Aquatic Macroinvertebrates

Objectives: Students will

- Be able to identify key features of a macroinvertebrate
- Be able to describe at least one thing that aquatic macroinvertebrates can tell us about the ecosystem.
- Be able to identify ways that aquatic macroinvertebrates change over their life cycles.

Overview: During this program students will learn to identify what an aquatic macroinvertebrate is, how they change over their life cycles, why they are important to an ecosystem, and what they can tell us about ecosystem health.

Materials: (the items that should be inside the kit or taken off the shelves in the storage building)

In Kit: nets, trays, bug boxes, hand sanitizer, ID sheets (check number, may need to print more), graphing sheet, adult/nymph form metamorphosis sheets, aquatic macroinvertebrate diagram with spaces for body part labels.

On shelf: easel

Before Class Prep: Read background information. Get kit from staff (or storage building). Set up at arranged area where students can sit off trail as well as water. Arrange teaching items in a way where it is easy for you to present them and reset between groups. Check which grade you're teaching and choose the appropriate set of guiding questions.

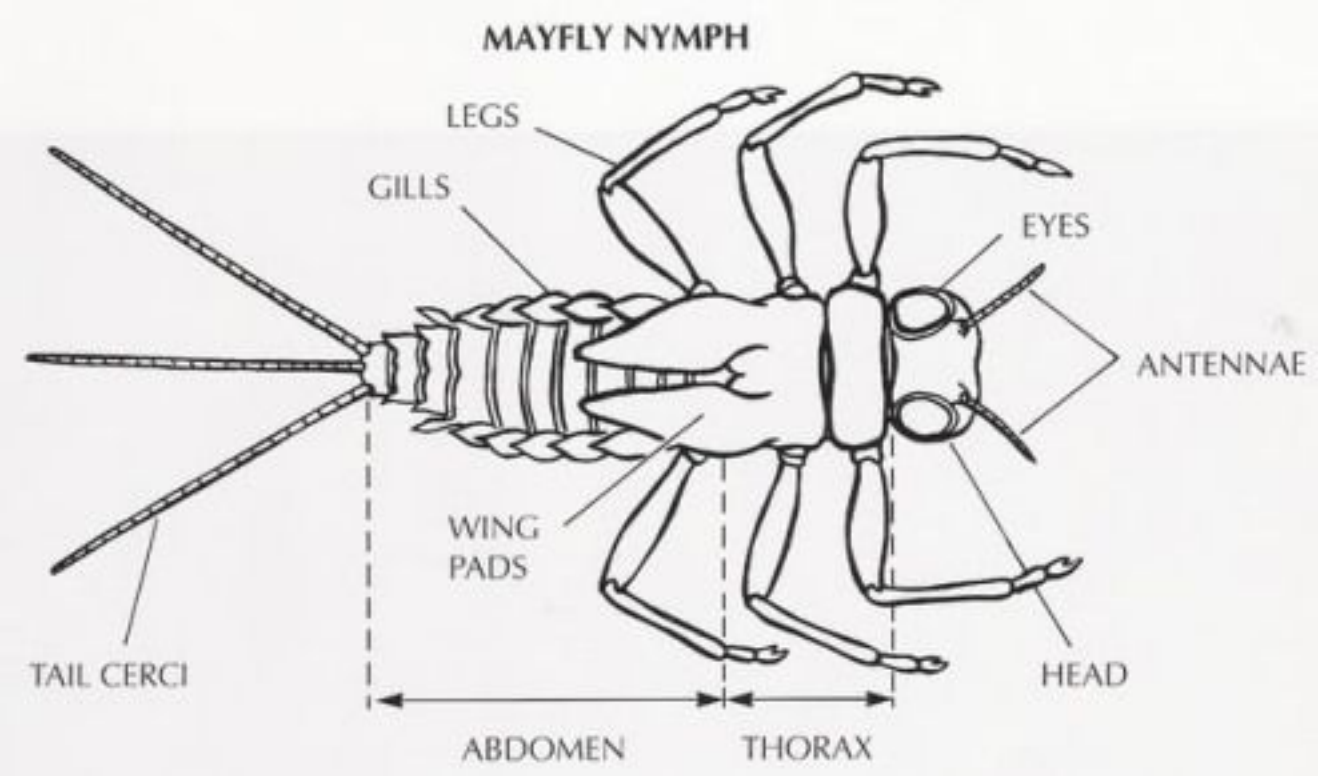
Background Information: (multiple pages)

Background information is for your knowledge and contains much more information than needed to share during school programs but may help answer your or participants questions.

