

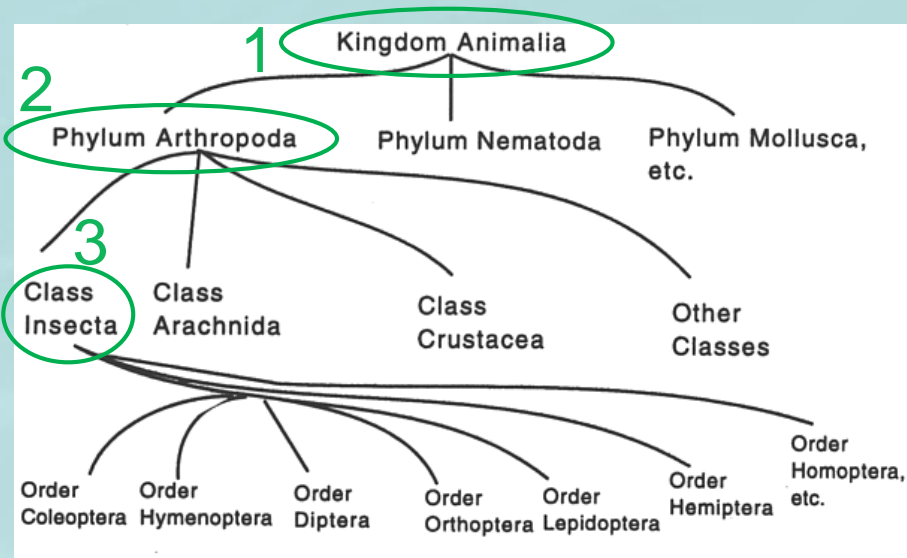


# Aquatic Insects

## D-BAIT Lesson

Purdue Polytechnic Institute  
Purdue Dept. of Entomology

# What is an Insect?

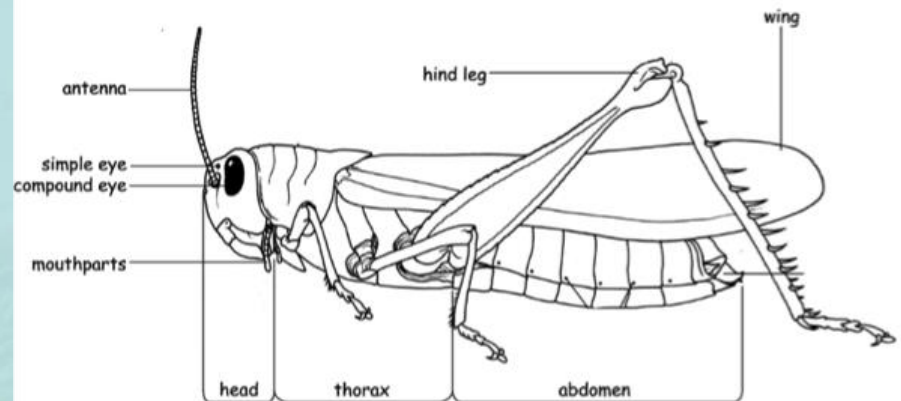


<https://cals.arizona.edu/pubs/garden/mg/entomology/intro.html>

Insects are:

- 1) Animals which are heterotrophs with internal digestion
- 2) Arthropods, which have an exoskeleton with jointed legs
- 3) Insects have external mouthparts, three body regions, and six legs

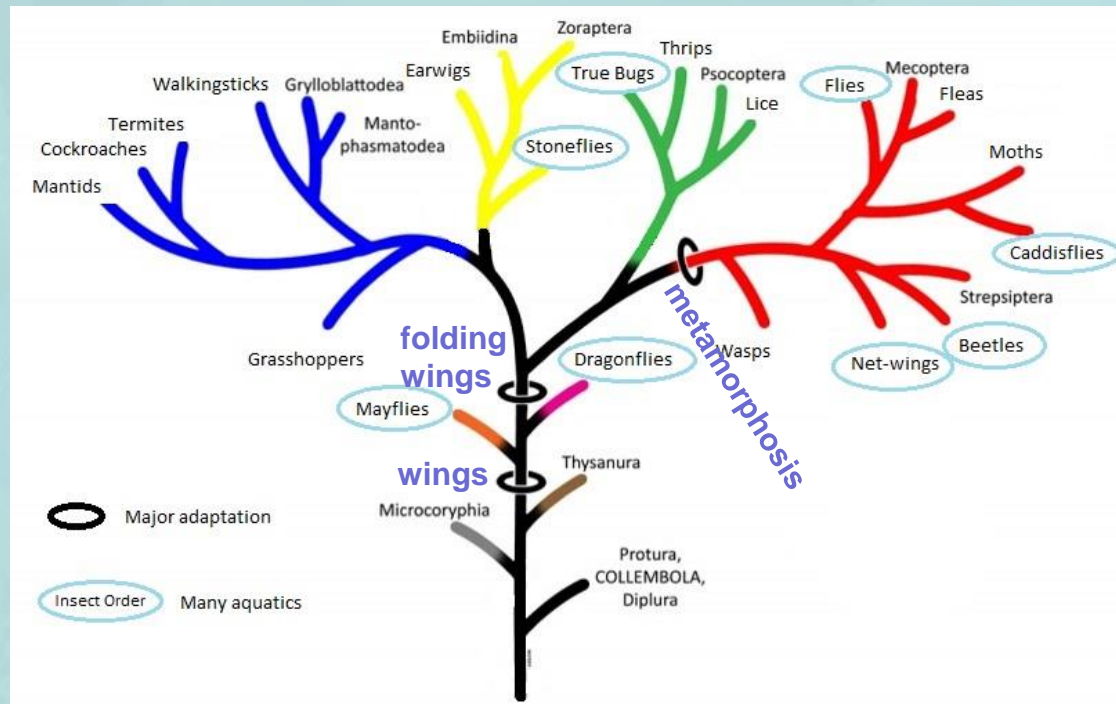
- 3 Insect Body Sections:
  - Head: sensory & feeding
  - Thorax: movement, legs & wings
  - Abdomen: reproduction, digestion



# Aquatic Insect Evolution



- All aquatic insects have wings as adults
- Primitive “old-winged” insects: mayflies & dragonflies
- “New-winged” insects derived before metamorphosis evolved: stoneflies, true bugs
- Most recently evolved groups have new folding wings and metamorphosis: flies, beetles, caddisflies, net-winged insects



