Lesson Plan

Author:	Molly Albecker
Author Affiliation and Location:	East Carolina University, Greenville, NC
Optional Author Website	http://albeckerm09.wix.com/mollyalbecker All resources, worksheets, PowerPoints, and videos can be accessed from my website.
Author Contact Information	albeckerm09@students.ecu.edu
Introduction/Abstract to Lesson Plan	This lesson plan uses real-world ecological dynamics to introduce students to the scientific method. The students will learn the process of observation, hypothesis, experimental design, data collection, and drawing conclusions that support or do not support their hypotheses via a simple, classroom experiment.
Learning Objectives	At the completion of this lesson, students will be able to describe the scientific method, formulate hypotheses, setup an experiment, collect data and plot on a graph, evaluate and interpret results, and make conclusions about the ecological dynamics that amphibians experience in their wetland habitats.
Appropriate Grade Levels	9-12
Group Size/# of students activities are designed for	<30
Setting (e.g. indoors, outdoors, lab, etc.)	Indoor classroom. Egg masses will be collected by the teacher outdoors.
Approximate Time of Lesson	~45 minutes for the initial lesson. It will take approximately 1.5 -3 months for tadpoles to metamorphose with periodic 20-30 minute teaching points.
Resources Needed for Students	Internet access, computer/notebook for taking notes
Resources Needed for Educators	4 Clear Tupperware containers or 4 small aquariums, Frozen spinach (or fish flakes), Dechlorinated tap water or pond water, small aquarium net. Salt, teaspoon, Supplied datasheets for data recording (Found on website). (Optional: scale for weight measurements, water dechlorinator).
Apps/Websites Needed	
Lesson Activity	1. Introduce students to the project using powerpoint (on website). Information on habitat, characteristics, requirements, and life cycle will be introduced. Additionally, the scientific method will be outlined and the experiment's protocols will be introduced and discussed. 2. Have students gather around the egg mass that you collected and engage the class in a discussion based on what they just learned. 3. Set up the experiment with student observation (Protocols in powerpoint). 4. Students should write hypotheses and justify them. 5. Over the next few weeks, students observe the developments and record their observations. 6. Students wait for metamorphosis and date and number that emerge each day (generally, tadpoles metamorph around the same time, within a week of the first). The response variable that we are interested in is the amount of time to metamorphosis. 7. Optional: Have one or two students weigh the metamorphs as they emerge and record the weight of each. This will yield an additional response variable of "weight at metamorphosis". This can be tricky though, as the froglets are very small, difficult to handle, and can be surprisingly jumpy.

	8. Place the metamorphs in a separate, container to be released to a wetland (husbandry techniques outlined below). 9. Enter data into Excel and create a graph using the time to metamorphosis and/or weight at metamorphosis according to treatment. 10. Questions for students: Is there a pattern in the data? What is the pattern? 11. Have students write lab report on the activity. A lab report format sheet and suggested rubric are available on the website.
Final Product	A lab report on the experiment including an introduction (including independent research accomplished by the student), hypotheses, a description of the experimental design, a graph depicting the results (can be excel or hand drawn), and the conclusions with clear assessment of whether or not their original hypothesis was supported.
Assessment/Evaluation	Lab reports can be graded. A suggested rubric for grading is provided in the supplementary materials.
NC Essential Standards	**Bio.1.2.1: Explain how homeostasis is maintained in the cell and within an organism in various environments (including temperature and pH).** • To maintain homeostasis, tadpoles must maintain a water balance. If tadpoles are placed in a habitat with high solute (hyperosmotic) concentrations, they will need to use energy to actively pump out excess solutes to stay alive. This means that energy that would otherwise be used for growth is used for the homeostatic demands. • How will that affect their weight at metamorphosis and how long that it takes to metamorph? **Bio.2.1.4: Explain why ecosystems can be relatively stable over hundreds or thousands of years, even though populations may fluctuate (emphasizing availability of food, availability of shelter, number of predators and disease).** • Animals face environmental stressors ranging from disease, predators, competition, and food shortages. In each case, animals will adapt or the strongest survive. If only the strongest survive, they will be better able to capitalize on the opportunities by better avoiding predation, exploiting food sources, outcompeting others for resources, and avoiding infection. • What can we infer about a tadpole's ability to endure salt stress? Will they be better or worse off after enduring the osmotic stress? (Answer: depends – they will probably be smaller which may mean fewer breeding opportunities. They may be better able to survive salty conditions as adults however. Emphasize trade-off.) **Bio.2.2.1: Infer how human activities (including population growth, pollution, global warming, burning of fossil fuels, habitat destruction and introduction of nonnative species) may impact the environment.** • We are learning how a "natural" component of ecosystems can affect tadpoles but many ecosystems are laced with various pollutants and chemicals. • Discuss: What about human caused pollutants- How might the principles we learned in this lesson help us understand how tadpoles are affected by pollutants and other introduced chemicals? **Bio.3.2.3: Explain how the environment can influence the expression of genetic traits.** • As tadpoles are under osmotic stress, they will up-regulate the transcription and translation of genes that code for sodium-potassium pumps. Since the gills are the primary sites of excess solute excretion, they can increase the numbers of sodium-potassium pumps in the cells that comprise the gill tissues to help get rid of excess salts. **Bio.3.4.2+Bio.3.4.3: Explain how natural selection influences the changes in species**

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over time, and how various agents can influence natural selection.

Questions for discussion: How might salt stress influence the natural selection of the tadpoles in that salt-invaded habitat?
Answer: To adapt to this environment, tadpoles must be able to excrete the excess salt. Some individuals may have an adaptation that allows them to excrete the salts with very little energetic cost. Therefore they may have more energy to acquire food, grow, escape predators, and metamorphose. Therefore, these individuals may have higher rates of reproduction and therefore pass the advantageous adaptation to its offspring (assuming it is a heritable trait).

