IS THERE MINE DRAINAGE IMPACTING THIS STREAM?

❑ **Grade Level:** Middle/High School	❑ **Subject Areas:** Biology, Environmental	❑ **Setting:** Classroom/Hallway/Outside
❑ **Duration:** 50 min.	❑ **PA Academic Standards:** 1.6.8A,D; 1.6.11A,D; 2.4.8F; 2.7.8D; 3.5.1D; 4.1.7B,C; 4.1.10B,C; 4.3.7A; 4.3.10C; 4.6.7A; 4.6.10A	❑ **Keywords:** identification, evaluation, macroinvertebrate, biological sampling, stream health

SUMMARY
Students will complete a biological sampling activity in which they will determine the types of organisms collected and calculate the water quality rating. The information obtained about the types and amounts of organisms found will be applied to illustrate how the insects sampled can become an indicator for streams impacted by abandoned mine drainage.

OBJECTIVES
- After collecting macroinvertebrate cards, the student will correctly identify organisms using a taxonomy key.
- After identifying organisms, the student will correctly calculate macroinvertebrate diversity.

MATERIALS
<u>Create on Your Own:</u>

1 - 100 foot roll of blue paper – *Stream #1*
1 - 100 foot roll of brown paper – *Stream #2*
15 medium to large rocks – *Stream Bottom*
10 artificial green plants – *Aquatic Plants*
15 pressed leaves – *Leaf Litter*
Brown Lunch Bags
Masking Tape
Pencils
Chalkboard
Chalk
Sheet A - *Macroinvertebrate Cards* (3 sheets for each group of two students)
Sheet B - *Macroinvertebrate Cards* (3 sheets for each group of two students)
Worksheet A- *Stream Health Checklist*

<u>Materials in Module:</u>

1 -Blue *Stream #1*
1 - Orange *Stream #2*
15 medium to large rocks – *Stream Bottom*
10 artificial green plants – *Aquatic Plants*
Brown Lunch Bags
Sheet A - *Macroinvertebrate Cards* (3 sheets for each group of two students)
Sheet B - *Macroinvertebrate Cards* (3 sheets for each group of two students)
Worksheet A - *Stream Health Checklist*
Samples of macroinvertebrates in jars

BACKGROUND

<u>*Part I:*</u> *Abandoned Mine Drainage*

The 'Pittsburgh coal seam' has been called the single most valuable mineral deposit ever discovered. A population map of western Pennsylvania reveals patterns similar to the map of Pennsylvania bituminous coal deposits. Most of the population of western Pennsylvania is still concentrated around the Pittsburgh seam because, historically, towns developed around the mining of coals and associated industries. Bituminous coal is a soft, black coal that is used in making 'coke,' the fuel that burns so hot it melts iron ore, and makes possible the manufacturing of steel. The Pittsburgh seam produced most of our nation's coal until the 1970's, and is still a major economic resource. In the early 20th century, coal was the major source of energy. To feed such a large demand, coal deposits were harvested and resources used without worry of the cost to the environment. When a coalmine became depleted, it was simply abandoned and a new one dug in a nearby vein.

Much of the damage abandoned coalmines have done to our streams is a result of water seeping through the ground and coming into contact with the remnants of the mine. This water eventually works its way back to the surface of the ground and forms a discharge. The problem with water interacting with the mine is that minerals easily dissolve into the water. 'Roof rubble,' the drainage composed of loosened earth which falls from the ceiling of an abandoned mine shaft, is typically pyrite (iron sulfide). Pyrite has a large surface area so it dissolves easily dissolves into water. The discharge from such mines contains a large amount of iron, resulting in the distinctive orange coloring.

