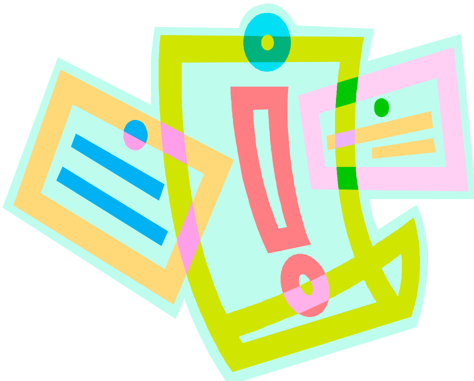
HEAL THE BAY
SANTA MONICA PIER
AQUARIUM

The Deep Sea

Teacher Packet

6th Grade



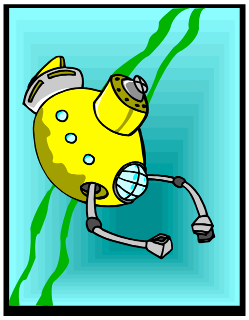
Notes for the teacher:

Thank you for picking the Santa Monica Pier Aquarium as your field trip destination! We are very excited that you will be visiting our facility. This packet was developed to help you, as the classroom teacher, and your students get the most out of your visit. Enclosed in this packet, you will find information and activities that correlate to the program you will be attending with your class. You are encouraged to complete as many of the activities as you can as they will help your students gain a better mastery of the California State Standards.

Packet Contents:

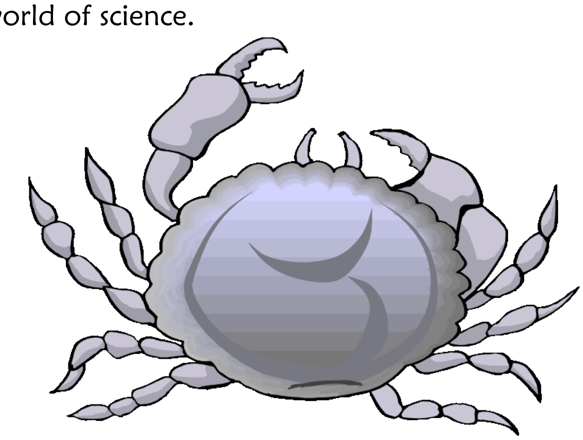
Deep Sea Program Introduction for the Classroom Teacher

The Santa Monica Pier Aquarium's *Out of the Fire & Into the Sea* Program is about life in the deep sea, specifically that life found at hydrothermal vent systems. It is based on California State Science Standard 5 for Grade 6 on Ecology (Life Sciences).



The ocean covers ¾ of our planet, and provides 99% of the available living space, yet we know more about the surface of the moon than we do about our ocean. Everyday we are learning more and more about this amazing environment; new and amazing discoveries occur everyday. One of the most amazing discoveries occurred in 1977. On a journey to view the longest mountain chain on Earth, the Mid-Ocean Ridge which runs down the center of the Atlantic Ocean, strange images were captured on film. In the film, scientists were able to see chimneys billowing out plumes of noxious gases. These gases heat the water to extreme temperatures (up to 400°C, 750°F). These features have come to be known as hydrothermal vents (hydro = water; thermal = heat; vent = release). At these depths, at such high temperatures, scientists never expected to find unique communities of animals living at the hydrothermal vents, but they did. Another reason that scientists were shocked to find the deep sea full of amazing animals, as opposed to the bleak, empty desert they expected, is that all life and accompanying food webs known up to this point were integrally linked to photosynthetic organisms, either plant or algae. Scientists knew that no sunlight for photosynthesis could ever reach these depths; therefore, their logic told them that no life could exist here.

As analysis of hydrothermal vent communities continued, it became clear that these organisms were even more unique than expected: they relied on chemosynthesis as the base of this food chain, as opposed to the photosynthesis that occurs at the surface. In photosynthesis (photo = light; synthesis = to create), plants and algae take in carbon dioxide, and, using light from the sun, produce oxygen gas and energy in the form of sugar. Chemosynthetic bacteria are able to do a similar process, but, instead of using light from the sun, they use the power of the noxious chemicals being released by the hydrothermal vents. These bacteria could, through chemosynthesis (chemo = chemical; synthesis = to create) produce energy for the other organisms living here and light never needs be present! This was huge! Chemosynthetic bacteria filled the role of producer for this system. A few species of chemosynthetic bacteria were previously known to science, but they were viewed as a rare anomaly, and did not have the importance to their environment that those found at the hydrothermal vents. An entire environment based on chemosynthesis rocked the world of science.



More amazing discoveries were to continue: Many organisms living on or quite near the vents actually had no digestive system. Certain species of mussels and tube worms actually harbored bacteria within their bodies. The bacteria provided the worms and mussels the energy they would need for life in exchange for a safe place to live; the bacteria and their hosts living together in a mutually beneficial symbiotic relationship. The primary consumers of this community, unlike the herbivores on the surface, did not seek out food; food came to them. Crabs, shrimp, lobsters, to name a few, feast upon the tube worms and mussels, working as secondary consumers. Ratfish, squid, and the occasional six-gilled shark serve as the top predators (tertiary consumers) in this deep sea biome. Brittle stars and small crabs, as well as some bacteria, fill the role of detrivore (detri = damaged/decaying; vore = eater) or decomposer in this system

Many of the interesting creatures at this depth have colorless bodies, no eyes or are blind. The lack of visible light makes vision unnecessary, and any color they possess would not be observable anyway.

This program will also look at abiotic components of an ecosystem or biome, ask students to differentiate between abiotic (nonliving) and biotic (living) factors, and talk about biotic and abiotic factors in the deep sea versus those on the surface of the Earth.

Pre-activity Lesson: What is a Biome?

Summary
In this lesson, students will learn about biomes, and the characteristics that separate one biome from another. Students will research a biome of their choice, using the computer lab, or informational articles provided in packets. Students will use their research as an opportunity to identify the necessary biotic/abiotic factors necessary for the success of their chosen biome, as well as identifying potential threats to their biomes. Finally students will create a haiku (poem) that synthesizes the most significant information about their biome into a brief summary statement.

