

Lesson 2 - Aquatic Indicator Organisms

Authors:

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Grade Level: 5-8

Lesson Time: Two 50 minute sessions

Suggested Class Structure: whole class lecture/slide presentation, small collaborative group work

Subject Areas: Science

BACKGROUND

See slide show text starting on page 41.



GOAL

Students will learn the key characteristics of the general types of aquatic organisms. They will gain the observation and identification skills to be able to use a key to aquatic organisms. They will develop an understanding of why the presence of certain aquatic organisms indicate the ecological conditions of the habitat in which they are found.

OBJECTIVES

The students shall:

1. List the three main types of aquatic indicator organisms and their characteristics.
2. Using the PA Fish and Boat Commission key, be able to correctly identify an aquatic organism from looking at a picture.

VOCABULARY

Abdomen – The back section of the body behind the thorax in an arthropod.

Appendages – Structures growing from the body, such as arms and legs.

Carnivore – A meat eater.

Field guide – A manual for identifying natural objects, plants or animals in the field

Freshwater – Clean, unpolluted water without salinity (as opposed to salt water)

Gill – In water-dwelling creatures, a breathing organ that extracts oxygen.

Invertebrate – Animals without backbones. Examples include insects, worms, spiders, crayfish and sowbugs.

Larva – Immature form of an animal that is physically very different from the adult.

Organisms – A living thing. This term refers to all animals, plants, algae, bacteria, fungus and all one-celled creatures.

Parasite – An organism that lives by getting benefit from the life processes of another organism, usually doing harm to the organism from which it gets benefit.

Segmented – One of the constituent parts into which a body, entity, or quantity is divided or marked off by or as if by natural boundaries.

MATERIALS

- Overheads or PowerPoint of aquatic organisms
- Aquatic organisms key from PA Fish and Boat Commission
- Picture sheets of aquatic organisms, one for each student group
- Macro Invertebrate Record Sheet, one for each student group
- “Aquatic Organisms and Pollution Monitoring Review Sheet” for each student.

ADVANCE PREPARATION

- ✓ Download aquatic organisms PowerPoint from Graver Web site, or borrow the CD or overhead version from the College.
- ✓ Run off copies of “Aquatic Organisms and Pollution Monitoring Review Sheet” for each student.
- ✓ Get copies of aquatic organisms key from the Pa. Fish and Boat Commission. The title of the publication is *Pond and Stream Study Guide*. It can be ordered from the Pennsylvania Fish and Boat Commission. Orders must be placed four weeks in advance of the date the guides are needed. For more information, go to <http://www.fish.state.pa.us> and click on “Education/Educational Resource Catalog.” There is a materials order form on the Web site that can be copied and sent in to the main office in Harrisburg, or you can call your local Aquatic Resources Program Specialist for the Southeast Region, 717-626-9081.
- ✓ Obtain a fishing license from the Pa. Fish and Boat Commission. For information, go to <http://www.fish.state.pa.us> and find the heading “Buy a License” in the left column, then click on “Application”.
- ✓ Obtain an educational collector’s permit from the Pa. Fish and Boat Commission.

For information, go to

<http://www.fish.state.pa.us> , click on “Education” at the top heading, scroll to “Instructors/Educators”, and click on “Educational Aquatic Field Study Permit”.

- ✓ Run off copies of the stream classification handouts—the sample organisms and the sheet for data recording, one for each group.

PROCEDURES – Outline and Narrative

1. Introduce the topic of indicator organisms through a PowerPoint slide presentation. See “Aquatic Indicator Organisms PowerPoint Outline” in the Lesson Appendix for the slide show script.
2. Handout the aquatic organisms key for the PA Fish and Boat Commission and review the identification system.
3. Have student groups practice identifying the pictures of the aquatic organisms, and record their results on the Macro Invertebrate data sheet.

You will find copy masters for “Aquatic Organism Examples” and the “Sample Count and Water Quality Rating” Data Sheet in the Lesson Appendix. The answer key for this activity is also in the lesson appendix.

ASSESSMENT

- “Aquatic Organisms and Pollution Monitoring Review Sheet” – See copy masters in the Lesson Appendix

RESOURCES



Books for the teacher:

Caduto, Michael J. *Pond and Brook: A Guide to Nature in Freshwater Environments*. University Press of New England, 1990.

Lawlor, Elizabeth P. *Discover Nature in Water and Wetlands: Things to Know and Things to Do (Discover Nature Series)*. Stackpole, 2000.

Peckarsky, Barbara L., Fraissinet, Pierre R., Penton, Marjory A., and Conklin, Don J. Jr. *Freshwater Macroinvertebrates of Northeastern North America*. Cornell University Press, 1990.

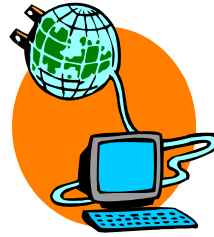
Books for the student:

Cushing, Colbert E., and Allan, J. David. *Streams: Their Ecology and Life*. Academic Press, 2001.

