Investigating Stream Salamanders

Background:

There are 20 frog species and 21 salamander species who call parts of Maryland home. These amphibians are similar to birds and mammals in having a vertebra (a backbone), but differ in that they are cold blooded. Cold blooded, or ectothermic, animals don't create their own warmth, but instead assume the same temperature as their surroundings. An amphibian's metabolism behaves similarly, and they are therefore more active during warm times of the year. A happy side effect of this is that they don't have to eat nearly as regularly as warm blooded animals. In fact, some amphibians only need to eat on several warm nights during their active season. One extreme example of this is the spadefoot toad, which can remain buried in the ground for several years before it emerges during or after a heavy rainfall. With only a few exceptions, amphibians are inactive during cold and dry environmental conditions. They don't have any protection from the weather like feathers or fur, so they are limited in where they can live depending on the combined conditions of temperature and moisture in the environment. This sensitivity to the weather leads to challenges with monitoring these animals. While they may be active and easy to find when conditions are optimal, they may be much more difficult to find when conditions aren't perfect – even when they are present in the environment.

Amphibians live in a wide variety of habitats but most do need some aquatic habitat for at least part of their yearly life cycle. Amphibians typically lay their unshelled eggs in water and often have an aquatic larval stage before transforming into a terrestrial adult. Throughout their lives amphibians have moist skin across which chemicals can easily pass. They are very vulnerable to harmful chemicals in their environment. Each individual may encounter chemicals and other pollutants in water, on land, and in the air throughout its lifetime. Amphibians are considered sensitive environmental indicators and will often be the first animals to be affected by a change to the environment. Stressed habitats with poor water quality may not be able to support amphibians, no matter how healthy the rest of the habitat appears to be.

Because of their habitat needs and unique adaptations, most amphibians are good indicators of the health of an ecosystem. When looking specifically at the health of a stream, stream salamanders are a good choice of animal to observe in smaller watersheds. Stream salamanders are relatively abundant in healthy ecosystems and fairly easy to find. These animals respond to multiple stressors on the environment so they can indicate when any part of the stream ecosystem is unhealthy. Many salamanders take years to fully mature, often spend their entire lives within 1,000 feet of where they were born, and some are more tolerant of pollutants than others. That means that when you find an animal that is especially sensitive to pollution, you can draw some conclusions about the surrounding habitat. Maryland Department of Natural Resources biologists are using stream salamanders as clues and counting how many of which type of salamanders they can find in different streams, to make an assessment on the health of the ecosystem.

Salamanders are fascinating animals to observe simply because of their unique adaptations and survival strategies. However, populations of these amazing creatures are shrinking around the world and scientists don't entirely know why, although many suspect climate change may be at least partly to blame. As the patterns of rainfall and temperature change around the world, animals that rely so heavily on external conditions may be particularly vulnerable. The increasing amount of human development in watersheds is also affecting salamander populations. Students and other citizen scientists in Maryland can help find answers by monitoring the number and species of salamanders they find in their local streams and reporting their findings on Maryland.Fieldscope.org. This can assist scientists in understanding exactly what is happening to these animals and how they can be helped.

References and Resources:

1. Partners in Amphibian and Reptile Conservation, "Habitat Management Guidelines for Amphibians and Reptiles of the Northeastern United States." Technical publication HMG-3, 2006.
2. Scientific American, "Salamanders slipping away, global warming may be to blame." John R. Platt. 2009 http://blogs.scientificamerican.com/extinction-countdown/2009/02/12/salamanders-slipping-away-global-warming-may-be-to-blame/

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Engage: Watch this video on how a wood frog copes with freezing winter temperatures.

Freezing North American wood frogs: https://www.youtube.com/watch?v=Fjr3A_kfspM

- Ask students to read the following article titled "Body Temperature Regulation" from a Cornell University Blog for medical students. The article describes the difference between ectothermic, endothermic and intermediate thermoregulation strategies. http://www.biog1445.org/demo/04/bodytempregulation.html
- Ask students to write a brief description of the differences between an ectotherm and an endotherm as well as between homeothermic and poikilothermic species. Ask students to identify how which category amphibians fall into and how the thermoregulation strategy they employ is a good choice for these animals.

