Lab #8: Sea Monkeys — Astronomy 184L — Life in the Universe

Due 30 October 2009

The goals of this lab are for you to learn how to construct, design, carry out, and interpret a scientific experiment, and to learn about reviving dormant forms of life under various extreme conditions. 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. **This assignment is due by 30 Oct 2009, and you will both turn in a written lab and also give an oral presentation of your results.** You should work with a partner on this project – someone you have not worked with so far this semester. Both group members 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 working on it.

1 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 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.

2 Your equipment

Each group will receive one Sea-Monkey kit. Each kit includes Sea-Monkey Water Purifer, Sea-Monkey Instant Live Eggs, Sea-Moneky Growth Food, and a tiny little spoon. 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: inactive (dormant) forms. Brine shrimp live in salty water under a range of temperature conditions. Lots of animals like to eat brine shrimp (for example, from Lake Abert in Oregen[1]).

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, salinities, 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.

Note: Once you have figured out who your partner will be, come and pick up your Sea Monkeys. Between Friday October 16 and Tuesday October 20, ask Jamie in the main Physics and Astronomy office (right next door to my office) for your Sea Monkeys. (They may still be in the mail, but are coming soon.) After Tuesday, I'll have the Sea Monkeys in my office. Then (or even before), you can start this project: find a partner; start to design your experiment (and consult with me if you'd like); acquire any materials you might need for your experiment(s).

[1] `http://www.oregondesertbrineshrimp.com/`

3 The scientific method

You need to follow the scientific method in constructing your lab. Recall 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) experimental 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[2]. 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....").

I have thought of many different kinds of experiments I would like to do with Sea Monkeys to test their hardiness against various extreme conditions; one is the vacuum test. Lots of other extremophile conditions might spring to your mind – if not, you could come talk to me. I'm also curious about salinity tests; temperature tests; high pressure tests; rehydrating Sea Monkeys in liquids that include water but also include other material(s); tests against radiation; and many others. I've had students be very creative with this lab in the past, testing high pressure, very high temperatures, radiation, etc. You can use one of these or come up with your own, but your experiment should have some relevance to astrobiological conditions (defined broadly).

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,

[2]I chose this example because it seems to me that this might be a difficult experiment for you to actually do, though I would be very interested in your finding a way to do it. I have some ideas, but they involve equipment you are not likely to have at hand (though we do have it in the department). While you are certainly encouraged to think creatively and use equipment that you can get access to around campus, it is not required: you can do this assignment without any fancy equipment. In the example here I have totally invented all the results just for the sake of giving an example – I have no idea what the actual results would be. Maybe you should try to find out!

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 animal cruelty and are opposed to killing dormant brine shrimp in the name of Scientific Research, you may want to chose experimental conditions that are quite extreme. Brine shrimp are known for their hardiness – after all, they are sold, dehydrated, in packets which probably have a ridiculous shelf life. A wimpy experiment like rehydrating your experimental group in mildly tepid water isn't going to show very much. Be aggressive[3], be creative, and be rigorous.

4 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 write-up probably should be in the range of 2–3 pages or so. 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.

5 What do we turn in?

You should turn in one assignment per group. You should turn in your step-by-step description of your scientific experiment, including a description of your results, conclusions, and discussion of the results, as described above. I do not need any leftover Sea Monkeys. You can keep them for further scientific use.

6 Oral presentation

On October 30, each group will give an oral presentation on their experimental design and results, and what they have learned about astrobiology. Naturally, this oral presentation is part of your grade. We'll do these presentations at 3 pm in our normal Friday afternoon room (Room 218).

7 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.

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.

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

[3]Historically, my students have had a very difficult time killing their Sea Monkeys!