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Medicines from the Deep Sea: Exploration of the Gulf of Mexico

Microfriends

Focus
Beneficial microorganisms

Grade Level
5-6 (Life Science)

Focus Question
How may microorganisms benefit humans?

Learning Objectives
Students will be able to describe at least three ways in which microorganisms benefit humans.

Students will be able to describe aseptic procedures.

Students will be able to obtain and culture a bacterial sample on a nutrient medium.

Materials
- ❒ Squirt bottle containing household bleach diluted to a 10% solution, one for each student group
- ❒ Paper towels
- ❒ Sterile cotton swabs (see Learning Procedure), 2 or more for each student group
- ❒ Culture dishes containing nutrient medium (see Learning Procedure), 1 or more for each student group
- ❒ Wax pencils or permanent markers
- ❒ "Glo-Germ" powder (order from Glo-Germ Co., POB 189, Moab, Utah 84532; 800-842-6622; or online at www.glogerm.com), 4 oz.
- ❒ Ultraviolet light
- ❒ Pressure cooker (not needed if pre-sterilized materials are used; see Learning Procedure)
- ❒ Safety glasses, 1 pair for each student
- ❒ Protective disposal gloves
- ❒ Marker board, blackboard, or overhead projector with transparencies for group discussions

Audio/Visual Materials
None

Teaching Time
One or two 45-minute class periods

Seating Arrangement
Groups of 2-3 students

Maximum Number of Students
30

Key Words
Cardiovascular disease
Cancer
Arthritis
Natural products
Microorganisms
Mutualism
Commensalism
Parasitism
Bacterial culture
Aseptic technique

Background Information
Despite the many advances of modern medicine, disease is still the leading cause of death in the United States. Cardiovascular disease and cancer together account for more than 1.5 million deaths annually (40% and 25% of all deaths, respectively).

In addition, one in six Americans have some form of arthritis, and hospitalized patients are increasingly threatened by infections that are resistant to conventional antibiotics. The cost of these diseases is staggering: $285 billion per year for cardiovascular disease; $107 billion per year for cancer; $65 billion per year for arthritis. Death rates, costs of treatment and lost productivity, and emergence of drug-resistant diseases all point to the need for new and more effective treatments.

Most drugs in use today come from nature. Aspirin, for example, was first isolated from the willow tree. Morphine is extracted from the opium poppy. Penicillin was discovered from common bread mold. To date, almost all of the drugs derived from natural sources come from terrestrial organisms. But recently, systematic searches for new drugs have shown that marine invertebrates produce more antibiotic, anti-cancer, and anti-inflammatory substances than any group of terrestrial organisms. Particularly promising invertebrate groups include sponges, tunicates, ascidians, bryozoans, octocorals, and some molluscs, annelids, and echinoderms.

The list of drugs derived from marine invertebrates includes:

Ecteinascidin – Extracted from tunicates; being tested in humans for treatment of breast and ovarian cancers and other solid tumors

Topsentin – Extracted from the sponges *Topsentia genitrix*, *Hexadella* sp., and *Spongosorites* sp.; anti-inflammatory agent

Lasonolide – Extracted from the sponge *Forcepia* sp.; anti-tumor agent

Discodermalide – Extracted from deep-sea sponges belonging to the genus *Discodermia*; anti-tumor agent

Bryostatin – Extracted from the bryozoan *Bugula neritina*; potential treatment for leukemia and melanoma

Pseudopterosins – Extracted from the octocoral (sea whip) *Pseudopterogorgia elisabethae*; anti-inflammatory and analgesic agents that reduce swelling and skin irritation and accelerate wound healing

ω-conotoxin MVIIA – Extracted from the cone snail, *Conus magnus*; potent pain-killer

This list reflects an interesting fact about invertebrates that produce pharmacologically active substances: most species are sessile; they are immobile and live all or most of their lives attached to some sort of surface. Several reasons have been suggested to explain why these particular animals produce potent chemicals. One possibility is that they use these chemicals to repel predators, since they aresessile, and thus basically "sitting ducks." Since many of these species are filter feeders, and consequently are exposed to all sorts of parasites and pathogens in the water, they may use powerful chemicals to repel parasites or as antibiotics against disease-causing organisms. Competition for space may explain why some of these invertebrates produce anti-cancer agents: if two species are competing for the same piece of bottom space, it would be helpful to produce a substance that would attack rapidly dividing cells of the competing organism. Since cancer cells often divide more rapidly than normal cells, the same substance might have anti-cancer properties.