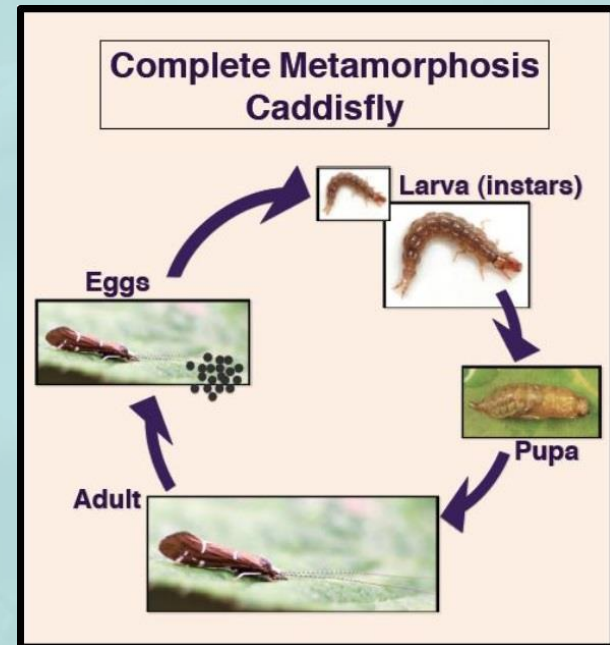
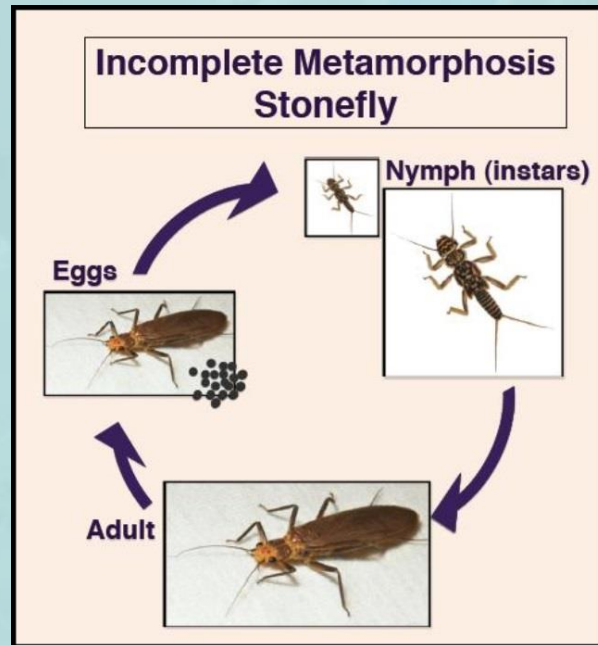
# Insect Life Cycles

## Incomplete metamorphosis

- get larger at each molt
- wing buds appear and increase
- adult can be aquatic or terrestrial

## Complete metamorphosis

- immature and adult very different
- wings visibly absent until adult
- adult can be aquatic or terrestrial



# Habitats & Challenges

- Habitat is the ecological area inhabited by a species that provides it with nutrition, shelter, and the ability to reproduce (mates, nesting sites, etc...)
- Each habitat type presents different benefits and challenges to species

## Ponds and Lakes

- Often full of plants
- Low oxygen content

## Streams and Rivers

- Moving water
- Higher oxygen content



# Life in the River Continuum

- Headwater streams



<http://www.nhdf.org/uploads/NHB%20photos/pisgah1a.jpg>

# Life in the River Continuum

- Mid-reach streams



[http://www.rollanet.org/~conorw/cwome/24\\_mill\\_creek\(phelps\\_county\\_mo\).jpg](http://www.rollanet.org/~conorw/cwome/24_mill_creek(phelps_county_mo).jpg)

# Life in the River Continuum

- Lower reaches / rivers
- Large, mostly unshaded, murky water

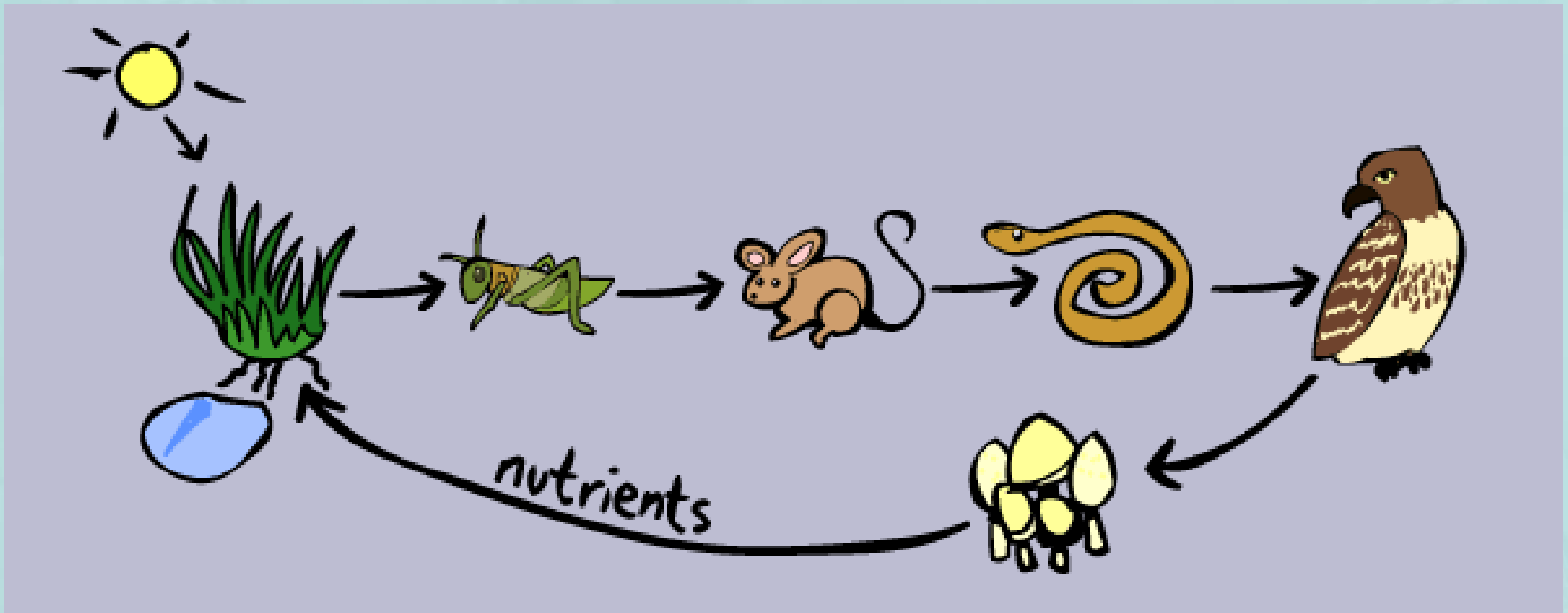


[http://americancruiselines.azureedge.net/images/default-source/cruise-library-complete-mississippi-river-cruise/complete\\_mississippi\\_9-min.jpg?sfvrsn=10&size=900](http://americancruiselines.azureedge.net/images/default-source/cruise-library-complete-mississippi-river-cruise/complete_mississippi_9-min.jpg?sfvrsn=10&size=900)