Objectives
Students will:

- ✓ Be able to define biome, abiotic factor, biotic factor, haiku
- ✓ Identify the abiotic and biotic factors within a chosen biome
- ✓ Identify potential threats to a chosen biome, and recommend possible measures to address identified threats
- ✓ Compose a summary haiku (poem) that synthesizes the significant information about their biome into a brief statement
- ✓ (Optional) Create a presentation designed to teach other students about their chosen biome

Targeted Standard(s)
California Science Standards, Grade 6
Ecology 5.c. *Students know populations of organisms can be categorized by the functions they serve in an ecosystem.*
Ecology 5.d. *Students know different kinds of organisms may play similar ecological roles in similar biomes.*
Ecology 5.e. *Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.*

Environmental Principles & Concepts (EEI) corresponding learning objectives:
- *Recognize different biomes.*
- *Identify the characteristics of various biomes.*
- *Explain how human practices make use of and/or have similar effects on organisms that play similar roles in different biomes.*
- *Provide examples of how human practices and rates of consumption affect the biotic and abiotic components (e.g., the availability of resources) in a natural system, thus influencing the number and types of organisms an ecosystem can support.*
- *Identify abiotic factors that affect ecosystems.*
- *Classify components of ecosystems as either living (biotic) or non-living (abiotic).*
- *Provide examples of how the quantities of resources consumed, and the quantity and characteristics of the resulting byproducts can affect natural systems.*

California English Language Arts Standard, Grade 6
Reading 2.4: Reading Comprehension *Clarify and understanding of texts by creating outlines, logical notes, summaries, or reports*
Writing 1.3: Writing Strategies *Use a variety of effective and coherent organizational patterns*

Materials

- Background File: What is a Biome? (class set or copied on transparency)
- Informational Article Packets on Biomes (if no computer lab is available)
- Copies of Biome Research Organizer (class set)
- Copies of Sample Biome Presentation Project and Scoring Rubric (Optional)

Implementation Overview

- Share with students the Background File "What is a Biome?" This may be copied onto an overhead transparency, or as a handout. Read the text aloud to students and use as a starting point for discussion about biomes.

- After reading the Background File, engage students in a discussion and chart their responses to the following discussion prompts:

  - What are some biomes that we are familiar with?
  - What are some biomes that we may not be familiar with? *(Kelp Forest, Deep Sea, Arctic Tundra)*
  - (Choose one of the familiar biomes listed) What animals might be living in this biome?
  - What do these animals need to survive?
  - What do these animals get from the biome to help them survive?

- Continue facilitating the discussion, modeling for students the questions you have, and things you are curious about (i.e. "I wonder…"). Explain to students that they are going to have an opportunity to do a little research of their own (using internet, or books from the library). They can work individually or in groups (as you desire).

- Distribute the Biome Research Organizer. Invite students to select one of the biomes listed on the brainstorm chart to research further. Instruct them to work together to complete sections 1, 2, & 3 of the Biome Research Organizer, for their chosen biome.

Instructional Note: For the research activity, if a computer lab is available you may wish to have students complete the rest of their activities there. If the lab is not available, an alternative might be to print a variety of informational articles on each biome from the Internet and to distribute to students. Additionally, students can be encouraged to bring in internet research that they have completed at home or in the public library. Finally, students can find books on many different biomes at the school or public library.

- Invite students to use their research to complete the rest of their Biome Research Organizer. As an extension, students may prepare biome presentations on poster board, or hanging mobiles, etc., in order to share their learnings with the class.

- So that students might reflect on their learnings about biomes, invite them to respond in their science journals (or on lined paper) to the following reflection questions:

What have you learned about the ways in which all the parts of a biome work together to sustain life?

How has learning about biomes strengthened your understanding of how the world works as a system?

What is a Biome?

The word *biome* comes from the Greek word "bio" meaning life. Science uses the word "biome" to describe a geographical area of distinctive plants and animals that are uniquely adapted to life in that area.

For example, a Coral Reef is a type of biome. It is full of algae (similar to plants) and animals that would be unable to live in any other biome. Just imagine, what would happen if you tried to move all of the creatures and plants from a coral reef to the middle of the desert? Do you think they would survive for very long? No they wouldn't. That's because the Desert biome does not have the things that Coral Reef organisms need to survive.

For example, coral polyps are uniquely adapted to life in the coral reef biome. Corals thrive in warm, relatively shallow parts of the ocean; they are uniquely adapted to this environment. That is why you will only find coral polyps growing in nutrient[1] rich ocean waters that are a certain temperature and depth. If you were to transplant some coral to another part of the ocean that was deeper and colder, or that had less nutrients the coral would die. Other parts of the ocean simply do not have what the coral polyps need to live.

Some animals are uniquely suited for life within a particular biome (like coral polyps). Other animals are able to live in many kinds of biomes (like humans). Animals that can exist in a variety of biomes can do so because they are able to change in order to survive. For example, humans wear warm clothes to live in colder environments.

Many animals and plants, however, are unable to change or adapt quickly enough. A frog couldn't suddenly grow fur if it was placed in the Arctic! If something about the environment changes, certain organisms are likely to die. For example, if the ocean suddenly got hotter in the places where coral reefs form, the corals would likely die before they had time to adapt. In some parts of the world this is already happening because of global warming. It's important to remember that all living things within a biome are connected. If any one thing changes (temperature, amount of water or food, nutrient levels, new types of animals introduced, etc.), the whole biome can be affected, most often in a negative way.

Think of other biomes that you might be familiar with (i.e. desert, rain forest, etc). What things make it possible for the animals of that biome to survive? How are the animals of that biome uniquely suited for life there?

[1] Nutrient: a substance necessary for life and growth.
Humans get nutrients from eating a balanced diet, including fruits and vegetables.

Biome Research Organizer

1. My Chosen Biome is:	
2. What do I already think or know about this biome? (list anything that comes to mind)	3. What do I wonder about? (list questions)
Biome Research Source:	
Physical (non-living) Characteristics:	Living Characteristics:
What are some possible threats to this biome? (i.e. impact of human activities, or changes in environment)	
What are some possible solutions to reduce the threats to this biome?	

Biome Haiku

A haiku is an ancient form of poetry that has three lines. The first line has 5 syllables, the second line has 7 syllables, and the third line has 5 syllables again. Haiku is a good way to summarize something that you have learned into three short ideas. Read the haiku below on the desert biome:

The desert blossoms
When sun has gone and moon reigns
Night, the time for life

On the back of this paper, write your own haiku about your chosen biome. Be sure to include the most important ideas that you have learned about your biome. Remember the pattern: 5-7-5 !

Internet Resources on Biomes:

Blue Planet Biomes
http://www.blueplanetbiomes.org/world_biomes.htm

Enchanted Learning
http://www.enchantedlearning.com/biomes/

ThinkQuest
http://library.thinkquest.org/11922/habitats/habitats.htm

UC Berkeley: The World's Biomes
http://www.ucmp.berkeley.edu/glossary/gloss5/biome/

Physical Characteristics
(ABIOTIC FACTORS)

The Desert Biome

The desert blossoms
When sun has gone and moon reigns
Night, the time for life

Living Characteristics
(BIOTIC FACTORS)

Potential Threats:

Possible Solutions:

Additional Suggestions:

- Consider allowing students to work in cooperative groups to prepare their presentations and their posters.
- If a computer lab is not available, the teacher might wish to prepare research "packets" that include a variety of source information on a particular biome (i.e. a desert packet, a rain forest packet, etc). Cooperative groups can then sift through the sources to gather the appropriate information for their presentation.
- Posters should include the information that students gather on their Biome Research Organizer. How students choose to organizer their poster is their choice.
- Additional information (images, charts, realia, etc) should be encouraged as space allows.
- To integrate technology, consider allowing students the opportunity to create a PowerPoint Presentation on their Biome, instead of a poster.