Aquatic macroinvertebrates are organisms that live in the water (aquatic), are big enough to see without magnification (macro), and do not have a spine (invertebrate). Most aquatic macroinvertebrates are insects, and have a head, thorax, abdomen, and 6 legs. Many undergo metamorphosis in their life cycle as well, which makes them great model organisms for teaching about metamorphosis and life cycles in general. Aquatic macroinvertebrates are an important part of many ecosystems because they provide food to fish, birds, and other organisms. In addition, they have varying levels of tolerance for water pollution, so their presence or absence can tell us a lot about the health of the ecosystem they live in. Aquatic macroinvertebrates are valuable organisms for both their inherent role in their ecosystems, and for their value as a teaching tool.

Body parts: Most aquatic macroinvertebrates are insects, and their body parts are generally referred to using the same terminology- head, thorax, and abdomen. Most also have some form of gills that

allow them to breathe underwater and may have specialized body parts that allow them to hunt prey or cling to rocks in fast flowing water.



Metamorphosis: Most (not all) aquatic macroinvertebrates' life cycles fit into two categories: 1. Those that undergo metamorphosis and spend part of their life in water, part on land; and 2. Those that spend their whole lives in the water and do not undergo metamorphosis. Those in category 1 include insects like caddisflies, mayflies, and stoneflies. Those in category 2 include crawdads, leeches, most aquatic beetles, and water striders (which arguably don't live *in* the water so much as *on* the water).

Two terms are commonly used to refer to the young form of an aquatic macroinvertebrate (and most other insects and kin)- nymph, and larva (plural larvae). Typically, "nymph" refers to the younger form of an insect that still strongly resembles the adult form (often lacking wings), while "larva" refers to a worm-like younger form that does not resemble the adult form. Young grasshoppers are nymphs, while caterpillars are larvae. For aquatic macroinvertebrates, the young form of a mayfly is a nymph, while caddisflies have larvae. That said, "nymph" and "larva" are often used interchangeably and using the correct term for each form in programs with kids isn't necessary (and may even be to your detriment, if you have to teach yet another vocabulary term).

Ecosystem importance: In many ecosystems, aquatic macroinvertebrates form a key part of the food chain. Most fish in North America are omnivores or carnivores, so aquatic macroinvertebrates form a key part of the diets of many fish. In addition, aquatic macroinvertebrates don't always stay aquatic- many spend the first part of their lives in the water and later exit it as adults to breed, where they form the diets of many birds. Bird life around riparian areas is not robust just because there are more plants to hide in, but also because there are more insects to feed on. In fact, high mountain

lakes without fish support more bird life because a higher percentage of aquatic macroinvertebrates reach their adult life stage than those in fish-inhabited lakes at a similar altitude (Epanchin, Knapp & Lawler, 2010).

Tolerance to pollution: Aquatic macroinvertebrates also have varying requirements in water quality, temperature, sediment, and oxygen content. Generally speaking, caddisfly, mayfly, and stonefly nymphs/larvae require cold water with a high oxygen content (like a mountain stream) and are intolerant of pollution. Species whose larvae can tolerate some pollution, but not much (semi-tolerant), include damselflies, dragonflies, and craneflies. Tolerant species include midges, leeches, diving beetles, backswimmers, water boatmen, and water striders. The presence of tolerant species does not mean that the water is polluted, but the absence of intolerant or semi-tolerant species can indicate the presence of pollution.