Pyrite + oxygen → Iron Hydroxide (orange solid) + Acid

Chemistry of Mine Drainage

Pyrite Dissolves:

$$FeS_2\,(s) + {}^{7}/_{2}\,O_2\,(g) + H_2O\,(l) \rightarrow Fe^{+2}\,(aq) + 2\,SO_4^{-2}\,(aq) + 2\,H^+\,(aq)$$

Iron (II) is oxidized:

$$2Fe^{+2} + \tfrac{1}{2}\,O_2 + 2H^+ \rightarrow 2Fe^{+3} + H_2O$$

Formation of Iron Hydroxide (above pH 3)

$$Fe^{+3} + 3\,H_2O \rightarrow Fe(OH)_3\,(s) + 3\,H^+$$

Further pyrite dissolution (below pH 3)

$$FeS_2 + 14\,Fe^{+3} + 8\,H_2O \rightarrow 15\,Fe^{+2} + 2\,SO_4^{-2} + 16\,H^+$$

Abandoned Mine Drainage disrupts the healthy function of a stream ecosystem in a variety of ways.

1. Habitat Bottom:
   Abandoned Mine Drainage "sludge" is both a slippery and sticky substance, somewhat the consistency of toothpaste. When mine drainage enters a stream, the iron oxide sludge mixes with the water forming a cloudy precipitate in the stream (orange color). The cloudy condition of the stream does not allow sunlight to penetrate to the bottom of the stream. This condition does not allow the macroinvertebrates to survive.
2. Sedimentation:
   Abandoned Mine Drainage "sludge" makes the water in a stream become turbid as pieces of iron begin to form and precipitate out of solution. The "rusty" pieces of iron make the water in a stream cloudy, therefore block sunlight from reaching the photosynthetic organisms and aquatic plants. This process destroys the producers in an aquatic food chain, thus destroying the healthy balance of "who eats who".
3. Lowers Dissolved Oxygen:
   Abandoned Mine Drainage utilizes the existing dissolved oxygen in the stream in the oxidation reaction as mine water enters a stream. It is the dissolved oxygen or DO in the water that allows macroinvertebrates or other gill-breathing organisms to survive and thrive in a stream.

Part II –: Macroinvertebrates, a Stream Health Indicator

Aquatic macroinvertebrates are found in lakes, streams, ponds, marshes and puddles and help maintain the health of the water ecosystem by eating bacteria and dead, decaying plants and animals. Overall water quality effects which types of organisms can survive in a body of water. "Water quality" may include the amounts of dissolved oxygen and the levels of algal growth, pollutants that may be present and the pH level. Some macroinvertebrates such as stoneflies, mayflies and water pennies require a high level of dissolved oxygen and their abundance is an indication of good water quality. Other macroinvertebrates can survive at a lower dissolved oxygen level because they can come to the surface to get oxygen through a breathing or "snorkel" tube or carry a bubble of air with them around their bodies or under their wings.

There are several reasons why macroinvertebrates are used as water quality indicators:

1. Aquatic macroinvertebrates are an important part of the food chain found in and around a body of water.

Aquatic macroinvertebrates are a link in the aquatic food chain. In most streams, the energy stored by plants is available to animal life either in the form of leaves that fall in the water or in the form of algae that grows on the stream bottom. The algae and leaves are eaten by macroinvertebrates. The macroinvertebrates are a source of energy for larger animals such as fish, which in turn, are a source of energy for other animals and even man.

2. Aquatic macroinvertebrates differ in their sensitivity to water pollution.

Some aquatic macroinvertebrates cannot survive in polluted water. Others can survive or even thrive in polluted water. In a healthy stream, the macroinvertebrate community will include a variety of pollution-sensitive macroinvertebrates. In an unhealthy stream, there may be only a few types of non-sensitive macroinvertebrates present.

3. Aquatic macroinvertebrates provide information about the quality of a stream over long periods of time.

It may be difficult to identify stream pollution with water analysis such as pH and dissolved oxygen, which can only provide information for the time of sampling. Even the presence of fish may not provide information about a pollution problem because fish can move away to avoid polluted water and then return when conditions improve. However, most aquatic macroinvertebrates cannot move to avoid pollution. A macroinvertebrate sample may provide information about pollution that is not present at the time of sample collection.

4. **Aquatic macroinvertebrates are relatively easy to collect.**

Useful aquatic macroinvertebrate data is easy to collect without expensive equipment. The data obtained by taking a macroinvertebrate survey can serve to indicate the need for additional data collection on water sample.

