OCEAN EXPLORATION LESSON PLAN

Molecular Explorations

Theme
Ocean Exploration

Links to Overview Essays and Resources Needed for Student Research
http://www.oceanservice.noaa.gov/topics/oceans/oceanex/
http://oceanexplorer.noaa.gov/explorations/03bio/background/molecular/molecular.html

Subject Area
Life Science/Chemistry

Grade Level
9-12

Focus Question
What are some molecular biology techniques that scientists use to explore Earth's deep oceans?

Learning Objectives
- Students will be able to explain and carry out a simple process for separating DNA from tissue samples.

- Students will be able to explain and carry out a simple process for separating complex mixtures.

- Students will be able to explain the process of restriction enzyme analysis.

Materials Needed
- Electrophoresis chambers and power supplies (see "Learning Procedure")
- 1% agarose gel (Carolina Biological Supply No. WW-21-7075)
- TRIS/Borate/EDTA buffer (Carolina Biological Supply No. WW-21-9025)

- Gel casting trays (Carolina Biological Supply No. WW-21-3655)
- Four test tubes, each containing a pure food color, plus a fifth test tube containing a mixture of food colors; one set for each student group
- Five micropipets (Carolina Biological Supply No. WW-21-1022)
- Liquid dish detergent, approximately 100 ml
- Sodium chloride, approximately 100 g
- Fresh meat tenderizer, approximately 50 g
- Distilled water, approximately 2 l
- 95% ethanol
- Ice, crushed, approximately 3 kg
- Paper towels
- Plastic sandwich bag, one for each student group
- Student instruction handout for each student (see "Learning Procedure")
- OPTIONAL: additional supplies for electrophoresis of student-prepared DNA extracts (see Learning Procedure, steps 5 and 6)

Audio/Visual Materials Needed

None

Teaching Time

Three or four 45-minute class periods, depending upon the number of activities selected

Seating Arrangement

Laboratory groups of 2 – 3 students

Maximum Number of Students

30

Key Words

DNA
Electrophoresis
Restriction enzyme
Molecular biology

Background Information

In the past twenty years, scientists have explored areas of the deep ocean that have never been visited before. These expeditions have discovered hundreds of new species, and even new ecosystems, but much of the world's oceans remain unexplored.

Why is it important to explore the deep oceans? Consider this: Most drugs in use today were initially found in living organisms, and almost all of these organisms are terrestrial. But recent systematic searches for new drugs have shown that antibiotic, anti-cancer, and anti-inflammatory substances are much more common among marine invertebrates than among terrestrial organisms. Particularly promising invertebrate groups include sponges, tunicates, ascidians, bryozoans, octocorals, and some molluscs, annelids, and echinoderms (see the Ocean Exploration lesson "Benthic Drugstore" at *http://oceanexplorer.noaa.gov/explorations/03bio/background/edu/media/Meds_Drugstore.pdf* for more information).

The National Oceanic and Atmospheric Administration (NOAA) created the Office of Ocean Exploration in 2001 to spearhead efforts to learn more about unexplored areas in the Earth's oceans. Recent expeditions have explored the Submarine Ring of Fire in the Mariana Arc, the New England seamount chain, the Gulf of Alaska seamounts, the Arctic Ocean, the Black Sea, the Galapagos rift, and the Northwestern Hawaiian Islands. Recent accomplishments include bioprospecting for new deep sea medicines, observation and monitoring of a new underwater volcano in Hawaii, testing non-invasive research tools to observe and collect deep-sea samples, and investigation of new species in previously unexplored deep-sea ecosystems.

Many of these accomplishments would have been impossible a few years ago, but innovations in equipment and techniques have given researchers powerful new tools for exploring Earth's ocean environments. Molecular biology techniques, in particular, are being used to answer questions about ecology, biodiversity, evolutionary genetics and systematics of marine organisms, as well as in prospecting for new natural products that can be used to treat disease. These techniques include

DNA extraction, RNA extraction, the use of gel electrophoresis to visualize DNA and RNA, polymerase chain reaction (PCR), and DNA sequencing. This lesson is intended to introduce students to several of these techniques.

Learning Procedure

[NOTE: This lesson is based upon activities designed by Ellen Averill, Karen Kyker, Sandy Collins, and Theresa Knapp while participating in the 1993 Woodrow Wilson Biology Institute. These activities are used with permission from the Woodrow Wilson National Fellowship Foundation. Visit *http://woodrow.org* for information on other activities and current programs. The restriction enzyme activity is obtained from the Access Excellence Classic Collection (*http://www.accessexcellence.org*).

1.

Download the following activities:

- "Isolation of DNA from Onion" (*http://www.woodrow.org/teachers/bi/1993/isolation2.html*)
- "Electrophoresis Analogy" (*http://www.woodrow.org/teachers/bi/1993/electrophoresis.html*)
- "Rainbow Electrophoresis" (*http://www.woodrow.org/teachers/bi/1993/rainbow.html*)
- "Desktop Electrophoresis Lab - Moving Molecules" (*http://www.woodrow.org/teachers/bi/1993/moving.html*)
- "How Restriction Enzyme, Probes and RFLP's Work" (*http://www.accessexcellence.org/AE/AEC/CC/word_activity.html*)

There are two options for obtaining the equipment needed for the electrophoresis activity. The first is to buy electrophoresis chambers and power supplies from a laboratory supply company (cost approximately $400 and up). The second is to build your own chambers and power supplies as directed in the "Desktop Electrophoresis Lab" activity (cost approximately $20 per system).

