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Lesson Plan Starters for
Wyoming's Stream Macroinvertebrates

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About aquatic invertebrates

Lakes, ponds, streams, rivers and wetlands are full of life. Many plants and animals live in water and these organisms can be very abundant. All of these organisms are interesting, but we will focus on aquatic invertebrates in this lesson plan starter. **Aquatic** means water, and **invertebrates** are animals that lack a backbone. **Macro** means big—in this case only big enough to see without a magnifying glass. Insects are by far the most abundant and diverse animals. That's true in water, too, so most aquatic macroinvertebrates are insects. Many insects spend only their "youth" in water (larvae or nymphs; longest part of their life), and spend their adult life on land (adults usually have wings), but other insects spend their entire life in water (for example, beetles and true bugs). Besides insects, aquatic macroinvertebrates include mollusks (mussels, clams and snails), worms and leeches, crustaceans, and water mites.

Aquatic invertebrates are useful indicators of ecosystem health because they are relatively sedentary (move small distances); are abundant and diverse (lots of species); easy to collect; and respond to lower water and ecosystem health with lower reproduction and survival and higher death rates. Aquatic invertebrates provide longer term data, because they live in the waterbody most of their life and are exposed to conditions their entire life (aquatic invertebrates live between weeks to over 100 years); however, data from water samples only provides information about a snapshot of time when the sample was taken (water quality may vary over time especially if pollutants are released periodically).

Some aquatic invertebrates are more sensitive to ecosystem health (the condition of the surrounding environment including water quality, habitat quality, etc.) and others are more tolerant of poor ecosystem health. Poor ecosystem health may be caused by habitat degradation in or near the waterbody, the release of pollutants into the water, increased erosion and the buildup of fine sediments, the invasion of non-native species, or the removal of too much water as a few examples. Because tolerant invertebrates are present in waters of both good and poor quality we often measure the number of sensitive invertebrates only to estimate conditions. Mayflies, stoneflies and caddisflies tend to be sensitive to conditions, so these insect orders are often used to estimate ecosystem health. Fortunately, they are usually easy to find and identify.

We hope this document will help you create lesson plans for your classes. We have geared the information for a range of ages (K-12 and undergraduate). No fancy or expensive equipment is needed but can be used if you have access to nets or other samplers.

Supplies needed:

Identification guide, *Wyoming's Stream Macroinvertebrates*
Ice cube trays
Forceps (fine points tweezers) (small paint brushes can be substituted)
White trays (about 8x10 inches, I like photo developing trays, but dish washing pans also work fine)

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Magnifying glasses or dissecting microscopes
Waders or hipboots or rubber boots

Optional items
Dipnets or Kicknet or Surber sampler
Buckets
Scrub brush (toilet brushes work well)
Ziplock bags or plastic jars
Ethanol or rubbing alcohol for preserving (alternatively, keep samples refrigerated)
Sieve (250-500 µm) or window screen in a plastic round quilting hoop

Sources
Wyoming's Stream Macroinvertebrates (identification guide) is available from the Biodiversity Institute at no cost to educators (http://wyomingbiodiversity.org/index.php?cID=403).
Wildco (http://wildco.com/) is a good source for nets of all kinds and have equipment priced for teachers (http://shop.sciencefirst.com/wildco/487-fieldmaster-student-sampling).

How to sample aquatic invertebrates

Rock picking: Aquatic invertebrates are easy to collect and you don't need much equipment. Have your students pick up rocks, wood, leaves, etc. in the waterbody and pick these animals off the rock with forceps and place them in a jar. Record the amount of time student collect for and multiply by the number of students to calculate an effort (10 students collected for 30 minutes = 5 hours of effort)

Kicknet (streams only): Have two students hold a kicknet in the stream making sure that the bottom of the net is against the stream bottom. Have a third student do a bug dance in the stream by shuffling his or her feet to stir the sediment and agitate the rocks. The student should dance for about 3-5 minutes in an area approximately one square meter. Carefully remove the net and rinse into a bucket.