- Caddisfly: Moth-like adult form, in many species the larval form creates a “case” out of bits of sediment that it then carries around and uses like a snail does its shell. Caddisfly larvae tend to live in clean, cold water that may or may not be flowing, depending on the species. Often found clinging to rocks in faster water. Adults can be seen laying eggs on the water’s surface, actively moving across the surface and often taking off again.
- Mayfly: Nymph form lacks the adult’s distinctive wings and may have much more robust legs than the adult form, which they use to cling to rocks in fast-flowing water. Adults only live for about 24 hours! ID tip: look for three thin tails and gills on the abdomen on the nymph.
- Stonefly: You’re not likely to see a stonefly nymph in a local pond, but they are in some of our streams! They often look similar to mayfly nymphs, but they only have two tail segments. Their legs also may look almost hairy- those are the gills. Adults often have a bit of orange on them around the head, and are BIG.
- Damselfly: Nymphs (also called naiads) of damselflies and dragonflies have jaws they can unhinge to engulf their prey. Nymphs have three tails that are much wider than the tails of mayflies, as they are actually gills!
- Dragonfly: Nymphs (also called naiads) of damselflies and dragonflies have jaws they can unhinge to engulf their prey. Dragonfly nymphs move through water using jet propulsion of water pumped out of their abdomen. They often hide from predators (and ambush prey) by burrowing into sediment and burying most of their body.
- Cranefly: These larvae are segmented and worm like. Their mouths have small tentacles that may extend when handled.
- Midge: One of the most common aquatic macroinvertebrates, midge larvae form an important part of the diet of many organisms. They typically look like a very small worm. Midge larvae can tolerate extremely low oxygen environments, allowing them to survive in deep lakes and warm ponds with algal blooms.
- Leech: Come on, you know what a leech looks like! They actually do a lot of inching along like a caterpillar, which I find interesting. They’ve got a suction cup on their butt to make that happen, which is a fun fact to bring out for kids.
- Diving beetles: It’s a beetle, it dives, most of the ones around here are pretty small. Fun! If you do find a bigger one, watch your fingers, they can pinch.
- Backswimmers and water boatmen: These beetles use paddle-like legs to propel themselves through the water. They can actually fly, allowing them to leave drying areas of water and

move to others, which is why you may sometimes find them in puddles, bird baths, and swimming pools.

- Water striders: These insects usually stay on the surface of the water, gliding across it using surface tension to stay afloat. They typically prey on whatever they can find floating on the water surface, but they are capable of diving to reach prey. Try throwing very small bits of leaves or twigs into the water near water striders and see if they come to check out what landed- they may think it's another bug for them to eat!

