Acid Ocean

Purpose: *Acid Ocean* is an inquiry-based virtual lab designed to investigate how ocean acidification could impact marine organisms.

Objectives:

1) Students will be able to explain how increasing levels of carbon dioxide in the air is resulting in the acidification of our oceans.
2) Students will use a virtual lab bench to set up an experiment to compare the development of sea urchin larva in pH 8.2, the average pH in today's oceans, and pH 7.7, the pH projected for 2100. They will "conduct" an experiment that could not be done in a typical high school lab setting.
3) Students will analyze authentic research data and measure changes larva to see possible effects of climate change.
4) Students will evaluate the significance of individual and class data.

Vocabulary: hypothesis, pH, acid, base, reactant, product, scenario, replicate, standard deviation

Procedure: Use the virtual lab to answer these questions as you navigate through parts 1, 2, and 3

Part 1

1. What does the graph of data from the Moana Loa lab indicate about the level of CO_2 in the atmosphere in 1960 compared to the present?

2. The more concentrated the carbon dioxide in the atmosphere, the more CO2 will dissolve in the oceans, and the more acidic the oceans will become. That means that the pH will be:

   a) lower b) higher c) remain the same

3. On the pH scale: _____ is neutral. The most acidic is _____.

The most basic/alkaline is _____.

4. The chemical equation $CO_2 + H_2O$ -----> H_2CO_3 shows the reaction that influences ocean acidification. Here is the equation in words:

   Carbon dioxide + water produces carbonic acid.

   What is/are the reactant(s)? _____

   What is/are the products? _____

4. Please use the page “Exploring carbon levels and effects” to answer these questions.

   How old will you be in 2050? _____

   The most pessimistic scenario predicts an ocean pH of _____ in 2050.

   The most optimistic scenario predicts an ocean pH of _____ in 2050.

   What things will determine which scenario will be correct?

5. Use the drawing of the ocean chemistry “Carbon in water” to predict the effect of increasing acidification on calcifying organisms.

Part 2

6. What is the model organism in the virtual experiment, & why was this organism chosen?

7. Why are the pH’s 8.1 and 7.7 selected for this experiment?

8. State a possible hypothesis for this experiment.

9. Why are there 3 replicates of cultures for each pH?

10. Why is the water drained from the samples and then re-added?

Part 3

11. List your data and the complete data set in the charts below.

Your data

	pH 7.7	**pH 8.1**
Replicate A		
Replicate B		
Replicate C		
Average		
Standard deviation		

	Your data		**Complete data set**	
Treatment	**pH 7.7**	**pH 8.1**	**pH 7.7**	**pH 8.1**
Average				
Standard deviation				

12. Please explain the importance of the data in this experiment. How do the arms of the larva in pH 7.7 compare to the larva in 8.1?

    Why might it be significant that larva in one group have shorter arms than those in the other group?

13. What can we do to decrease the trend of acidification in the world's oceans.

Further explore the data and statistics

Download an excel file containing all of the sea urchin larval measurement data used in the experiment, and additional statistics (a simple ANOVA comparing the two treatments).

Excel spreadsheets: http://virtualurchin.stanford.edu/docs/OA_MeasureData_Stats.xls

or

PDF file: http://virtualurchin.stanford.edu/docs/OA_MeasureData_Stats.pdf

(note that this PDF file is essentially just an offprint of the excel sheets for those without access to a program that can open an .xls formatted file):

The specific experiment in our virtual lab with the European common sea urchins (*Paracentrotus lividus*) has not yet been published. But a similar study using the purple urchin (*Strongylocentrotus purpuratus*) has been recently published by our partner scientists Drs. Sam Dupont & Michael Thorndyke and their colleagues.

Download that study for more information on the protocols and observed impacts of acidified water on sea urchin development.

> M Stumpp, J Wren, F Melzner, MC Thorndyke and ST Dupont. 2011. CO2 induced seawater acidification impacts sea urchin larval development I: Elevated metabolic rates decrease scope for growth and induce developmental delay. Comparative Biochemistry and Physiology, Part A 160: 331–340. http://virtualurchin.stanford.edu/docs/Stumpp_etal_2011a.pdf

For advanced study: Part 2 of the above research, examining impacts of ocean acidification on gene expression in purple urchin larvae. Hot off the press!

> M Stumpp, ST Dupont, MC Thorndyke and F Melzner. 2011. CO2 induced seawater acidification impacts sea urchin larval development II: Gene expression patterns in pluteus larvae. Comparative Biochemistry and Physiology, Part A. In press. http://virtualurchin.stanford.edu/docs/Stumpp_etal_2011b.pdf

Expand the conversation

By late 2011 students will be able to attend an interactive multimedia talk by Dr. Sam Dupont using VoiceThread to gain a better understanding of the challenges we are facing with ocean acidification. In this interactive talk Dr. Dupont will discuss the larger impact of ocean acidification on global ecosystems and the human population. While viewing, students will be able to ~~leave~~ comments and questions for Dr. Dupont.

(Link to come!)

For Further Study

Follow these links for more information about ocean acidification (OA).

> EPOCA's (European Program on OCean Acidification) blog with the latest information on OA. http://oceanacidification.wordpress.com/
>
> oceanacidification.net: lots of good info and resources from the Ocean Ark Alliance. http://www.oceanacidification.net/
>
> NOAA's (National Oceanographic and Atmospheric Administration) OA site: http://www.pmel.noaa.gov/co2/story/Ocean+Acidification
>
> NRDC's (Natonal Resource Defense Council) excellent *Acid Test* film (22mins feat Sigourney Weaver!) http://www.nrdc.org/oceans/acidification/aboutthefilm.asp