Headstrom, Richard. *Adventures with Freshwater Animals*. New York: Dover Publications, Inc., 1964.

Reid, George K, and Zim, Herbert S. *Pond Life: A Guide to Common Plants and Animals of North American Ponds and Lakes (Golden Guide)*. St. Martin's Press, 2001.

Voshell, J. Reese, Jr. *A Guide to Common Freshwater Invertebrates of North America*. The McDonald & Woodward Publishing Company, 2002.



Web sites: Since the Web is constantly changing, check Muhlenberg's Outreach Web site for updated listings. [<http://www.muhlenberg.edu/cultural/graver/>]

Web sites for the teacher:

Pa. Fish and Boat Commission –
[<http://www.fish.state.pa.us>]

This website provides order information for macroinvertebrates guide. Click on "Publications", category "Critters".

Stroud Water Research Center –
[<http://www.stroudcenter.org>]

In addition to teacher workshops and resources, this water research center in Avondale, PA sponsors the Leaf Pack Network using the *Leaf Pack Experiment Kit* from LaMotte Company to investigate local stream ecology. Students share data and compare results through a database sponsored by the center and hosted on their Web site.

Web sites for the student:

Key to Stream Invertebrates.
[<http://imc.lisd.k12.mi.us/msc1/invert/key.html>]

This Web site is an interactive key for students to identify aquatic organisms. Pictures are available to aid in identification.

Biological Indicators of Watershed Health.
U.S. Environmental Protection Agency.
[<http://www.epa.gov/bioindicators/html/invertebrate.html>] Lots of background information and photos.

Water Bug Detective Guide. Government of New South Wales, Australia.
[http://www.bugsurvey.nsw.gov.au/html/pdfs/wb_detective_guide_a4.pdf] Free PDF field guide from “Down Under” but generic enough to use in the U.S.



STATE STANDARDS FOR ENVIRONMENT AND ECOLOGY

4.1.7 Watersheds and Wetlands

- C. Explain the effects of water on the life of organisms in a watershed.

4.3.7 Environmental Health

- A. Identify environmental health issues.
 - Identify various examples of long-term pollution and explain their effects on environmental health.
- C. Explain biological diversity.

4.6.7 Ecosystems and their Interactions

- A. Explain the flows of energy and matter from organism to organism within an ecosystem.
 - Describe and explain the adaptations of plants and animals to their environment.
 - Demonstrate the dependency of living components in the ecosystem on the nonliving components.
 - Explain the importance of the predator/prey relationship and how it maintains the balances within ecosystems.
 - Understand limiting factors and predict their effects on an organism.
 - Identify niches for producers, consumers and decomposers within an ecosystem.

4.7.7 Threatened, Endangered and Extinct Species

- A. Describe diversity of plants and animals in ecosystems.
- B. Explain how species of living organisms adapt to their environment.
- C. Explain natural or human actions in relation to the loss of species.

Lesson 2 - Appendix



Copy Masters for:

Aquatic Indicator Organisms PowerPoint Outline

Macroinvertebrate Examples

1. Bushkill Stream
2. Jordan Creek
3. Cedar Creek
4. Little Lehigh Creek
5. Spruce Run
6. Pennypack Creek

Macro Invertebrate Sample Count and Water Quality Rating Data Sheet

Answer Key to Macroinvertebrate Identification and Water Quality Rating Practice Activity” (For the teacher)

Aquatic Organisms and Pollution Monitoring Quiz

Answer Key- Quiz

Aquatic Indicator Organisms PowerPoint Outline



Living Things
as Indicators of Water Quality



How can we use living things as indicators of water quality?

All organisms need certain conditions to survive and multiply. Since each aquatic organism has specific tolerances of chemical and physical conditions, the presence or absence of particular organisms can tell us a lot about the body of water we are studying. Compared to complex chemical analysis, using surveys of organisms to determine water quality can be done relatively simply and effectively.

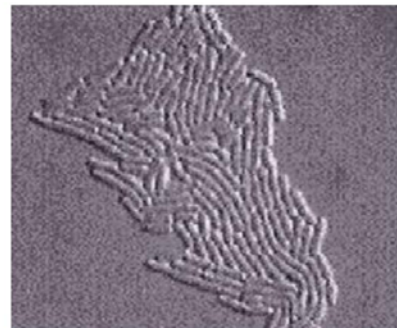
Indicators

A species which is normally present in an aquatic ecosystem under specific conditions is called an indicator organism.

Pathogens as water quality indicators

Bacteria are an example of a pollution indicator organism. Pathogens are of great importance in the study of water quality. Many diseases around the world are linked to the water as a carrier for bacteria, viruses or parasites. All water samples being inspected or tested for human consumption should be tested for coliform bacteria. An intestinal bacteria, *Esherichia coli* is often associated with fecal material.