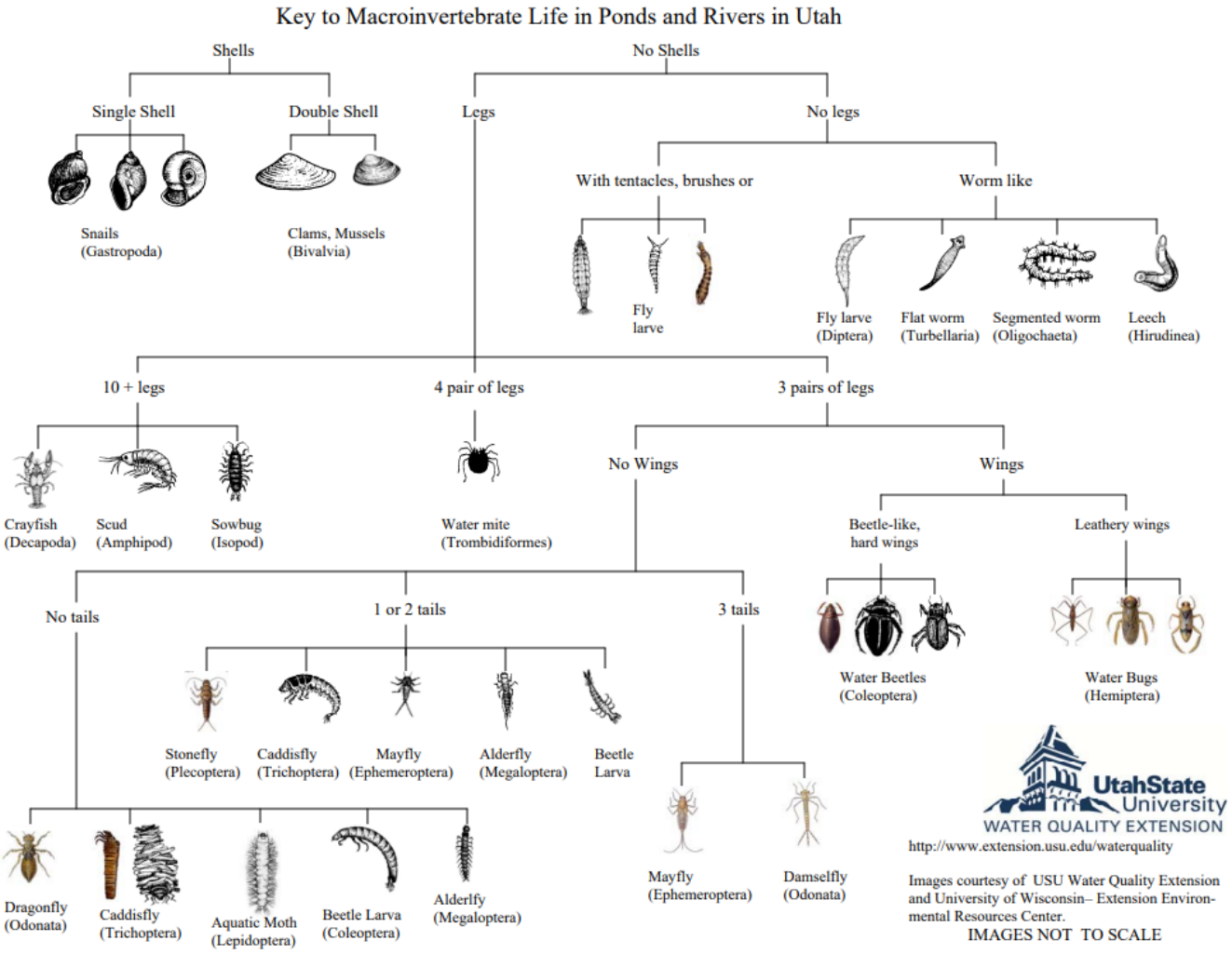
Vocabulary:

- Aquatic: living in water
- Macro: big enough to see without magnification
- Invertebrate: animal without a spine. Invertebrates may have hard support structures on the outside (like a beetle), or they may have none (like a jellyfish or worm).
- Nymph: a younger form of an adult insect that resembles the adult but does not look exactly like it (often lacking wings).
- Larva: a younger form of an adult insect that does not resemble the adult, often worm-like in form.
- Metamorphosis: a process by which an animal changes its body, typically significantly, when going from its early life-stage to its adult life stage. Examples include caterpillars turning into butterflies, and tadpoles turning into frogs.
- Predator: an animal that eats other animals.
- Exoskeleton: Hard protective external structure of an animal

Other reading:

- Aquatic macroinvertebrate:
  - Common aquatic macroinverts and information about them: https://extension.usu.edu/waterquality/files-ou/whats-in-your-water/aquatic_macroinvertebrates/pond_macroinvertebrate_guide.pdf
  - Utah extension service (my new best friend) aquatic inverts site: https://extension.usu.edu/waterquality/educator-resources/lessonplans/macro

- Aquatic macroinvertebrate key:



- Use the following document for the lesson on pollution:
  - https://streamsidescience.usu.edu/ou-files/pdfs/macroinvertebrae-graphing_2017.pdf (graph sheet, followed by three pages grouping aquatic macroinvertebrates by their pollution tolerance. Ignore the instructions sheet)
- Use the following documents for the lesson on metamorphosis:
  - Illustrations of larval form of macroinvertebrates followed by adult form: https://extension.usu.edu/waterquality/files-ou/Publications/AllBugs-2sides.pdf
  - Coloring sheet with adult/larvae matching game, page 16: https://extension.usu.edu/waterquality/files-ou/Lesson-Plans/Aquatic-Macroinvertebrate-lesson-plans/BugsDontBugMe-ColoringBook.pdf

Guiding Questions:

Some guiding questions are the same for all grades, while others will focus on certain grades. Based on the grade you are teaching, choose an appropriate set of guiding questions. Follow the set of guiding questions you've chosen through the lesson outline below.