The goal of the 2003 Medicines from the Deep Sea Expedition is to discover new resources with pharmaceutical potential in the Gulf of Mexico. To achieve this goal, the expedition will:

- collect selected benthic invertebrates from deep-water bottom communities in the Gulf of Mexico (sponges, octocorals, molluscs, annelids, echinoderms, tunicates), identify these organisms, and obtain samples of DNA and RNA from the collected organisms;
- isolate and culture microorganisms that live

in association with deep-sea marine invertebrates;
- prepare extracts of benthic invertebrates and associated microorganisms, and test these extracts to identify those that may be useful in treatment of cancer, cardiovascular disease, infections, inflammation, and disorders of the central nervous system;
- isolate chemicals from extracts that show pharmacological potential and determine the structure of these chemicals;
- further study the pharmacological properties of active compounds; and
- develop methods for the sustainable use of biomedically important marine resources.

The last objective is particularly important, since many potentially useful drugs are present in very small quantities in the animals that produce these drugs. This makes it impossible to obtain useful amounts of the drugs simply by harvesting large numbers of animals from the sea. Some alternatives are chemical synthesis of specific compounds, aquaculture to produce large numbers of productive species, or culture of the cells that produce the drugs.

Notice that in addition to selected benthic invertebrates, scientists on the Medicines from the Deep Sea Expedition are equally interested in associated microorganisms as possible sources of useful pharmaceuticals. Many students assume that most microorganisms are dangerous and cause diseases in humans. This activity is designed to introduce students to some of the ways that humans benefit from microorganisms.

Learning Procedure

[NOTE: Steps 2 – 5 are based, in part, on activities developed during the 1996/7 teacher internship program of the Center for Engineering Plants for Resistance Against Pathogens at the University of California, Davis. You may want to download a copy of "Microbial World" which has other background information and activities from http://ceprap.ucdavis.edu/acrobat/microkit_00.pdf]

1. Review the importance of finding new drugs for the treatment of cardiovascular disease, cancer, inflammatory diseases, and infections. Describe the potential of marine communities as sources for these drugs, and introduce the objectives of the 2003 Medicines from the Deep Sea Expedition. Highlight the fact that researchers are focussing on microorganisms as well as the larger benthic invertebrates with which the microorganisms are associated.

   Briefly review (or introduce) basic information about bacteria:
   - Bacteria have existed on Earth longer than any other known organism.
   - Bacterial cells are structurally simpler than those of other organisms and do not have a nucleus.
   - Bacteria are extremely hardy; some can live well below freezing, others survive in boiling water, and others live in solid rock.
   - Bacteria are everywhere, and in large numbers; a teaspoon of garden soil contains about ten billion bacteria, and there are more bacteria in the human mouth than the total number of people who have ever lived.
   - Virtually all plants and animals live in association with bacteria and other microorganisms; these associations may benefit both organisms (mutualism), benefit one organism without affecting the other (commensalism); or benefit one organism and harm the other (parasitism).
   - Most bacteria are not parasitic.

2. Prepare culture dishes: Petri dishes containing sterile nutrient agar can be purchased from biological supply companies, or you can prepare your own. If you are using nutrient agar, prepare the solution according to manufacturers' instructions. Sterilize the agar solution in a pressure cooker by placing the agar container in a basket just above the water level. Seal the lid onto the cooker and allow steam to flow freely for 10 minutes. Place the pressure control on the vent and maintain the pressure at 15 pounds for 30

minutes. At the end of this time, let the cooker cool, then pour the agar into sterilized petri dishes, baby food jars, or shallow glass dishes with glass covers.

As an alternative to nutrient agar, you can use unflavored gelatin. Prepare the gelatin according to directions on the package, but substitute beef broth (made from a bouillon cube) for boiling water. Sterilize the gelatin as described above and pour it into sterilized petri dishes or other containers.

Prepare sterile cotton swabs by wrapping one or two swabs in white paper (butcher paper), taping with masking tape, and sterilizing in a pressure cooker as described above. Alternatively, you can buy pre-packaged sterile swabs from a biological supply company.

3. "Infect" student lab stations with Glo-Germ powder by rubbing the powder into a few areas on each station and brushing off any excess powder.

