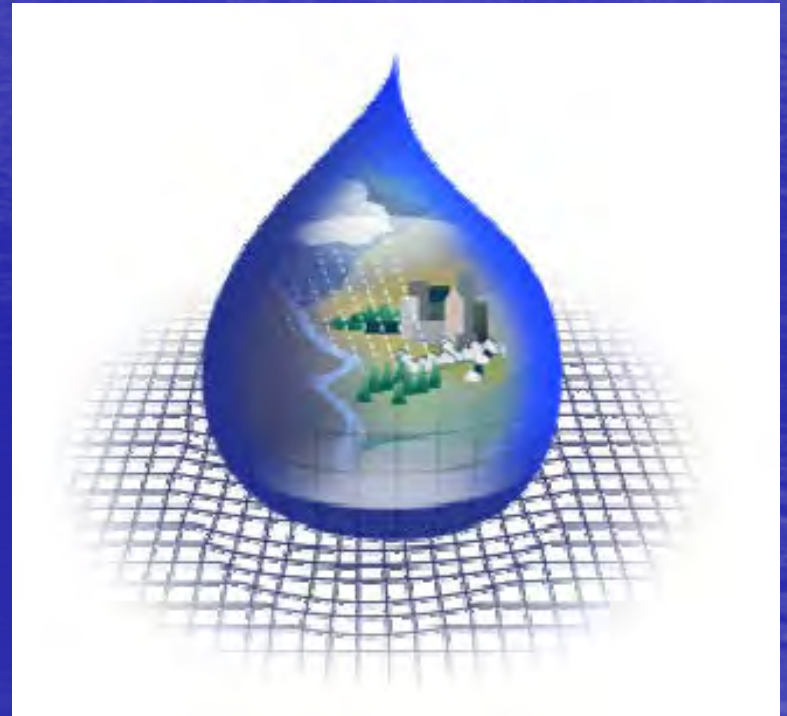
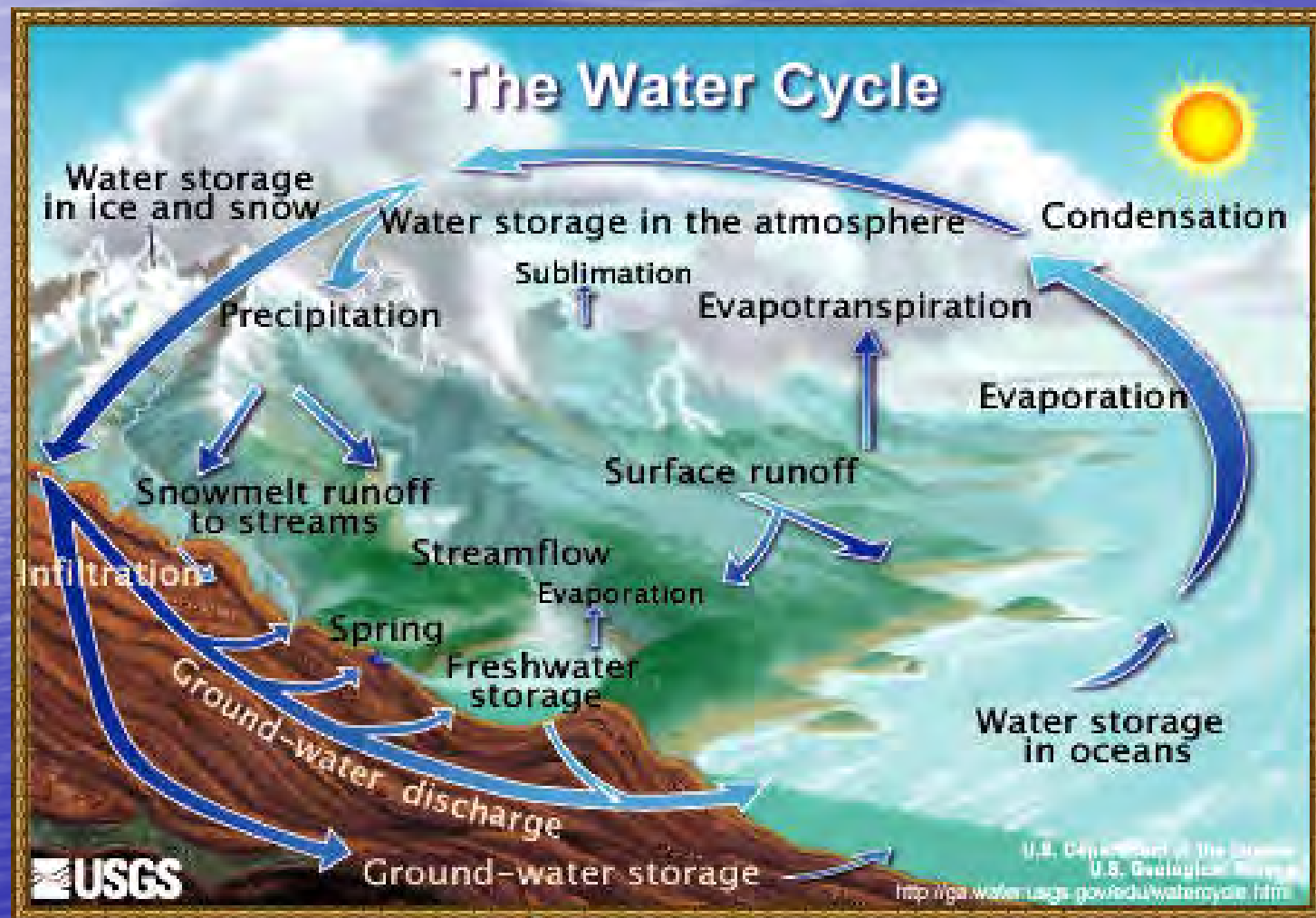


# Aquatic Ecology

- Water Cycle
- Watershed Ecology
- Water Pollution
- Water Quality



# Water Cycle



# Watersheds



- Watershed ecology



# Polluted Streams



## Point Source Pollution

Industrial wastes empty directly into a stream



## Non-point Source Pollution

Garbage in streams can create poor water quality conditions from leachates



# Pollution Sources

## Point-Sources

(permit regulated)

- factories
- food processors
- confined animal feeding operations
- sewage treatment

## Non-Point Sources

(stormwater runoff)

- parking lots (oil, gas, antifreeze)
- household detergents (N / P)
- household chemicals
- excess fertilizers (N / heavy metals)
- Ag and urban pesticides
- Sediment (erosion)
- illegal dumping / litter leachates
- pet waste / waterfowl (N / P, bacteria)

# Why Monitor ?

- Baseline data collection
- Analyze data for trends and Identify potential problems
- Determine further testing needs OR  
Take Action to correct problems
- Address concerns on a local level where agencies may not have data



# Water Testing Resources

- Oregon's DEQ offers Water Quality training to volunteer groups
- Marion SWCD/ some Watershed Councils
- OSU Extension
- Adopt-A-Stream at local High Schools

# Water Quality Testing



Gather data for presentations, project monitoring, local stream studies

Collecting Field Samples





# Water Tests

## Basic -Physical Chemistry:

- pH
- Temperature
- Dissolved oxygen
- Electrical conductivity (hardness)
- Turbidity
- Nutrients (nitrates/phosphates)
- Bacteria (E. coli or fecal coliform tests)