What are aquatic macroinvertebrates?
Why are aquatic macroinvertebrates important to their ecosystem?

1) Set 1 (4^{th}-5^{th} grade):
    a) What is pollution?
    b) What effect does it have on aquatic macroinvertebrates?
    c) What can aquatic macroinvertebrates tell us about water quality?
2) Set 2 (3^{rd} grade):
    a) Do baby macroinvertebrates look like their parents?
    b) What is metamorphosis?
3) Set 3 (1^{st}-2^{nd} grade):
    a) What are the body parts of an aquatic macroinvertebrate?
    b) How are their body parts adapted to the places they live?

Colorado Academic Standards:

First Grade: Life Science 2.1 – All organisms have external parts that they use to preform daily functions

First Grade: Life Science 2.2- Young organisms are very much, but not exactly, like their parents, and also resemble other organisms of the same kind.

Second Grade: Life Science 2.2- A range of different organisms lives in different places.

Third Grade: Life Science 2.1- Organisms have unique and diverse life cycles.

Fourth Grade: Life Science 2.1 - Organisms have both internal and external structures that serve various functions.

Fifth Grade: Earth and Space Science 3.5- Societal activities have had major effects on land, ocean, atmosphere and even outer space.

Second, Third, Fourth, Fifth Grade: Math- Data, Statistics, and Probability 3.5.MD.B- Represent and interpret data.

Third Grade: Math- Data, Statistics, and Probability 3.MD.A. Measurement & Data: Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects.

Works Cited

Epanchin, P.N., Knapp, R.A., & Lawler, S.P. (2010). Nonnative trout impact an alpine-nesting bird by altering aquatic-insect subsidies. *Ecology 91*(8), 2406-2415.

Lesson Outline

Opening/Introduction (~3 min)	Welcome students to station and what you will be talking about today. Ask questions to gain an understanding of the group's knowledge and start point. Remember to choose a set of guiding questions to follow through the program. Guiding questions: Can anyone tell me what an invertebrate is? What does aquatic mean? How about macro? • Guiding questions 1 (recommended 4th-5th grade): Can anyone tell me what pollution is? • Guiding questions 2 (recommended 3rd grade): Can anyone tell me one animal that does metamorphosis in its life? (If they answered something that lives its whole life on land, ask: Can anyone tell me one animal that starts out its life in the water and then moves to land all the time or at least sometimes?) • Guiding questions 3 (recommended 1st-2nd grade): Does anyone know the body part of an insect? What part is it? Does anyone know what an adaptation is? (a part of an organism that helps it survive- claws on a bear, a wolf's sense of smell, an insect's wings)

Key Talking Points
 	
(~5 min)
	• Aquatic- lives in water
	• Macro- big enough to see with just our eyes
	• Invertebrate- animal with no backbone/spine.
	• Aquatic macroinvertebrates feed lots of animals that live in the water and on the land.
	  o Guiding questions set 1: Aquatic macroinvertebrates need different things- some need very cold, clean water, and others are less picky. Which aquatic macroinvertebrates are around tell us what is going on with the water.
	  o Guiding questions set 2: Aquatic macroinvertebrates can become bugs that live on land later in their life. Changes in what an animal looks like is part of the life cycle of many aquatic macroinvertebrates, and is called metamorphosis.
	  o Guiding questions set 3: Adaptation- a part of an organism that helps it survive- claws on a bear, a wolf's sense of smell, an insect's wings