# Food Webs

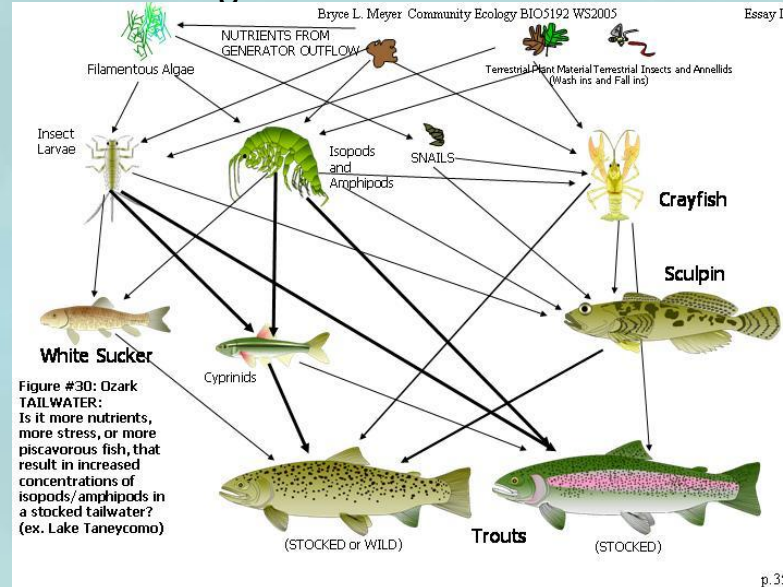
- Food chain: simplified depiction of energy transfer



<http://www.sheppardssoftware.com/content/animals/kidscorner/images/foodchain/fullchain.gif>

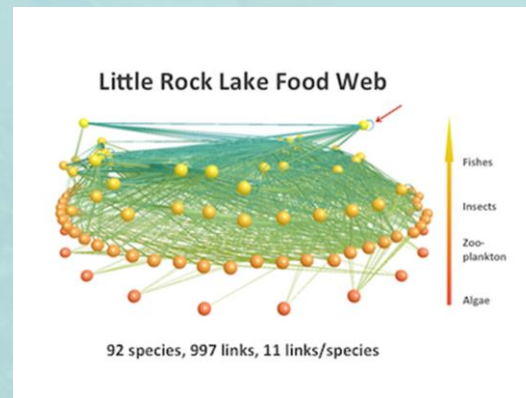
# Aquatic Food Webs

- Food Webs: multiple chains woven together



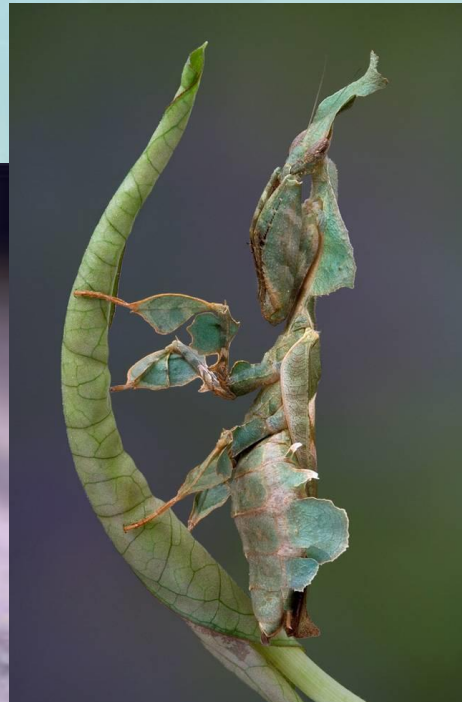
<http://www.combat-fishing.com/OZarkTailwaterSimplifiedFoodWeb.JPG>

- Can be very complex



# Adaptation

- Modification in population over time in response to increased reproductive success
- Need to move, breathe, eat, and avoid predation in a specific habitat
  - Note importance of habitat and food web in adaptation
- Driving force in evolutionary process