Dipnet: My favorite nets are D-frame dipnets, but any dipnet made for water will be fine as long as the mesh is small enough to retain invertebrates (500 µm or 0.5 mm is a good size). Dipnets can be used similar to a kicknet where a student stands upstream of the net and agitates the sediments and rocks with their feet (streams only). They can also bump the net along the bottom of the waterbody while moving the net forward so the invertebrates are swept into the net. Invertebrates can be picked directly out of the net or students can turn the net in-side-out and dip the net into a bucket of water or tray.

Surber Sampler: Surber samplers are great for streams with rocky bottoms. Have one student hold the sampler and the other student collect the sample. Place the Surber sampler with the net dangling downstream so the currently flows into the net. Make sure there are no large gaps between the back of the sampler and the bottom of the stream. Have the students scrub all the rocks and agitate all the sediment within the 1 foot by 1 foot area. Invertebrates will flow into the net. Rinse the net into a bucket or tray. A Hess sampler is similar to a Surber sampler and can be used in the same manner.

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Caddisfly cases attached to a rock

Dipnetting in a pond

Collecting Surber samples in a stream

Storing and Processing Samples

No matter how you collected the samples, you can take them back to the classroom and process them. The kicknet, dipnet and Surber samples will all be in water. Use a sieve or window screen in a quilting hoop and pour the sample through the sieve. Invertebrates will be retained on the sieve or screen. Invertebrates tend to be lighter than rocks and sand so swirl the bucket and pour the water and invertebrate off but keep the rocks and sand in the bucket (this process is called elutriation.) Place the sample in a bag (I recommend double bagging them) or plastic jar with water. If you plan to keep the invertebrates alive, you can store the samples in the refrigerator. Alternatively, you can preserve the invertebrates in alcohol (ethanol or rubbing alcohol) and store them at room temperature.

Back in the classroom, pour the sample into a tray (lighter color is better) and pick out all the invertebrates that can be found. As they pick the invertebrates out of the sample, students can sort them by placing different taxa (species) in different sections of an ice tray. You may want to first sort to order, then do further sorts to family or species, depending on which water quality index you are using.

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Calculating water quality

All grade levels

Mayfly (**E**phemeroptera), stonefly (**P**lecoptera) and caddisfly (**T**richoptera) index or **EPT index**

To estimate water quality with the EPT index, first sort mayflies (E's), stoneflies (P's) and caddisflies (T's) into species. Use the key to invertebrates (page 10) and photos in the guide to help sort (mayflies, pages 48-75; stoneflies, pages 76-95; and caddisflies, pages 14-47). The range maps may help eliminate some species. Only mayflies, stoneflies and caddisflies need to be sorted for this index.

Add up the number of species of E's, P's and T's to calculate the EPT Index:

One or fewer EPT taxa = poor ecosystem health
Two to five EPT taxa = moderate ecosystem health
Six or more EPT taxa = good ecosystem health

Middle school and higher

The following method is a modified version of the Izaak Walton League of America Save our Streams method that includes information on all of the invertebrates in the sample. This method takes more time, because the students need to identify (not just sort) all of the invertebrates to family. The math is still very simple.

For each family, find the tolerance value (sensitive, moderately sensitive, moderate and tolerant) in the guide for each family. (These terms refer to how sensitive these insect families are to pollution.)

Have the students count how many different types of invertebrates they collected in each group. Multiply the number of sensitive families by 3, moderately-sensitive and moderate families by 2 and tolerant families by 1. Add the four products together for a grand total.

Tolerance value	Value		Number of families		Total
Sensitive	3	x		=	
Moderately-sensitive	2	x		=	
Moderate	2	x		=	
Tolerant	1	x		=	
			Grand Total	=	

Tolerance values for non-insects

Sensitive	Moderate	Tolerant
Gilled snails (shell visible in opening)	Crayfish Scuds or Amphipods Isopods or Sowbugs Clams Mussels	Worms Leeches Lunged snails (can see their fleshy foot in opening)

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Use the table below to estimate the ecosystem health of the waterbody.