Esherichia Coli (E. Coli)



<http://science.kennesaw.edu/~whomes/crtp/lat/crtp/lat01.htm>

E. Coli Colonies on Agar Plate



<http://www.bart.wisc.edu/Bart330/lecture01>

Fecal contamination in water

An agar plate inoculated with stream water that grows *E. coli* will be suspected of fecal contamination due to the presence of the bacteria.

Dissolved Oxygen, (DO) and Pollution

Pollution often affects the level of dissolved oxygen in the water. Certain organisms cannot live in areas of low DO, they serve as a biological index for monitoring the health and pollution levels of freshwater.

Dissolved Oxygen Testing



Collecting Aquatic Organisms



Finding out about water quality by collecting organisms

Scientists studying water quality have developed an index system for classifying streams by counting the number and categories of macroinvertebrates present in the stream community. If lots of organisms that are **intolerant** of low oxygen levels and pollution are found living in the stream, then the water quality is assumed to be good. If the only organisms found are those that tolerate low levels of dissolved oxygen, then the water can be considered poor quality and possibly polluted.

It is important to note however, that some aquatic communities are naturally low in oxygen or will go through low oxygen phases. For example, it would be unreasonable to expect a pond community to have the same habitat conditions as a fast flowing stream.

Ponds and other still waters absorb more of the sun's heat energy and retain it for longer periods of time, so they tend to be warmer than fast flowing streams. Because of this heat retention and lack of motion that would incorporate oxygen, ponds are usually much lower in dissolved oxygen than streams. This critical difference affects every aspect of the pond food web. Therefore, biological indexes designed for fast flowing streams cannot be used to accurately assess the water quality of ponds.

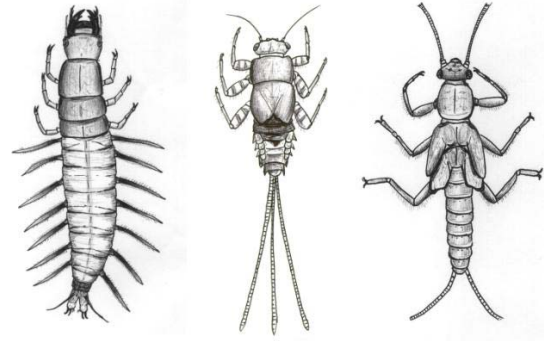
- Fast running streams with cold water - high dissolved oxygen levels.
- Still, shallow bodies of water - low dissolved oxygen levels.



Pollution- Intolerant Organisms

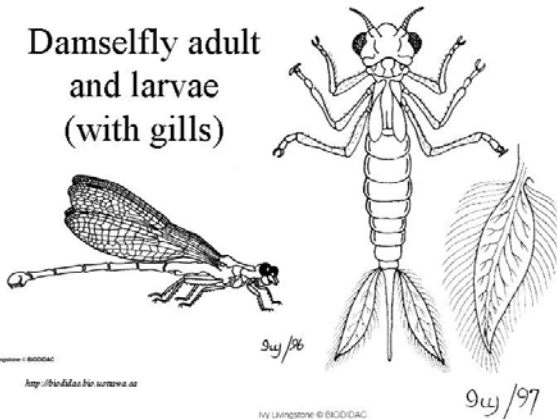
These organisms need high levels of DO and are sensitive to chemicals and fertilizers. The quality of water needed for these organisms is very high. Examples: Dobsonfly Larva, Stonefly Nymph and Water Pennies.

Larvae: Dobsonfly, Mayfly, Stonefly



Illustrations by Jamie Bugawter

Damselfly adult and larvae (with gills)



http://bioideas.bio.uconn.edu

9/4/96

ky.livingstone © BIODIDAC

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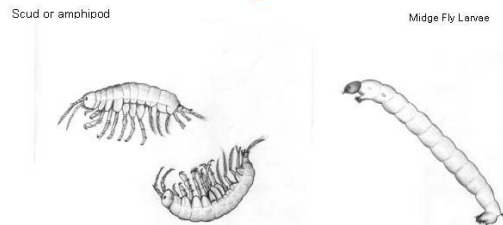
Moderately Intolerant Organisms

These organisms can survive in areas with low levels of nutrients from farm run-off, occasional sedimentation, medium to low levels of DO fluctuations in the water. Examples: Mayfly Nymph, Damselfly Nymph, Caddisfly Larva and Crayfish.