<http://www.buglogical.com/images/catalog/category58.jpg>

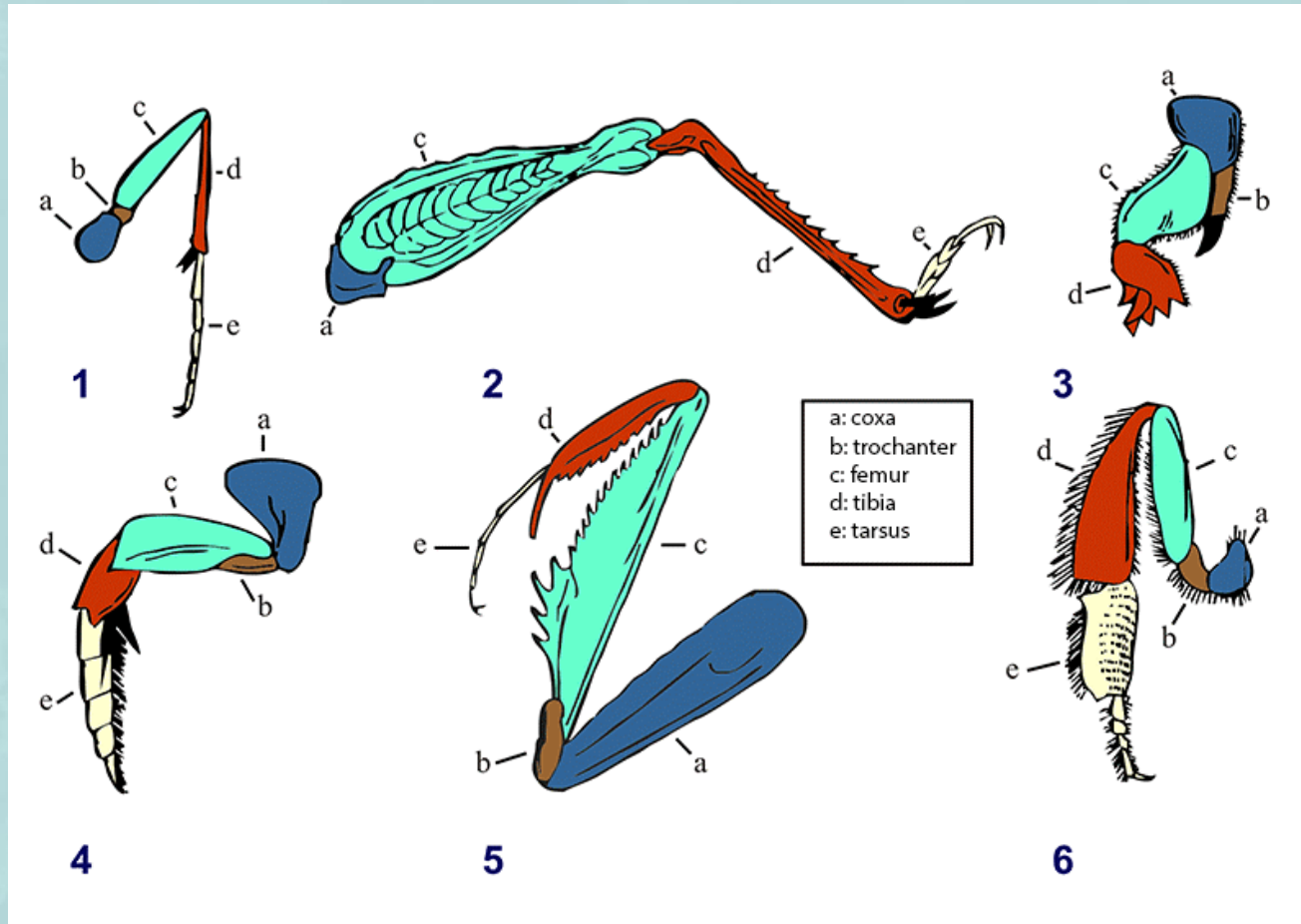
<http://media.mnn.com/assets/images/2014/11/ghost-mantis.jpg>

<https://i.ytimg.com/vi/Hdy9gzz4hQE/maxresdefault.jpg>

# Adaptation

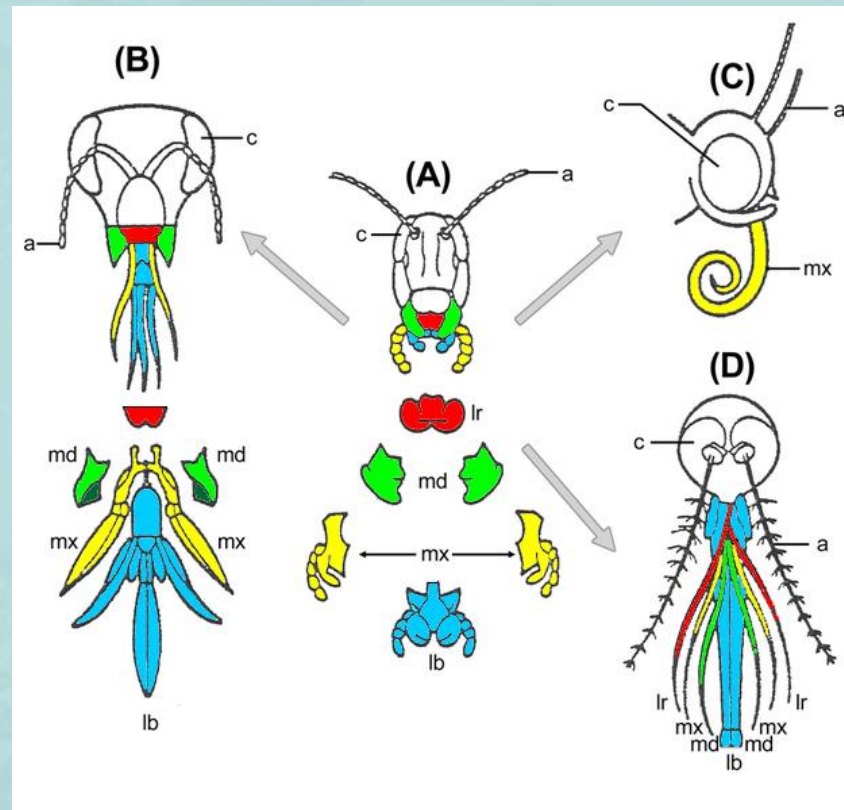
Example: Modifications of insect leg parts suited to various functions

Question: what is each of these legs adapted to do?