## More advanced tests:

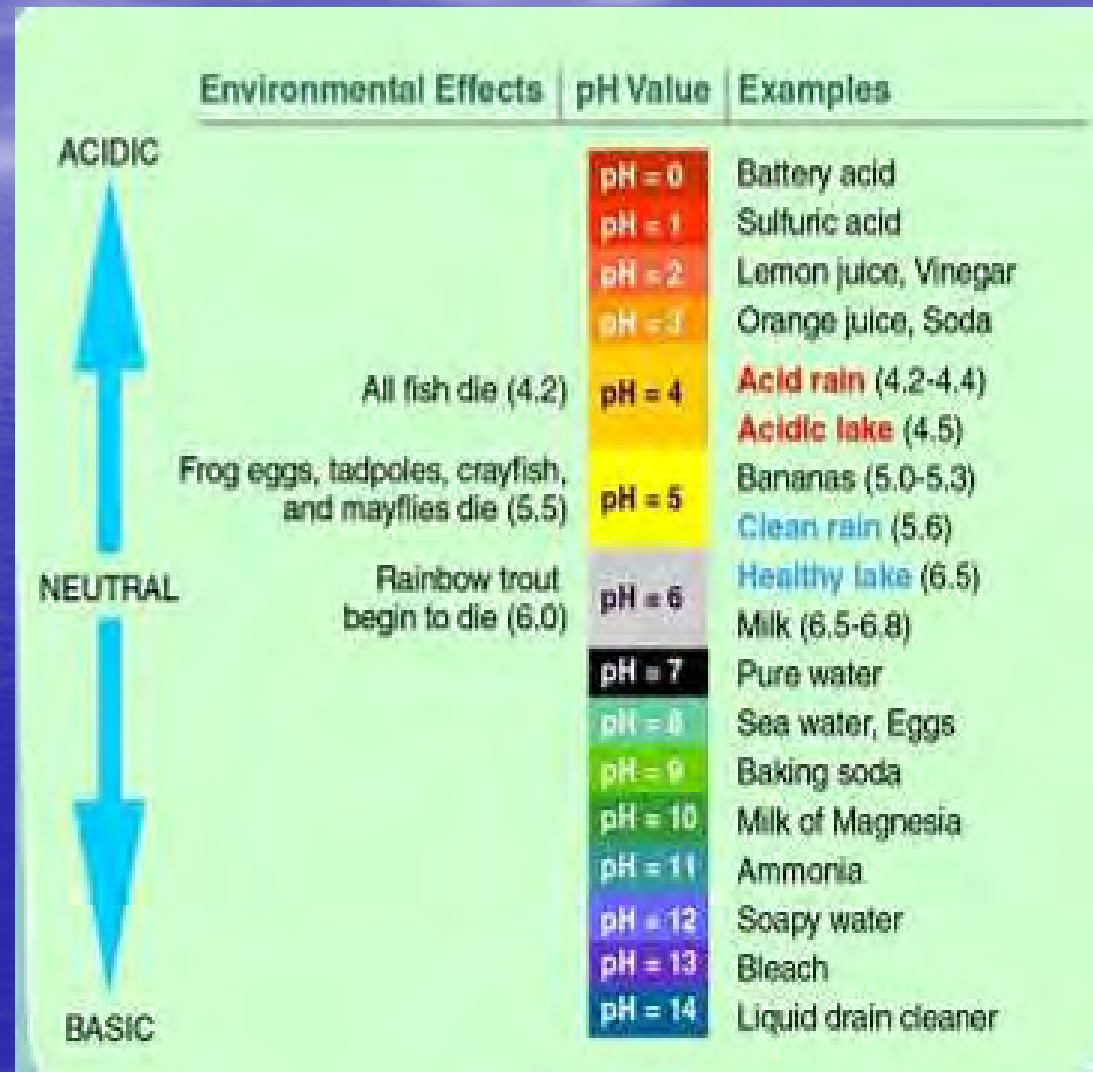
- Toxins/Pesticides
- Heavy metals

## Biological testing:

- Macroinvertebrate sampling

# pH

- alkalinity and acidity ( $H_2O$  also has free  $H^+$  and  $OH^-$  ions that determine pH)
- Natural soil characteristics - charged particles like  $Mg^{++}$ ,  $Ca^{++}$ ,  $Na^+$  can alter pH
- Rainwater is acidic at 5.6
- Fertilizers, plant decomposition (tannic acid) lowers pH
- Most fish and aquatic life survives in 5-9 pH range





# Temperature

- Many Oregon streams exceed state standards
- Salmon & trout prefer clear cool streams, begin to die at **70 ° F**
- Most aquatic life is cold-blooded and adapted to conditions **41 & 77 ° F**

## **Factors that influence stream temperature:**

**Shade:** Streamside vegetation keeps streams cooler longer (especially small streams)

**Turbidity:** excess causes increased temperature by suspended particles absorbing more solar radiation

**Flow:** slow-moving water heats up more quickly

**Volume:** Shallow streams heat up more quickly

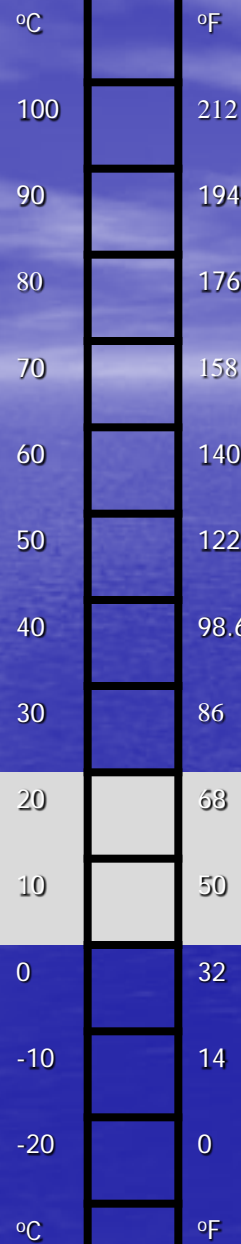
**Snow Pack:** melting ice / snow in headwaters keeps streams colder.

**Air Temp:** surrounding air temperatures influence stream temperatures.

20-25 C / 68-77° F  
(warm water fish)  
bass, bluegill, bullheads,  
carp, crappie,  
pikeminnow, suckers  
dragonflies, some  
caddisflies, true flies

13-20 C / 55-68° F  
Some salmon/trout,  
lamprey, sturgeon,  
shad, dace,  
stickleback, walleye,  
Sculpins, mayflies,  
caddisflies

5-13 C / 41-55 ° F  
(cold water fish)  
Salmon, trout, sculpins,  
mayflies, caddisflies,  
stoneflies



**water boils**



**human body**

**lethal for salmon**

**water freezes**



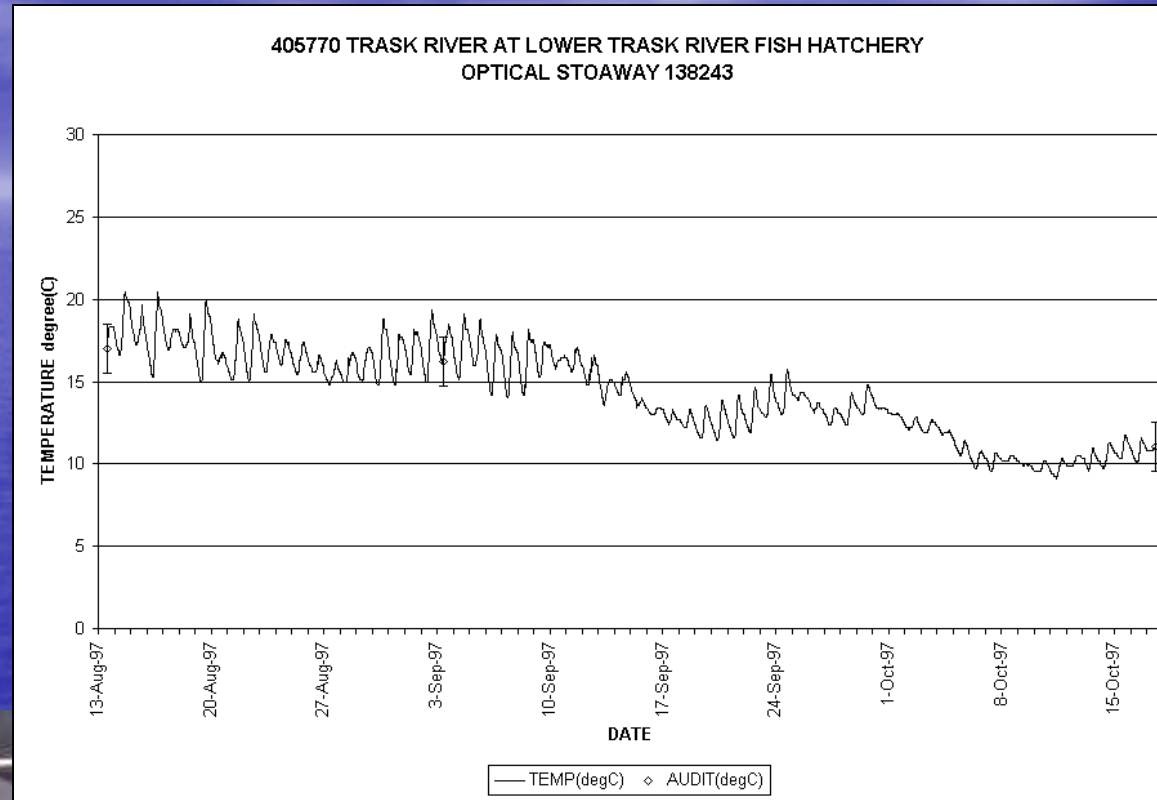


# Collecting Continuous Temperature data

Summer deployment  
of units in streams

collect continuous  
summer temperature  
data

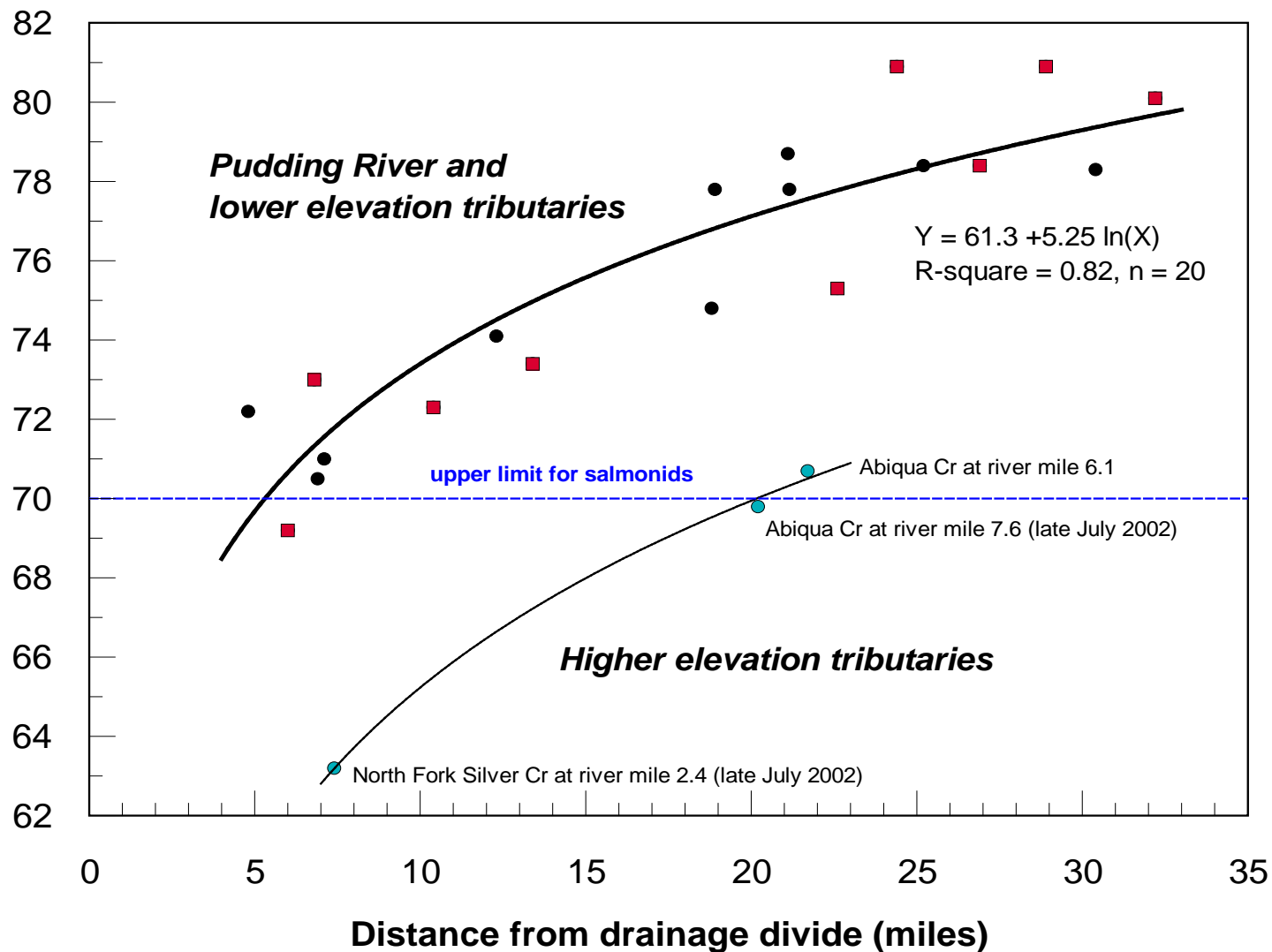
download and create  
graphs of Maximum  
Temps



# Maximum 7-day water temperature

Late July 2004 hot spell, except as noted

Water Temperature (deg F)



Circles are Pudding Watershed Council data.

