

Astrobiology Lab –Life in the Universe

This assignment is an alternative to the written exam described in your syllabus. The goals of this astrobiology lab are: (1) for you to learn how to design, carry out, and interpret results from a scientific experiment, (2) to learn about reviving dormant forms of life under various extreme conditions and, (3) to think about the results in the greater context of life elsewhere in the Universe. I don't think this lab is going to take you very long to do, but it is important that you put some careful thought into it before you begin. I think it should be fun too!

The astrobiology assignment is described below. You should work in groups of *two to four* on this project (no more). If you are not able to find group partners, let me know, and I will try to play matchmaker. Each group member will receive the same grade for this lab. You should turn in one (1) final lab per group. Please do not procrastinate in designing and carrying out your experiment(s). You might choose to make several attempts, or take days to finish an individual experiment. You should have plenty of time to do a good job on this lab if you do not procrastinate.

The assignment

Your assignment is the following: (1) Design a scientific experiment to examine the effects of some kind of extreme conditions on the revival and/or survival of dormant life forms; (2) Carry out your scientific experiment, recording your observations; (3) Discuss your results in terms of your hypothesis; and (4) Discuss your results in the broader context of astrobiology.

Your equipment

Each group will receive Sea Monkey Instant Live Eggs and Sea Salts. You can divide up your eggs for however many samples you need for the experiment (you could easily divide it up into 6 or more samples). Sea monkeys are brine shrimp (*Artemia* sp.) which reproduce in one of two ways: either through fertilized eggs developing directly into live (swimming) offspring or by eggs becoming cysts (dormant eggs). Brine shrimp live in salty water under a range of conditions. I also will have some pH test strips available if you would like them. Any other materials you need you will have to find yourself.

In the packet you will find dehydrated brine shrimp cysts - these are eggs that are dormant and can remain inactive for a long time. Living brine shrimp can withstand a relatively wide range of conditions, and cysts can survive an even bigger range of temperatures, pressures, salinities, chemicals, and moisture. As such, Sea Monkeys turn out to be a very interesting analog for doing astrobiology experiments to understand how living creatures can survive extreme conditions.

The scientific method

You need to follow the scientific method in constructing your lab. Recall from your book (p. 77) that the scientific method has some important steps: (1) Identify a question; (2) create a hypothesis; (3) design an experiment to test your hypothesis; (4) predict your result; (5) conduct

your experiment; (6) observe your results; (7) draw conclusions about your hypothesis; and (8) re-ask your question, create a new hypothesis, and design and perform a new experiment, as necessary. In a well-constructed experiment, you might have two (or more) groups whose conditions differ only by 1 significant factor, the factor you are examining (see the example in the next paragraph). In this ideal case, you would have a *control group* in which you apply the "normal" conditions and one or more *experimental group(s)* in which you apply conditions which differ from the control group by only the factor you are testing.

You should follow all of the above steps rigorously for this lab. A good scientific experiment has a very specific question it asks. "How do Sea Monkeys like weird environments?" is *not* sufficiently specific - you need to ask a question for which you can form a hypothesis and about which an experiment can be created. You might therefore ask the question, "How well do Sea Monkeys, in their cyst state, survive at very low pressure?" which is a very specific question. You could then create a hypothesis ("Sea Monkey cysts are not at all affected by low pressures or vacuum.") and create an experiment to test this ("Place half the Sea Monkey cysts in a hypobaric chamber for some amount of time, remove them, and rehydrate them. Rehydrate the other half of the Sea Monkey cysts in the normal way under normal pressure."). You can then carry out your experiment, observe your results, and draw conclusions ("No vacuum-ized Sea Monkey cysts rehydrated. Therefore, extremely low pressures must be quite detrimental for Sea Monkey cysts."). As a final step, you might choose to go back to the first stage with a revised question (perhaps "What is the minimum amount of time that Sea Monkey cysts can spend at vacuum pressures and still have more than 50% of them rehydrate as viable creatures?"). This new question is somewhat more sophisticated than the first question because we have learned something from the first experiment. You could then go back and make a new hypothesis and design a new experiment, and so on ("Divide the Sea Monkeys into several groups. Place the first in the hypobaric chamber for one hour, the second for 10 minutes, the third for ten seconds, and the fourth for no time at all...").

There are many different kinds of experiments to do with Sea Monkeys to test their hardiness against various extreme conditions. One is the vacuum test example above. However, salinity tests, temperature tests, water chemistry, electricity tests, radiation tests, light vs. dark, high pressure tests, rehydrating Sea Monkeys in liquids that include water but also include other material(s), whether or not Sea Monkeys can be rehydrated with Boulder Creek water, and many others. Lots of these could be done with the cysts, the living brine, or both. You can use one of these or come up with your own, but your experiment should have some relevance to astrobiological conditions (defined broadly). You might review the "Life in Extremes" Lecture 16 and Chapter 24 to see what other ideas strike you.