The life cycle of a macroinvertebrate goes from egg to adult form and they can undergo either complete or incomplete metamorphosis. Complete metamorphosis has 4 stages, egg, larvae, pupa and adult. Organisms, which undergo complete metamorphosis, include true flies, beetles and caddis flies. Many of these organisms are aquatic for the egg and larval stages, but not in the adult stage. Incomplete metamorphosis has 3 stages, egg, nymph and adult. Organisms that undergo incomplete metamorphosis include stoneflies, mayflies, dragonflies and true bugs. Many of these organisms, such as dragonflies, do not live in an aquatic ecosystem as adults. Other species such as true bugs, which include the backswimmers, water scorpions and the water striders, are examples of macroinvertebrates, which spend their entire lives in the water.
The length of the life cycle of a macroinvertebrate can vary from less than 2 weeks for some midges and mosquitoes and two years or longer for some stoneflies, dragonflies and Dobson flies.

PROCEDURE

WARM UP

- Brainstorm with the students what conditions are necessary for a healthy stream ecosystem.
- The teacher will write student responses on the board.
- Ask the students what would happen to the stream if these conditions were eliminated or altered?
- Ask the students how they would assess the health of the stream?
- Ask the students what would happen to the stream if these conditions were eliminated or altered?
- Today we are going to learn one way that scientists determine if a stream is unhealthy due to mine drainage.

THE ACTIVITY – STREAM GAME

1. Show students pictures or sample jars of macroinvertebrates used to monitor stream quality. Discuss with the students where you would find these organisms in a stream (under rocks, buried in sediment, clinging to leaf litter, around aquatic plants, etc.)

2. Following the *Game Set-up Diagram*, in a hallway or in a classroom, roll out the blue paper and tape down the paper to the floor. This BLUE paper will represent the high quality stream in which the students will collect macroinvertebrates. Randomly place rocks, plastic plants, and leaves on top of the paper roll. **–OR- Use the Blue Stream #1 Located in Module.** Using *Sheet A Macroinvertebrates*, randomly place macroinvertebrates face down along the stream, under rocks, around plants, and within leaf litter, etc.

3. With a partner, each group of students receives a brown bag (this is their net). They are to sample upstream to downstream collecting at least 15 macroinvertebrates, two must be collected from under rocks, two from around a plant, and two from leaf litter, and place them into their brown bag. They are not to look at the types of macroinvertebrates being collected as they take their samples.

4. Using a check mark for each macroinvertebrate, students record the types of macroinvertebrates collected in Stream #1 Column on the *Stream Health Checklist Worksheet*.

5. After all groups have sampled Stream #1. On the other side of the hallway or classroom, roll out the brown paper and tape down the roll of brown paper. This BROWN paper will represent the poor quality stream in which the students will collect macroinvertebrates. Randomly place the rocks, plants, and leaves on top of the brown paper. **–OR- Use Orange Stream #2 found in Module**. Using *Sheet B Macroinvertebrates*, randomly place macroinvertebrates face down along the stream, under rocks, around plants, leaf litter, etc.

6. Students repeat step #3.

7. Using a check mark for each macroinvertebrate, students record the types of macroinvertebrates collected in Stream #2 Column on the *Stream Checklist Worksheet.*

8. Students calculate the total number of tolerant, somewhat sensitive, and sensitive macroinvertebrates for each stream on the chart at the bottom of the *Stream Checklist Worksheet*, then complete the questions found on the bottom of the worksheet.

9. The teacher should create a class Stream Checklist Worksheet on the blackboard. Collect class results to show data from the class and record on the chalkboard.

WRAP UP

1. Discuss the results of their macroinvertebrate collection for stream #1 and stream #2. Have students compare numbers and types of macroinvertebrates found in each stream.
2. Review with the students why some species of macroinvertebrates were found in stream #1 and not found in stream #2.
3. Ask students if they knew what type of pollutant makes a stream appear "Orange-Colored"? Pass around pictures of orange colored streams.
4. Why are these streams orange? What are some possible reasons as to why these streams appear orange? (Answer: Abandoned Mine Drainage).

