Experimental Design

Duration:
1 or several classes

Objectives:
Students will:
- Learn about climate change studies in the intertidal zone
- Learn about experimental design
- Using a given research question create an experimental design

Vocabulary:
Experiment
Controlled testing or investigating to answer a specific question
Scientific Method
A systematic approach to answer scientific inquiries using observations, testing hypotheses, and drawing conclusions

British Columbia PLO's:
Science 6, 7, 8

Background:
In this activity students will read about a scientist and his work examining how climate change will impact the intertidal zone. Given a research question and some general information students will then come up with an experimental design that will test variables related to climate change in the oceans.

Dr Chris Harley and his students at the University of British Columbia are some of the many who are working to understand how climate change will affect the marine world. They are interested in understanding more about how the impacts of climate change will affect intertidal organisms and ecosystems. This way we can do more to protect the areas that will be most negatively impacted by the abruptly changing environment due to global climate change.

Their main areas of research are how changing temperature and pH levels in the oceans will affect the intertidal environment. As the sea surface temperatures of the oceans rise some organisms will thrive in the warmer waters, but many will be pushed beyond their thermal tolerances. Scientists have already observed an increase in water temperatures with this trend predicted to continue. What Dr. Harley and his group are testing is how different organisms will respond to these temperature changes.

Climate change is also having an impact on the pH of the oceans. Naturally the oceans absorb carbon dioxide from the atmosphere. As carbon dioxide has increased in the atmosphere over the last several centuries it has been estimated that the ocean has absorbed as much as a third of it. When CO_2 dissolves into the water it becomes carbonic acid. This increase in dissolved acid in the oceans is causing the pH of the water to decrease, becoming slightly acidic. It is this chemical change that could have major impacts on ocean life. In more acidic waters organisms have been shown to have lower survival and lower reproductive success.

Researchers are faced with the challenge of studying how these predicted changes in temperature and pH will affect marine organisms. Many experiments can be carried out in the lab under controlled conditions with the variables being altered very specifically. After initial observations are done in the laboratory the next step is to take the experiments to the intertidal zone and see if the results are consistent.

To date Dr. Harley and his students have carried out numerous lab experiments that have examined how increasing temperatures and decreasing pH will affect intertidal organisms.

They are now challenged with how to run similar experiments on the intertidal shore to expand their tests to the next level. The idea is to alter the temperature and pH of some of the individuals on the shore, while keeping all the other biotic (predators, competition) and abiotic factors (light, salinity) constant. This lab is more about experimental design than it is about what the results will be.

Materials:

- Lined paper and pens for their materials and methods section
- Blank, unlined paper for drawings
- Pencils for drawing
- Creative juices flowing

Optional

Building materials such as

- popsicle sticks
- glue
- pipe cleaners
- string
- construction paper
- aluminum foil
- scissors
- any other building equipment

Procedure:

1. Together out loud as a class or individually have the students read the *Ocean News* article *Notes from a scientist: Dr. Chris Harley*.
2. Answer any questions about vocabulary or understanding about the article.
3. Have the students summarize what they understand about Dr. Harley's work on paper, either with drawings or writing.
4. Introduce or review the concept of experiments and the scientific method depending on your class. The main areas to cover are: hypothesis, materials and methods, results, discussion and conclusions. For a simple outline of these see the resource section.
5. Explain the class challenge of coming up with an experimental design that would allow Dr. Harley and his students to test how rising temperatures and decreasing pH will affect intertidal organisms that can be carried out on the shore. The challenge is to create some type of design that will create small zones on the rocky intertidal that will test temperature and pH separately, and in another area potentially be combined to test both temperature and pH. See below for a specific list of experimental constraints.
6. Have the students move into small groups where they will review the challenge and begin to design their experimental design. It may be easiest to have them start with a list of what they will to change as variables, and then what are the items that they will need to control on the shore.
7. As the students are brainstorming circulate around and give suggestions and ideas if they are needed. Remind students to focus their ideas and efforts into creating the treatments rather than coming up with a hypothesis.
8. The students will prepare a methods and materials section that is written out and takes into consideration controls, variables, treatments, etc. Also have the groups draw out a plan of their experimental design to help explain it to others.
9. When the designs are complete have the small groups present their designs to another small group. This gives the students an opportunity to share their ideas, and hear other plans, without needing the large amount of time for the entire class to hear everyone's designs.
10. Depending on your goals for the activity have the students hand in their written plans for marking.

11. When the designs are complete ask the students what they found was the hardest part of designing the experiment, and what was the biggest challenge with working in the intertidal zone?

Experimental Constraints:

- Create small compartments in the intertidal area that are easily accessible for observing
- Compartments must be open to organisms to move through such as seastars, crabs, and snails that are part of the natural ecosystem
- Within each compartment you must be able to alter the temperature, either warmer or cooler
- Within each compartment you must be able to increase the pH or decrease the pH slightly but not have it carried off to other areas
- The experimental design can be set up over several different near by rocky beaches
- The experimental set-up needs to be anchored so that it does not drift away at high tide, or moved to a different location for following low tide
- In the different compartments you must be able to test temperature affects, pH affects and in one set of compartments both temperature and pH

Discussion:

- What type of consideration does one need to make when designing an experiment?
- How is designing an experiment in the intertidal zone so challenging?
- Why do we what to re-test experiments in the real world and not just see the results in the lab?
- Why is having a step-by-step procedure important in science?

Extension and Resources:

- A simple outline of Scientific Methods to help familiarize the students with experimental design
- You can have the students plan out experiments and have them build small models of their proposed set-up.
- Visit Dr. Chris Harley's website at http://www.zoology.ubc.ca/~harley/

Risk management:

If the lab is extended and the students build models of their experimental designs all labs should utilize proper equipment. All the materials in this lab are household items and are not harmful, but this lab can be used to practice and reinforce safe practices.