Evaluation

Sample Biome Presentation Rubric:

Categories	1	2	3	4
Physical Characteristics	Student(s) include almost none, or have incorrectly identified the physical characteristics (abiotic factors), contained within their chosen biome. Student(s) use incorrect or inappropriate vocabulary.	Student(s) state few of the physical characteristics (abiotic factors) contained within their chosen biome, using little appropriate vocabulary.	Student(s) state some of the physical characteristics (abiotic factors) contained within their chosen biome, using some appropriate vocabulary.	Student(s) clearly articulate the physical characteristics (abiotic factors) contained within their chosen biome, using appropriate vocabulary.
Living Characteristics	Student(s) include almost none, or have incorrectly identified the living characteristics (biotic factors), contained within their chosen biome. Student(s) use incorrect or inappropriate vocabulary.	Student(s) state few of the living characteristics (biotic factors) contained within their chosen biome, using little appropriate vocabulary.	Student(s) state some of the living characteristics (biotic factors) contained within their chosen biome, using some appropriate vocabulary.	Student(s) clearly articulate the various living characteristics (biotic factors) contained within their chosen biome, using appropriate vocabulary.
Threats and Solutions	Student(s) have not identified, or have incorrectly identified a potential threat to their chosen biome. No possible solution or an inappropriate solution has been posed in relationship to the threat.	Student(s) identify one potential threat to their chosen biome and propose a possible solution in connection with that threat.	Student(s) identify some of the potential threats to their chosen biome. Possible solutions are posed with some discussion and explanation.	Student(s) clearly articulate and describe the potential threats posed to the biome, and highlights the causes of those threats. Possible solutions are posed and discussion in connection with the threats.
Visual Presentation	Visual aid (poster) includes few of the required components (physical & living characteristics, threats, solutions, title, resources), and is not clearly understandable.	Visual aid (poster) includes most of the required components (physical & living characteristics, threats, solutions, title, resources), and is somewhat understandable.	Visual aid (poster) contains all of the required components, (physical & living characteristics, threats, solutions, title, resources) presented in an understandable manner.	Visual aid (poster) is neat and clearly understandable. All required components (physical & living characteristics, threats, solutions, title, resources) are included with additional information (i.e. images).
Oral Presentation	Ideas are not clearly presented, and the poster may not be used effectively as a visual aid. Presenter makes little use of eye contact, voice inflection, etc. to engage his/her audience.	Ideas are adequately presented and the visual aid (poster) is highlighted and used during presentation. Presenter makes some use of eye contact, voice inflection, etc. to engage his/her audience.	Ideas are presented clearly and the visual aid (poster) is highlighted and used during presentation. Presenter frequently makes use of eye contact, voice inflection, etc. to engage his/her audience.	Ideas are presented clearly, and well articulated for the group. Visual aid (poster) is highlighted and used during presentation. Presenter consistently makes use of eye contact, voice inflection, etc. to engage his/her audience.

Pre-activity Lesson: What is Density?

Summary
Density is perhaps one of the most misunderstood concepts in science, and yet one of the most critical for students to master if they are to pursue higher levels of science education. In this activity, students have the opportunity to both investigate the property density, and also to engage and practice their scientific inquiry skills at the same time.

Objectives
Students will:

- ✓ Observe a self-guided investigation
- ✓ Generate hypotheses based careful observations
- ✓ Create questions based on observations
- ✓ Record observations, questions, and hypotheses in their science journal
- ✓ Be able to define the concept density

Targeted Standards
California Science Standards, Grade 6
Investigation and Experimentation 7.0: *Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:*
Investigation and Experimentation 7.a: *Develop a hypothesis.*
Investigation and Experimentation 7.e: *Recognize whether evidence is consistent with a proposed explanation.*

Materials for Experiments A & B
- Bowls filled with water – one per station
- Plastic cup filled with water – one per station
- Plastic cup filled with rubbing alcohol – one per station
- Oranges, peeled and unpeeled – one of each per station
- Candles – one per station
- Water (extra in case of spillage)
- Alcohol (extra in case of spillage)
- Science journals – one for each student)
- Student Directions for Experiments – one per station

Materials for Guided Discussion
- Large glass or clear beaker filled with water
- Large glass or clear beaker filled with corn syrup
- Large glass or clear beaker filled with vegetable oil
- Miscellaneous Items (paperclips, crayons, coins, Popsicle sticks, etc)

Implementation Overview

Class Structure:

Introduction
Safety and Protocols
Self-Guided Stations: Experiments A & B
Discussion
Guided Discussion & Demonstration

Self-guided Stations: At a variety of investigation stations you have arranged around the room, set up the following two experiments. Be sure to have enough stations and investigation materials that each student group has the opportunity to participate in both investigations.

Experiment A: Students will predict (generate a hypothesis) what will happen when they drop a peeled orange and an unpeeled orange into a bowl of water. Students will generate questions and predict answers to those questions based on their observations.

Experiment B: Students will generate hypotheses about what will happen when they drop a candle into a glass of water, and what will happen when they drop the candle into a glass of rubbing alcohol. They will generate more questions and make some predictions based upon their observations.

- Prior to beginning this lesson, explain to students that they will first be participating in two self-guided investigations. Students will record their observations, hypotheses, and questions in their journals.

- Divide the class in half. Half will do experiment A first, and the other experiment B. After 10 minutes, they will switch.

- At each station, students will read the directions for the experiment and answer the questions in their journal as stated on the Experiment instruction card. After they have done the experiment, they will reevaluate their questions, generate new questions, and draw some conclusions about what they've observed.

- Briefly review the steps of scientific inquiry (The Scientific Method):
    - Make observations
    - Generate Questions about what you've observed
    - Develop a hypothesis (a prediction based on your observations)
    - Develop an experiment (a way to test your hypothesis)
    - Record data or gather information
    - Draw conclusions (summarize your findings)
    - Publish results (share your findings with others!)

- Explain that in today's experiment, you will only be focusing on the first three steps of scientific inquiry: generating questions and developing hypotheses (predictions) based on observations. Share that in the professional world, this is how scientists practice authentic scientific research, by generating questions and hypotheses based on what they see. Today, students will be thinking like a scientist!

- Remind students of experimental safety protocols, especially noting that students CANNOT eat or drink the materials for their experiment.

- Invite students to participate in the station activity described above.