ASSESSMENT OPTIONS

1. The teacher will visually check to see if each student's collected macroinvertebrate were correctly identified. (Objective 1)
2. The teacher will verbally prompt students, through discussion and review, to complete the Stream Health Checklist. (Objective 2)

EXTENSION

1. Students could develop a matching game in which pictures of streams polluted and not polluted are matched with the corresponding macroinvertebrates found in those streams.
2. Have students sample the stream game using all the same species of macroinvertebrates, and have them discuss the health of the stream.

RECOMMENDED RESOURCES AND REFERENCED INFORMATION:
Credits: Jennifer Brashear – Macroinvertebrate Cards, Saint Vincent College
Books:
Firehock, Karen. *Hands on Save Our Streams*: Izaak Walton League of America, 1996.

Websites:
The purpose of this page is to provide students, citizen volunteers, and others interested in benthic macroinvertebrates and/or biomonitoring with assistance in identification of specimens and to provide information on the habitat and general ecology of common benthic macroinvertebrates.
http://www.iso.gmu.edu/~avia/intro.htm

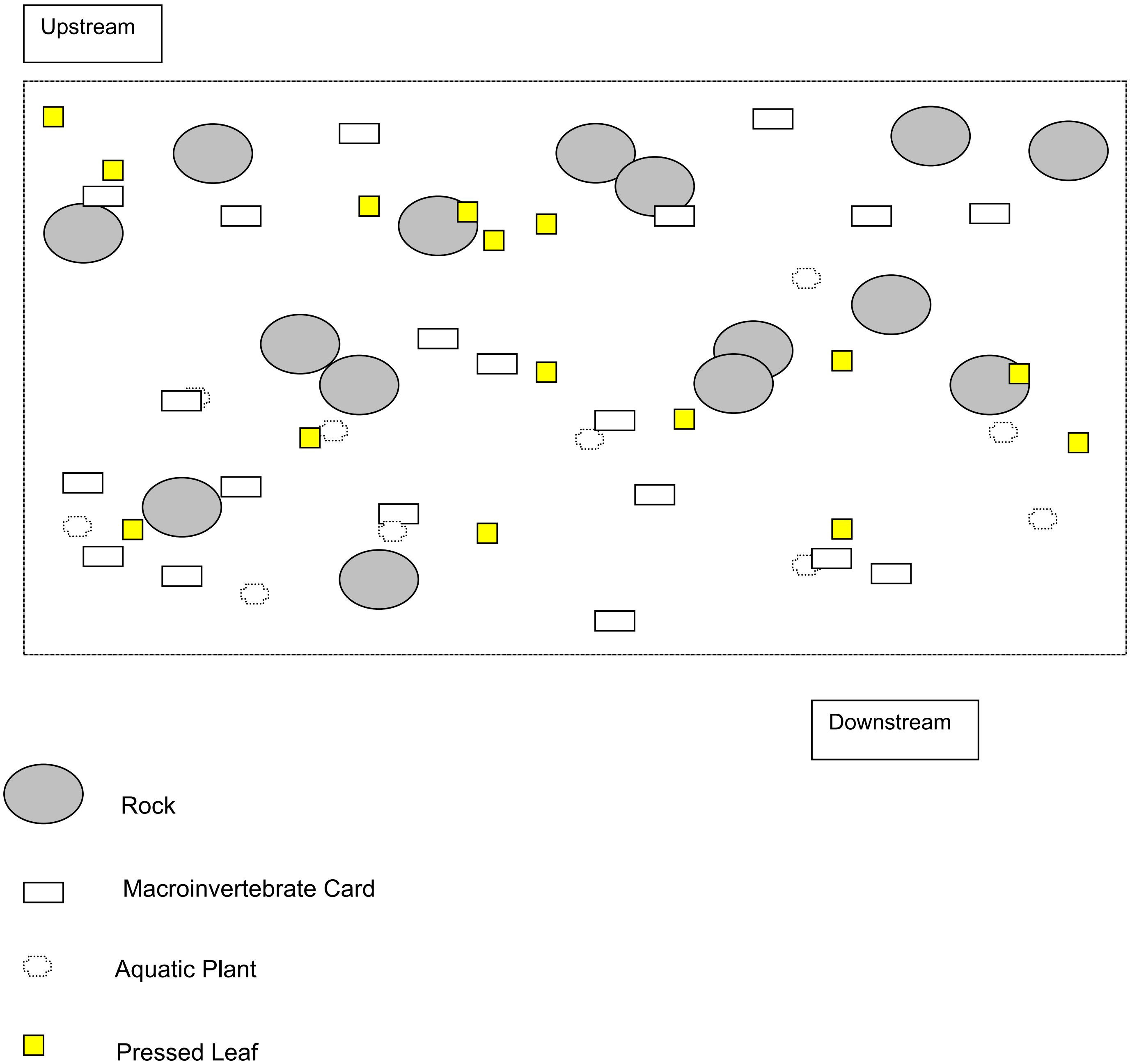
A page of links to several aquatic macroinvertebrate keys. Insect larvae can be quickly and easily identified down to family level by making a series of choices that correctly match observable traits.
http://www.net1plus.com/users/tdriskell/macroinvertebrates.html