Fairly Tolerant Organisms

These organisms can survive low DO, and medium to high nutrient levels. Many of them are scavengers or bottom feeders. Examples: Midge Larva, Snail, Black Fly Larva, Scud

Examples of Fairly Tolerant Organisms

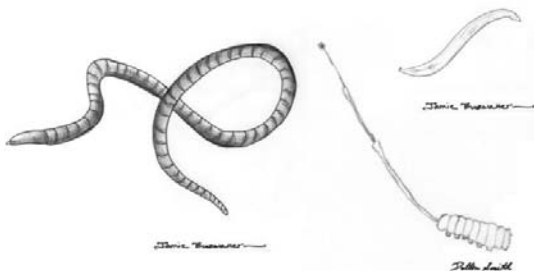


Scud or amphipod

Midge Fly Larvae

Illustrations by Jamie Bugawter

Aquatic Earthworm, Rat-tailed Maggot, Nematode



Pollution- Tolerant

Organisms can survive low DO, high nutrient levels, sewage and sedimentation. Most of these organisms are bottom feeders and actually eat the organic material that may be clogging the streams. Examples: Nematodes, Aquatic Earthworm and Rat-tailed Maggot.

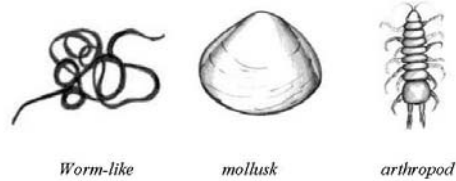
HOW TO IDENTIFY INDICATOR ORGANISMS

3 main types of macro-invertebrates

There are many types of organisms found in water. For our purposes, we will use 3 main classifications for macroinvertebrates, depending on their general shape and physical characteristics: worms, mollusks and arthropods.

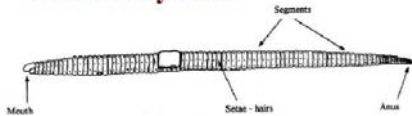
Following is a brief description of the 3 main classifications.

Main types of macroinvertebrates



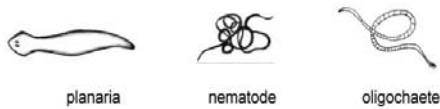
Pictures reprinted with permission from Leska-Fiore, King County Regional Water Quality, <http://www.seanet.com/~Leska>

Worm Body Plan



Pictures reprinted with permission from Kerrie Gato, <http://www.compostworms.com>

Some Examples of Different Types of Worm-like Organisms



Pictures reprinted with permission from Leska-Fiore, King County Regional Water Quality, <http://www.seanet.com/~leska>

Worms

These organisms usually have simple body outline and are found in almost any type of water--from low DO and high pollution to cool streams.

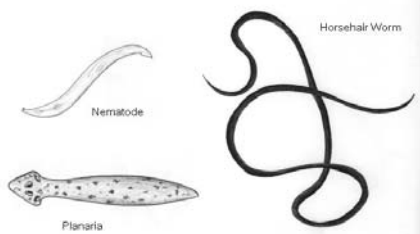
Worms and the food chain

Worms are usually decomposers and are at the bottom of the food chain. Worms often are found living in the mud or leaves on the bottoms of streams and ponds and help decompose the wastes found there.

Graver Pond with Leaves



Non Segmented Worm-like Organisms



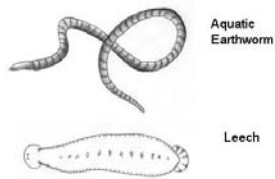
Illustrations by Jamie Buschaker

Non-segmented Worm-like Organisms

There are a variety of non-segmented worm types ranging from the flatworms (planaria) to horsehair worms and nematodes--many of which are parasitic.

Planaria live on the bottom of aquatic ecosystems, under rocks, and break down organic matter lodged there.

Segmented Worm-like Organisms



Illustrations by *Jamie Bugascher*

Segmented Worm-like Organisms

One of the most commonly found segmented worm-type organisms is the aquatic earthworm. They perform the same soil building functions in aquatic ecosystems as they do on land.

The leech, on the other hand can be found under rocks or attached to a victims skin, sucking blood.

Leeches

Leeches can be found on fish, turtles or other aquatic organisms.

Horsehair Worms

Horsehair worms spend their youth growing inside crickets and grasshoppers, only to emerge as adults when they have totally devoured the host insect! These worms look like long coiled hairs and are often found in stock tanks or in the shallows at the edge of lakes. No need to worry, they don't invade humans!

Leeches on Fish



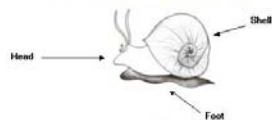
Horsehair Worm Inside a Grasshopper



Clam Anatomy



Snail Anatomy

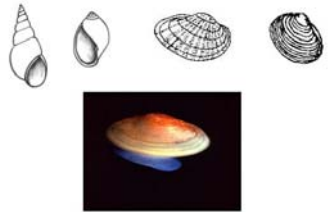


Illustrations by *Jamie Bugascher*

Mollusks

Mollusks also have a simple body plan. There are 3 main parts to a mollusk: head, shell, and foot.

