    - Go through the key and ask, “does the macro have a shell or no shell?” Then go to the appropriate branch. Continue asking the branched questions laid out on the key till you reach a group of macros that should include the macro you are trying to identify.
- Ask each group to examine their macros in the collection tub and work to identify them using the key. They can pull them out one at a time using spoons and placing them in the ice tray.*Be sure the ice tray has water in it from your collection site.
- They should write what they find on the dry erase board and use the macroinvertebrate identification key (not the dichotomous key) to specify if each macro is pollution tolerant or not. This key doesn’t identify pollution tolerances for every macroinvertebrate, but it covers the common species.
- After some time, bring all the students back together to share what they found

in their sample.
    - Tell students where you collected the macros from that they are investigating and ask them to make an educated guess as to if that water way is healthy or not based on the macros they've identified. Why do they think so?
- Critical thinking questions: Ask the students what might be impacting their water, what might be impacting their samples and if their information could be used to inform water decisions. Why or why not.

Optional Additions:

Utilizing the materials in the Macro Collection box from the Gallatin Conservation District & MCC traveling trunk you could collect live macros for the students to examine. See activity instructions for more details

Resources

1. Adapted from both the "Macroinvertebrate Mayhem" lesson from the Project Wet Curriculum and Activity Guide 2.0 and the Utah State University Water Quality Extension. https://extension.usu.edu/waterquality/educator-resources/lessonplans/macro