Biological Stream Assessment
http://water.nr.state.ky.us/ww/introtxt.htm

April J. Cleveland, *Water Quality and Aquatic Macroinvertebrates.* http://www4.ncsu.edu/~ajclevel/macroinvert.html

The Science of Abandoned Mine Drainage and Treatment
http://www.dep.state.pa.us/dep/deputate/minres/bamr/amd/science_of_amd.htm

STREAM GAME SET-UP



Stream Health Checklist

ORGANISM	TOLERANCE	STREAM #1	STREAM #2
CADDISFLY LARVA	Sensitive		
MAYFLY NYMPH	Sensitive		
STONEFLY NYMPH	Sensitive		
GILLED SNAIL	Sensitive		
DOBSONFLY (HELLGRAMMITE)	Sensitive		
DRAGONFLY NYMPH	Somewhat Sensitive		
DAMSELFLY NYMPH	Somewhat Sensitive		
CRAYFISH	Somewhat Sensitive		
CLAM	Somewhat Sensitive		
SOWBUG	Somewhat Sensitive		
MIDGE LARVA	Tolerant		
RAT-TAILED MAGGOT	Tolerant		
LEECH	Tolerant		
FLAT WORM	Tolerant		
POUCH SNAIL	Tolerant		
AQUATIC WORMS	Tolerant		

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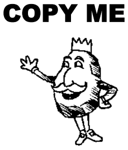

One Per Group

MACROINVERTEBRATES	**Stream #1**	**MACROINVERTEBRATES**	**Stream #2**
Sensitive		Sensitive	
Somewhat Sensitive		Somewhat Sensitive	
Tolerant		Tolerant	

1. Was there a difference in types of macroinvertebrates found between Stream #1 and Stream #2?

   Yes ____ No ____

2. Where did you find more tolerant species of macroinvertebrates?

   Stream 1 ____ Stream 2 ____

3. Why were more tolerant species found in this stream?

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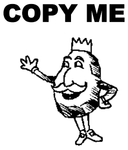
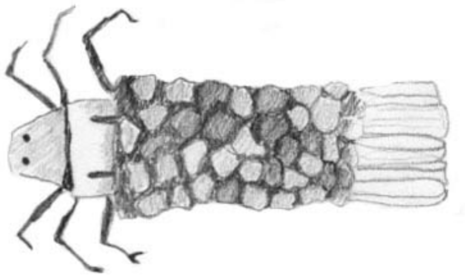
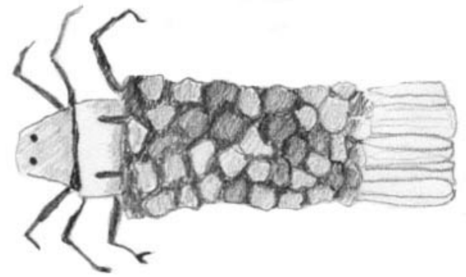


