**Lesson Title:** Habitat for Stream Insects: What Kind of Substrate is the Best Habitat for Aquatic Insects?

**NSF GK-12 Fellow:** Tommy Detmer (Boulder, CO)

**Grade Level:** Middle School

**Type of Lesson:** Life Science

**Objectives:** The primary goals for this activity are to encourage students to ask scientific questions, to collect the data to answer questions, to think of scale in the context of organisms and nature, and consider the relationship between form and function from the perspective of habitat. In addition, this activity will encourage students to think about aquatic ecosystems and how the health of the environment is related to us. The data can be analyzed at a later date in the classroom if pressed for time (the students generally really enjoy working in the creek and looking at organisms and may take longer than expected). This activity takes approximately 1.5 hours.

For this activity, students should be broken into groups of two or three. Each group should have the following supplies:

1. Science Journal
2. Two pencils (just in case one gets lost)
3. Rain coat (if the weather looks questionable)
4. Macroinvertebrate Sampling Sheet (provided here)

**Background Information:**
Students gain more from the exercise if they know or can be provided with a rudimentary understanding of asking scientific questions. In addition, students should know basic information on insects and their role in food webs (information provided in the following paragraph if this is lacking).

Aquatic insects are an important component in the structure of aquatic food webs, because they are a key source of food for fish, birds, otters, frogs, and other vertebrates. In fact, many of these taxa rely solely on aquatic insects for food. In addition to being utilized as a food source, aquatic insects can control algae in streams and lakes. The control of algae in streams and lakes is important because algae can influence water quality.

Because of evolution, organisms usually have adaptations to a particular habitat type. Discuss a couple examples of different habitats and what kinds of animals would be

found there (e.g., grasslands- cheetahs, lions, zebras; forest- squirrel). Also discuss habitats where organisms do not fit well (e.g., whale-forest; cheetah-mountains).

An extension of this exercise is to get students to begin thinking about body size as it relates to organisms; therefore, some background on body size is beneficial. Body size is important for many reasons, notable are the relationship of body size to habitat and the relationship of body size to metabolism. The former of these can be explained by trying to understand how an organism operates in a particular habitat. For example, could a gray whale, even though it is adapted to water, thrive in a small pond? The latter is mathematically intensive but can be summarized by the statement that small organisms have a higher metabolism per body mass than larger organisms; 10 X 1mg mayflies eat more than 2 X 5mg mayflies even though the weight of the two groups is equivalent (10mg).

There are many resources on the web that can help you learn what the different taxa look like. One that has nice pictures is http://www.dep.wv.gov/WWE/getinvolved/sos/Documents/Benthic/AquaticInvertGuide.pdf Your students will use a dichotomous key to identify the invertebrates they collect.

**Lesson Vocabulary:**

*Macroinvertebrate* – an insect (invertebrate) that is large enough to be seen without the assistance of a microscope

*Dichotomous Key* – a method for categorizing and identifying different taxa using logical choices

*Habitat* – the type of area where a species lives

*EPT Index* – the quantity of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The EPT Index is based on the premise that high quality streams usually have greater numbers of these taxa than low quality streams.

**Materials Required:**

Net to collect aquatic insects (1 per student or per group)

- nets improve sample collection greatly but picking up rocks works as well if nets are not available

White trays to view insects (1 per student or group)

Rulers with mm for measuring insects (1 per student or group) – for extension exercise

Magnifying glasses for viewing (1 per student)

Waders (if the water is too cold for wading in wading shoes)

**Preparation (<5 minutes)**:

Organize all of the equipment along the river so that students can quickly get in the stream when it is time.

**Safety Information:**

In addition to your school and district's field trip policies, review the following rules with the students before walking to the stream. These are as follows:

- Stay in your group **at all times.**

- Stay within sight and sound of a group leader (never go where someone can't SEE and HEAR you!) at all times.
- Do not go into the stream without proper footwear (in the summer this can be wading shoes and in cooler streams or in colder weather waders should be used; sandals are poor because feet can be cut by glass and flip flops generally get lost).

**Engagement**:
Upon approaching the stream, ask the students to identify some of the plants and animals they observe living around the stream (if someone mentions an animal that could live around a stream but isn't observed, remind them that they are correct in thinking that the creature could be around a stream, but scientists try and make hypotheses based only on what they observe). Ask them how streams differ from lakes and ponds. Tell them that this activity will focus on aquatic insects, also known as aquatic macroinvertebrates. Ask the students why they think it might be important to collect and analyze aquatic macroinvertebrates. Explain to them that collecting macroinvertebrates is important for understanding water quality, how much food there is for fish and that many aquatic insects have a terrestrial stage that is food for birds.