Snails and Clams



Drawings reprinted with permission from Leika Fire, King County Regional Water Quality and The Soil & Water Conservation Society of Metro-Hallco, <http://lakesci.cheltona.org>
Photo reprinted with permission from Eric Lind, Audubon Society, <http://life.bio.sunysb.edu>

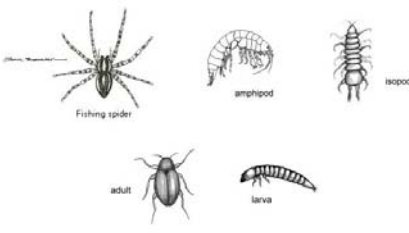
Snails
The mollusk most often found in freshwater is the snail. It is tolerant of pollution and can live in waters of varying quality. The snail is an herbivore and is commonly found under rocks or moving on the bottom eating algae or other aquatic plants

Clams
Also found on the bottom are the clams which are filter-feeder decomposers.

Arthropods
The arthropods come in many different types in a freshwater ecosystem.

Arthropod characteristics
Adult arthropods have segmented bodies and jointed appendages, which act like armor for protection, but severely limit movement. Many aquatic arthropods have gills that make them specially suited for life in the water.

**Arthropod Families-
Spiders, Crustaceans, Insects**



Pictures reprinted with permission from Leika Fire, King County Regional Water Quality, <http://www.seonet.com/~leika>

Fishing spider with bubble



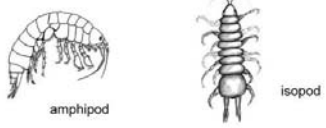

Photo reprinted with permission from David Cookman, Univ. of Nebraska Lincoln Dept. of Entomology, <http://entomology.unl.edu/magazine/ spiders/ spiders.html>

Fishing spiders
A relatively common aquatic arthropod is the fishing spider or water spider. They are interesting due to the bubbles of air they attach to their abdomens to catch fish or prey in the water. Spiders or arachnids have 8 legs and 2 body segments.

Crustacean characteristics
Tiny crustaceans such as isopods and amphipods act as decomposers on the bottom of streams and ponds.

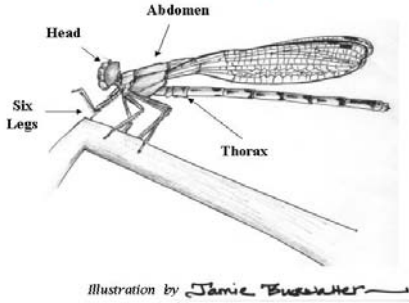
Crayfish are larger crustaceans and they eat a variety of foods, even each other!

Isopod & Amphipod



Picture reprinted with permission from Leika Fire, King County Regional Water Quality, <http://www.seonet.com/~leika>

Adult Damselfly Insect



Insect characteristics

Insects have 6 legs and 3 body segments in the adult form and are the most common arthropods in most freshwater ecosystems.

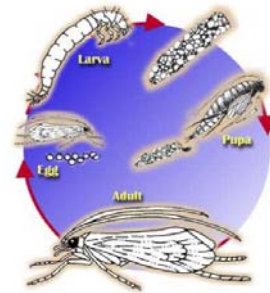
Life cycles

The water supports the young arthropods of certain species, allowing them to be wormlike in the larval stage- grubs.

From larvae to adult

Insects have many larval forms, which look totally different from the adults, thus consulting a field guide is essential.

Caddisfly life cycle



Aquatic predator eating prey



Picture reprinted with permission from Clarissa Quast, Natural Reserve System, University of California, <http://nrs.uccop.edu>

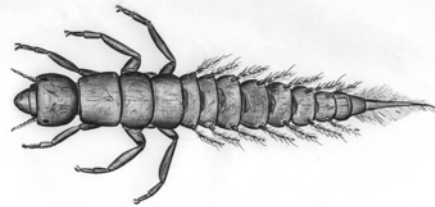
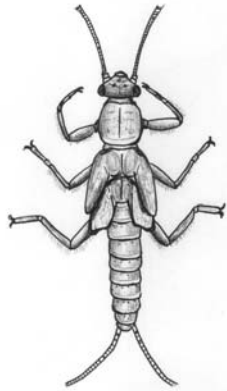
Some insects hunt the bottoms to find prey- other insects or even small fish and tadpoles.

Use a Field Guide!