One Per Group

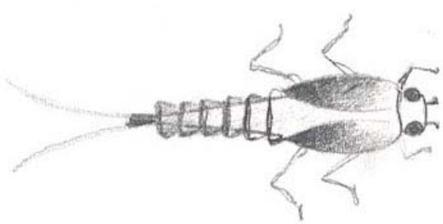
Macroinvertebrate Cards
Sheet A – High Quality Stream

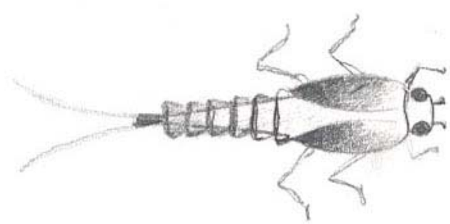

Caddisfly Larva

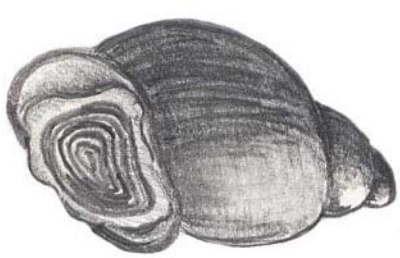

Caddisfly Larva

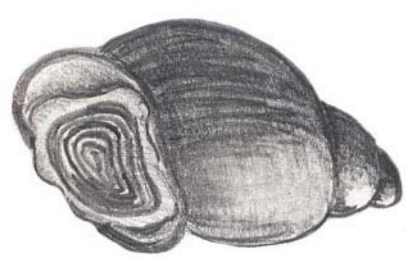

Hellgrammite


Hellgrammite

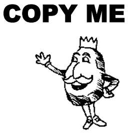

Mayfly Nymph


Mayfly Nymph


Gilled Snail

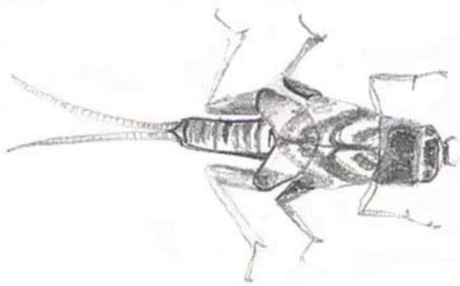

Gilled Snail

COPY ME

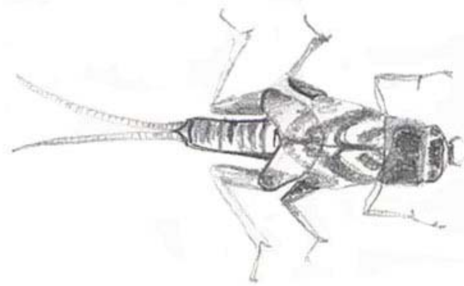


3 Per Group

Macroinvertebrate Cards
Sheet A – High Quality Stream

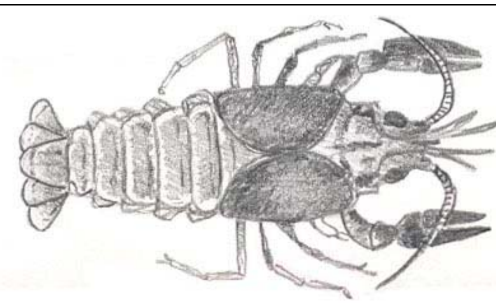


Stonefly Nymph

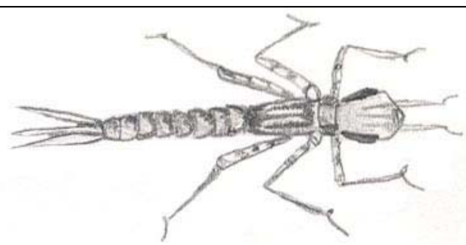


Stonefly Nymph

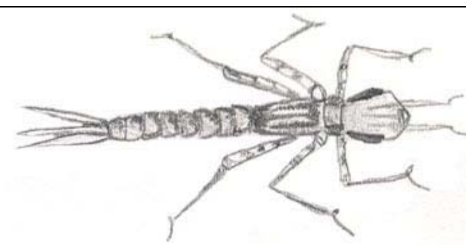
Clam



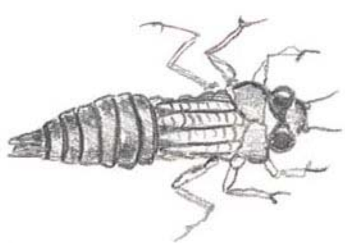
Crayfish



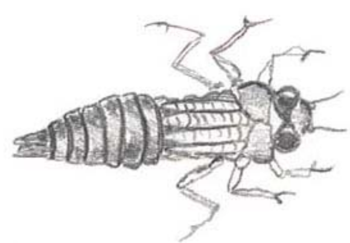
Damselfly Nymph



Damselfly Nymph



Dragonfly Nymph



Dragonfly Nymph