Tell the students that just like zebras need live in open grasslands and whales live in the oceans, different organisms in a stream live in different habitats. Today, we are asking two questions. First, is there a pattern in the type of habitat where stream insects live? Second, do different habitat types have different sized insects? Encourage them to look at the habitat variables they will analyze for ideas.

In order to determine what habitat which species prefer, you need to be able to identify the different taxa. Explain that a dichotomous key is a chart used for identifying organisms. Mention here that the key can be developed to identify anything. As an example, create a dichotomous key with the students (use the dichotomous key handout and see list of attributes, for example, for identifying styles of shoes).

**Exploration:**
Review what kinds of insects the students should expect to find in the stream on the data sheet, and how they can use the key to identify what groups they are in (using the dichotomous key).

Demonstrate to the students how to record data on the environment, collect and evaluate samples, and finally how to record the data.

Divide the students into groups of four. Students will rotate between the following positions: official sampler, official recorder, and two sample evaluators.

*Official sampler* - takes the sample that the group will analyze for that particular site
*Official recorder* - records all the data for that particular site
*Sample evaluators* - analyze sample for macroinvertebrates. All recorded values will be the average of what the two sample evaluators saw for that site.

Tell the students that they need to choose an area along the stream between the upper boundary and lower boundary (determine the boundaries based on line of site and the condition of the stream). The area for sampling should be easily accessible and have a range of substrate varieties and sizes (small pebbles, sand, large rocks, or woody debris). Have the students come up with a hypothesis for the driving factors that influence the quality of habitat for macroinvertebrate (choose two types of habitat to compare). Tell the students that they will analyze the data when they return to the classroom, so they need to collect really good data. The students must collect data from at LEAST TWO sites.

Remind the students that recording absences (zeros) can be just as important as recording the number of organisms that are there.

**Explanation:**
Scientists can learn a lot about a stream from the types of insects that are present. Generally, the three insect groups that are dominant in streams with low nutrient levels, high water quality, and a healthy stream are Ephemeroptera, Plecoptera, and Trichoptera (known as the EPT index). The group Diptera is found in most habitat types but are typically in higher abundances in streams where there are higher nutrient levels, lower water quality, and a stream of poor health. How do your data line up with these common assumptions? Although the presence of the E, O, T taxa typically indicate the health of a system, it does not always.

Have the students discuss as a class about what kinds of organisms they found and where they found them.

Did you find any differences in what types of organisms were present in different habitats?

**Extension:**
Body size can be a very useful tool in looking at organisms in relation to their habitat and their nutritional requirements of the ecosystem.

In terms of an organism's relationship with its habitat, ask the students if they think that an environment has a relationship with an organism's length? Can the class come up with an answer to the question, why are insects in streams so small? *Perhaps, they live in very small habitats such as on the sides of rocks or in the sediments*. Is that a similar reason why giraffe necks are so long? *The food source they like, in the habitat they live in is very high*. Discuss briefly in your class if you can describe a mechanism that would act on organisms over time and result in a species fitting that habitat. Does this mechanism sound like evolution?

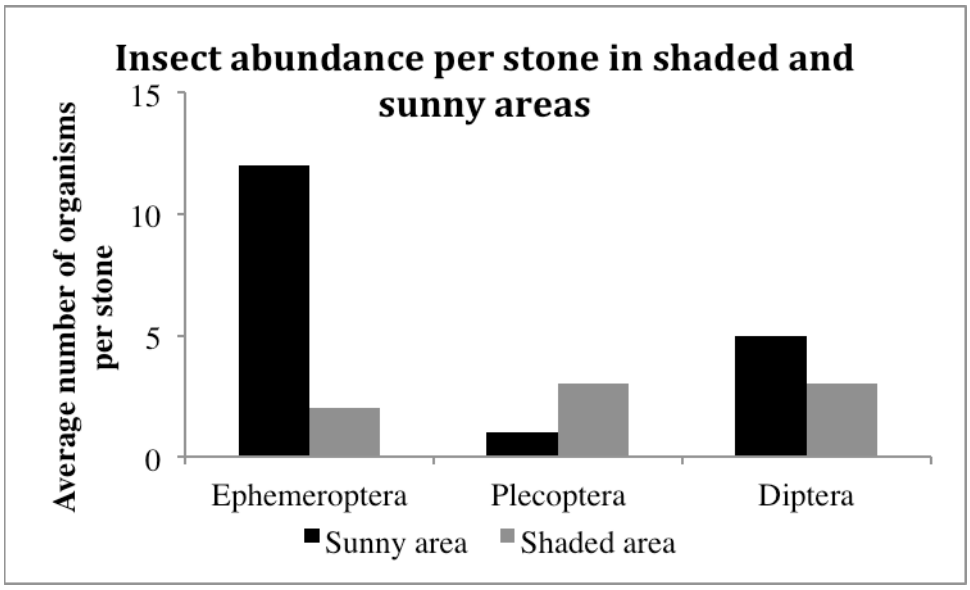
**Evaluation:**
Choose a variable that you evaluated, construct a simple summary table for your data for three taxa and graph it (see below for a model).

