Ecological Study of Stream Life
Purpose of Lab

- Learn about stream ecology and the benthic macroinvertebrates that live there
  - BENTHIC = bottom dwelling
  - MACRO = large enough to be seen without the aid of a microscope
  - INVERTEBRATE = without a backbone
- Do a comparative study of two streams
  - Kromme Kill, Menands, NY
  - Fox Creek, John Boyd Thacher State Park
- Types of benthic macroinvertebrates found in streams are good indicators of the water quality
Why Study Benthic Macroinvertebrates?

- Important part of the community found in and around streams.
- Bio-indicators of water quality.
  - have different tolerances to pollution
  - live in habitat continuously over an extended period of time
  - affected by sporadic changes (e.g., chemical leaks)
  - affected by seasonal variations of stream
- Easy to collect.
Food Chain along a Stream and River

- **SHREDDERS** feed on the bacteria, algae and smaller invertebrates
- **COLLECTORS** feed on bacteria and other fine particulate organic matter (FPOM) created by the shredders
- **SCRAPPERS** and **GRAZERS** obtain food by scraping algae and moss
- **PREDATORS** are invertebrates and fish that feed on the shredders, collectors and scrapers

**Figure 1:** Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980.
Kromme Kill Impacted Stream
Collection Site: Albany Rural Cemetery

At ARC, we collected from a 2\textsuperscript{nd} order stream.
Fox Creek, Thacher Park
Pristine Stream
Identification of Macroinvertebrates

- **Examine Physical Characteristics**
  - distinguishing features (distinct head, legs, wings...)
  - life cycle (larva, pupa, adult)

- **Classification of Organisms**
  - different levels of classification (taxa)
  - trend: general groupings to more specific
  - ID to Order level (possibly Family)

- **Biologists Use Scientific Names**
  - based on Latin/Greek language
  - binomial (two names)
  - scientific Name = *Genus species*
CLASSIFICATION
OF ORGANISMS

- different levels of classification (taxa)
- trend: from general to more specific
- ID to Order level (possibly Family)
Major Characteristics of Aquatic Larvae

- Head
- Thorax
- Abdomen
- Jointed legs
- 2 plates
- Gills
- Tails
- Abdominal gills (Netspinner)
- Prolegs with hooks
- Prolegs
Aquatic Insect Life Cycle Stages

Complete Metamorphosis

Trichoptera
Net-spinning Caddisflies

Eggs
(1 week; aquatic)

Larva
(5 larval instars inside sealed cocoon; aquatic)
(10 months)

Pupa
(2-3 weeks; aquatic)

Adult
(1 month; terrestrial)
(lays eggs in mass near shore)

Plecoptera - Stoneflies

Eggs
(3-4 weeks or diapause (dormant period) from 3 months to several years; aquatic)

Larva or Nymph
(molt 12-22 times; months to years; aquatic)

Adult
(few days to few weeks; female lays eggs near or in water; may drop them during flight)

Incomplete Metamorphosis
EPT - Pollution-Sensitive Species

- Ephemeroptera - mayflies
- Plecoptera - stoneflies
- Tricoptera - caddisflies
Order: Ephemeroptera - Mayflies

- Six legs attached to thorax
- Thorax does not appear divided
- Gills along the abdomen
- 3 tails (sometimes 2)
- 1 pair wing pads, if present
- Collector gatherers and shredders
- Pollution-sensitive (sometimes moderately tolerant)
Order: Plecoptera - Stoneflies

- Thorax in 3 segments
  - Pair of legs on each
  - 2 claws at end of each leg
- 2 pair wing pads (if present)
- 2 tails
- Gills may be visible on thorax (“hairy armpits”) or under neck
- Shredders and predators
- Pollution-sensitive
Order: Tricoptera - Caddisflies