Squares are Department of Environmental Quality data.



# Dissolved Oxygen

- Warmer water holds less DO
- Algae give off oxygen when they respire during the day and use up oxygen when they decompose
- Biological Oxygen Demand or BOD: total O<sub>2</sub> use by plants & animals
- DO concentrations often lowest late at night
- Salmon and trout need levels above 4 mg/L, prefer to spawn in areas above 8 mg/L

# Nutrients (nitrates/phosphates)

- Water needs plant nutrients in small quantities
- Too much can cause unstable “blooms” of algae that, when decomposing, consume all the available dissolved oxygen

**Sources:** artificial fertilizers, decomposing plant material, open manure piles, detergents, wildlife and pet waste



## Oregon Water Quality Standards and Classification for Salmon and Steelhead

Parameter	Class AA	Class A	Class B
<b>Temperature °Celsius</b>	< 12° Celsius	< 18° Celsius	< 21° Celsius
<b>pH</b>	pH shall not fall outside 7.0 to 8.0	pH shall not fall outside 6.5 to 8.5	pH shall not fall outside 6.5 to 8.5
<b>Dissolved Oxygen</b>	> 11.0 mg/l	> 8.0 mg/l	> 6.5 mg/l
<b>Nitrates</b>	< 0.1 mg/l	< 0.5 mg/l	< 1.0 mg/l
<b>Phosphates</b>	< 0.1 mg/l	< 0.4 mg/l	< 1.0 mg/l

# Turbidity

- Suspended particles in water column
- Instrument measures amount of light that can pass through the water column in NTUs Nephelometric Turbidity Units
- **Suspended sediment** often carries soil-attached pesticides, fertilizers or other polluted runoff
- Sediment buries aquatic eggs, suffocates gills, warms water
- Accelerated erosion costs money in loss of topsoil, highways and sometimes homes, resulting in dredging costs and lifespan of dams
- 5 NTU's drinking water limit, 25 NTU's fish begin to be impaired, 100-1000 NTU's often the level found during floods or when accelerated erosion is occurring, such as on disturbed, unprotected soil.



# Erosion



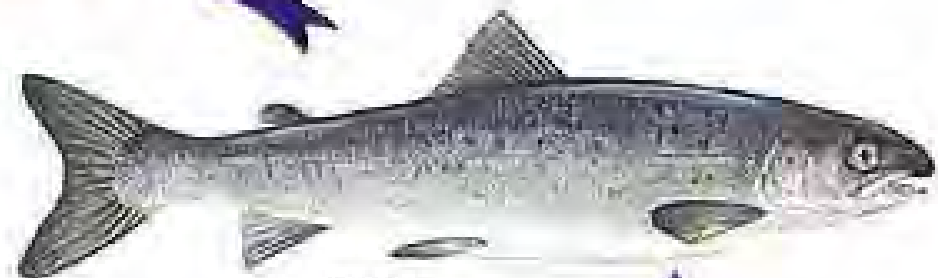
**Erosion causes  
sedimentation  
and turbidity**

# Wild Atlantic salmon *a wondrous life cycle*



© Atlantic Salmon Federation  
All Rights reserved

Adult



Smolt



Parr



Fry



Alevin

Spawning in a Redd



Eggs



Eyed eggs

Visit [www.asf.ca](http://www.asf.ca)  
to learn more

**Atlantic Salmon Federation**

P.O. Box 5200, St. Andrews, NB E5B 1S8

P.O. Box 807, Calais, ME 04619-0807

(506) 529-4581

[www.asf.ca](http://www.asf.ca)



# Bacteria (E. coli or fecal coliform)

- Indicator of human or animal waste
- Increases in E. coli also increase the chances for associated pathogenic bacteria which cause disease

**Rural Sources:** failing septic systems, wildlife, runoff from cattle or horses near streams, runoff from confined animal feed lots (horse, pig, dairy, etc)

**Urban Sources:** Pet waste, sewage overflows



# Flow Testing



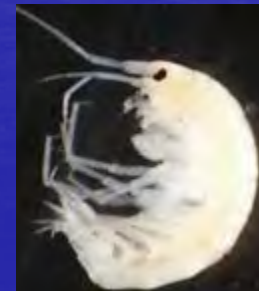
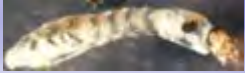
- Quantify seasonal flow in Cubic Feet / second (CFS) by taking incremental flow measurements across the stream channel
- A quick method to find a rough discharge in CFS is to record the feet/second a floating object travels and multiply by the stream cross sectional area.
- Stream gage stations allow us to quantify water volume moving through the site all through the year