Example summary table:

| | Sunny area | Shaded area |
|---|---|---|
| Ephemeroptera | 12 | 2 |
| Plecoptera | 1 | 3 |
| Diptera | 5 | 3 |

If you have the available software to graph the data in the table, have the students make a bar chart of their data so they can easily visualize similarities and differences between habitats.

Example bar chart:




**Wrap up**:
Ask the students if they think they were successful in answering the following questions. Was the class able to identify different habitat types? Were these differences in community composition different in different habitats? Ask the students to link their knowledge of organisms and habitat and apply it to their stream. Is it a healthy stream or an unhealthy stream? What if you found a stream with lots of Ephemeroptera, Plecoptera, and Trichoptera, would that be a healthy stream? What about a stream full of Diptera?

**Macroinvertebrate Sampling Sheet**

Student 1:_____ Student 2:_____
Student 3:_____ Student 4:_____
Date:_____ Weather_____
Air temperature_____ Water temperature_____
Habitat factor that they think is most important for determining macroinvertebrate communities (e.g. rock size, substrate variety, speed of the water)_____

Site Number 1

What does the surrounding area look like (e.g., forested, grassy, houses)_____

Is the sampling site shaded?_____
What is the speed of the water (fast, medium, slow, not moving)_____
What is the substrate (bottom material) size being sampled_____
What is the material being sampled (rock, gravel, wood)_____
Other notes on this site_____

| Macroinvertebrate Type | Average Size (mm) | Tally of individuals |
|---|---|---|
| Ephemeroptera (mayflies) | | |
| Plecoptera (stoneflies) | | |
| Trichoptera (caddisflies) | | |
| Diptera (fly larvae) | | |
| Odonata (dragonflies) | | |
| Coleoptera (beetles) | | |
| Worm like (worms) | | |
| Other | | |

Site Number 2

What does the surrounding area look like (e.g., forested, grassy, houses)_____

Is the sampling site shaded?_____
What is the speed of the water (fast, medium, slow, not moving)_____
What is the substrate (bottom material) size being sampled_____
What is the material being sampled (rock, gravel, wood)_____
Other notes on this site_____

| Macroinvertebrate Type | Average Size (mm) | Tally of individuals |
|---|---|---|
| Ephemeroptera (mayflies) | | |
| Plecoptera (stoneflies) | | |
| Trichoptera (caddisflies) | | |
| Diptera (fly larvae) | | |
| Odonata (dragonflies) | | |
| Coleoptera (beetles) | | |
| Worm like (worms) | | |
| Other | | |

Site Number 3

What does the surrounding area look like (e.g., forested, grassy, houses)_____

_____

Is the sampling site shaded?_____

What is the speed of the water (fast, medium, slow, not moving)_____

What is the substrate (bottom material) size being sampled_____

What is the material being sampled (rock, gravel, wood)_____

Other notes on this site_____

| Macroinvertebrate Type | Average Size (mm) | Tally of individuals |
|---|---|---|
| Ephemeroptera (mayflies) | | |
| Plecoptera (stoneflies) | | |
| Trichoptera (caddisflies) | | |
| Diptera (fly larvae) | | |
| Odonata (dragonflies) | | |
| Coleoptera (beetles) | | |
| Worm like (worms) | | |
| Other | | |