2.

Prepare detergent/salt solution, meat tenderizer solution, sodium chloride solution, electrophoresis gels, TRIS/Borate/EDTA buffer, and student instruction sheets (from the downloaded activities) prior to the lab. If you want to use the (lower cost) "Desktop Electrophoresis" apparatus, prepare the chambers and power supplies as well, unless you plan to have students do this.

3.
Briefly discuss the fact that much of the Earth's ocean is totally unexplored, particulary the deepest areas. Highlight some of the discoveries that have been made by recent expeditions to study the deep ocean. You may want to mention hydrothermal vent communities, cold seeps, methane ices, and deep sea medicines. The following websites have useful information for this discussion:

http://www.bio.psu.edu/cold_seeps for a virtual tour of a cold seep community; http://www.bio.psu.edu/hotvents for a virtual tour of a hydrothermal vent community;

http://oceanexplorer.noaa.gov/explorations/deepeast01/logs/oct1/oct1.html and *http://oceanexplorer.noaa.gov/explorations/03windows/welcome.html* for background on methane ices; and

http://oceanexplorer.noaa.gov/explorations/03bio/welcome.html for background on deep sea medicines.

4.
Tell students that recent advances in molecular biology techniques provide powerful tools for many kinds of scientific investigations, from marine research to crime scene investigations. Discuss the ways in which ocean exploration expeditions might use these techniques. Suggestions should include:

- distinguishing between different species and different growth forms or life cycle stages of the same species (see the lesson plan "Bad Algae" for an example of why this is important);
- investigating genetic similarities between species to obtain clues about evolutionary relationships and geographic dispersal; and
- determining the genes responsible for synthesizing natural products that can be used as disease treatments, such as anti-inflammatory or anti-tumor drugs (this information could allow these products to be synthesized, rather than endangering wild populations of species that produce these chemicals)

Tell students that the purpose of these activities is to introduce three of these techniques.

5.
Have students complete the "Isolation of DNA from Onion" lab activity as directed in the student instructions.

If you want students to use their DNA isolates for the electrophoresis activity, have them transfer the DNA to a clean test tube, rinse with 70% ethanol to remove excess salts, then pour off the ethanol from the test tube. Add 0.5 ml distilled water to the test tube, cover, and refrigerate until the next day. Each student or student group should record their procedures and results in a lab notebook or written report.

6.
Introduce the technique of electrophoresis using the "Electrophoresis Analogy." Have students complete the "Rainbow Electrophoresis" lab activity as directed in the student instructions. Each group should prepare written answers to the questions included in the activity, either in a lab notebook or separate written report.

If you are having students use the DNA extracts prepared in Step 5 for this activity, have them put 85 µl of their extract into a clean test tube, add 15 µl TRIS/Borate/EDTA buffer, and load the electrophoresis gels as directed in the student instruction sheets. Run the gels at 81 volts (use nine batteries in the power supply) for about one hour. Stain the gels by soaking overnight in a 0.02% solution of methylene blue in distilled water. Procedures and results should be recorded in a lab notebook or written report.

7.
Introduce the technique of restriction enzyme cleavage using the word analogy activity described in "How Restriction Enzyme, Probes and RFLP's Work." If you want to do an actual restriction enzyme cleavage procedure, visit the University of Arizona's Biotech Project Web site (*http://biotech.biology.arizona.edu/labs/labs.html*) for a list of biotechnology laboratory experiments. The teacher guide and studentguide for the Restriction Enzyme Analysis lab can be downloaded from *http://biotech.biology.arizona.edu/word/restenzy_tg.doc* and *http://biotech.biology.arizona.edu/word/restenzy_sg.doc*, respectively.

The Bridge Connection

http://www.vims.edu/bridge/ – Click on "Ocean Science Topics" in the "Site Navigation" menu, then "Human Activities," then "Technology," then "Biotechnology" on the topics bar at the top of the page.

The Me Connection

Have students write a brief essay describing three personal benefits that might result from molecular-level explorations of the deep ocean.

Extensions

1. Visit *http://oceanexplorer.noaa.gov/* for details of Ocean Exploration expeditions (many with detailed daily logs) and over 150 hands-on, standards-based lesson plans and a curriculum based on the explorations.

2. For a virtual restriction mapping activity, visit *http://www.geospiza.com/outreach/bio21/materials/restriction_mapping.pdf*

3. Biological supply companies have a variety of materials and kits suitable for other DNA research techniques.

Resources

http://www.oceanservice.noaa.gov/topics/oceans/oceanex/ – Introductory page for the Ocean Exploration website

http://biotech.biology.arizona.edu/ – Web site for the University of Arizona's Biotech Project

http://www.dnaftb.org/dnaftb/ – An animated primer on the basics of DNA, genes, and heredity from the DNA Learning Center at the Cold Spring Harbor Laboratory

http://www.woodrow.org/teachers/bi/1993/ – Background and activities from the 1993 Woodrow Wilson Biology Institute on Biotechnology

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Chemical reactions

Content Standard C: Life Science

- The cell

- Molecular basis of heredity
- Interdependence of organisms
- Biological evolution

Content Standard E: Science and Technology

- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Natural resources
- Science and technology in local, national, and global challenges

Links to AAAS "Oceans Map" (aka benchmarks)

5D/H3 – Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.