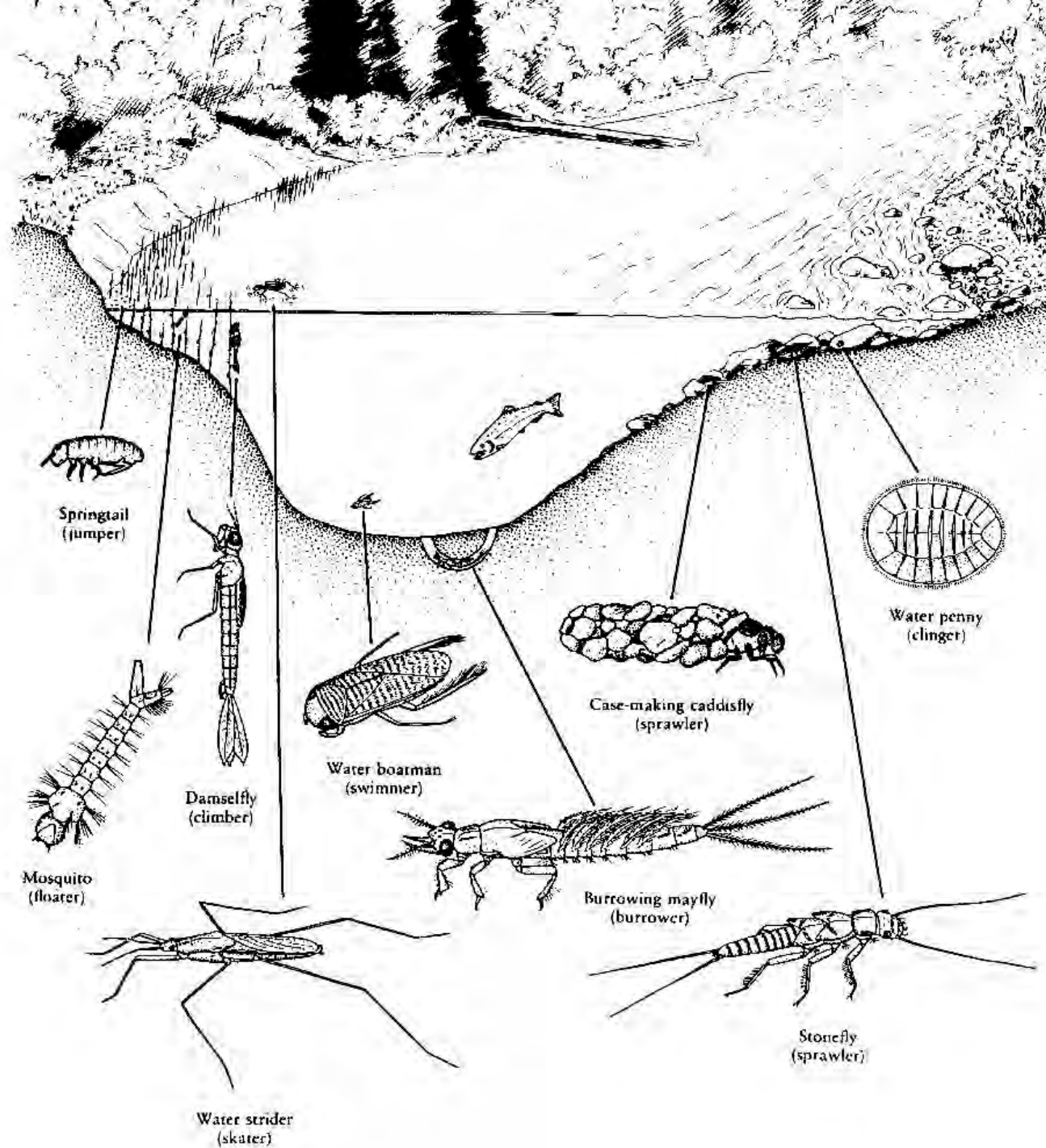


# Aquatic Bugs or Macroinvertebrates

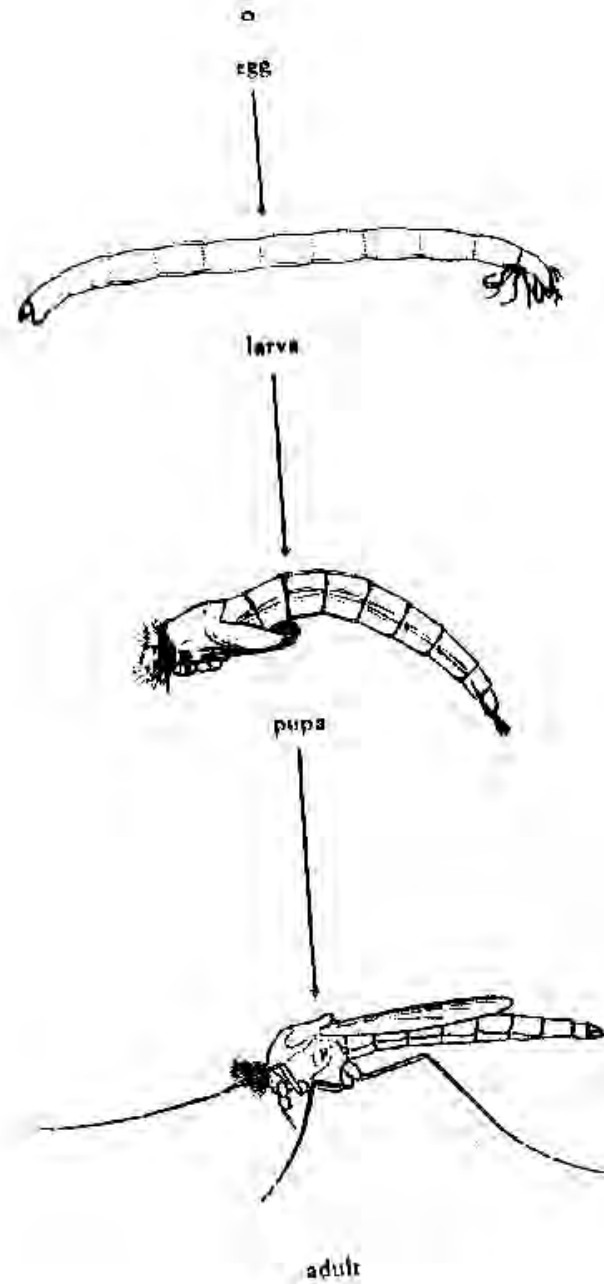
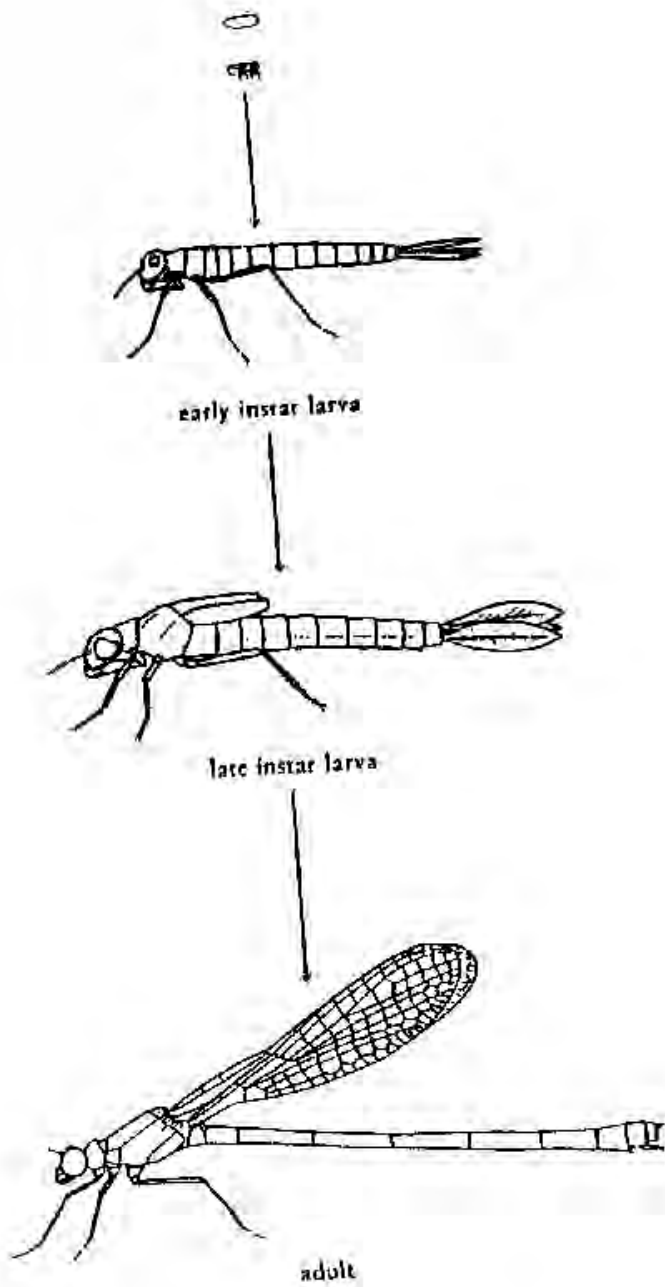
“Macro” is relative











# Macroinvertebrate Adaptations to Life Underwater

What does it take to survive under flowing water?

# List of possible items that represent characteristics

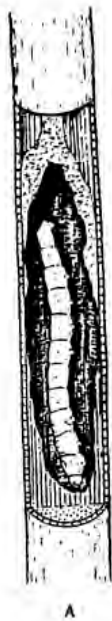
- breathing siphon - snorkel
- natural camouflage - camouflage clothing
- hard exoskeleton - bicycle helmet
- chemical defense - insect repellent canister (preferably empty or safely non-functional) or perfume or cologne for younger kids
- claws -
- suction cups -
- air bubble - bubble wrap
- gills -
- anchor silk -
- great eyesight - magnifying glass or binoculars
- strong swimmers - swimming fins
- strong jaws -
- piercing mouthparts - Dracula teeth
- antennae -
- filter-feeding - yard rake



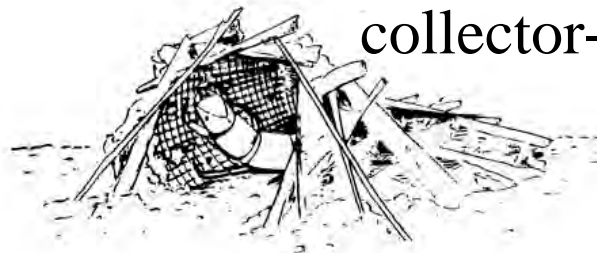


Eating

Finding and Gathering Food

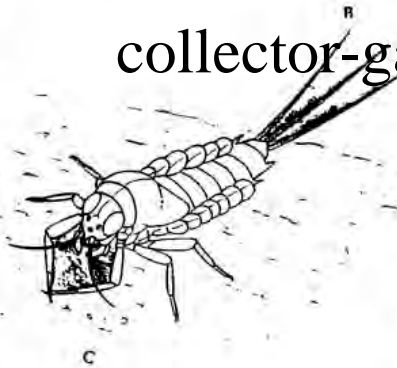


A



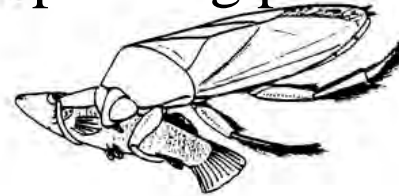
collector-filterer

collector-gatherer



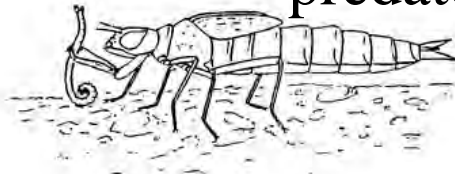
C

piercing predator



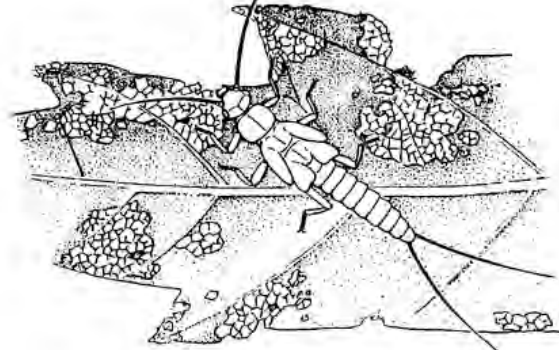
A

predator



D

shredder



B

grazer (scraper)