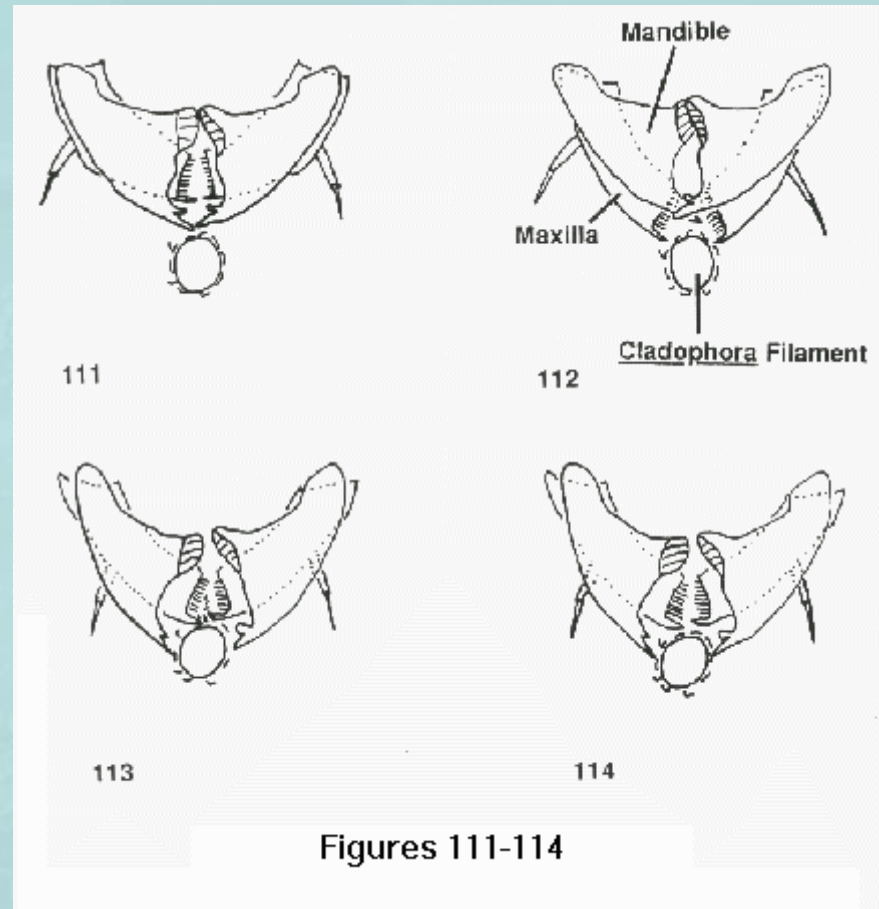
# Adaptation

- Example: Modifications to mouthparts for different sources of food
- Structure of mouthparts can suggest food source



# Adaptation of Mouthparts

- Chewing mouthparts: chewing mandibles of a mayfly



# Adaptation of Mouthparts

- Sickle type mandibles of a hellgrammite
- Mandibles, but modified for predation



<https://leahskey.files.wordpress.com/2013/03/hellgrammite.jpg>

# Adaptation of Mouthparts

- Piercing mouthparts of a water bug
- Modified for piercing and sucking

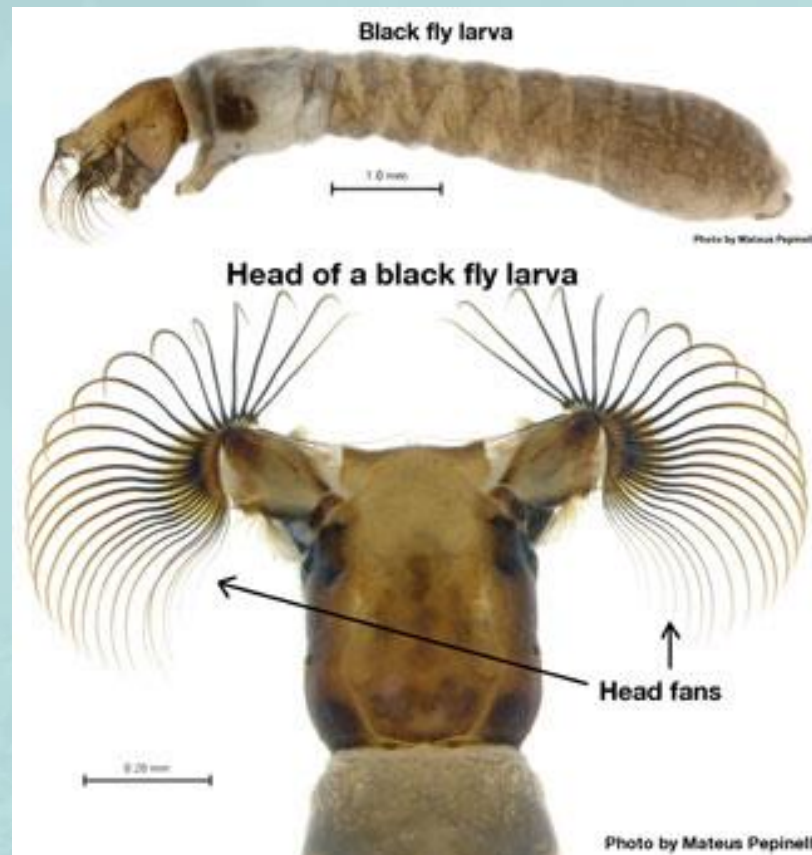


<https://www.sccs.swarthmore.edu/users/03/cweiss/bugs/opisthogn-hemip.jpg>



# Adaptation of Mouthparts

- Fan-type mouthparts of black fly larvae are modified for “filter feeding”
- Mouthparts very modified to allow filtering of organic matter from moving water
- Food comes to them
- What are the benefits and constraints?



# Other Adaptations for Feeding

Net of a caddisfly



[http://lh6.ggpht.com/\\_X6JnoL0U4BY/S8H0RUe3N7I/AAAAAAAAAYsg/UDtjjMyV53o/s1600/tmp2810\\_thumb3.jpg](http://lh6.ggpht.com/_X6JnoL0U4BY/S8H0RUe3N7I/AAAAAAAAAYsg/UDtjjMyV53o/s1600/tmp2810_thumb3.jpg)

Water scorpion



<https://naturallycuriouswithmaryholland.files.wordpress.com/2015/07/water-scorpion-005.jpg>

Dragonfly nymph



alamy stock photo

alamy  
www.alamy.com

# Avoiding Predators

- Physical adaptations

Stonefly nymph



[http://4.bp.blogspot.com/-9KhKHMpZUKg/UYaaqjj8hzI/AAAAAAAARDg/Hrd7AoG-XSU/s1600/IMG\\_0307.JPG](http://4.bp.blogspot.com/-9KhKHMpZUKg/UYaaqjj8hzI/AAAAAAAARDg/Hrd7AoG-XSU/s1600/IMG_0307.JPG)

Caddisfly larva



<http://ww2.kqed.org/science/wp-content/uploads/sites/35/2016/08/DL313-06-caddis-on-rock-case-CRX.jpg>

# Avoiding Predators

- Behavioral

## Mayfly nymph burrowing

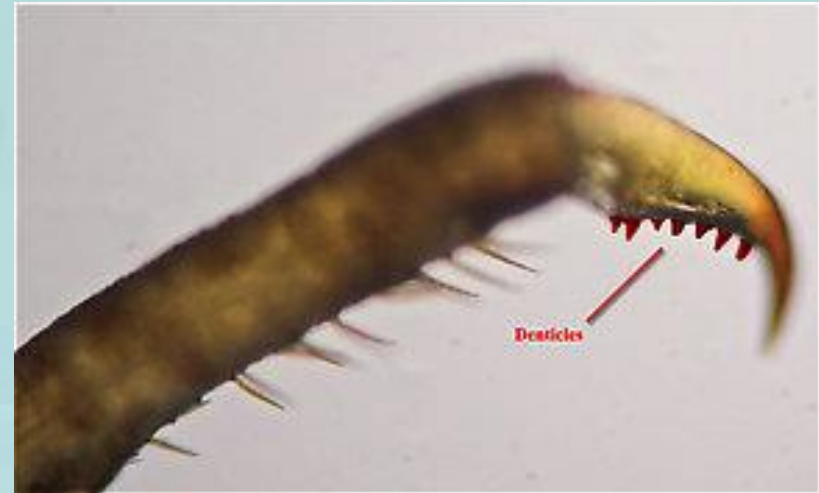


<http://lifeinfreshwater.net/wp-content/gallery/common-burrowing-mayfly-nymphs-ephemeridae/Burrowing-mayfly-nymph-Ephemeridae-07.jpg>

Fly larvae in temporary water  
(no fish!)