- 3 pairs of legs attached to thorax
- Fleshy abdomen; some with hair-like gills
- Prolegs
  - hooks at end of abdomen
  - some have tufts of hair
- **Net-spinners:**
  - spin nets as a retreat and to collect detritus
  - Moderately pollution-tolerant
- **Case-builders:**
  - build cases from rocks and/or plant material
  - Pollution-sensitive
- **Free-living** - crawl around in search of prey
Order: Tricoptera - Caddisflies

Common Families:
- Case-builders
- Net-spinners
- Free-living
Other Common Taxa

- **Insects:** true bugs, beetles, dragonflies & damselflies, dobsonflies & alderflies, midges, black flies, & crane flies
- **Arachnids:** water spiders and water mites
- **Mollusks:** snails, mussels, & clams
- **Crustaceans:** aquatic sowbugs, scuds, & crayfish
- **Worms:** flatworms, earthworms, & leeches
Pollution-sensitive - require ample oxygen and fast water flow
Order: Megaloptera
Dobsonflies and Alderflies

- Alderflies
  - Large gill filaments along abdomen; pointed tail filament
  - More pollution-tolerant than dobsonflies

- Dobsonflies
  - Flexible filament along abdomen
  - Long, somewhat flattened body
  - 2 prolegs at the end, with two claws on each proleg
  - Pollution-sensitive
**Order: Odonata**

**Dragonflies and Damselflies**

- **Predators**
- **Jaws for capturing prey**
- **Somewhat tolerant**

- **Dragonflies**
  - Large abdomen tapers to point; no tail
  - Internal gills are not visible

- **Damselflies**
  - Narrow abdomen ends with 3 paddle-like gills (“tails”)
Order: Diptera
Midges and Blackflies

Midges
- Worm-like, definite head and prolegs
- “Twitchy” swimmers
- Pollution tolerant

Blackflies
- Bowling pin shape
- Two fans on head for filtering
- Use hooks to attach to substrate
- Single proleg beneath head
- Pollution tolerant
Order: Diptera - Craneflies

- Long, fleshy abdomen
- Head often withdrawn & concealed by thorax
- Some have pairs of prolegs beneath abdomen
- Pollution-tolerant (other Diptera are more tolerant)
- Some are shedders, other predators
Order: Arachnida
Spiders and Water mites

Water mites
- Look like fat little spiders
- 4 pairs of legs
- 1-5mm length
- Sensitive to moderately pollution-tolerant

Water spiders
- 4 pairs of legs
- Longer legs than water mites
- Walk on water or swim
- Sensitive to moderately pollution-tolerant
**Crustacea**

Amphipoda - scuds
- Look like shrimp
- Flattened laterally
- 7 pairs segmented legs
- Swim on side

Isopoda - sow bugs or woodlice
- Flattened dorso-ventrally
- 7 pairs segmented legs
- Tan, brown or gray

Decapoda - crayfish

Maxillopoda - copepod
Mollusca

Snails (Class: Gastropoda)

- **Gilled snails**
  - (right-side opening with narrow end up)
  - pollution-sensitive
- **Pouch snails**
  - (left-side opening)
  - Pollution-tolerant
**Annelida**

**Earthworms and Leeches**

Round, segmented body

- **Earthworms** (Class: Oligochaeta)
  - Reduced head-size
  - Small hair-like bristles along body
  - Pollution-tolerant

- **Leeches** (Class: Hirudinea)
  - Flattened body
  - Suckers at anterior and posterior ends
  - Pollution-tolerant
Flatworms

- Flattened body; not segmented
- Eyespots (usually visible)
- “Glides” over surfaces
- Somewhat tolerant
- Find attached to rocks
- Moderately pollution-tolerant
Comparing Two Streams