# Filter feeder



Black fly larva

# Excellent Eyesight





# Antennae



# Scud (Sideswimmer)

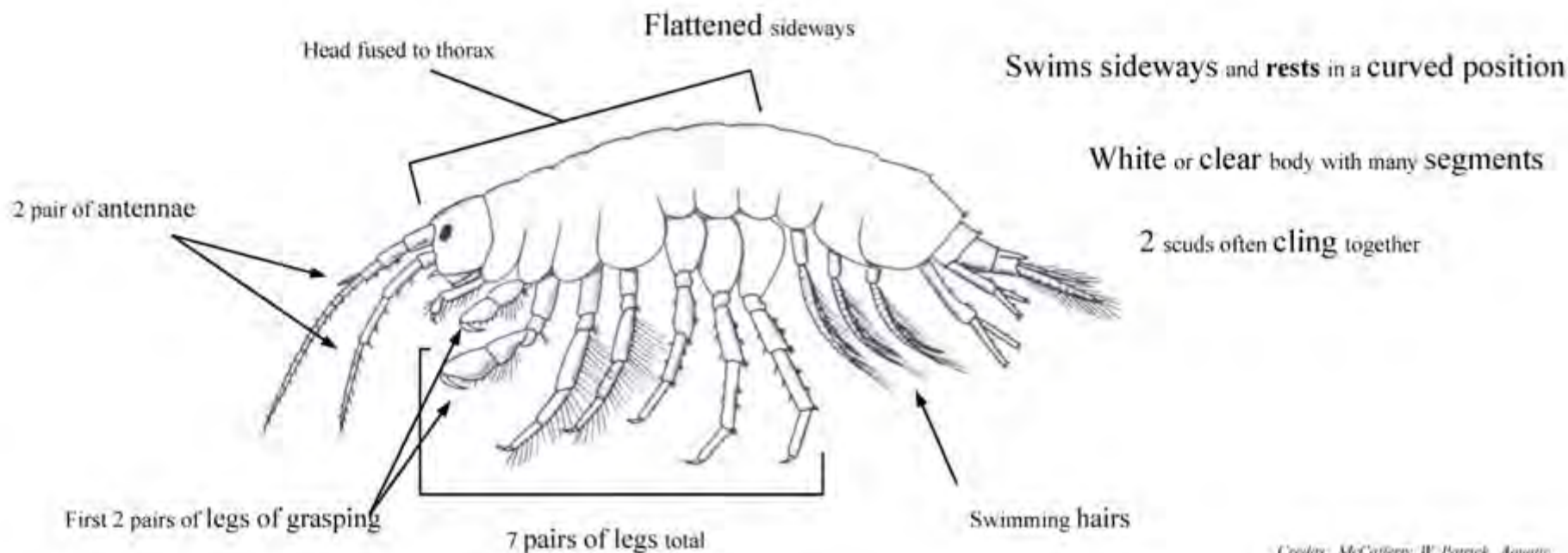
Size: 5-20mm

Order: Amphipoda Family: Gammaridae

Number of species in North America: 150



CREEK CONNECTIONS  
Allegheny College



*Credits: McCafferty, W. Patrick. Aquatic Entomology, 1981.*

## SIMILAR TO: Aquatic Sowbug

- Body flattened side to side (scud) vs. body flattened top to bottom (aquatic sowbug).

**Diet:** Detritus (dead animal and plant pieces or other organic matter). Some may filter feed.

**Food for:** Fish, predaceous water insects.

**Habitat:** Open water and rests on bottom and on debris in shallow water environments.

**Movement:** Swims on side. Also crawls and walks. Often will swim in circles. More active at night.

**Breathing:** Movement of swimming hairs pushes oxygen into the gills under its body.

**Water Quality Indicator:** Group II – Can tolerate some water pollution.

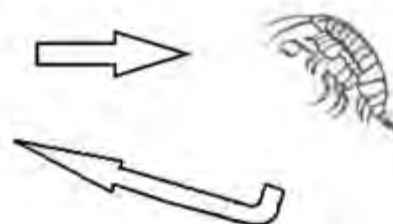
## Life Cycle Corner

### Incomplete metamorphosis

Eggs kept with female in portions of a shedded skeleton.



Eggs hatch in 9 - 30 days revealing miniature adults that stay with female for a few days until she molts releasing the young.





# Strong Jaws

Dobsonfly



# Stronger Jaws



Dragonfly  
Nymph



# Piercing Mouthparts



Water striders



# Raptorial Legs



Giant water bug



by Daniel Pickard



# Locomotion and Stability in Fast Moving Water

# Strong Swimmers



Minnow mayfly



# Suction n



Some spiny crawler mayflies have very dense hairs for suction.

# Suction n



Flat-headed or clinger mayflies - have modified gills for suction.



# Suction

Net-winged midge larvae



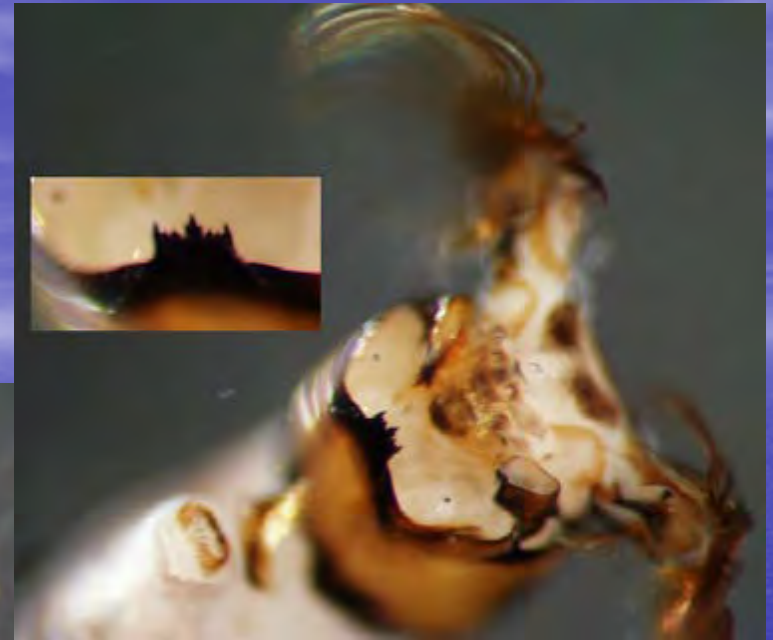
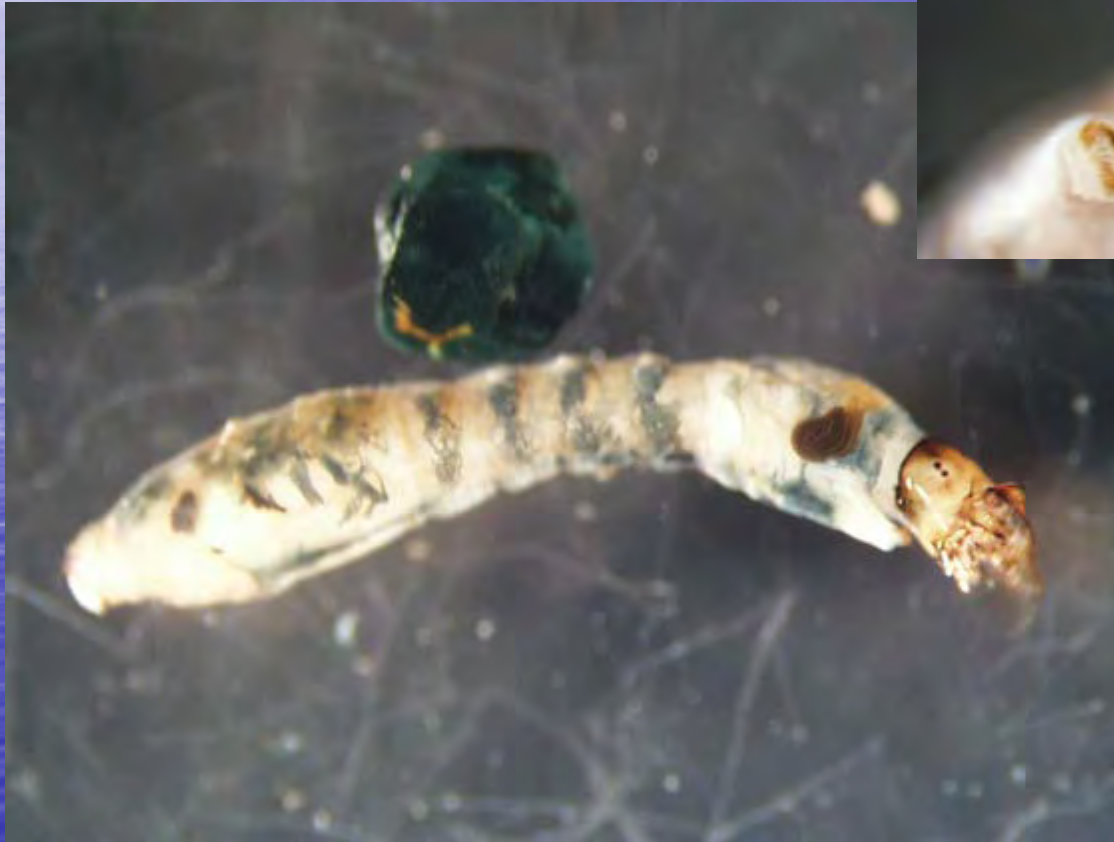
# Suction