Hands-on Activity (15 -20 min)	Move to hands on activity
Conclusion (~3 min)	**Guiding questions set 1:** show a sheet with common aquatic macroinvertebrates on it- together, ID the macroinvertebrates and graph how many of each they've found on a graph sheet where each species is highlighted with its pollution tolerance. How many macroinvertebrates did we find in each tolerance category? What does that tell us about how clean the water is? What happens to aquatic macroinvertebrates if the water they live in isn't very clean? What happens to the animals that eat aquatic macroinvertebrates if the aquatic macroinvertebrates aren't there because the water isn't clean? • Post-field trip activity: Using the graphs we made, figure out what macroinvertebrates tell us about water quality. If we had lots of aquatic macroinvertebrates that like dirty water, but not very many that like clean water, what does that tell us about the water? (Or the other way around). If we don't have aquatic macroinvertebrates, what does that mean for the animals that like to eat them? What are some things that could cause the water to be cleaner or less clean? **Guiding questions set 2:** Have each team observe their aquatic macroinvertebrates and identify what kind of macroinvertebrate they have on a class sheet of common aquatic macroinvertebrates- estimate how many of each one they found. What is an aquatic macroinvertebrate? Do lots of them change what they look like through their life cycle? What is the word for that? What are some other animals that do the same thing? Show the life cycle and metamorphosis of one or two common aquatic macroinvertebrates. Since they live in the water and the land, do you think aquatic macroinvertebrates are important for animals that live in the water and outside the water? What if the aquatic macroinvertebrates weren't there? • Post-field trip activity: Pick out the two most common invertebrates and show what they look like in their

	metamorphosis/life cycle. How are they different? How are they similar? What other organisms do they know that do metamorphosis? **Guiding questions set 3:** Bring out posters of a couple common macroinvertebrates, then ask the kids to help you label the parts of each macroinvertebrate (head, thorax, abdomen, legs, etc) What makes this animal an aquatic macroinvertebrate? • Aquatic- lives in water • Macro- big enough to see • Invertebrate- doesn't have a spine! What are some parts on this animal that help it live in this pond? What would happen to the aquatic macroinvertebrates if this wetland dried up? Would they be able to adapt?
Assessment Questions	What does aquatic mean? What does macro mean? What does invertebrate mean? Share one characteristic of an aquatic macroinvertebrate. Guiding questions set 1: What is one thing that can happen to aquatic macroinvertebrates in polluted water? Guiding questions set 2: What is the life cycle of an aquatic macroinvertebrate? Guiding questions set 3: Share one body part of an aquatic macroinvertebrate.

	Hands-on Activities
Activity & Materials	Instructions

• nets
• jars/trays
• ID sheets
• graphing sheet
• adult/nymph form metamorphosis sheets
	• Start by setting a few boundaries:
	  o Tell them that you're going to demonstrate pond dipping, and THEN they are going to get to do some pond dipping themselves.
	  o Let students know that if they mistreat the nets, they won't get to have nets anymore.
	  o Let students know that if they mistreat the aquatic macroinvertebrates or other animals, they will not get to do the pond dipping part of the activity anymore.
	  o Set time expectations- let them know how long they are going to do pond dipping
	  o Ask parents/adults to help you
	• Split students into teams of 2-3
	• Pond dipping demonstration
	  o DO NOT GET IN THE WATER. Tell the kids NOT TO GET IN THE WATER.
	  o Show how the net works in the air by swiping back and forth a few times- show them how you have to keep the open part of the net moving forward, or it won't work. Repeat in the water.
	  o Do we want to scoop up lots of mud? No. Do we want to only swipe the net in the water, where there are no hiding places? No. Swipe the net near vegetation, being careful not to catch on sticks or damage plants.
	• Give a tray, net, and ID sheet to each team with some water already in the tray
	  o Helpful tip- set a timer for 5 minutes and 1 minute before you need to be done pond dipping, and let kids know at those points how much time they have left and that they need to start wrapping up
	• Have kids do some pond dipping and try to ID some of the macroinvertebrates on their own
	• Bring everyone back together
	• Move to conclusion/discussion
	• After conclusion/discussion, carefully return aquatic macroinvertebrates to the water.

Pond dipping and insect parts (recommended 1st grade)	• Bring out posters of a couple common macroinvertebrates, then ask the kids to help you label the parts of each macroinvertebrate (head, thorax, abdomen, legs, etc) • Move to conclusion/discussion.