1. Work with water from one stream at a time. Finish identifying all organisms from this stream before moving on to the other stream. This means examining several beakers of water from each stream.
2. Stir up sediment. Fill plastic beakers with stream water; examine vegetation, too, as organisms hide in it.
3. Pour some of the stream water from beaker into trays.
4. Transfer things you find to Petri dish using spoons or transfer pipettes and examine with dissecting microscope. Use only small drops of water to restrict organisms.
5. Use keys to identify organisms. Record on data sheet and white board.
6. Return water to “Waste Water” bucket. It will be returned to stream.
7. Once all the water from one stream has been examined, repeat steps 1-6 with water from other stream.
8. Record pooled data for your lab. You will be given the data for all of the labs meeting this week.
Data Collection Sheet

Put both names on this sheet

Your data

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Your Group</th>
<th>Entire Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odonata - dragonflies, damselflies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ephemeroptera - mayflies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plecoptera - stoneflies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichoptera - caddisflies (case-building)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trichoptera - caddisflies (not spinning &amp; free-travel)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemiptera - bugs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diptera - fly larvae, flies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diptera, Chromatomyiina - midges</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coleoptera - beetles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heteroptera - dobsonflies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyclorrhapha - mayflies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amphipoda - amphipods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daphnia - sowbugs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastropoda - snails</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nematoda - round worms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annelida - segmented worms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annelida - Spirochaetes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coleoptera - Springtails</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxillopoda - Coproel crustaceans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phylumplanaria - planaria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amphibians (salamanders)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Characteristics of good ecological community

• Species diversity (richness)
• Species evenness
Quantifying Diversity

Species richness and evenness
Analyzing The Data

Assess stream quality three ways:

1. Shannon Diversity Index (H)
   looks at species richness

2. Evenness Index (J)
   looks at species evenness

3. EPT Index
   looks at the abundance of organisms from these three orders
**Shannon Diversity Index**

\[ H = -\sum p_i \ln p_i \]

- **H** = Diversity Index
- **p_i** = proportion of individuals in total sample belonging to the “i\(^{th}\)” species
- **ln** = natural log
An example of two streams:

- Both have same total number of organisms - 100
- Both have 5 species - same diversity (richness)
- However, Stream A has almost all organisms belonging to Species 5 (96/100)

<table>
<thead>
<tr>
<th>Stream</th>
<th>Sp1</th>
<th>Sp2</th>
<th>Sp3</th>
<th>Sp4</th>
<th>Sp5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>96</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

Which one is of better quality - stream A or B?
**Shannon Diversity Index**

**Stream A**

<table>
<thead>
<tr>
<th>Taxa</th>
<th>$P_i = n_i/N$</th>
<th>$\ln p_i$</th>
<th>$P_i \ln p_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1/100$</td>
<td>$\ln(1/100)$</td>
<td>$1/100 \ln(1/100)$</td>
</tr>
<tr>
<td>2</td>
<td>$1/100$</td>
<td>$\ln(1/100)$</td>
<td>$1/100 \ln(1/100)$</td>
</tr>
<tr>
<td>3</td>
<td>$1/100$</td>
<td>$\ln(1/100)$</td>
<td>$1/100 \ln(1/100)$</td>
</tr>
<tr>
<td>4</td>
<td>$1/100$</td>
<td>$\ln(1/100)$</td>
<td>$1/100 \ln(1/100)$</td>
</tr>
<tr>
<td>5</td>
<td>$96/100$</td>
<td>$\ln(96/100)$</td>
<td>$96/100 \ln(96/100)$</td>
</tr>
</tbody>
</table>

Sum the last column

$H = 0.2161$

**Stream B**

<table>
<thead>
<tr>
<th>Taxa</th>
<th>$P_i = n_i/N$</th>
<th>$\ln p_i$</th>
<th>$P_i \ln p_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$20/100$</td>
<td>$\ln(20/100)$</td>
<td>$20/100 \ln(20/100)$</td>
</tr>
<tr>
<td>2</td>
<td>$20/100$</td>
<td>$\ln(20/100)$</td>
<td>$20/100 \ln(20/100)$</td>
</tr>
<tr>
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<td>$20/100$</td>
<td>$\ln(20/100)$</td>
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<tr>
<td>5</td>
<td>$20/100$</td>
<td>$\ln(20/100)$</td>
<td>$20/100 \ln(20/100)$</td>
</tr>
</tbody>
</table>