# Adaptations for Locomotion



[http://www.troutnut.com/im\\_glossary/picture\\_113\\_small.jpg](http://www.troutnut.com/im_glossary/picture_113_small.jpg)



[http://whyfiles.org/wp-content/uploads/2015/07/waterstrider\\_shtrstk.jpg](http://whyfiles.org/wp-content/uploads/2015/07/waterstrider_shtrstk.jpg)

# Adaptations for Swimming

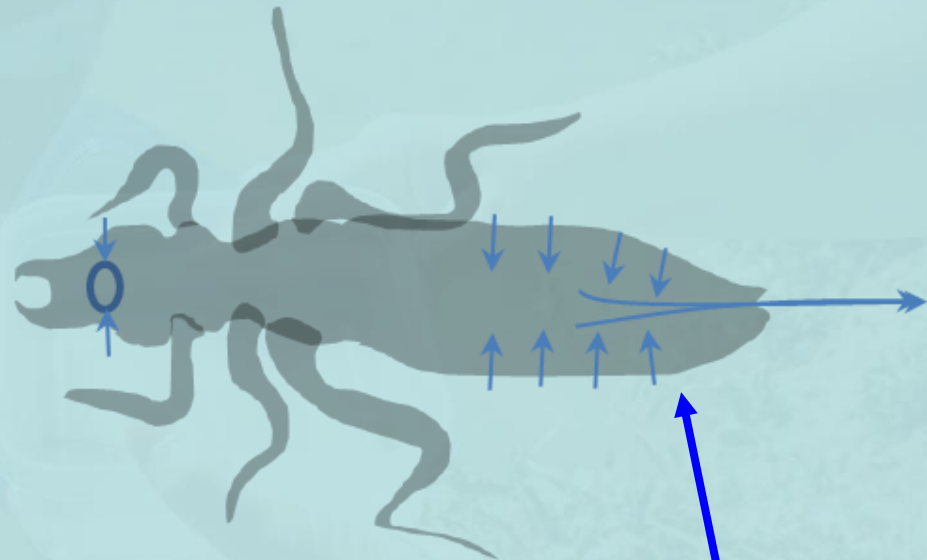
Predacious  
diving beetle



[http://farm9.static.flickr.com/8056/8102110173\\_c59b3e6ce6.jpg](http://farm9.static.flickr.com/8056/8102110173_c59b3e6ce6.jpg)

Legs modified into paddles

Dragonfly nymph



<https://katatrepsis.files.wordpress.com/2012/10/dragonfly-larva-locomotion.png>

“Jet propulsion”

# Adaptations for Hanging On

Net of caddisfly



<http://www.stroudcenter.org/research/projects/schuylkill/taxa/images/taxon42.jpg>

Terminal claws on caddisfly



[http://3.bp.blogspot.com/-KNNAZqKMmxE/UxyshUCfEAI/AAAAAAAAVDo/FBBe5MxuxXk/s1600/IMG\\_6333.JPG](http://3.bp.blogspot.com/-KNNAZqKMmxE/UxyshUCfEAI/AAAAAAAAVDo/FBBe5MxuxXk/s1600/IMG_6333.JPG)

# Adaptations for Breathing

- Gills
- Efficient when oxygen concentration is high
- Which habitats could these insects live in?

Damselfly nymph



<http://www.sacsplash.org/sites/main/files/imagecache/medium/photos/DamselflyLarva.jpg>

Mayfly nymph



<https://scrubmuncher.files.wordpress.com/2011/08/merge.jpg>



# Adaptations for Breathing

- Air tubes
- Do not extract oxygen from the water

Water scorpion (a true bug)



Rat-tailed maggots (true flies)



# Adaptations for Breathing

- Carry an air bubble (scuba!)
- Adaptations: space under beetle elytra/wing covers, hydrophobic hairs

## Predacious diving beetles



## Water boatman



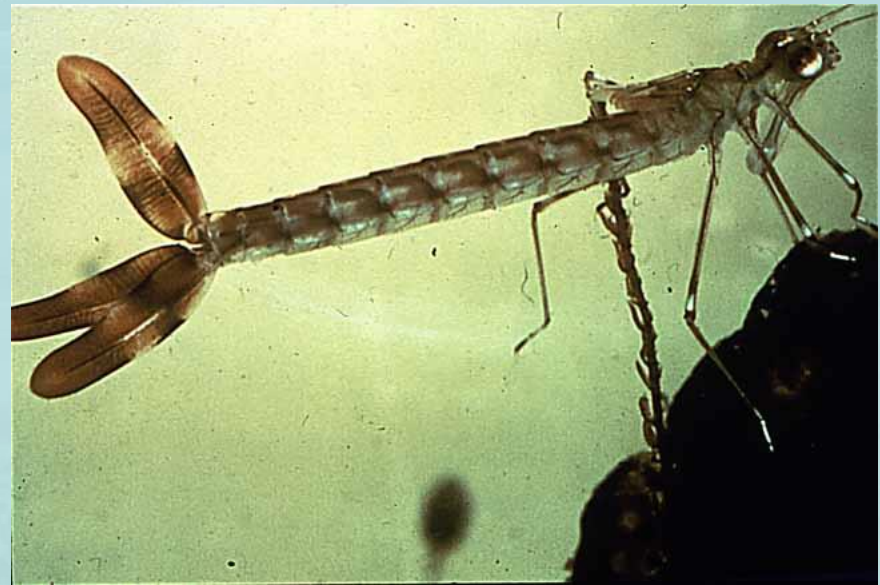
# Interesting Aquatic Insects: Dragons & Damsels