Torrent midge larvae

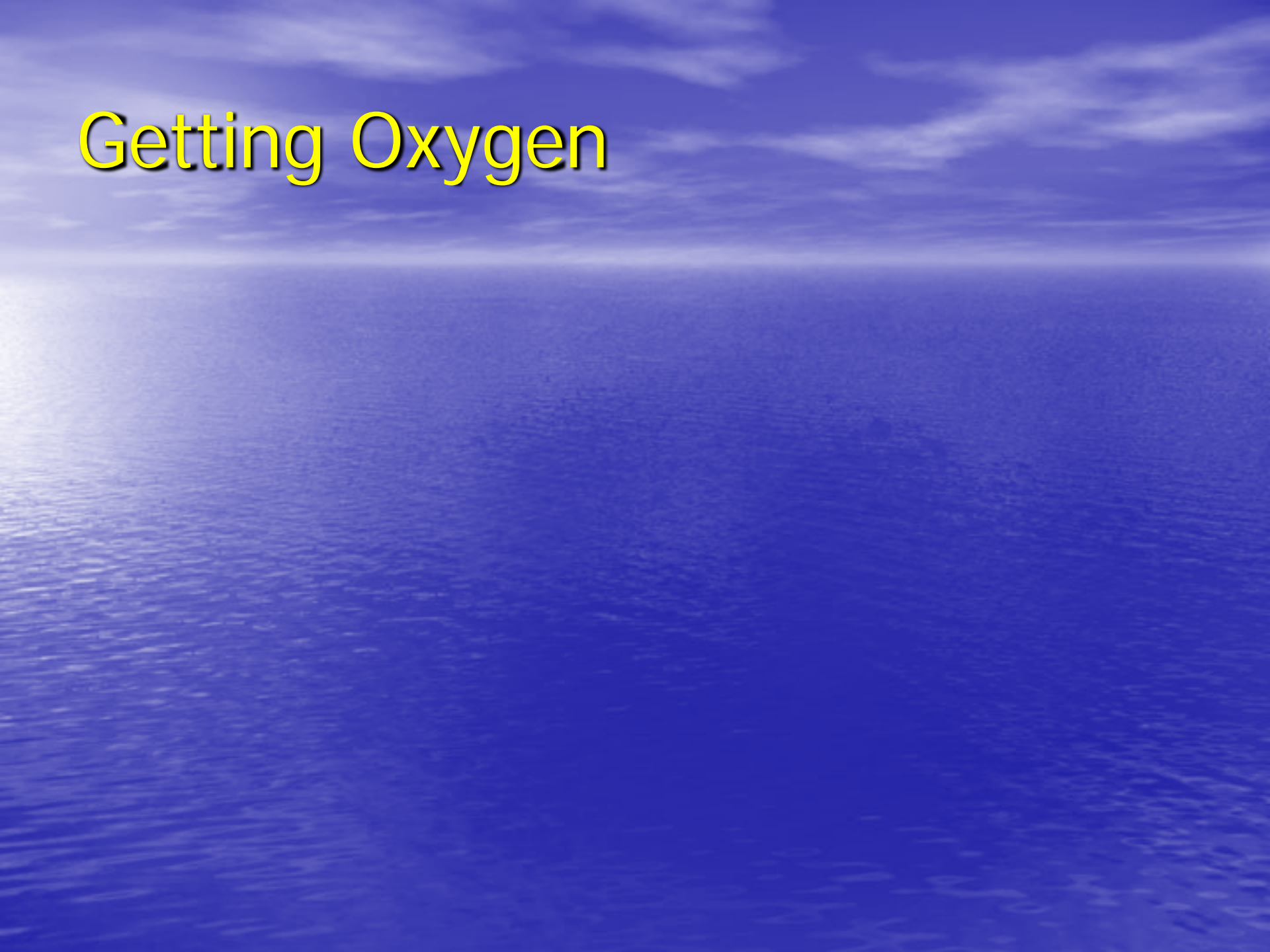


# Anchor Silk

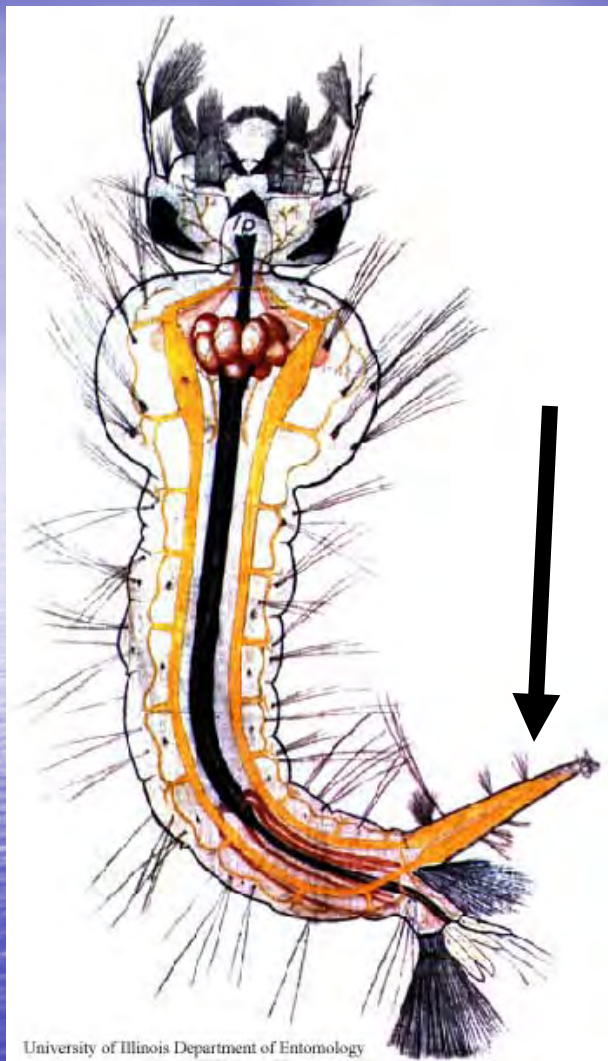


Blackfly larvae

# Getting Oxygen







Breathing  
Tubes

# Attached Air Bubble



Aquatic  
beetles





# Riffle Beetle

Order: Coleoptera Family: Elmidae

Number of species in North America: 80



CREEK CONNECTIONS  
Allegheny College

Size: 1-8mm (adult)



Breathe dissolved oxygen through  
gills at end of abdomen

RIFFLE BEETLE LARVAE



Gills protrude and  
wave to collect water

2 prominent claws



Pocket with door protects  
abdomen from sediment abrasion

ADULT RIFFLE BEETLES



So efficient with breathing,  
adults do not need to resurface af-  
ter diving ... Breathe via a **plastron**  
( a thin film of air held by tiny unwet-  
table hairs)

Credits: McCafferty, W. F. (1981). *Aquatic  
Entomology*, 1981.

**Diet:** Scrapers, collector-gatherers. Periphyton, detritus.

**Food for:** Game fish, predaceous water insects.

**Habitat:** Swift portions of stream, on stones or pebbles.

**Movement:** Clingers, climbers- slow movers.

**Breathing:** Through pocket door (larva) and plastron (adults).

**Water Quality Indicator:** Group I- generally sensitive to pollution; a large number indicates GOOD water quality.

## Life Cycle Corner

Complete metamorphosis

Fly immediately after  
emergence, then lose ability  
after entering water. Hind  
wings fall off.

Pupae crawl into terrestrial  
chambers in moist soil, under  
rocks, or inside of rotting wood

Eggs are laid either singly or in  
small groups on submerged rocks,  
organic debris, or vegetation.

Six larval in-  
stars; can take  
up to three  
years.



Larval riffle beetle

# Gills



Drunella mayfly



# Mayfly Nymph

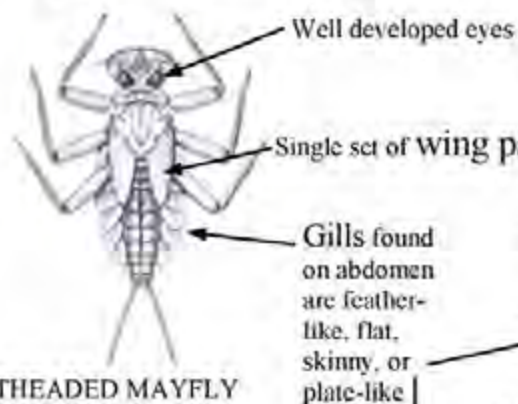
*Ephemeroptera* - *Ephemeroidea*  
*Ephemeroidea* - Common Burrower



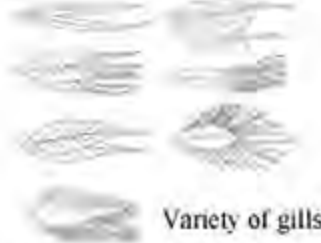
CREEK CONNECTIONS  
 Allegheny College

Number of species in North America: 149

Size: 3-20mm (nymph) / 5-8mm (adult)



FLATHEADED MAYFLY  
 NYMPH



Variety of gills

Usually 3 tails that are stick-like  
 (sometimes hairy sticks) and not  
 leaf-like (see \*)



COMMON BURROWER  
 MAYFLY NYMPH



SMALL MINNOW  
 MAYFLY NYMPH



3 pair of legs with  
 single claw at the end

Some Mayflies use hairs on  
 their forelegs to filter food  
 out of the water. Most, but  
 not all, are filter-feeders.

Adults have triangular-  
 shaped wings that are  
 held straight-up when  
 body is at rest



SMALL MINNOW MAYFLY ADULT

## SIMILAR TO: stonefly

- Mayflies have 3 tails\*, while stoneflies have 2.
- Mayflies have 1 claw, while stoneflies have 2.
- Mayflies have abdominal gills, while stoneflies do not.
- Mayflies have a single set of wingpads, while stoneflies have double.
- Mayflies have short antennae, while stoneflies have long.

\* Just a general rule; some species only have 2 tails. Often, tails break off easily.

**Diet:** Microscopic algae, small bits of organic matter, pieces of plants; a few eat other insects.

**Food for:** Game fish, predaceous water insects.

**Habitat:** Bottom dwellers; flowing waters (streams and rivers), ponds and shallow lakes.

**Movement:** Swim, cling to rocks, some burrow.

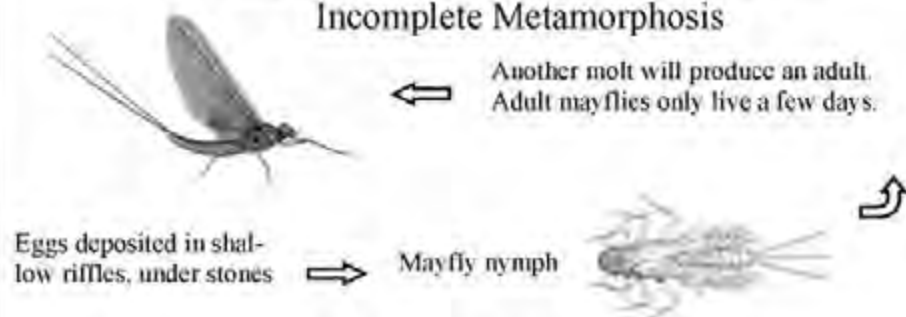
**Breathing:** Through gills on abdomen.

**Water Quality Indicator:** Group 1- generally sensitive to pollution; a large number indicates GOOD water quality.

Credits: McCafferty, W. Patrick. *Aquatic Entomology*  
 [1981]

## Life Cycle Corner

### Incomplete Metamorphosis



# More Gills





# Protection From Predators



# Chemical Defense



Plus, they have cool eyes!