Discussion

- Invite students to share some of their observations, questions, and predictions from the station activity. If desired, chart them on the board or chart paper like so:

Observations: What did we see?	Questions: What did we wonder about?	Predictions/Hypotheses: What to we think to be true?

- Use student responses to generate a discussion about density. You might begin by asking, *How can we describe the differences in materials?* Explain to students that all materials have certain qualities which we describe in words. For example, we might say *this material feels "rough"*, *"light"*, or *looks "shiny".* Explain that terms like "cool," "weird," or "gross" are not descriptive, and, therefore, NOT useful scientific terms. The qualities of a material that we can describe are called **properties**.

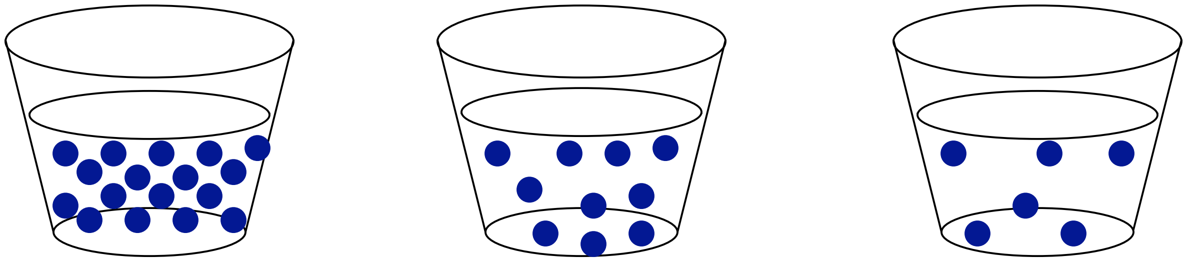
- Share with students that there are various types of properties—some you can see, some you can feel, some you can taste and smell—but there are also properties that you can not see or feel. In the station activity, students were actually experimenting with a property that is not easily sensed. That property is **density**.

- It is likely that students have heard the word density before. However, many students have misconceptions about the property that need to be addressed. To help students understand what density really is, use the following guided discussion.

Guided Discussion and Demonstration

- In a place where students all have a good view, display three cups of liquid (water, oil, corn syrup). Outwardly, each cup of liquid looks strikingly similar. Invite students to make some predictions about the liquids. Are they the same or different? What will happen if we mix them together? Ask them to hold on to their ideas while you explain a little more about density.

- Explain to students that every material is made up of tiny particles, but it is also made up of space between those particles. Some materials have more particles and less space, while others are made up of more space and fewer particles. Draw the following example on the board:



Instructional Note: Please note that the cups above are arranged from most dense (at the far left) to the least dense (at the far right). Encourage the students to make predictions about the density from the drawings.

- Ask students to look at the drawings. Help students to understand that materials that have more particles, packed closer together, have less space between the particles. They are said to have higher density. Materials that have less particles and more space between the particles have less density. Explain that the blue dots represent the particles contained in the liquid.

- Invite students to predict again what might happen when the materials are mixed. Then perform the demonstration by pouring each of the liquids into a tall clear container (a large glass or beaker will work). Ask students which of the cups in the drawing might represent the liquid that "sinks" (corn syrup) to the bottom in the demonstration? Ask students which visual example represents the liquid (oil) that "rests" on top of the other liquids?

- Based on what the students now know about density, invite them to explain some possible reasons for the liquids separating in the way that they did. Why did the oil rest on top? (Because it's less dense/has a lower density.) Why did the corn syrup sink to the bottom? (Because it's more density/has a higher density.) Help them to understand that the densest of the three liquids sinks to the bottom, while the least dense of the liquids will "rise" to the top.

Instructional Note: Many students confuse the concept *weight* with the concept *density*, reinforce the idea that density refers to how many particles are contained in a certain volume of material. *Weight*, on the other hand, is the force that gravity exerts on those particles. For example, a bowling ball would have the same *mass* (amount of particles) on Earth as it would on the Moon. However, the *weight* would be dramatically different. On the moon the bowling ball would weigh significantly less, because the Moon's gravitational force is significantly lower than that of the earth. The *mass* and *density* would remain constant, as the matter contained in the bowling ball would remain the same.

- Ask students to think about how this idea of density relates to the experiments conducted earlier with the orange and the candle. Invite them to generate new hypothesis about their initial experiments based on what they now know about density.

- **Challenge:** as a way to challenge student thinking, invite them to predict what might happen as you drop a variety of objects into the corn syrup/water/oil mixture. Use objects such as broken crayons, paper clips, coins, Popsicle sticks, etc. Where will each object come to rest, and why?

Experiment A: Peeled vs. Unpeeled?

STEPS:

1. Will the peeled orange sink of float? What about the unpeeled orange? Record your hypothesis (prediction) in your journal.

2. Carefully place the unpeeled orange in the bowl of water. Does it sink or float? Record your observations in your journal.

3. Carefully place the peeled orange in the bowl of water. Does it sink or float? Record your observations in your journal.

4. What conclusions can you draw from your observations? Generate a new hypothesis based in your journal.

5. Return the station to its original state before moving on (in other words, leave it clean and neat!)

Experiment B: To Sink or not to Sink?

STEPS:

1. Will the candle sink in water or alcohol? Record your hypothesis (prediction) in your journal.

2. Carefully place the candle in the glass of water. Does it sink or float? Record your observations in your journal.

3. Carefully place the candle in the glass of alcohol. Does it sink or float? Record your observations in your journal.

4. What conclusions can you draw from your observations? Generate a new hypothesis based in your journal.

5. Return the station to its original state before moving on (in other words, leave it clean and neat!)

Evaluation

Evaluation for this activity is formative. During the discussion, the teacher can gauge if students seem to be grasping the concept based on their answers, and proceed once it seems all students understand. A review of their science journals is also helpful in determining their grasp of the subject.

A more summative approach might be to have all students define density and draw a picture of a very dense object and less dense object either in their journals or on a loose leaf sheet of paper to be turned in.

Pre-activity Lesson: Photosynthesis

Summary
In this activity and lab investigation, students have an opportunity to literally see the process of photosynthesis happening. Through their investigations, they also have an opportunity to observe how the process of photosynthesis is affected by certain abiotic factors such as amount of light and chemical composition of water.