Explain:

- Share with students the background information for them to read or this article from the Virginia Cooperative Extension, "Sustaining America's Aquatic Biodiversity – Salamander Biodiversity and Conservation" by David Bishop and Carola Haas, Department of Fisheries and Wildlife Sciences, Virginia Tech : http://pubs.ext.vt.edu/420/420-528/420-528.html and ask students to answer the following questions:
  - What role do these animals play in the forest and stream ecosystem?
  - How are these animals vulnerable to habitat changes?
- Additional reading resources:
  - Scientific American - Amphibians in U.S. Declining at "Alarming and Rapid Rate."
  - Scientific American - "Salamanders slipping away, global warming may be to blame."

Explore:

- Assign students (or allow them to choose) 1 each of the 8 salamander species they will be investigating, making sure that at least a couple of students are investigating each salamander species. These are: 1. northern red salamander, 2. eastern mud salamander, 3. northern spring salamander, 4. northern two-lined salamander, 5. long-tailed salamander, 6. northern dusky salamander, 7. Allegheny mountain dusky salamander, and 8. seal salamander.
- Give them the Maryland DNR website: dnr2.maryland.gov/wildlife/Pages/plants_wildlife/herps/Fieldguide_OrderCaudata.aspx and/or the appropriate page from the Salamander guide: www.dnr.state.md.us/streams/pdfs/HerpKeyForWeb.pdf and complete worksheet #2.

  Ask students to answer the questions on the **Species Investigation Worksheet** attached.
- Project this map up on a Smart Board: http://www.freeusandworldmaps.com/images/US_Counties_Maps/MarylandCounty.jpg. Have students come up and shade in the area where the salamander they investigated is found in Maryland.
- As a class, hypothesize on which salamanders you think you will find when you search your stream based on your combined map.
- Ask students why biologists need their help. Answer: Biologists can't possibly monitor every stream in Maryland. Citizens and students like themselves can help scientists learn more about what's happening in the natural world by sharing information.
- Follow **Salamander Investigation Procedure** and conduct salamander search.

Evaluate:

- Have students relate their findings back to their prediction and answer these questions as a group:
    1. Was our hypothesis supported?
    2. Were there any surprises? Did we find species we didn't think would be there according to the historical ranges of the species?
    3. Did we fail to find species we thought we should have found?
    4. If the answer to either question 2 or 3 was yes, ask students to explain why they think this might be.
- As a class, enter your data onto Maryland.Fieldscope.org and filter your search according to others who have entered data on salamanders. Do their findings fit where they should on the map you created?
- Use the watershed map on maryland.fieldscope.org to map out the size of the land that drains into the stream you are investigating. Using the draw tools, determine the amount of impervious surface in your watershed.

  The % of impervious surface in your watershed is _________.

    1. Scientists believe that impervious surface in the watershed can have negative impacts on streams. When a watershed reaches 5 % or greater impervious surface, scientists have seen evidence that salamanders and other sensitive animals begin to decline in numbers. If your watershed is made up of less than 5 % of impervious surface and you did not find the anticipated number and species of salamanders, your stream may be showing some evidence of impacts other than urbanization. Possible impacts on finding salamanders include: Weather, pollution, climate change, road salt, and stream channelization. Do you believe that any of these situations may apply to your stream? If so, why and how is your stream being impacted?
    2. Were there other obvious signs of poor habitat for stream salamanders? If so, what were they?
- Determine what your class could do to improve the stream habitat (such as litter clean-up, storm drain stenciling, other action projects).

Extend:

- Read: Salamander's Hefty Role in the Forest from the New York Times. This is an article written by Richard Conniff that identifies a new reason to monitor salamander populations. http://www.nytimes.com/2014/04/08/science/salamanders-hefty-role-in-the-forest.html?_r=0
    1. Have students describe 3 reasons why salamander populations should be monitored.
    2. Ask students if they believe salamanders are being impacted more by land use in their stream or by climate change based on the article and evidence from their stream.