# Natural Camouflage

Caddisfly case  
(periwinkle)





# Hydropsychidae - filter feeding caddisflies



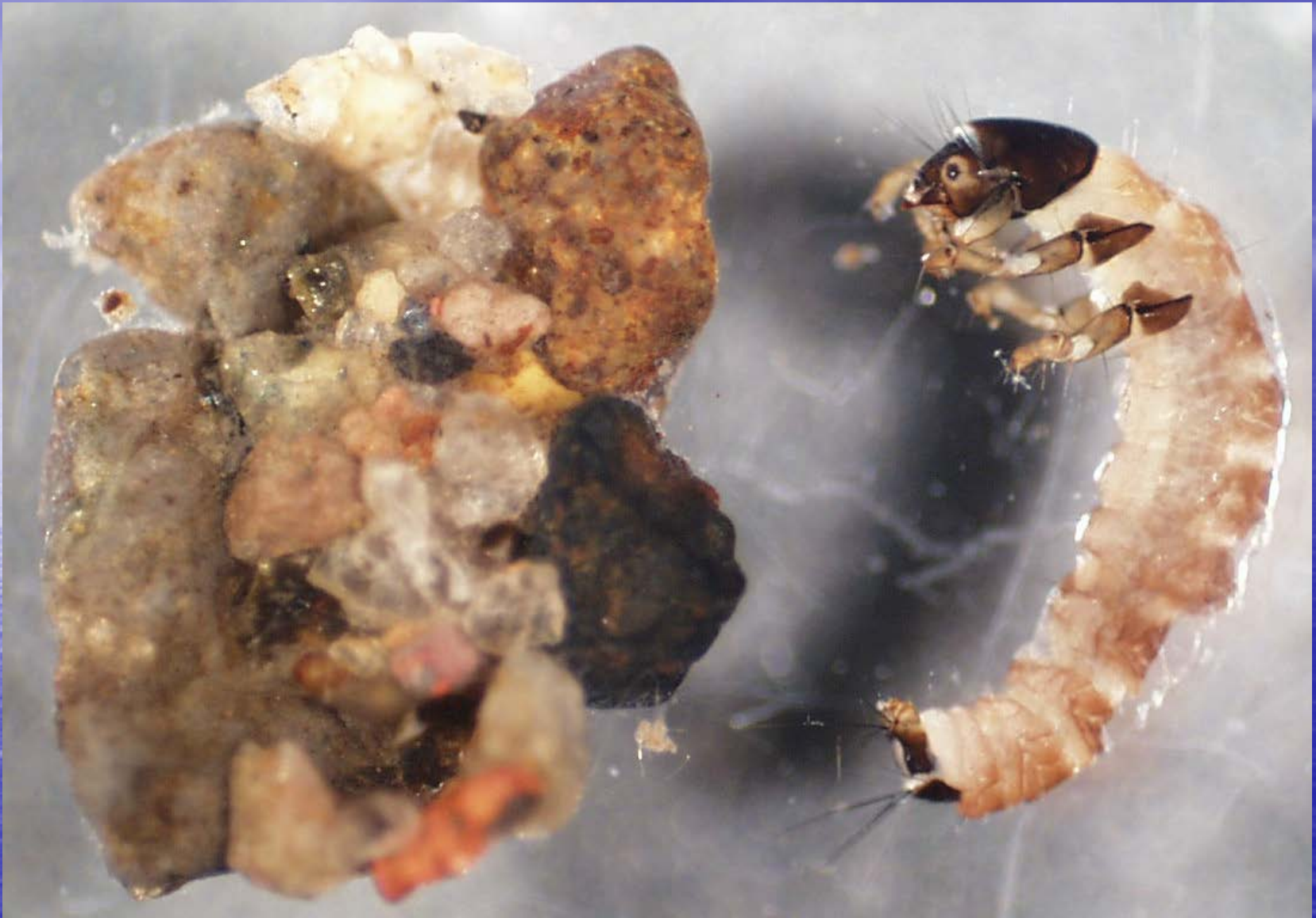


Rhyacophilidae -  
green rock worm

Free living  
predatory caddis fly

Adaptation: Hooks  
on Abdomen





Glossosomatidae - saddle-case maker; turtle case maker



# Case Building Caddisfly

Order: Hydropsychidae Family: Limnephilidae  
Number of species in North America: more than 300



CREEK CONNECTIONS  
Allegheny College

Size: body: 20-30 mm/ case 25-50 mm



Limnephilus larval case



Farula larval case



Pycnopsyche larval case



Apatania larval case



Manophylax larval case



Limnephilus larval case



Neophylax larval case

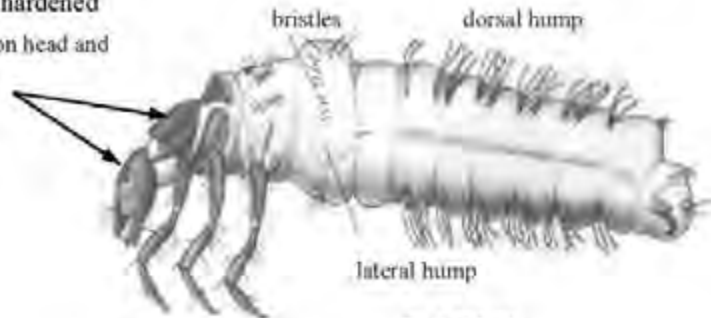


Cases are made from a variety of mineral and organic materials

Protruding head and front legs



Thick, hardened skin on head and thorax



LARVA



Anterior hook plate

Posterior hook plate



ADULT

Credits: McCafferty, W. Patrick. Aquatic Entomology, 1991.  
and  
Voshell, J. Reese Jr. A Guide to Freshwater Invertebrates of North America, 2002.

## Life Cycle Corner

Complete metamorphosis

Adults emerge in late spring or early fall and live for approximately 30 days.

The pupa stage lasts 2-3 weeks. Pupae are aquatic and obtain oxygen in the same way as larvae.

Eggs are deposited in gelatin masses in the stream. Masses vary from a few eggs each to several hundred eggs in each mass. Egg masses are sometimes green, yellow or orange.

The larval stage can last from 2-3 months to 2 years. Larva shed their exoskeleton approximately 5 times.

Larvae create a cocoon in the water for the pupa.

**Diet:** Shredder-detritivores, shredder-herbivores, collector-gatherers, scraper.  
**Food for:** Game fish, predaceous water insects.  
**Habitat:** Lentic and lotic habitats, streams, rivers, springs, marshes and ponds.  
**Movement:** clingers, crawlers and climbers.  
**Water Quality Indicator:** Groups I and II - can exist under a limited or wide range of water quality conditions; a large number indicates GOOD water quality.

# Natural Camouflage



Color patterns on the exoskeleton



Adaptations:  
camouflage /  
misdirection



# Natural Camouflage and Tough Exoskeleton





Cool  
Picture



**Dragonfly:  
Incomplete  
metamorphosis**



*Jeff Adams, 2002*

# Dragonfly Nymph

Gomphidae- Clubtails

Libellulidae- Common Skimmers



CREEK CONNECTIONS

Allegheny College

Number of species in North America: 243

Size: Damers: 45mm (larvae) / 79mm (adult)  
Clubtails: 30mm (larvae) / 50mm (adult)  
Common Skimmers: 21mm (larvae) / 50mm (adult)

Thick, hardened skin on head and thorax

2 pairs of wing pads on thorax

Short antennae

Large eyes

Scooplike lip (called labium) to capture food.  
Large chewing mouthparts.

2 claws at the end of each leg

No tail. Abdomen terminates with 3 stubby wedge-shaped structures.

DARNER NYMPH AND ADULT

COMMON SKIMMER  
DRAGONFLY NYMPH

CLUBTAIL DRAGONFLY NYMPH

3 pairs of segmented legs extend from thorax

## SIMILAR TO: damselfly

- A dragonfly's head is narrower than thorax and abdomen, while a damselfly's head is wider.

**Diet:** Insects (and larvae), other dragonfly nymphs, worms, small crustaceans. Will go after movement and even stalk prey.

**Food for:** Gamefish, frogs, birds, beetles, other dragonflies.

**Habitat:** Ponds, marshes, lake edges, shallow streams, slow streams and rivers

**Movement:** Climb and crawl on bottom. Some burrow. Can propel through water by sending water out their rear (rectal chamber).

**Breathing:** Through gill folds on rear area of body, and thin-walled body regions

**Water Quality Indicator:** Group II- can exist under a wide range of water quality conditions, a large number indicates MODERATE water quality

## Life Cycle Corner

Incomplete metamorphosis

Last molt occurs with head out of water. Adult flies away

Eggs deposited onto plant leaves/stems underwater. Sometimes eggs are just laid in shallow water.

Nymph hatches and molts 12 times.

Credits: McCafferty, W. Patrick. *Aquatic Insectology*, 1981.



Annelida - segmented worms (leeches, crayfish worms, aquatic earthworms)





Midge Larvae



# Crane Fly Larvae

Order: Diptera Family: Tipulidae

Number of species in North America: 300



CREEK CONNECTIONS  
Allegheny College

Size: 10-100 mm (larvae) / 25-38 mm (adult)

## LARVA

## ADULT



Rear end disc section. Has breathing structure here.

Fleshy, plump, segmented, worm-like body

Retracted head (head can be pulled inside)



spiracular disc

Rear end disc section

spiracular lobe

spiracle

Variety of rear ends



Sometimes a rear swollen section

No legs and no wings

Usually brown, white, or green in color.

3 to 6 finger-like extensions surrounding an open disc at rear end

retracted head

Credits: McCafferty, W. Patrick. *Aquatic Entomology*, 1981.

**Diet:** Small microorganisms (plants and animals), periphyton, even wood. Most eat plants.

**Food for:** Trout, bass (game fishes), beetles, predaceous water insects.

**Habitat:** Bottom dweller in streams, some in ponds, marshes, and lakes. Sometimes in algal growths or woody debris.

**Movement:** Cling to bottom, some swim.

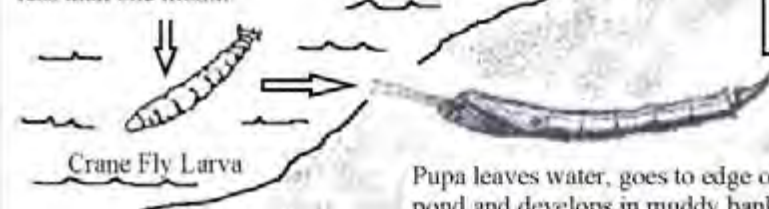
**Breathing:** Through skin in well oxygenated water and from air through rear end in poorly oxygenated water.