Dragonfly nymph  
- jet propulsion escape

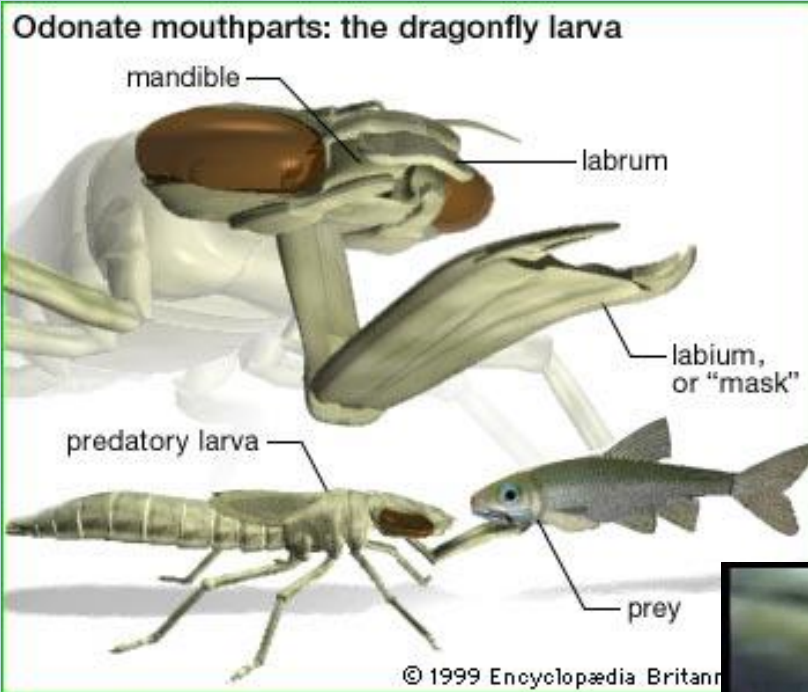


Damselfly nymph

- gills
- also hunt with labial mask



# Dragonfly Nymph Eating



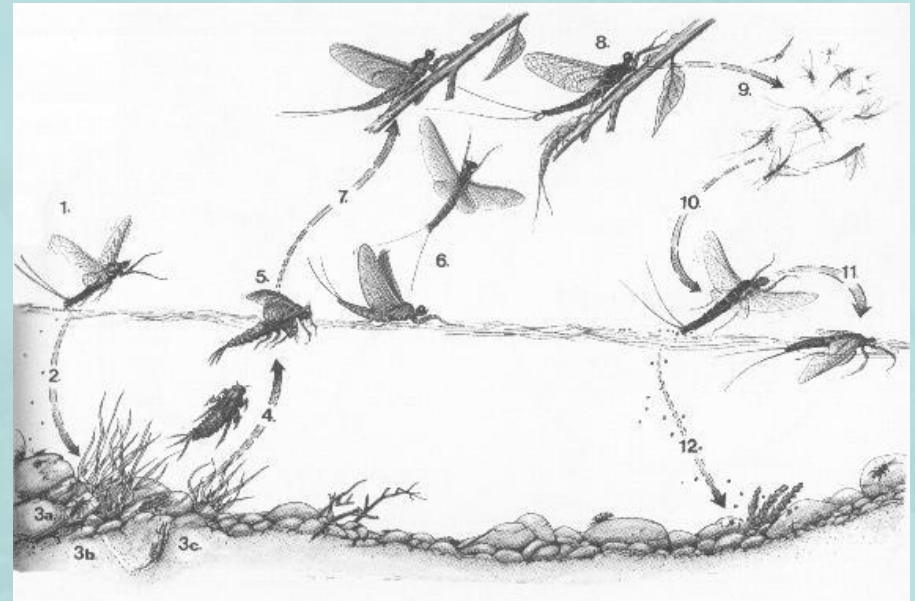
[https://www.youtube.com/watch?v=W557aSVdW\\_g](https://www.youtube.com/watch?v=W557aSVdW_g)



# Mayflies

Note: one word because not a true fly

- Plant and detritus feeders
- Many types are not tolerant of pollution
- Mass flights of adults is a behavioral adaptation to a short adult life cycle



# Stoneflies

- Pollution intolerant
  - missing in polluted water
- Require well-oxygenated water
  - cool, shaded streams
- Require rocky substrate
  - faster moving streams
- In some species, adults emerge in late winter
  - behavioral adaptation to avoid many vertebrate predators such as birds





Figure 7 - Antennae of Corixidae adult.

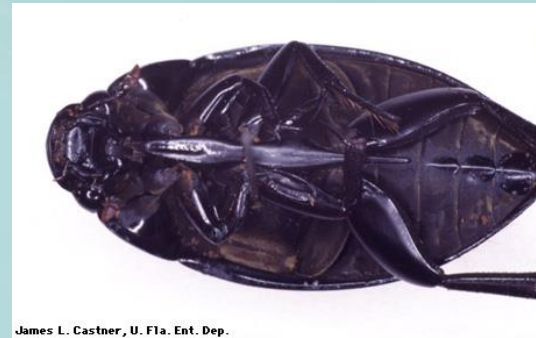
Why would the antennae be reduced?

# True Bugs

All breathe with spiracles, not gills



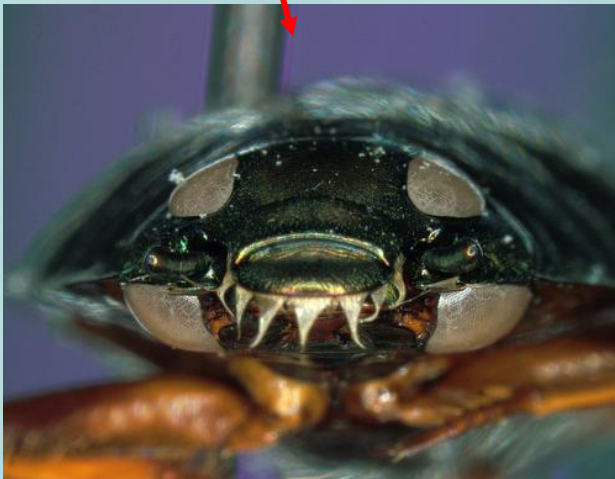
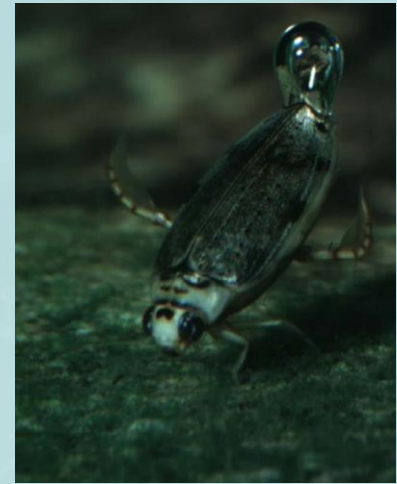
Figure 8 - Foreleg of Corixidae adult.