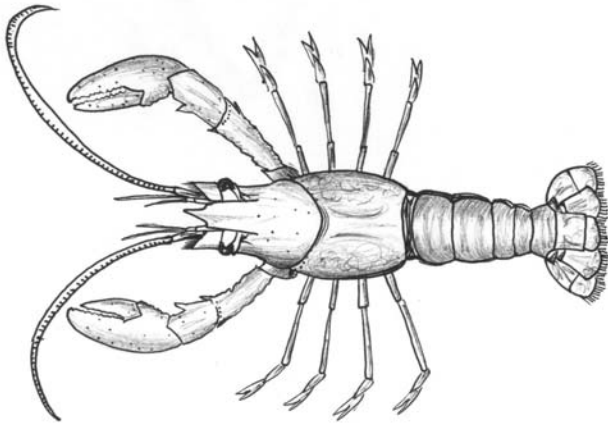
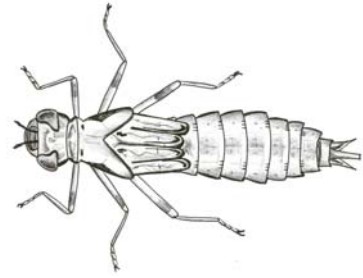
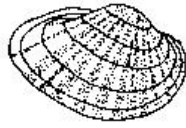
A field guide can help in a more in-depth study and proper identification of aquatic organisms



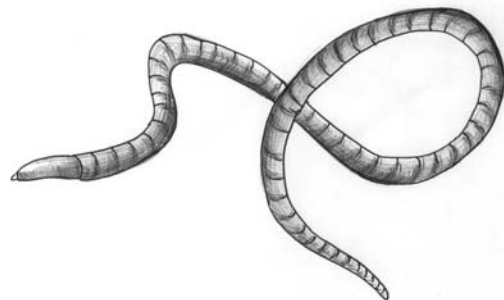
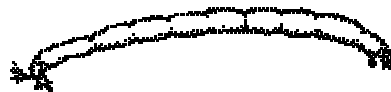
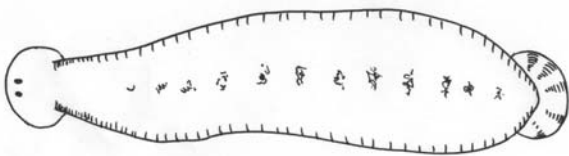
1. Bushkill Stream



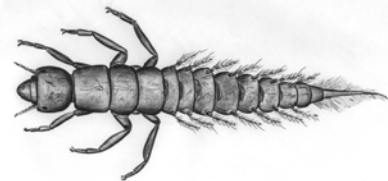
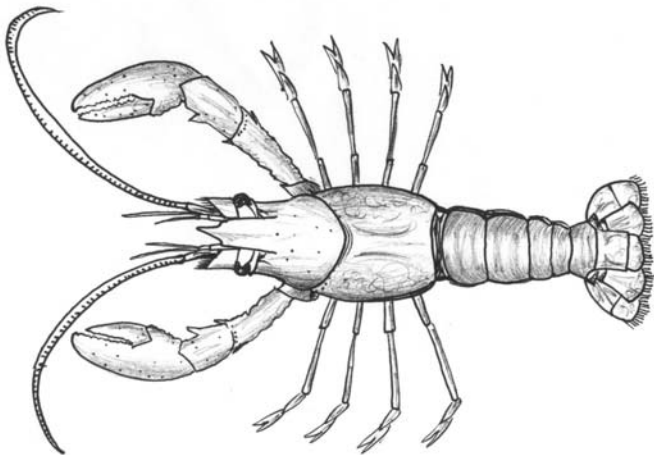
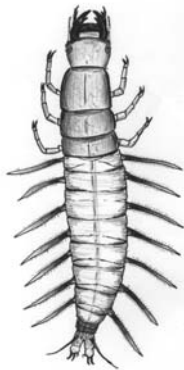
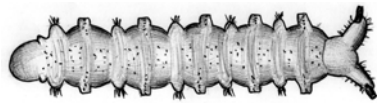
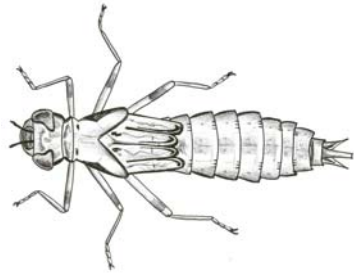
2. Jordan Creek