Site Number 4

What does the surrounding area look like (e.g., forested, grassy, houses)_____

_____

Is the sampling site shaded?_____

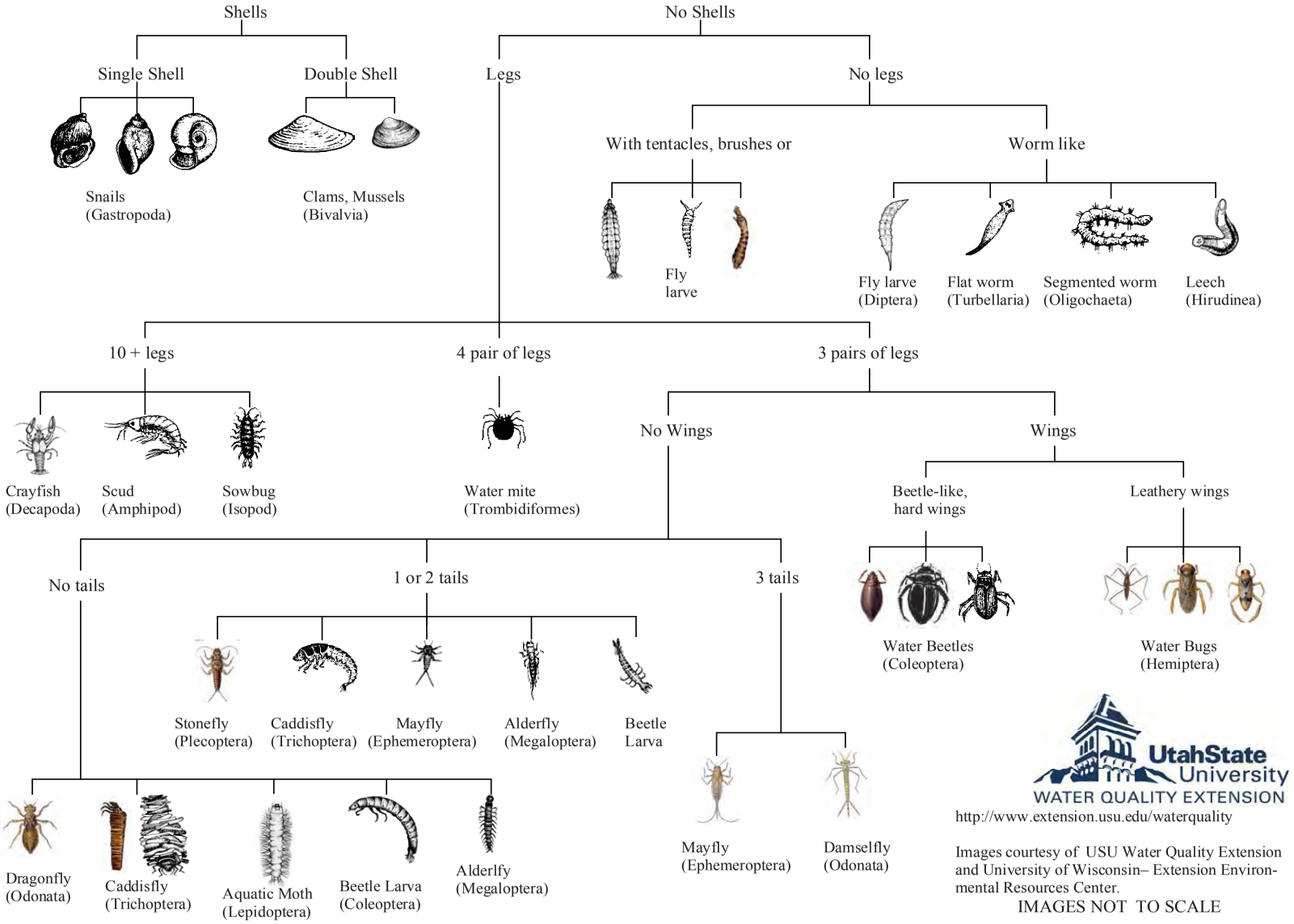
What is the speed of the water (fast, medium, slow, not moving)_____

What is the substrate (bottom material) size being sampled_____

What is the material being sampled (rock, gravel, wood)_____

Other notes on this site_____

| Macroinvertebrate Type | Average Size (mm) | Tally of individuals |
|---|---|---|
| Ephemeroptera (mayflies) | | |
| Plecoptera (stoneflies) | | |
| Trichoptera (caddisflies) | | |
| Diptera (fly larvae) | | |
| Odonata (dragonflies) | | |
| Coleoptera (beetles) | | |
| Worm like (worms) | | |
| Other | | |