Ecosystem health	**Grand Total**
Excellent	>22
Good	17-22
Fair	11-16
Poor	<11

High School or higher

The most complex and sensitive water quality index that we present is **Hilsenhoff's Biotic Index** (HBI) for families. This index uses a 0 to 10 sensitivity scale (see table below), where 0 = highly sensitive to pollution, and 10 = extremely tolerant of pollution. The HBI incorporates the number of individuals in each family and the tolerance value for each family. For each sample, have the students record: 1) the family that each invertebrate belongs to, 2) how many they collected in each family, and 3) the tolerance value for each family (from the table).

The formula for Hilsenhoff's Biotic Index is: $HBI = \frac{\sum Number_i \times Tolerance_i}{Total\ number}$

To calculate an HBI value for a sample, first multiply the number of individuals by the tolerance value for each family. Then, calculate the total number of individuals in the sample. Finally, divide the numerator by the total number of individuals collected. A sample data sheet is given here:

Family	**Number collected**		**Tolerance Value**		***Number* x *Tolerance***
Chironomidae (midges)	20	x	6	=	120
Baetidae (mayfly)	5	x	4	=	20
Brachycentridae (caddisfly)	6	x	1	=	6
Tipulidae (Cranefly)	2	x	3	=	6
Total Number =	33		**Grand Total**	=	152

For this example, HBI = 4.6 (152/33). HBI can be thought of as the average tolerance value of an invertebrate in the sample, and ranges from 0 to 10. Invertebrates with a tolerance value of 0 are extremely sensitive to ecosystem health and invertebrates with a tolerance value of 10 are extremely tolerant of conditions. Use the chart below to estimate ecosystem health in the waterbody you sampled.

HBI value	**Ecosystem Health**
0.00-3.75	Excellent
3.76-4.25	Very good
4.26-5.00	Good
5.01-5.75	Fair
5.76-6.5	Fairly poor
6.51-7.25	Poor
7.26-10.0	Very poor

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The example above would be considered a stream with good ecosystem health.

Chart of Tolerance Value

Insect Order and Family	**Tolerance Value**
Plecoptera (Stoneflies)	
Capniidae	1
Chloroperlidae	1
Leuctridae	0
Nemouridae	2
Perlidae	1
Perlodidae	2
Pteronarcyidae	0
Taeniopterygidae	2
Ephemeroptera (Mayflies)	
Baetidae	4
Baetiscidae	3
Caenidae	7
Ephemerellidae	1
Ephemeridae	4
Heptageniidae	4
Leptophlebiidae	2
Oligoneuriidae	2
Polymitarcyidae	2
Siphlonuridae	7
Leptohyphidae	4
Trichoptera (Caddisflies)	
Apataniidae	1
Brachycentridae	1
Glossosomatidae	0
Helicopsychidae	3
Hydropsychidae	4
Hydroptilidae	4
Lepidostomatidae	1
Leptoceridae	4
Limnephilidae	4
Molannidae	6
Philopotamidae	3
Phryganeidae	4
Polycentropodidae	6
Psychomyiidae	2
Rhyacophilidae	2
Uenoidae	3
Odonata (Dragon and Damselflies)	
Aeshnidae	3

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Calopterygidae	5
Coenagrionidae	9
Cordulegastridae	3
Corduliidae	5
Gomphidae	1
Lestidae	9
Libellulidae	9
Megaloptera (Alderfly)	
Sialidae	4
Lepidoptera (Moths)	
Crambidae	6
Diptera (True flies)	
Athericidae	2
Blephariceridae	0
Ceratopogonidae	6
Chironomidae	6
Empididae	6
Psychodidae	10
Simuliidae	6
Tabanidae	6
Tipulidae	3
Coleoptera (Beetles)	
Dytiscidae	5
Elmidae	4
Gyrinidae	5
Halipidae	7
Hydrophilidae	5
Non-insects	
Mollusks (Snails and Clams)	
Lymnaeidae	6
Physidae	8
Sphaeriidae	8
Crustaceans	
Amphipods (Scuds)	4
Isopods	8
Decapoda (Crayfish)	8
Annelids (Worms and Leeches)	
Oligochaeta (Worms)	8
Hirudinidae (Leeches)	7
Other	
Acari (Mites)	4
Hydridae (Hydra)	5
Turbellaria (Flat Worms)	4