Objectives
Students will:

- ✓ Observe and analyze the effects of light and water composition on the process of photosynthesis
- ✓ Record and synthesis data to form conclusions
- ✓ Demonstrate findings in a graph

Target Standard(s)
California Science Standards, Grade 6
Ecology 5.a. *Students know energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs.*
Investigation and Experimentation 7.c. *Construct appropriate graphs from data and develop qualitative statements about the relationships between variables.*

Materials
- Elodea (water plant available at pet stores and aquarium supply stores for nominal cost)
- Test tube
- Dechlorinated water (room temperature)
- Sodium bicarbonate powder (baking soda)
- Metal stand with rod or test tube rack
- Lamp (40 watt)
- Scissors
- Tape
- Clock or timer
- Metric ruler
- Background file on Photosynthesis (class set, or transparency)
- Copies of Handouts (class set)

Implementation Overview

- Share the Background File: "Photosynthesis" with students (either as photocopy or on an overhead transparency). Read through the text with students using a think-aloud strategy. For example, stop at various points in the text to engage students in brief discussions about the information the text is presenting. Encourage student thinking by asking prompting questions such as, "Have you ever wondered where our air comes from?" "Is it possible for the world to ever run out of oxygen?" Etc.

- After reading the Background File, explain to students that they are going to be conducting an experiment to deepen their understanding about how photosynthesis works. Distribute the Experiment Instructions handout and the DATA Sheet for recording the information they gather during the experiment.

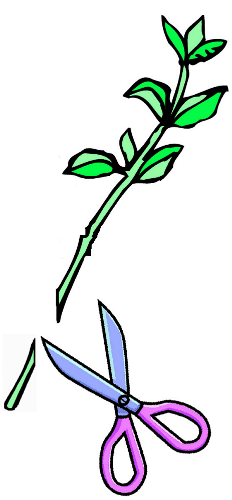
- Read through the Experiment Instructions with students and clarify any questions they may have. Ensure that each group has the materials needed to successfully complete the experiment. See below:

  Materials (needed for each group):

  Elodea (water plant)
  Test tube
  Dechlorinated water (room temperature)
  Sodium bicarbonate powder (baking soda)
  Metal stand with rod or test tube rack
  Lamp (40 watt)
  Scissors
  Tape
  Clock or timer
  Metric ruler

- After ensuring that all students are clear on conducting the experiment, allow them to begin. Remind them to record their results on the DATA Sheet, as they will need this information to create a graph showing their conclusions at the end of the lesson.

- Circulate the room to monitor student engagement and understanding, and to clarify any questions that may arise.



- Procedure for Student Group Experiments:
  - Slice off the end of a sprig of Elodea, removing several leaves from the cut end of the stem. Slice off a portion of the stem at an angle (see the diagram at left) and lightly crush the cut end of the stem.
  - Place the elodea sprig, stem up, inside a test tube filled with water.
  - Place and secure the test tube to a stand with tape, or place in a test tube rack.
  - Place a 40 watt lamp 5 cm from the plant in the test tube. Wait one minute, then begin to count and record the number of oxygen bubbles rising from the cut end of the stem. Continue to count bubbles for five minutes. If bubbles do not appear, cut off more of the stem and recrush.

- Repeat the process, counting and recording bubbles for another five minutes. Average the counts from the two five minute periods to find the average number of bubbles for five minutes.
- Begin a new 5 minute trial. This time, move the lamp so that it is 20 cm away from. Count and record bubbles for 5 minutes. Repeat the process, counting and recording for another 5 minutes. Average the number of bubbles and record it on your data sheet.
- Add a pinch of sodium bicarbonate powder to the test tube. Wait one minute, then begin to count bubbles for two separate 5 minute periods. Average the number of bubbles and record on your data sheet.
- Use the information on your data sheet to prepare a graph of your results.

• After students have completed the experiment and recorded their data on the DATA Sheet, invite them to use the data to create a graph demonstrating their conclusions. For example, students might notate the average number of bubbles on the vertical (y) axis, and the environmental condition for the horizontal (x) axis.

Sample Graph:

Ave. # Bubbles	Environmental Conditions			
30 bubbles per minute				
20 bubbles per minute				
10 bubbles per minute				
5 bubbles per minute				
	Light at 5 CM	Light at 20 CM	Light at 40 CM	Baking Soda Added Light at 5 CM

* Other types of graphs may work as well (line graph template is included as a student handout).

Background File: Photosynthesis

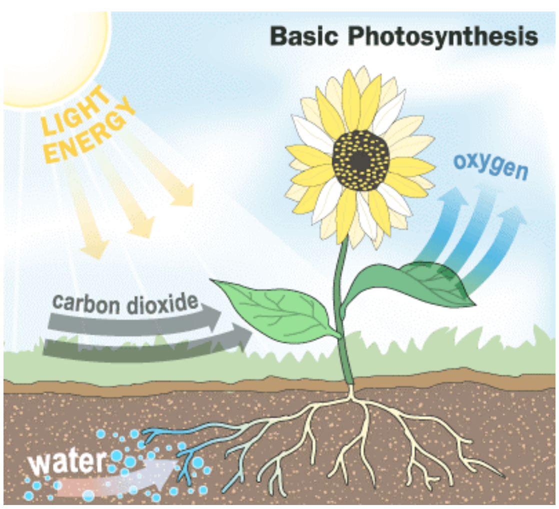
When you think about all the things we (as humans) need to survive on this earth, what is the single most important thing? Why doesn't life exist on other planets? Chances are, you said "air". That's because without air, more specifically oxygen, none of us would be living here today. But have you ever wondered how we get the air we breathe?

Some of you may know that oxygen is produced by plants and trees. It's true. Plants are an important part of the "air" equation. You see, the air in our world is made up of more than just oxygen. It also includes carbon dioxide with a little bit of nitrogen thrown in. When we breathe, we are inhaling air made up of oxygen, carbon dioxide, and nitrogen. Our body keeps the oxygen, and we exhale everything else. This is where the plants come in.

Plants "breathe" carbon dioxide in much the same way that we breathe oxygen. The plant "inhales" the carbon dioxide and uses it, along with sunlight and water, to make glucose, or sugar – which is food for the plant. This process is called photosynthesis. It's during this process that the plant breaks down carbon dioxide into carbon and oxygen molecules. The plant then uses the carbon to make glucose, and "exhales" the oxygen (which it doesn't need) back into the atmosphere. Basically, plants help to recycle our air and replenish our oxygen supply.

Though you really never see it, photosynthesis is happening all around us. But, the process is impacted by the availability of abiotic factors, such as light, water, and air. For example, if a certain area receives less sunlight, or has a limited supply of water, the amount of photosynthesis occurring in that area will be different than in an area where plenty of sunlight and water are available.

You are going to have an opportunity to see photosynthesis in action by performing a simple experiment. As you think about the process of photosynthesis, consider these questions:



- ✓ How might an increase in light affect a plant's ability to make oxygen?
- ✓ How might an increase of carbon dioxide affect a plant's ability to make oxygen?
- ✓ How might plants have adapted to make the most of the resources they have available to them?