Stream Salamander Investigation

Materials:

- 4 or more clear plastic containers with fresh water and lids. Label the bins each with a number from 1 – 4.
- Large aquarium nets (4” X 6”)
- Identification materials: dichotomous key and photos
- Digital cameras
- Measuring tape or measuring wheel
- Stakes or pins and brightly colored tape

Preparing the search area:

1. Identify an appropriate 75 meter stretch of stream reach. Make sure the area you want to sample includes the same stretch of stream where you have done all your other measurements. This length of stream should include a good riffle and safe access into the stream. Searchers will not be walking in the water, but along the damp portions of the bank.

2. Measure out the 75 meter stream reach along the edge of the water in the stream. Use a Trundle (measuring) wheel or a surveying tape to accurately measure the stream. **Do NOT** simply measure 75 meters in a straight line, but **DO** follow the meandering of the water in the stream following the deepest part of the channel. Mark the beginning and end of this 75 meter stretch with pins and/or brightly colored tape on both sides of the stream bank. Also place a stake at the 25 m mark and the 50 m mark.

3. Lay out containers of stream water along the search area to place the salamanders in once they have been found. The #1 bin should be placed at the 0 m point, the #2 bin at the 25 m point, #3 at the 50 m, and #4 at the 75 m point. The containers should have about an inch of water in them and have sides that are at least 3 inches tall with a lid so the salamanders cannot crawl out.

4. Fill out the **Environmental Conditions** portion of the data sheet.

Directions for salamander search:

1. Search any suitable habitat between the water portion of the actual stream and any part of the bank that is slightly damp. The search should focus on cover objects - cobbles, small boulders, logs, and other objects like “safe” trash where sufficient moisture is present. During the search, **all suitable cover adjacent to the site should be carefully turned over and then returned as closely as possible to the original position**. In some streams, suitable cover can extend several meters from the edge of the stream before the habitat is completely dry and unsuitable.

2. All participants should **begin** and **end** at the same time. How long they search is up to the educator but 15 minutes of searching is usually sufficient.

3. After finding a salamander, place it into the nearest container of water, secure the lid, and then resume searching. Do **NOT** stop to identify the salamander at this time. Please make sure to pick up and hold salamanders the correct way. A small salamander should be held cupped between two hands or in a net. A larger salamander should be picked up and carried by grasping it in the middle of its body with one hand and using the other hand to support the body from underneath.

4. Search individually or in pairs along the stretch of 75 meters on both sides of the stream bank.

5. Search continuously for the designated period of time without stopping.

6. When the search is finished, record how many people searched and the length of time they searched on the data sheet.

7. Ask participants to bring their containers with the found salamanders back to a flat area by the stream where all can gather and identify the salamanders using the dichotomous key, fact sheets, and other resources.

8. Complete the rest of the data sheet.

9. Return the containers of water to their positions at the 0, 25, 50, and 75 m points and **return the salamanders to as close to where you found them as possible**.

10. Submit your data sheet to the Maryland DNR.

Name___________________________________

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Stream Salamander Data Sheet

Environment conditions

1. a. Date: ______________________________ b. Time of day: ____________________
2. a. Temperature of water_________________ b. Temperature of air: ______________
3. Humidity _____________________________

Measuring point	Width of the water in the stream channel	Stream depth at deepest point	Width of damp area on Right bank (looking upstream)	Width of damp area on Left bank (looking upstream)
0 meters				
25 meters				
50 meters				
75 meters				
Average				

4. Describe the riparian area on both sides of the stream:

____

____

5. Identify any other environmental conditions that might influence your results:

____

____

Salamander Search:

Search hours:

1. Number of students ____________.
2. Each student searched for __________ minutes.
3. Multiply the number of students by the number of minutes they searched:

_______________ X ________________ = _____________________

Number of students   Minutes searched   Total minutes of search

4. Divide the total minutes of search by 60 minutes (1 hour) to determine the total number of hours in the search:

__________________ ÷ _____________________ = _____________________

Total minutes of search   60 minutes   Number of hours in search

Habitat Type Searched:

Put an **X** next to each habitat that was included in your search:

_____ Seeps, springs, or wetlands entering the stream from surrounding floodplain
_____ Beneath damp cover objects such as rocks, logs, bar, and vegetation
_____ Under or between larger, flatter rocks with spaces underneath
_____ Beneath safe human refuse such as boards, shingles, and tarps/pieces of plastic
_____ Beneath leaf littler and buried in dark/oxygen-rich mud
_____ Among or under small rocks and gravel

Salamander identification

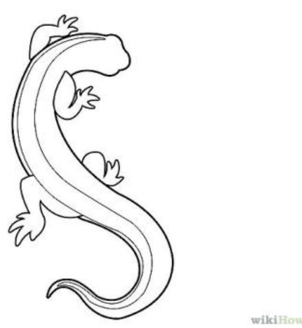
Have students use the dichotomous key and pictures to identify each salamander.
Take a picture of each salamander found.
Record the species and total number of animals found:

Species Name	Number of specimens	Picture #'s

Stream Index of Biotic Integrity:

Poor – No Salamanders
Fair – Only two-line salamander
Good – Any stream salamander species besides two-line
Excellent – Two species of salamanders other than two-line OR three species of salamanders including two-line.

Stream Rating: ______________________

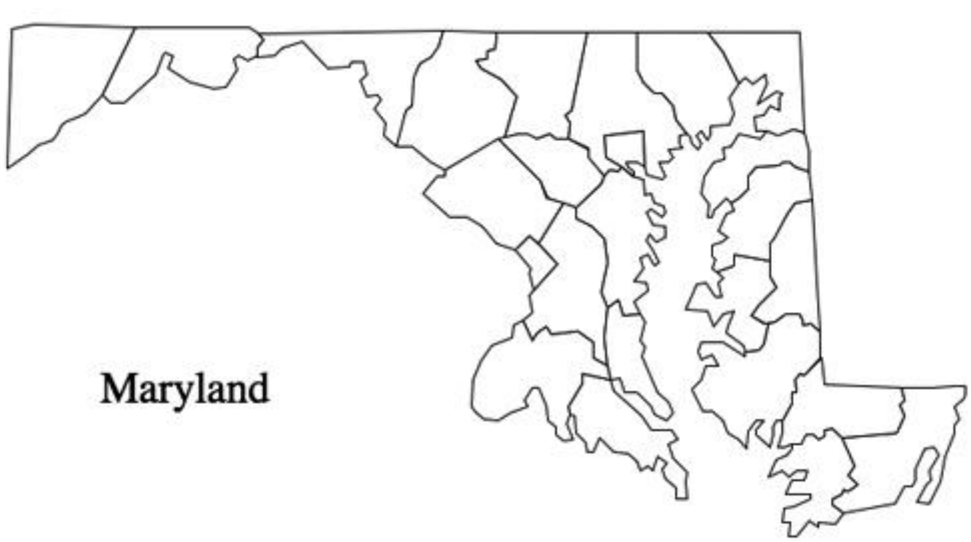


Name________________________________ Date_______________

Salamander Species – Classroom Investigation

Choose one of the following species of salamander: 1. **northern red salamander**, 2. **eastern mud salamander**, 3. **northern spring salamander**, 4. **northern two-lined salamander**, 5. **long-tailed salamander**, 6. **northern dusky salamander**, 7. **Allegheny mountain dusky salamander**, and 8. **seal salamander**.

1) Which salamander species are you researching?
____



2) On the map above, color in the range of the salamander you are investigating.

3) What size is the adult of this species?

4) Draw a picture of an adult of this species on the back of this worksheet and label distinguishing features.

5) Where and when does this species breed and lay eggs?

6) Where (within the stream habitat) does this species spend its time as an adult when it is not breeding?

7) What are possible limiting factors specific to this species of salamander?

8) Predict whether you think you will find this species in your stream and explain why or why not you think you will find it.