4. Tell students that they are going to culture some bacteria living in your classroom, and that this type of work requires special procedures called aseptic technique to minimize the risks of contamination. Say that to practice some of these procedures, their lab stations have been "infected" with glowing particles that represent bacteria. Show students what an "infected" area looks like under ultraviolet light. Provide students with protective gloves, eye protection, paper towels, and squirt bottles of 10% bleach solution. Have them carefully wipe down the entire lab area with the bleach solution, then inspect the area with ultraviolet light.

4. Provide student groups with one or more culture dishes containing nutrient agar or gelatin, sterile cotton swabs, and wax pencils or markers. Each group should select an area of the classroom that students believe will have large numbers of bacteria, and sample the area by having one student rub the surface with a sterile swab. Have students remove the tops from their culture dishes and gently streak the surface of the agar or gelatin with the swab, being careful not to tear the surface. After replacing the tops, students should seal the tops to the dishes with strapping tape and label the dishes with their names and collection site. Have students place their dishes upside down in the incubation area. If an incubator is not used, be sure that the dishes are not placed in direct sunlight or a cold part of the room. Have students clean their lab stations and wash their hands before leaving the lab.

After 2 – 4 days, students should record their observations, including how many different types of bacteria seem to be present. Have each group present their results, and lead a discussion focussing on which parts of the classroom seem to have the most bacteria and why.

Following this activity, collect the culture dishes, remove the covers, and immerse in a 10% bleach solution for at least 15 minutes. Drain the excess solution and seal the dishes in a plastic bag for disposal. Alternatively, you may sterilize the dishes for 30 minutes in a pressure cooker at 15 lb pressure.

5. Have students prepare a short written report about at least three ways in which bacteria that are beneficial to humans. Summarize students' findings, and lead a discussion focussing on how bacteria benefit humans. Some benefits are:
   - bacteria in human intestines aid in the digestion of certain foods;
   - production of cheese, yogurt, and other foods;
   - decomposition and recycling of dead organisms;
   - fixation of nitrogen from the atmosphere into useable nitrogen in soils;
   - production of antibiotics;
   - photosynthetic bacteria produce oxygen; cyanobacteria produced the Earth's oxygen atmosphere 2,000 million years ago;

- bacteria are responsible for the production of fossil fuels;
- bacteria are used to clean up polluted areas, including oil spills;
- bacteria produce a variety of chemicals used in many industries, including acetone, butanol, and citric acid;
- bacteria are used to treat sewage;
- bacteria are what makes composting work;
- and bacteria can be used to generate methane gas from sewage waste.

The BRIDGE Connection

www.vims.edu/bridge/ – Click on "Ocean Science" in the navigation menu to the left, then "Chemistry" for resources on drugs from the sea. Click on "Ecology" then deep sea for resources on deep-sea communities. Click on "Human Activities" then "Technology" then "Biotechnology" for resources on biotechnology.

The "Me" Connection

Have students write a short essay describing how bacteria affect their own lives in a typical day.

Connections to Other Subjects

English/Language Arts; Chemistry

Evaluation

Written and oral reports in Steps 4 and 5 provide opportunities for evaluation.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest discoveries of the 2003 Medicines from the Deep Sea Expedition.

Visit the following websites for other activities related to microorganisms:

www.glogerm.com
http://ceprap.ucdavis.edu/acrobat/microkit_00.pdf
http://spikesworld.spike-jamie.com/science/index.html
http://www.umsl.edu/~microbes/

Resources

http://oceanica.cofc.edu/activities.htm – Project Oceanica website, with a variety of resources on ocean exploration topics

http://www.umsl.edu/~microbes/pdf/steriletechnique.pdf - Worksheet on sterile technique

http://www.umsl.edu/~microbes/ – Website of the Science in the Real World: Microbes in Action of the Department of Biology, University of Missouri - St. Louis

www.glogerm.com – Website of the Glo-Germ Company, with activity ideas related to microorganisms

http://ceprap.ucdavis.edu/acrobat/microkit_00.pdf – Activity manual developed during the 1996/97 teacher internship program of the Center for Engineering Plants for Resistance Against Pathogens at the University of California, Davis

http://spikesworld.spike-jamie.com/science/index.html — Website with lots of background and activities on multiple science topics, including microorganisms

National Science Education Standards

Content Standard A: Science As Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science
- Structure and function in living systems
- Populations and ecosystems
- Diversity and adaptations of organisms

Content Standard E: Science and Technology
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives
- Personal health
- Natural hazards
- Risks and benefits
- Science and technology in society

For More Information

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