Bio.4.1.2+Bio.4.2.2: Summarize the relationship among DNA, proteins and amino acids in carrying out the work of cells and how this is similar in all organisms, Explain ways that organisms use released energy for maintaining homeostasis (active transport).

A portion of the DNA code is translated and transcribed into the amino acids that make up the sodium-potassium pumps (proteins). These active transport pumps are crucial to maintain a proper osmotic balance in all living organisms, including humans. They do require the use of energy that is released from ATP (<u>A</u>denosine <u>T</u>ri<u>P</u>hosphate).

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<tr><td>Next Generation Standards</td><td>
HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Maintaining osmotic balance is a fundamental process in maintaining homeostasis. This experiment highlights osmotic stress and the costs associated with actively maintaining water balance.

HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

As discussed before, this experiment may demonstrate that some individuals are better able to tolerate the osmotic stress of a salty larval environment. If these differences are genetic and heritable, the individuals may produce the next generation of tadpoles that can handle osmotic stress better than others and capitalize on resources.
In their lab reports, students should indicate a basic understanding of these principals but also understand that natural selection involves a tradeoff between energetic demands (osmotic balance vs. growth). The particular environment will dictate which particular strategy is more adaptive (salty environments will likely select for ability to regulate osmotic balance well, while other environments may select for the ability to grow fast and metamorphose quickly to escape predation or a food-starved larval habitat.)

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Images:

Egg mass pictures:

Sample aquaria:

Notes:

Egg mass collection: Around the end of February, frogs will emerge from hibernation and begin to breed. The easiest method to find a wetland first involves finding a productive wetland. To find one, drive around and listen for frogs on a warm, rainy night (no need to get wet, just listen from the car!). Frogs are eager to breed and will lay eggs in water-filled roadside ditches, tire ruts, ponds, and swamps. You will have a high likelihood of finding egg masses the next morning if you heard a chorus in that location the night before. Look for gelatinous clumps with black dots in the center (see pictures above). Egg masses float on the surface or may be attached to branches/plants near the surface. Dip your container below the egg mass and scoop it up with water. Try not to shake or disrupt the egg mass.

Tadpole care: Tadpoles are very easy to maintain which makes this an ideal classroom “pet” and activity. Tadpoles feel very vulnerable out in the open and would love some hiding places in their tanks. A few rocks/leaves from outside will be excellent. Since they are cold-blooded, placing them in a sunny window location will help keep them warm. After hatching (~2-7 days) they will feed for a couple days on remaining yolk (during this stage they will be immobile) and will begin foraging after they start to swim freely. Depending on the species that you collect, they may take between 1.5 months to 3 months to fully develop. They can feed on boiled spinach (thaw from frozen) or fish flakes (feeding should be standardized between the tanks to avoid confounding your results). They do not need extra oxygen into the water as they can gulp air if necessary. Froglets will sprout back legs first and will remain bipedal in the water for several days until the front limbs emerge. They will climb out of the water and onto the side of the tank and begin to reabsorb their tails in the final stages of metamorphosis. It would be ideal to pull these individuals out and place them in a separate container lined with a moist paper towel. These frogs are now ready to be released back to the wild, and should be kept in a moist container until you return them to the wetland. They will not eat for a couple days after emerging but prompt release is best.

Note:

1. There is a chance that the egg mass you collect will not develop as fertilization is external and not always successful.
2. Be careful about allowing students to touch the tadpoles/frogs as they are very small and fragile. Frog skin easily tears and limbs are easily broken.
3. If the water becomes dirty and you decide to change it: if you use tap water, be sure to dechlorinate it first (dechlorinators are available at any pet store). Untreated pond/lake/wetland water can be also used to replace/supplement the water in the aquarium.

Appendices:

Suggested Lab Report Grading Rubric: 25 possible points.

Points	Introduction	Experimental Design	Results	Conclusion/Discussion	Grammar and Spelling
5	Well researched, excellent comprehension of material, hypothesis clearly stated	Students relate design to specific question. Protocols outlined clearly. Students show understanding of experimental concepts like standardization, replication, etc.	Students have labeled, legible graph of correct data with figure caption that explains graph and data.	Students demonstrate comprehension by linking results back to original hypothesis (i.e. Original hypothesis was supported or not). Students discuss natural selection implications of osmotic balance using their results.	<3 errors
4	Decent background, moderate understanding, hypothesis clearly stated	Students detail experimental design but do not link to hypotheses. Protocols outlined. Some understanding of experimental concepts.	Neat and clean graph with correct data. Graph has figure captions but no axis labels.	Students link results to hypothesis but do not clearly state whether they hypothesis was supported. Some discussion of implications towards natural selection.	<6 errors
3	Some background, little understanding, hypothesis mentioned	Students poorly communicate experimental design, protocols barely mentioned, little understanding of experimental concepts.	Graph does not have proper data or mixed up axes. Graph is missing labels or figure caption as well.	Students do not link results to hypothesis, merely restate methods and results. Little or no discussion of broader concepts.	<9 errors
2	Little background information, little comprehension of the topic, no hypothesis	Experimental design is protocols only with no indication that students understand reasoning behind the design or its relationship to hypothesis.	Graph is incorrect data, lacks axis labels, figure captions, etc.	Students repeat previous sections with zero discussion of implications or relationships.	<12 errors
1	No background research, very little comprehension, no mention of hypotheses	Experimental design is a picture or diagram with little or no text explaining protocols. Hypothesis not mentioned.	Graph is illegible or absent.	Students demonstrate little understanding, do not link the sections together, do not make any broader inferences on work.	>13 errors