Photo from: http://static.howstuffworks.com/gif/irrigation-photosynthesis.gif

Group: _______________

Photosynthesis Investigation
Student Group Instructions:

1. Check your materials to make sure that everything is there:
   Elodea (small sprig of water plant)
   Test tube
   Dechlorinated water (room temperature)
   Sodium bicarbonate powder (baking soda)
   Metal stand with rod or test tube rack
   Lamp (40 watt)
   Scissors
   Tape
   Clock or timer
   Metric ruler

2. Slice off the end of a sprig of Elodea, removing several leaves from the cut end of the stem. Slice off a portion of the stem at an angle and lightly crush the cut end of the stem.

3. Place the elodea sprig, stem up, inside a test tube filled with water.

4. Place and secure the test tube to a stand with tape, or place in a test tube rack.

5. Place a 40 watt lamp 5 cm from the plant in the test tube. Wait one minute, then begin to count and record the number of oxygen bubbles rising from the cut end of the stem. Continue to count bubbles for five minutes. If bubbles do not appear, cut off more of the stem and recrush.

6. Repeat the process, counting and recording bubbles for another five minutes. Average the counts from the two five minute periods to find the average number of bubbles for five minutes.

7. Begin a new 5 minute trial. This time, move the lamp so that it is 20 cm away from. Count and record bubbles for 5 minutes. Repeat the process, counting and recording for another 5 minutes. Average the number of bubbles and record it on your data sheet.

8. Add a pinch of sodium bicarbonate powder to the test tube. Wait one minute, then begin to count bubbles for two separate 5 minute periods. Average the number of bubbles and record on your data sheet.

9. Use the information on your data sheet to prepare a graph of your results.

DATA SHEET: Photosynthesis Investigation

Lamp placed at 5cm:

Number of bubbles counted in the first 5 minutes: ______________________

Number of bubbles counted in the second 5 minutes: ___________________

Average number of bubbles for a five minute period: ___________________
(*hint: add both numbers together and divide by two)

Lamp placed at 20cm:

Number of bubbles counted in the first 5 minutes: ______________________

Number of bubbles counted in the second 5 minutes: ___________________

Average number of bubbles for a five minute period: ___________________
(*hint: add both numbers together and divide by two)

Lamp placed at _______________________cm : (you choose the distance)

Number of bubbles counted in the first 5 minutes: ______________________

Number of bubbles counted in the second 5 minutes: ___________________

Average number of bubbles for a five minute period: ___________________
(*hint: add both numbers together and divide by two)

A pinch of Sodium Bicarbonate Added:

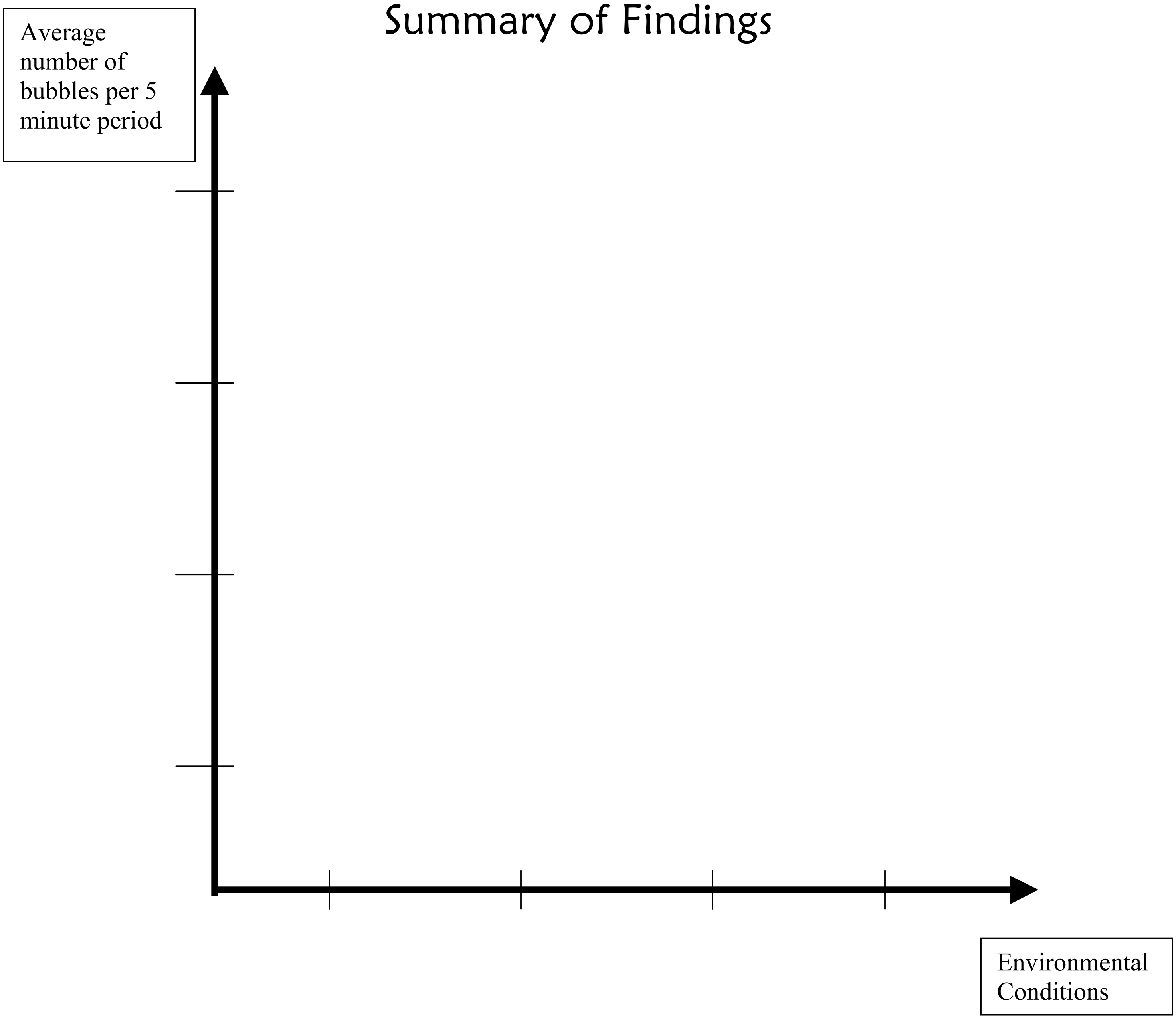
Number of bubbles counted in the first 5 minutes: ______________________

Number of bubbles counted in the second 5 minutes: ___________________

Average number of bubbles for a five minute period: ___________________
(*hint: add both numbers together and divide by two)

Photosynthesis Investigation

Summary of Findings



How does the rate of photosynthesis change when the light source is moved farther away?

How does the rate of photosynthesis change when sodium bicarbonate (CO_2) is added to the water?

Post-activity Lesson: Protect a Biome!