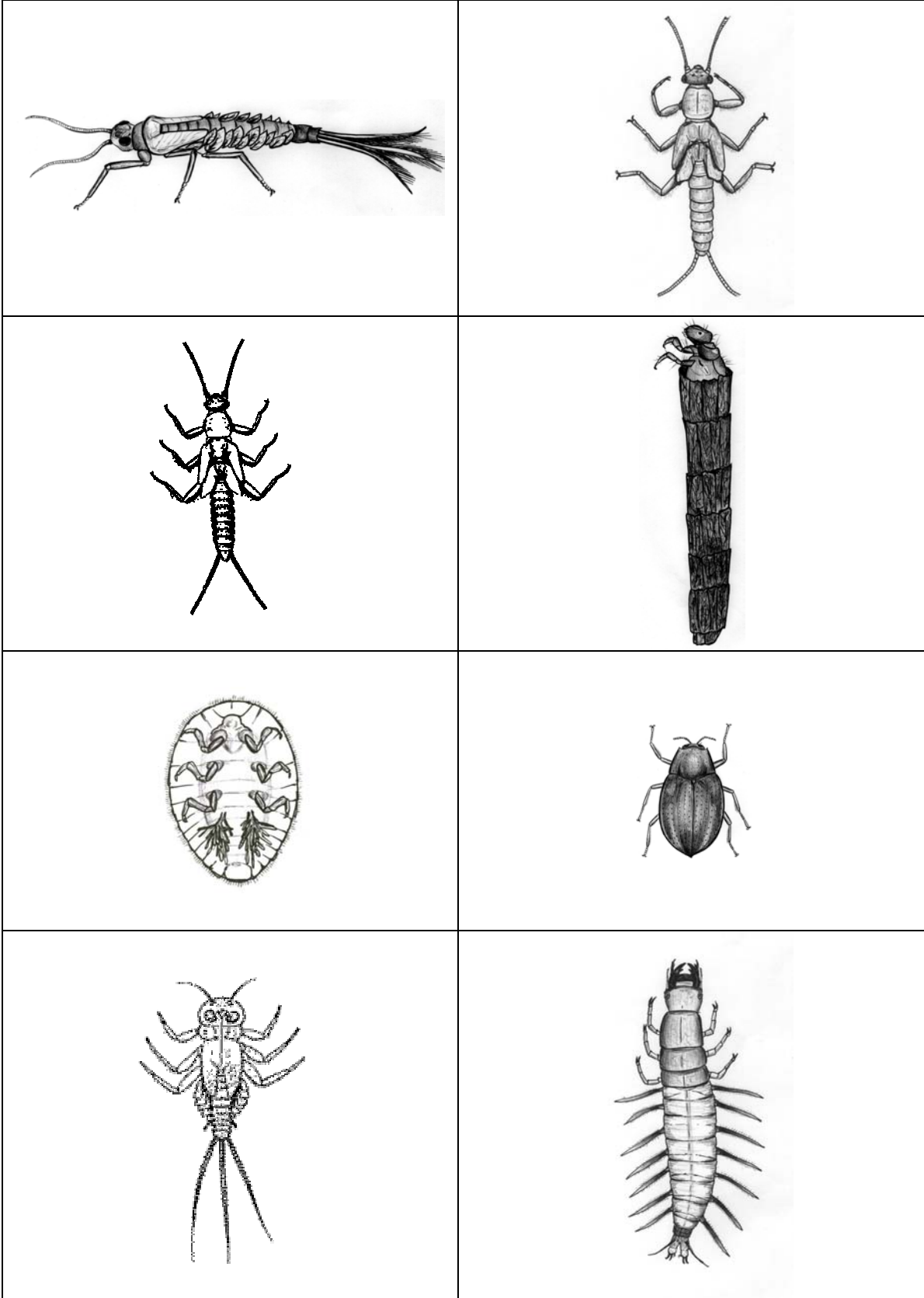
3. Cedar Creek



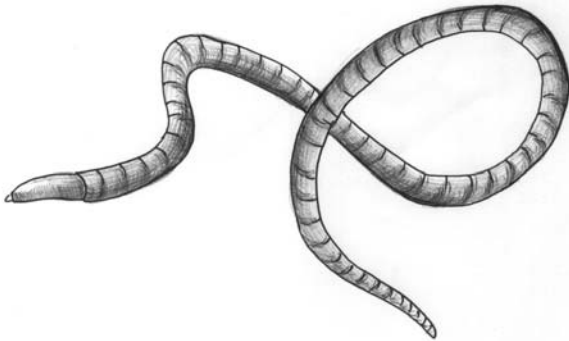
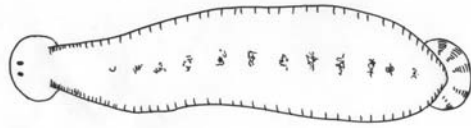
4. Little Lehigh Creek