A note of caution: I suggest you think three times about your experiment before carrying it out. You might want to make sure that there is only one difference between your experimental group and your control group. For example: You chose to microwave your Sea Monkeys to test their hardiness against radiation. You placed half in a control group in a glass of water and placed half in an experimental group in a different glass of water, which you then microwaved. You then made some observations and conclusions. It turns out you haven't tested what you think you have! Because when you microwave Sea Monkeys in a glass of water, you in fact have irradiated not only the Sea Monkeys but also the water - in other words, you have tried to rehydrate irradiated Sea Monkeys in boiling water. There are now *two* crucial differences between the control and experimental groups: the experimental group has been irradiated, and it has been rehydrated in boiling water. If all the experimental Sea Monkeys end up dead (not viable), you will not know whether it is the radiation or the boiling water that did them in.

On the other hand, don't be shy. Unless you care a lot about invertebrate cruelty and are opposed to killing dormant brine shrimp in the name of Scientific Research, you may want to choose experimental conditions that are quite extreme. Brine shrimp are known for their hardiness - after all, they are sold, dehydrated, in packets which have a many-year shelf life. A wimpy experiment like rehydrating your experimental group in mildly tepid tap water isn't going to show very much. Be aggressive, be creative, and be rigorous.

Your discussion

You should explicitly state all of the stages of the scientific method you went through in this experiment. Make sure that you discuss what you have learned from your experiment, what questions that leads you to, and what some follow-on experiments could be. Lastly, you should discuss the relevance of your experiment to astrobiology and life in the Universe.

Your *entire typed discussion* probably should be in the range of 3-5 pages or so. Say 1.5 point spacing, 12 point font and don't go over 10 pages. If you are able to record the results of your experiment in some useful way (sketches? plots? digital images?), you should include that in your discussion.

What do we turn in?

You should turn in one assignment per group. You should turn in your *typed* step-by-step description of your scientific experiment, including a description of your results, conclusions, and discussion of the results, as described above.

Divide it into sections that seem fit. I suggest the following: (1) an Introduction saying what question(s) you are trying to answer and why it is important, (2) Methods section describing in detail your experiment, (3) Results giving your major findings, (4) Discussion that talks about what you have learned or proved, if it is what you expected, and what questions or tasks you would do next. *Important:* You also need to include as part of your discussion how/why Sea Monkeys are a good proxy for astrobiology studies and what they tell us about life in extreme environments and life elsewhere in the Universe. This should include a discussion of any places in our solar system or beyond that (currently or in the past) have similar conditions to your experiment. Finally, you should write about what the results of your experiment suggest about the survival of life in those places (dormant or living)?

This should be a formal lab report – meaning in proper English, grammatically correct, and concise yet thorough. We reserve the right to deduct points for lack of these elements.

I do not need any leftover Sea Monkeys and you can keep them for further scientific use. And the specimens can be safely dumped down the drain.

Parting shots

I will be happy to review your experimental design with you if you like before you proceed with the experiment. This is not a requirement, but it might help you crystallize your thoughts.

Don't procrastinate – it will take a couple days for the sea monkeys to hatch.

I will *not* be grading you on the results of your experiment as long as it is a well-conceived, well-executed, well-reported experiment with a stated relevance to astrobiology.

Here is some good information on growing the Sea Monkeys under the recommended conditions:

http://www.sfb.com/product_popup.asp?category=brine&prod=Hatch%20Mix#

<http://www.discoverthis.com/sea-monkey-instructions.html>

Have fun! Good luck and I wish your new family of pets a long and happy life.



TEACHER NOTES:

Brine Shrimp can be cheaply purchased at most any pet store (they are used as fish food). Sometimes you can buy just the eggs or a “Hatch Mix” that includes the sea salt (mostly NaCl with some MgSO₄). You are likely to have pH strips, thermometers, UV lights, and any number of other tools/instruments that the students may need.

The shrimp take a few days to hatch and start out really tiny. I suggest hatching a batch beforehand at nominal conditions to see what they look like and how long they take. These things are really quite easy to hatch under a range of conditions. The student have to figure out a way to quantify their results. It is easiest just to do a qualitative assessment of number of sea monkeys and their size and this is usually sufficient. There are other involved ways to quantify growth but these are probably beyond the scope of the project.

I do this as a take-home lab for undergrads but it could easily be modified to do in the classroom over a week's time. This supervised approach is probably best for younger students.

Students really like this lab and get quite creative. I have had an amazing range of environmental conditions tested and here are some cheat sheet guidelines: The eggs are quite hearty and can survive freezing and even heating up to 150 degrees F. They can be microwaved, irradiated with x-rays, or UVA, UVB, or UVC. They can hatch in acidic (~3 pH) to basic (~11 pH) water and in a variety of liquids other than water (different alcohols for example). The live specimens aren't quite as heart y but can still survive limited ranges of extreme environments.

This is a great lab to teach the scientific method and/or astrobiology concepts.