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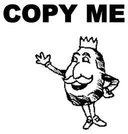
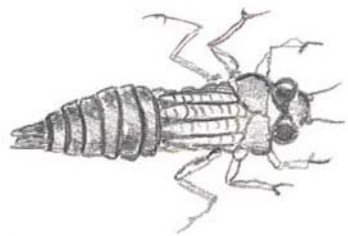
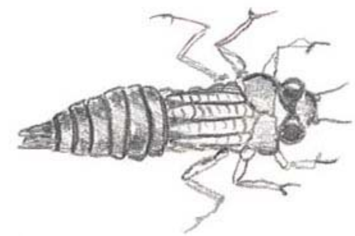


3 Per Group

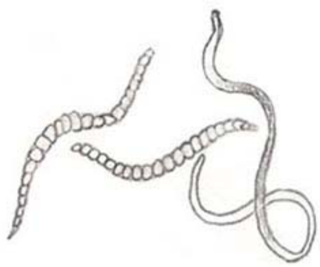
Macroinvertebrate Cards
Sheet B – Low Quality Stream



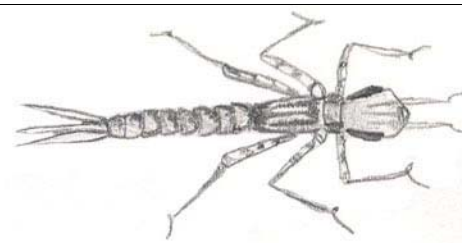
Dragonfly Nymph



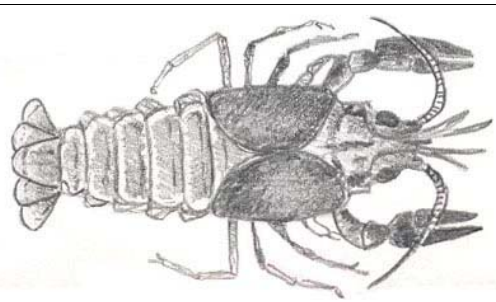
Dragonfly Nymph



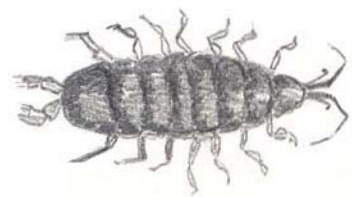
Aquatic Worms



Damselfly Nymph

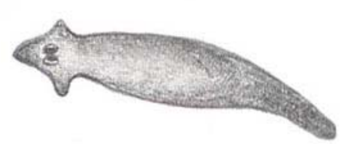


Crayfish



Sowbug

Leech



Flatworm

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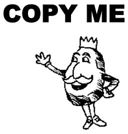

3 Per Group

Macroinvertebrate Cards
Sheet B – Low Quality Stream

Blackfly Larva

Blackfly Larva

Midge Larva

Midge Larva

Pouch Snail

Pouch Snail

Rat-Tailed Maggot Larva

Rat-Tailed Maggot Larva

COPY ME

3 Per Group