5. Spruce Run





6. Pennypack Creek



Macro Invertebrate Study: Sample Record and Assessment

Collector's Names: _____

Date: _____ School: _____

<i>Intolerant of Low Oxygen Levels</i>	<i>Somewhat Sensitive to Low Oxygen Levels</i>	<i>Tolerant of Low Oxygen Levels</i>
<input type="checkbox"/> case-building caddisfly larvae <input type="checkbox"/> hellgramite <input type="checkbox"/> mayfly larvae <input type="checkbox"/> riffle beetle adult <input type="checkbox"/> stonefly nymph <input type="checkbox"/> water penny larvae <input type="checkbox"/> dobsonfly larvae	<input type="checkbox"/> blackfly larvae <input type="checkbox"/> riffle beetle larvae <input type="checkbox"/> clam <input type="checkbox"/> crane fly larvae <input type="checkbox"/> crayfish <input type="checkbox"/> damselfly nymph <input type="checkbox"/> dragonfly nymph <input type="checkbox"/> scud <input type="checkbox"/> aquatic sowbug <input type="checkbox"/> alderfly larvae <input type="checkbox"/> net-spinning caddisfly larvae <input type="checkbox"/> water snipe larvae	<input type="checkbox"/> segmented worm <input type="checkbox"/> leech <input type="checkbox"/> midge larvae <input type="checkbox"/> lunged/pouch snail <input type="checkbox"/> mosquito larvae <input type="checkbox"/> rat-tailed maggot <input type="checkbox"/> tubifex worm <input type="checkbox"/> planaria <input type="checkbox"/> horsehair worm <input type="checkbox"/> threadworm/nematode <input type="checkbox"/> pyralid/moth caterpillar
	<p><i>Pollution Sensitive Organisms For Ponds:</i></p> <input type="checkbox"/> water boatmen and giant water bug <input type="checkbox"/> diving beetle	
Boxes checked x 3 = _____ index value	Boxes checked x 2 = _____ index value	Boxes checked x 1 = _____ index value

Water Quality Rating (Streams only):

Total Index Value = _____
 Excellent (>22)
 Good (17-22)
 Fair (11-16)
 Poor (<11)

Total # of species _____

Total # of tolerant species _____

Total # of EPT species _____

EPT Count – Streams Only (Advanced)

Ephemeroptera species (Mayflies)

Plecoptera species (Stoneflies)

Trichoptera species (Caddisflies)

Answer Key to Macroinvertebrate Identification and Water Quality Rating

1. Bushkill Stream – Very sensitive to pollution
2. Jordan Creek – Moderate
3. Cedar Creek – Not Sensitive
4. Little Lehigh Creek – Moderate
5. Spruce Run – Very sensitive
6. Pennypack Creek – Not sensitive

Quiz

Aquatic Organisms and Pollution Monitoring

Questions for comprehension.

1. Why does water need to be tested for bacteria before drinking?

2. What is the greatest limiting factor in determining which organisms can live in the water?

3. What could be a source of nutrient pollution in streams and ponds?

Define the following terms:

Pollution Indicator Organism:

Pathogen:

DO:

Tolerant:


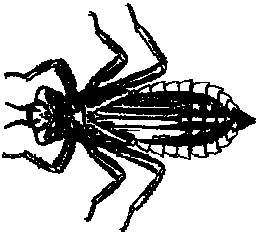
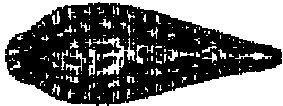
Application Questions.

1. How can a survey of the macroinvertebrates found living in a stream measure the water quality?

2. Your teacher tells you that a worm-like organism you found in a stream is an insect. How can this be, according to the definition of an insect?

3. During a study of a muddy stream, you find a clump of mud on your leg that turns out to be some kind of organism. What type is it and how can you know for sure?
4. If a stream is very polluted by sewage, what organisms do you think would live there? Why?
5. Where would you look to find worms in a stream?
6. What are the main characteristics of a mollusk?
7. What are two traits of an adult arthropod?

Identify the following organisms:

 <p>8. _____</p>	 <p>9. _____</p>	 <p>10. _____</p>
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Answer Key - Quiz

Aquatic Organisms and Pollution Monitoring

Questions for comprehension.

1. Water should be tested for bacteria before drinking because an intestinal bacteria, *Esherichia coli* is often associated with fecal material.
2. Oxygen is the greatest limiting factor in determining which organisms can live in the water.
3. Untreated sewage or animal waste, leaking septic tanks, or runoff from farms and suburban yards could all be sources of nutrient pollution in streams and ponds.

Term definitions:

Pollution Indicator Organism:

A species that is normally present in an aquatic ecosystem under specific conditions is an “indicator” of those conditions.

Pathogen:

A pathogen is a disease causing organism, often bacteria or virus.

DO:

The level of dissolved oxygen in the water.

Tolerant:

Organisms that can survive low DO, high nutrient levels, sewage and sedimentation.

Application Questions.

1. If many organisms that are *intolerant* of pollution are found living in the stream, then the water quality is assumed to be good. If the only organisms that can be found are those that tolerate low levels of dissolved oxygen, then the water can be considered poor quality and possibly polluted.
2. Insects have many larval forms, which look totally different from the adults.
3. It might be a leech or other type of flatworm, which can be confirmed by checking a field guide or identification key.
4. Rat-tailed maggot, nematodes, and aquatic earthworms might be found in polluted streams, because they are pollution tolerant bottom feeders thrive on the organic material that may be clogging the streams.
5. You would find worms on the bottom of the stream in the mud or decaying leaf litter.
6. Mollusks have 3 main body parts: a head, shell, and foot.
7. Adult arthropods have exoskeletons, segmented bodies and jointed appendages.

Identify the following organisms:

8. snail
9. dragonfly larvae
10. leech