Summary
In this post activity, students will be assuming the role of their chosen biome. They will write a persuasive letter to the President of the United Nations, in an effort to convince the U.N. to protect their biome from threats of pollution, overuse, global warming, etc.

Objectives
Students will:
- ✓ Know a variety of biomes and their biotic/abiotic factors, including the biome they choose to "become" for the writing assignment
- ✓ Be able to evaluate their biome as the most "worthy" biome to protect, as opposed to other biomes that might be chosen
- ✓ Describe their biome in detail, and explain what the world would lose if their biome no longer existed
- ✓ Identify specific threats to their biome, and suggest possible solutions to eliminate those threats.
- ✓ Follow friendly letter format
- ✓ (Optional) Create an advertisement or promotional poster for their biome, including images and persuasive slogans.

Targeted Standards
California Science Standards, Grade 6
Ecology 5.e. *Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.*
Environmental Principles & Concepts (EEI) corresponding learning objectives:
- *Recognize different biomes.*
- *Identify the characteristics of various biomes.*
- *Provide examples of how human practices and rates of consumption affect the biotic and abiotic components (e.g., the availability of resources) in a natural system, thus influencing the number and types of organisms an ecosystem can support.*

California English Language Arts Standards, Grade 6
Writing Applications 2.5: *Write persuasive compositions: (a) State a clear position on a proposition or proposal. (b) Support the position with organized and relevant evidence. (c) Anticipate and address reader concerns and counterarguments.*

Materials
- Informational Article Packets on Biomes (if no computer lab is available)
- Copies of Student Checklist: Protect a Biome! Campaign (class set)
- Copies of Scoring Rubric (class set)
- Copies of the sample letter (optional)

Implementation Overview

- Remind students that leading up to and during the visit to the Santa Monica Pier Aquarium, students have been studying the various biomes of their world. They have learned about both the biotic and abiotic factors in a biome that are necessary to sustain life. They have also learned about potential threats to various biomes, and have researched possible solutions to address those threats.

- To set the context for the project, share the following imaginary scenario: *The United Nations has decided to grant lifetime protection status to one of the earth's biomes. However, many of the members of the UN disagree on which biome should be protected. There are so many, and each is important in its own unique way. The President has decided to hold a contest to help him decide which biome to choose. The winning biome will receive the U.N.'s protection and a large sum of money ($1,000,000) to help fight against threats to that biome. Your job is to convince the President of the UN that your biome is the one that should be selected for protection!*

- Explain that out of the various biomes they have studied, including those biomes they learned about at the Aquarium, students are going to select a biome for the "Protect a Biome! Campaign" project. Explain that this project will required students to:

    1. Write a letter to the President of the U.N. to convince the UN to chose their biome to win the "Protect a Biome! Campaign". They will write this letter from the point of view of the biome, for example, "I am the desert biome and I should be protected because…"

    2. Create a promotional poster to raise public awareness of their biome, its uniqueness and importance in the world (optional).

- Remind students that in order for their letters to truly be effective, their letters should answer the following questions:

    What are the biotic (living) and abiotic (non-living) factors that make your biome unique and special?

    How would the world be affected if your biome no longer existed – what would we lose?

    Why is your biome more in need of protection than other biomes?

    What would be gained by protecting your biome?

    What would you use the prize money for – in other words, how would you use the money to help eliminate threats to your biome?

- Help students to remember that they will be writing their letters as if they ARE the biome, not just someone who is arguing in favor of the biome. Writing in first person gives the appeals an immediacy that would otherwise be absent.

- Each student will complete their own letter, though they may create promotional posters in groups (if desired).

Instructional Note: If students have not done previous research on various biomes, they may complete this project on the deep sea biome (studied at the Aquarium) or any of the Aquarium biomes they were introduced to in the Aquarium gallery. If students have completely research on other biomes prior to attending the Aquarium, they may select from any of the biomes they have been studying.

Sample Letter:

June 10, 2006

Dear President of the U.N.,

I am writing today to say that you should definitely select me, the Deep Sea Biome, as the biome to protect! I know that I may not get as much press as my friends Coral Reef Biome, and Tropical Rain Forest Biome, but believe me – I deserve your consideration even more than they do. You see, I am the last great frontier on this planet – the last unspoiled, unexplored corner of the earth that has yet to be plundered by humankind's desire for money making resources! You must protect me before it's too late!

That million dollar prize would do so much good for all of the creatures in my biome. It would pay to put protection programs in place, and keep people from collecting my beautiful iridescent glow in the dark shrimp, crabs, and octopi for novelty pets. It would keep big oil and deep earth drilling companies from trying to harness my secret energy source (heat and bacteria) for some financial gain back on the surface! If they take away my bacteria, all of my other creatures will die because they depend on the bacteria to produce the nutrients necessary for chemosynthesis! You see, we don't have sunlight down here. Without those chemical producing bacteria, nothing here would survive.

I know you will believe me when I say that I, the Deep Sea Biome, am definitely the biome to protect. Please award me the million dollar prize so my supporters can pass and enforce laws protecting me from plunder!

Yours Truly,

Deep Sea Biome

Student Checklist: Protect a Biome! Campaign

- ❑ I have followed the “friendly letter” format
- ❑ I have written the letter in first person (as if I were the biome)
- ❑ I have described my biome in detail, including descriptions of both the biotic (living) and abiotic (non-living) characteristics
- ❑ I have described why my biome is unique, special, or interesting
- ❑ I have identified potential threats to my biome, and have shared at least one solution
- ❑ I have explained why my biome needs protection more than other biomes I am familiar with
- ❑ I have explained what the world would lose if my biome was no longer part of the world (i.e. your biome was lost because it wasn’t protected)
- ❑ I have explained what the world would gain if my biome was protected
- ❑ I have offered a plan for the $1,000,000 prize money, and explained how I would use that money to save my biome