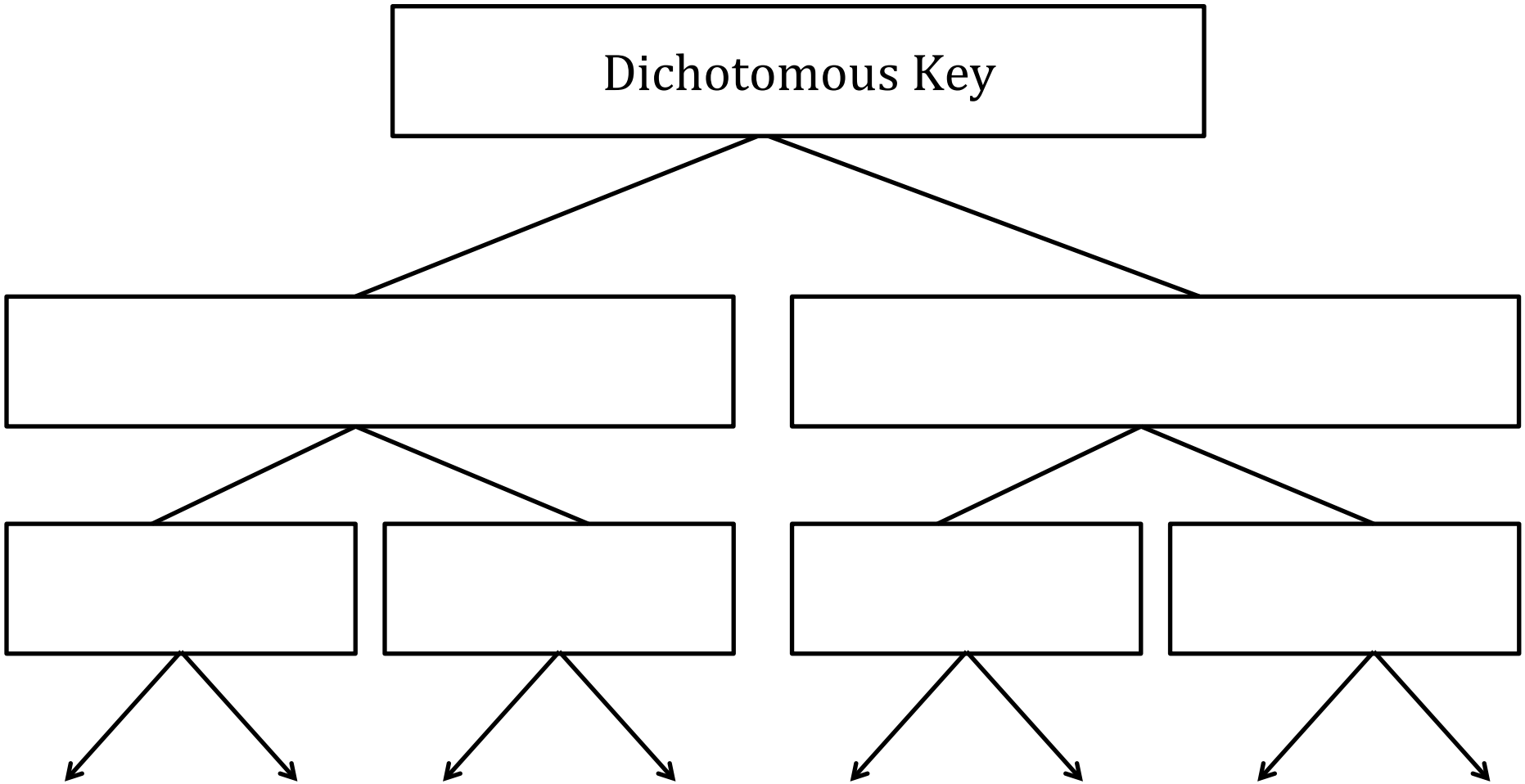



UtahState University
WATER QUALITY EXTENSION

http://www.extension.usu.edu/waterquality

Images courtesy of USU Water Quality Extension and University of Wisconsin– Extension Environmental Resources Center.

IMAGES NOT TO SCALE


Dichotomous Key

**Developing a Dichotomous Key Based on Shoe Types**

**Attributes to work through for key to shoes** (may want to do this for only four or five shoes in a group for sake of time)

Attributes that can be clearly split
Laces vs. no laces
Boots (greater than X inches high) vs. non-boots
Dominant shoe color
Straps
Rounded toe vs. not rounded toe
Open toes vs. non-open toes
Swoosh vs. no swoosh

Example to be printed out and filled in for each group

Because students tend to wear similar shoes for the field trips, it can be easier to choose animals to go through the key (think very different groups of animals like elephants, moose, lions, salmon, hawks, and bumble bees).