James L. Castner, U. Fla. Ent. Dep.

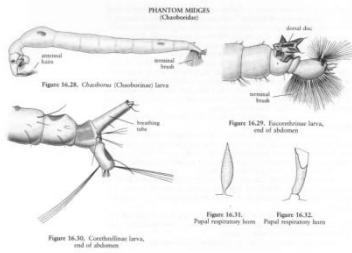
# Beetles

Very diverse

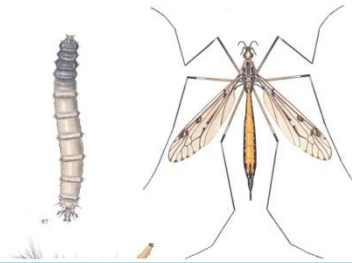




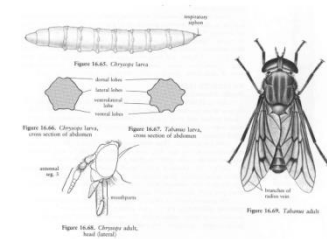
## CHAOBORIDAE



## TIPULIDAE ADULT/LARVA



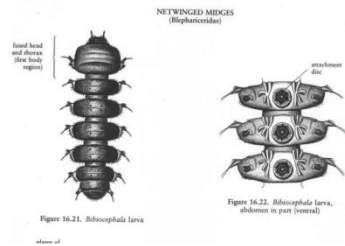
## TABANIDAE



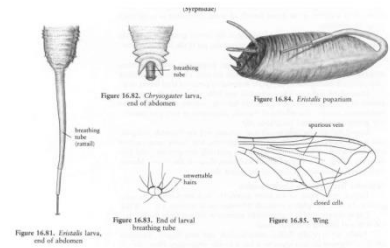
# True Flies

Many with aquatic larvae  
Very diverse  
Very diverse adaptations

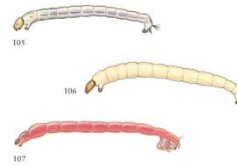
## BLEPHARICERIDAE



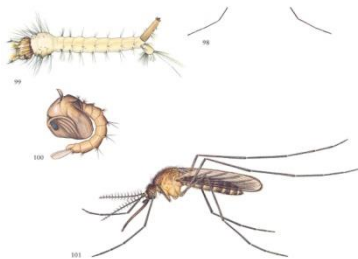
## SYRPHIDAE



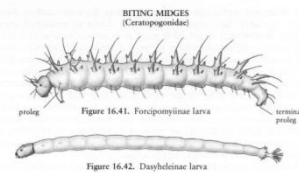
## CHIRONOMIDAE



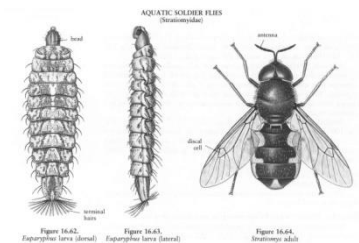
## CULICIDAE



## CERATOPOGONIDAE



## STRATIOMYIDAE



# Caddisflies

Adults look like small brown moths

Primitive (older) groups spin anchored home



Recent groups spin mobile homes



Later evolving groups spin web beside home



Plate armor !



# Other Weird Aquatic Groups



Hellgrammite



Pyralid caterpillar



An aquatic wasp



Alderfly



©Dale Parker, AquaTax Consulting

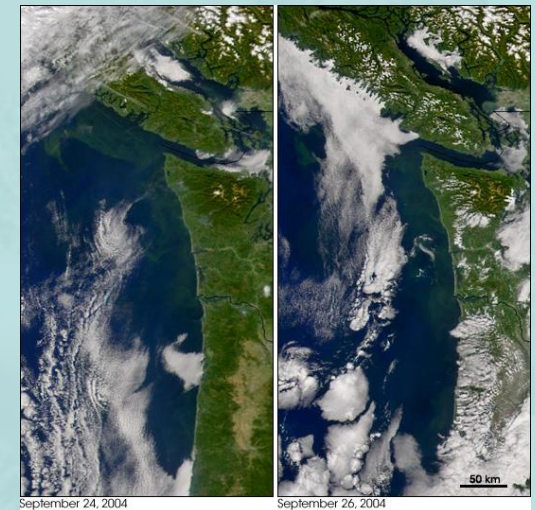
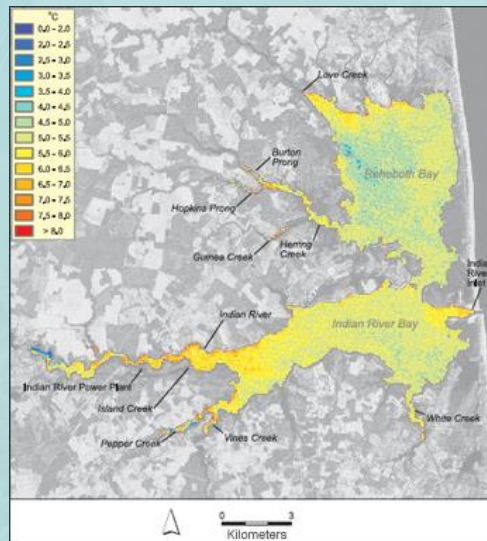
# Biological Indicators

Changes in environment leads to changes in the types of aquatic insects present

Why?

Therefore, the types of insects present can tell us about the state of their habitat

Example: EPT index =  
diversity of mayflies + stoneflies + caddisflies



# Biomimicry & Humans in the Food Web



# Biomimicry-Inspired Design

## To Fool a Fish

- behavior (function)
- location (habitat)
- appearance



## These will be determined by

- adaptations for life underwater
- life cycle
- how species moves to get food and O<sub>2</sub>



# Using Aquatic Entomology Knowledge

A background photograph showing a group of people at a riverbank. In the foreground, a person's hand holds a clear plastic container filled with water and small aquatic insects. Other people are visible in the background, some looking into the water. The scene is outdoors with sunlight reflecting on the water.

**1) D-BAIT lesson:** design a 3-d printed fishing lure that uses biomimicry to function as an aquatic insect that fish prey upon

**2) Biological indicators lesson:** sample aquatic insects and identify them to calculate an index of water quality based upon their tolerance of pollution