Evaluation

Protect a Biome! Campaign
Scoring Rubric

Categories	1	2	3	4
Ideas and Explanations	Student includes little or no additional details about his/her biome. Specific references to biotic/abiotic factors are absent. Student has not mentioned specific threats or solutions. Student has not identified ways to appropriately spend the prize money.	Student includes few details about his/her biome with some reference to the biotic/abiotic factors. Student has suggested a possible threat to the biome, but may not have a solution. Student has given little or no appropriate reasons for saving his/her biome and has offered no suggestion of how to spend the prize money.	Student describes biome in some detail, including biotic/abiotic factors and some points of interest. Student has identified at least one threat and suggested a possible solution. Student has given some reasons for protecting the biome and has suggested how the prize money might be spent.	Student has described biome in detail, including biotic/abiotic factors, points of interest, and has identified at least one threat and possible solution. Student has effectively argued why his/her biome deserves to be protected and has clearly described how the prize money would be spent.
Organization	Student has used little or no elements of the friendly letter format. Student has used little or no elements of persuasion (it may be presented as a story or just statement of fact). Student has not written the letter in first person.	Student has used some elements of the friendly letter format and some elements of persuasion. Student has not written the letter in first person.	Student has used some elements of the friendly letter format, and has used some features of persuasion (compare/contrast, proposition/support, etc). Student has written letter in the first person voice.	Student has used the friendly letter format, including date, salutation, body, etc. Student has effectively used the tools of persuasion, i.e. proposition, support, addresses the counter argument, etc. Student has written the letter in first person.
Overall Presentation	Letter is not legible or barely understandable. No transitions are used to improve the flow of ideas. Mistakes in grammar /mechanics significantly hinder the message.	Letter is legible, and ideas are mostly understandable. Few transitions are used to improve the flow of ideas. Mistakes in grammar/mechanics somewhat hinder the message.	Letter is somewhat neat and legible. Ideas are understandable. Some transitions are used to improve the flow of ideas. Mistakes in grammar/mechanics do not hinder the message.	Letter is written neatly and legibly. Student's ideas are presented clearly and understandably. Transitions are used to improve the flow of ideas. There are no significant mistakes in grammar/mechanics.
Promotional Poster (Optional)	Poster is not neatly presented, and may include few images that may be unrelated to the argument. Poster fails to highlight threats and solutions. Poster makes no appeal to inspire the viewer to action.	Poster is somewhat neatly presented, and includes various images that may or may not be related to the creator's argument. Poster attempts to highlight a potential threat or a reason protection is needed. Poster makes a limited appeal to inspire the viewer to action.	Poster is relatively neat and appealing to the target audience. Images are included that are related to the creator's argument. Poster attempts to highlight potential threat(s) and solution(s), and attempts to interest viewers in the cause of protecting the biome.	Poster is neat and appealing to its target audience. Images are included that are persuasive or significant to the creator's argument. Poster highlights potential threats and solutions, and encourages viewers to become involved with the cause of protecting the biome.

Out of the Fire & Into the Sea Vocabulary List

Abiotic	Non-living, not alive
Biome	An ecosystem characterized by a specific set of geologic and climatic characteristics
Biotic	Living, alive
Chemical	A substance with a defined molecular composition
Chemosynthesis	Process of making energy from chemicals
Community	Populations of different species living at a specific place and time
Consumer	An organism that feeds on other living organisms
Consumption	1. Utilizing or using up a resource 2. The process of ingesting food or beverage
Decomposer	An organism that breaks down dead organisms into their parts
Density	How tightly packed molecules are in relation to one another
Discussion	An extended, interactive communication about a topic
Ecosystem	A community of organisms interacting with the non-living parts of their environment
Energy	The ability to do work
Environment	All of the surroundings and conditions that affect the growth and development of living things
Experiment	The act of testing an idea
Factor	A component or contribution
Food Web	Connections between the eaten and eating organisms in an area; many food chains connected together
Function	What something is used for
Habitat	The natural area or home for an organism
Haiku	A traditional Japanese poem that has a three-line structure with the lines containing 5-7-5 syllables, respectively

Hydrothermal Vent	A crack in the ocean floor, where hot chemicals spew up into the water
Hypothesis	An educated guess based on observation
Investigation	An examination or inquiry; looking in depth at something
Mineral	A natural, non-living, inorganic compound
Nutrients	A substance necessary for life and growth
Observation	Information collected with the senses
Organism	A bacterium, plant, alga, fungus, or animal
Oxygen	A gas that is necessary for life
Photosynthesis	Process of making energy using light
Population	A collection of organisms of a particular species that live in a specific place
Prediction	A guess about the future; a statement about expectations
Pressure	The measured amount of push on an object; force per unit area
Producer	An organism that can make its own food
Property	A basic, essential, or characteristic attribute
Scientific Inquiry	The mindset or perspective characteristic of real scientific work
Shimmering Water	The ripple look or shimmer effect of extremely hot water spewing out of hydrothermal vents
Synthesis	The process of making something
The Scientific Method	The step by step process scientists use to investigate
Vitamin	A key nutrient that animals need to function properly

Resources & Reference Materials

Videos/DVDs

The Blue Planet - Seas of Life: The Deep. 2001. BBC/Discovery Channel, BBC Video. **ASIN:** B00005UM1S.
ISBN: 0-7907-6605-1.

Nova: Volcanoes of the Deep. 1999. Boston: WGBH. **ASIN:** 630537337X. **ISBN:** 1-578071-61-5

Reference & Activity Books

Awesome Ocean Science!: Investigating the Secrets of the Underwater World. Littlefield, Cindy A. Charlotte, VT: Williamson Publishing Co. 2003. **ISBN:** 1-885593-71-6

Creatures of the Deep. Hoyt, Erich. Buffalo, NY: Firefly Books. 2001. **ISBN:** 1552093409

Current: The Journal of Marine Education. "Deep Hydrothermal Vents." Vol. 21, No. 3. 2005 (Available from the National Marine Educator's Association; www.marine-ed.org)

The Deep-Sea Floor. Collard, Sneed B. & Gregory Wenzel (il.) Charlesbridge, Watertown, MA. 2003. **ISBN:** 1570914028

Deep Sea Biology: A Natural History of Organisms at the Deep Sea Floor. Gage, John D. & Paul A. Tyler. Cambridge University Press. 1991. **ISBN:** 0521336651

Deep Ocean. Rice, Tony. London: The Natural History Museum. 2000. **ISBN:** 1560988673

Dive to the Deep Ocean: Voyages of Exploration and Discovery. Kovacs, Deborah. Austin, TX: Steck-Vaughn Company. 2000. **ISBN:** 0-7398-0021-3

Dive! My adventures in the deep frontier. Earle, Sylvia. National Geographic Survey. 1999. **ISBN:** 0-7922-7144-0

The Octopus's Garden: Hydrothermal Vents and Other Mysteries of the Deep Sea. Dover, Cindy Lee Van. Perseus Books. 1996. **ISBN:** 0201407701.

The Mid-Oceanic Ridges: Mountains Below Sea Level. Nicolas, Adolphe. Springer-Verlag. 1995. **ISBN:** 0387573801

Oceanus: Reports on Research from Woods Hole Oceanographic Institution. "Deep Ocean Exploration." Vol. 42, No. 2, 2004. **ISSN:** 0029-8182

On-line Resources

http://www.usc.edu/org/cosee-west/resources.html → Listing: **Mysteries in the Mud: Coping with Stress in the Deep - February 2006**

http://oceanexplorer.noaa.gov/explorations/02mexico

http://www.amnh.org/nationalcenter/expeditions/blacksmokers/

http://www.whoi.edu/VideoGallery/vent.html

http://lostcity.jason.org/home.aspx

http://www.pbs.org/wgbh/nova/abyss/life/extremes.html