Cornell University Blog article:
http://www.biog1445.org/demo/04/bodytempregulation.html

Body Temperature Regulation

Depending on the source of an organism's body warmth, it may be classified as either an **ectotherm** or an **endotherm**. An ectotherm is an animal that warms itself primarily by obtaining heat from the environment, perhaps by sunning itself. An endotherm is an animal that produces most of its own heat metabolically. Endothermy is more familiar to humans because they, like other mammals, produce their own heat through the metabolic breakdown of food. This heat is mostly a by-product of the inefficiency of the anabolism and catabolism occurring in the cells of the body. (Remember, approximately 60% of the energy stored in food is lost as heat during catabolism.) Of course, practically all endothermic animals depend on environmental heat at some point in their lives. This is a principle well understood by house cats and winter campers (rather unrelated species). All birds and mammals are endotherms. More surprising, organisms such as tuna fish, skunk cabbages, butterflies, honey bees, crocuses, and others regularly warm their bodies to an appreciable extent through the use of metabolic heat.

Ectothermic animals include most fish, amphibians, and reptiles as well as most invertebrates. Many such animals do, however, control body temperature through behavior. The well-known image of the lizard sunning itself on a rock provides a good example. The color, body shape, and the timing of the activities of these organisms all contribute to thermoregulation. Most ectothermic organisms are able to maintain body temperatures both higher and more constant than the air or water around them. Some alpine lizards, for example, can maintain uniform body temperatures 30^{o}C above their surroundings even in winter conditions. Desert lizards can maintain their body temperature to within 0.1^{o}C during the daytime and then control how much they cool off at night by how deeply they burrow. It now seems that all organisms, whether ectotherms or endotherms have at least some adaptations for thermoregulation. Thus the old idea of "poikilotherms" - animals whose body temperature remains equal to that of their surroundings - is outmoded.

A second way of classifying animals is according to whether or not they keep their body temperature more or less constant at all times. Of course, no organism maintains a perfectly uniform body temperature. Humans, for example, tend to have low body temperatures early in the morning and higher ones in the afternoon. However, some animals substantially lower their body temperature on a regular basis. We are all familiar with the winter hibernation of bears and squirrels who can lower their body temperatures considerably while they are hibernating. Other vertebrates, such as some bats and small birds, actually cool off for a period of time each day. This apparently is an adaptation to save energy that is especially important to these animals because of their small size and high metabolic rate. Animals that maintain more or less constant body temperatures at all times are known as **homeotherms**. Organisms such as bears and small birds that allow their body temperature to vary to an appreciable extent on a regular basis are known as **poikilotherms**.

As should be apparent to you by now, there are organisms that can fit into each of the four possible categories created by these two ways of subdividing the thermoregulation of organisms. The following chart summarizes this:

	Endothermic	Ectothermic
Homeothermic	Mostly birds and mammals, although the tuna and some other large fish come close. (Why do you suppose it tends to be large fish that have this capability?)	Some tropical reptiles and possibly dinosaurs come close; of course, this box should include organisms occurring deep in the ocean or even in deep lakes; some pupfish (see below) constitute a good example.
Poikilothermic	Some birds and mammals (those that allow their body temperature to vary during certain time periods) as well as many insects and some other invertebrates.	Most fish, amphibians, and reptiles as well as most invertebrates.

A final question to answer might be: "If endothermy, especially homeothermic endothermy, is so wonderful, why isn't every organism doing it?" One answer might be that it requires a complex set of adaptations and most organisms have not yet evolved them. A better answer is that in fact it's not necessarily a better strategy for many organisms. We tend to think of amphibians and reptiles as being primitive because they are ectothermic. On the contrary, their way of life is superior to that of birds and mammals in many environments. Consider the following fact: birds and mammals perform 80% of their metabolism just to maintain their high body temperatures! This means that the typical bird has committed itself to needing five times as much food energy to stay alive as does a reptile of equivalent weight. For this reason, ectotherms can survive in many habitats and take advantage of many food resources unavailable to the less efficient (from this standpoint) bird or mammal.

Desert Pupfish - Homeothermic Ectotherms

Some pupfish live in the water flowing from desert hotsprings. The spring water may be near boiling point when it first flows from the ground but cools as it flows away. These pupfish maintain very high and very constant body temperatures all year long by regulating where they are in the spring flow. The pupfish shown here is the **Devil's Hole Pupfish**(*Cyprinodon diabolis*), an endangered fish species that lives in a constant temperature spring. See preserved pupfish in the study center demo!