**Water Quality Indicator:** Group II—Can tolerate some water pollution. Does better in well oxygenated water.

## Life Cycle Corner

Elongated, shiny, black eggs are deposited in soil or algae mats near shore and hatch in less than one month.

Complete metamorphosis



Adult pushed out of soil.



# Gastropoda – snails and limpets





# Freshwater Clams and Mussels



# Macroinvertebrate sampling

## Factors:

- Pollution tolerance
- Diversity
- Abundance
- Feeding groups
- Sediment dependence
- Stream size



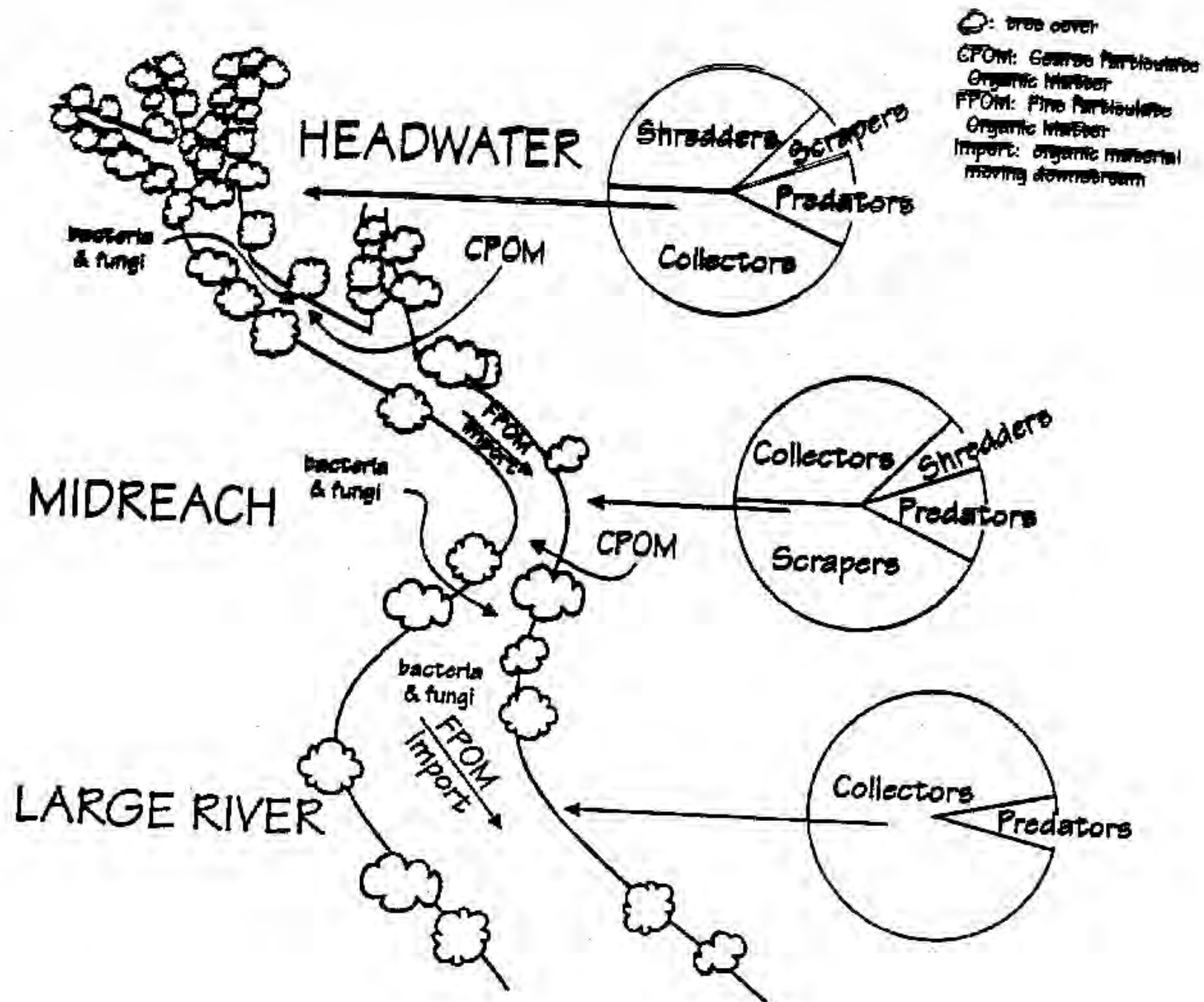


# Biological Sampling

Using macroinvertebrate species pollution tolerance to measure stream health



Riffle sampling with D-frame kicknet





# Macroinvertebrate sampling

## Insect Orders

Mayflies ([Ephemeroptera](#))  
Stoneflies ([Plecoptera](#))  
Caddisflies ([Trichoptera](#))  
True flies ([Diptera](#))  
Aquatic beetles ([Coleoptera](#))  
Dobsonflies and alderflies  
([Megaloptera](#))  
Aquatic moths ([Lepidoptera](#))  
Dragonflies and damselflies  
([Odonata](#))  
Aquatic true bugs ([Hemiptera](#))  
Springtails ([Collembola](#))

## Non-Insect Groups

Water mites, Hydracarina ([Acarina](#))  
Scuds, sowbugs, crayfish, and pals  
([Crustacea](#))  
Snails, limpets, clams, and mussels  
([Mollusca](#))  
Aquatic worms ([Oligochaeta](#), [Polychaeta](#))  
Crayfish worms ([Branchiobdellida](#))  
Leeches ([Hirudinea](#))  
Hydroids ([Cnidaria](#))  
Flatworms ([Turbellaria](#))  
Ribbon worms ([Nemertea](#))  
Roundworms ([Nematoda](#))  
Horsehair worms ([Nematomorpha](#))  
Moss animals ([Ectoprocta](#))  
Sponges ([Porifera](#))

# Pollution-Sensitive Macroinvertebrates

Mayfly larva



- Important fish food
- They eat plants and algae
- Sleek body
- Abdominal gills
- Most have 3 tails
- Most have a single claw at the end of each leg



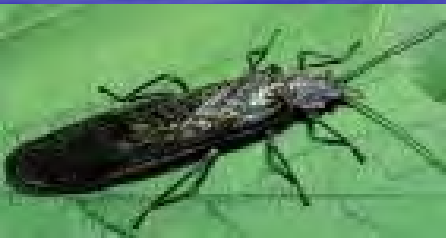


# Pollution-Sensitive Macroinvertebrates

Stonefly larva



- Often found on rocks
- Predators and shredders
- Sensitive to human disturbance
- Flat in appearance
- Have two tails with many segments
- Have two claws at the end of each leg



Adult Stoneflies live only for a week to a month

# Pollution-Sensitive Macroinvertebrates

Water penny larva



- Armored segments
- Oval body
- Live on rocks in fast water
- Eat algae off rocks



As an adult beetle, the water penny looks very different from the larva stage.





# Somewhat Tolerant Macroinvertebrates

Cranefly larva



- Worm-like appearance
- Predators that may eat mosquito larvae
- Found in most aquatic habitats
- Related to flies
- Soft body
- Good food for most aquatic organisms
- No jointed legs

The adult is often mistaken for mosquitoes.



# Somewhat Tolerant Macroinvertebrates

Dragonfly and damselfly larva



- Not showy like the adults
- Prey on other insects
- Generally found in still water
- Have jet propulsion
- Dragonflies have thick abdomen and damselflies have thinner abdomen





# Somewhat Tolerant Macroinvertebrates

## Scuds



- Shrimp-like animals with flat bodies
- Mainly collect and gather dead food
- Found almost anywhere
- Good food source for fish
- Found in urban streams

Scuds are crustaceans not insects.

# Somewhat Tolerant Macroinvertebrates

Crayfish / Crawdad



- Have 8 legs and two small to very large claws
- Have muscular and obvious tail
- Predators
- Can be found in urban streams





# Pollution Tolerant Macroinvertebrates

Mosquito larva



- Do not need good water quality to reproduce
- Found in creeks and other places of standing water.
- Some eggs can dry out and still hatch when flooded.
- Feed on organic matter
- Wriggle

Only female mosquitoes bite.



# Pollution Tolerant Macroinvertebrates

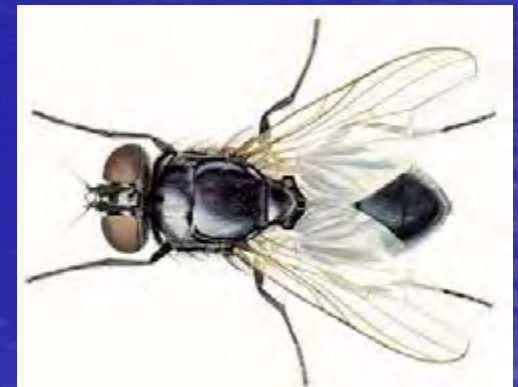
Black fly larva



- Very common in streams
- Bowling pin shaped
- Well-developed head
- Usually fans on top of head
- Adults are biting insects



Adult females of most black fly species require a blood meal to produce eggs.





# Pollution Tolerant Macroinvertebrates

## Flat worms



- Triangular head
- Noticeable eyes spots
- Oblong
- No segments
- Common in urban areas
- Common in biology studies

# Pollution Tolerant Macroinvertebrates

## Leeches



- Variety of shapes and sizes
- Highly segmented, usually flattened bodies
- 34 body segments
- Suckers evident on one or both ends
- Dark eye spots
- Have long been used for medical purposes



# Marion Soil & Water Conservation District



*For more information:*

<http://marionswcd.net>

**503-391-9927**  
**(Salem)**