Sum the last column

$H = 1.6094$

$H$ increases with additional taxa (diversity) or with greater species evenness.
**Evenness (J) Index**

\[ J = \frac{H}{H_{\text{MAX}}} = \frac{H}{\ln S} \]

*S = number of species (taxa)*

**Stream A:**
- \( J = \frac{0.2161}{\ln 5} = \frac{0.2161}{1.609} = 0.1343 \)
- Species are only about 13% as evenly distributed as they could be.

**Stream B:**
- \( J = \frac{1.6094}{\ln 5} = \frac{1.6094}{0.475861} = 1.00 \)
- Species are as evenly distributed as they could possibly be - 100%.
EPT Index

EPT INDEX = $\sum EPT/total\ number\ organisms$

- **EPT** = acronym for Ephemeroptera, Plecoptera, and Trichoptera
- These taxa contain most pollution-sensitive species
- Sometimes no significant differences are found in the H and J values for two streams. This does not necessarily mean that one has better water quality than the other.
- Thus, we use EPT Index as another way of assessing stream quality
Lab Report

- Calculate H, J values, and EPT for the two streams
  - Use the data from your own lab
  - Repeat the calculations with the data from all BIOL-1010 lab sections
- Determine if there is significant differences between mean H and J values and EPT indexes using T-tests
- Research one organism from each stream that interests you

**Due Dates:**
- Sections 06-07, 03, 04 & 01: next lab
- Sections 05 & 02: Friday, November 19th
Due in two weeks: Lab notebooks
Lab Exam

Tuesday, November 30th at 9AM
Caddisfly Egg Masses
Thacher Park

a) Egg masses on rock
b) Enlarged view of masses
c) Caddisfly larvae and eggs
Using a Dichotomous Key

Does the invertebrate have legs?

Identification Guide to Freshwater Macroinvertebrates

Jointed legs

- 10 legs or more
  - amphipod - scud
- 8 legs
  - mite
- 6 jointed legs
  - *Go to Page 3*

No jointed legs

- Worm-like (no shell)
  - *Mollusks* - small clam
- Body enclosed in hard shell
- Head and/or fleshy protrusions
  - *Go to Page 2*
- Non-segmented flat-worm
- Segmented worms

CRUSTACEANS

- crayfish
Using a Dichotomous Key

Does the invertebrate have legs? No . . .

- Head small, often hidden from view
  - Fleshy protrusions at posterior end
    - Tipulidae (crane flies)
  - Distinct head
    - 8 pairs of prolegs; posterior with 2 pointed protrusions longer than prolegs
      - Athericidae (water snake flies)
- Approximate size range:
  - Minimum maximum
  - Simuliidae (black flies)
  - Chronomidae (midges)
Using a Dichotomous Key
Does the invertebrate have legs? Yes . . .
Caddisfly Art

http://www.youtube.com/watch?v=NLGGar0u2em
References and Credits

Websites:

- NW Nature Net: www.nwnature.net
- Aquatic Macroinvertebrate Identification Key: http://people.virginia.edu/~sos-iwla/Stream-Study/Key/MacroKeyIntro.HTML
- EPA Biological Indicators of Watershed Health: http://www.epa.gov/bioindicators/index.html
- Project Watershed - Taxonomic Key http://watershed.syr.edu/taxkey/
- Water-Kentucky: http://www.water.ky.gov/NR/rdonlyres/A0DC8D47-AEF9-45CB-8346-4BBF37BE2495/0/Appendix_KPart_2.pdf

Video: Far Mill River Macroinvertebrate Sampling
http://video.google.com/videoplay?docid=1004462448368375407&q=stream +sampling +macroinvertebrates&total=1&start=0&num=10&so=0&type=search&plindex=0