CORAL REEF LESSON PLAN

Caution: Do Not Bleach!

Focus
Coral reef bleaching

Grade Level
9-12 (Life Science)

Focus Question
Why are coral reefs important, and what are possible explanations for the phenomenon known as "coral bleaching?"

Learning Objectives
- Students will be able to identify and explain five ways that coral reefs benefit human beings.

- Students will be able to identify and explain three major threats to coral reefs.

- Students will be able to describe major components of the Coral Reef Early Warning System.

- Students will be able to identify and discuss actions that can be undertaken to reduce or eliminate threats to coral reefs.

- Students will be able to discuss at least one hypothesis that explains why corals under stress may expel their zooxanthellae

Materials
- Copies of either "Coral Reef Subject Review" *(fill-in-the-blank version, with or without word bank)* or "Coral Reef Subject Review Crossword Puzzle," one copy for each student or student group
- Computers with internet access

Audio/Visual Materials
None, unless students require A-V equipment for their public education programs

Teaching Time

One or two 45-minute class periods

Seating Arrangement

Classroom style or groups of 4-6 students

Maximum Number of Students

30

Key Words

Coral reefs
Zooxanthellae
Symbiosis
Bleaching

Background

Coral reefs are one of the most biologically productive ecosystems on Earth. Most people have seen images of brightly colored fishes and other reef-dwelling organisms, yet many do not understand why these systems are personally important. Programs and articles about coral reefs typically point out benefits that include protecting shorelines from erosion and storm damage, supplying foods that are important to many coastal communities, and providing recreational and economic opportunities. These benefits are obviously important to people who live near reefs, but there is another aspect of coral reefs that can benefit everyone: the highly diverse biological communities are new sources of powerful antibiotic, anti-cancer and anti-inflammatory drugs.

The idea of coral reefs as a source of important new drugs is new to many people; but in fact, 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. Although almost all of the drugs derived from natural sources come from terrestrial organisms, recent 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.

Some of the drugs derived from marine invertebrates are:

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

Think a moment about the invertebrates in this list. Notice that most of these species are sessile, and live all or most of their lives attached to some sort of surface. Several reasons have been suggested to explain why these animals are particularly productive of potent chemicals. One possibility is that they use these chemicals to repel predators, since they are 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.

For more information on drugs from the sea, visit *http://www.reefcheck.org/articles/june_03/drugs_sea.pdf* and *http://www.reefcheck.org/articles/june_03/marine_pharmacology.pdf*

Despite their numerous benefits to humans, many coral reefs are threatened by human activities. Sewage and chemical pollution can cause overgrowth of algae, oxygen depletion, and poisoning. Fishing with heavy trawls and explosives damages the physical structure of reefs as well as the coral animals that build them. Careless tourists and boat anchors also cause mechanical damage. Thermal pollution from power plants and global warming cause physiological stress that kills coral animals and leaves the reef structure vulnerable to erosion. Many of these impacts are the result of ignorance; people simply aren't aware of the importance of coral reefs or the consequences of their actions, but the damage and threats to reefs continues to increase on a global scale.

Some of the most severe damage appears to be caused by thermal stress. Shallow-water reef-building corals live primarily in tropical latitudes (less than 30° north or south of the equator). These corals live near the upper limit of their thermal tolerance. Abnormally high temperatures result in thermal stress, and many corals respond by expelling the symbiotic algae (zooxanthellae) that live in the corals' tissues. Since the zooxanthellae are responsible for most of the corals' color, corals that have expelled their algal symbionts appear to be bleached. Because zooxanthellae provide a significant portion of the corals' food and are involved with growth processes, expelling these symbionts can have significant impacts on the corals' health. In some cases, corals are able to survive a "bleaching" event and eventually recover. When the level of environmental stress is high and sustained, however, the corals may die.

Prior to the 1980s, coral bleaching events were isolated and appeared to be the result of short-term events such as major storms, severe tidal exposures, sedimentation, pollution, or thermal shock. Over the past twenty years, though, these events have become more widespread, and many laboratory studies have shown a direct relationship between bleaching and water temperature stress. In general, coral bleaching events often occur in areas where the sea surface temperature 1°C or more above the normal maximum temperature.

In 1998, the President of the United States established the Coral Reef Task Force (CRTF) to protect and conserve coral reefs. Activities of the CRTF include mapping and monitoring coral reefs in U.S. waters, funding research on coral reef degradation, and working with governments, scientific and environmental organizations, and business to reduce coral reef destruction and restore damaged coral reefs. Using high-resolution satellite imagery and Global Positioning System (GPS) technology, the National Oceanic and Atmospheric Administration (NOAA) has made comprehensive maps of reefs in Puerto Rico, the U.S. Virgin Islands, the eight main Hawaiian Islands and the Northwestern Hawaiian Islands. Maps of all shallow U.S. coral reefs are expected to be completed by 2009. NOAA monitors reefs using a system of specially designed buoys that measure air temperature, wind speed and direction, barometric pressure, sea temperature, salinity and tidal level, and transmit these data every hour to scientists. Satellites are also used to monitor changes in sea surface temperatures and algal blooms that can damage reefs. Research and restoration projects on selected coral reefs are conducted by NOAA's National Undersea Research Program.

The first part of this lesson is intended to:

- introduce students to coral reefs and improve their understanding of why these systems are important, how they are threatened, and what can be done to protect and restore these unique and valuable ecosystems; and to
- introduce students to hypotheses that explain why corals under stress may expel their zooxanthellae.

In the second part of this lesson, students design and prepare educational programs to improve public awareness of the importance of coral reefs and what needs to be done to reduce or eliminate harmful impacts from human activities. This activity offers many opportunities for cross-curricular activities, and may be extended over several weeks or months. If time is limited, you may choose to use the first part alone.

Learning Procedure

Part 1

1.

Direct students to the coral reef tutorials at *http://www.oceanservice.noaa.gov/education/kits/corals*. You may want to assign different tutorial sections to each student group. Have each student or student group complete one version of the Coral Reef Subject Review and lead a discussion to review the answers. Be sure that students understand the relationship between coral animals and their symbiotic algae (zooxanthellae), and that under thermal stress many corals will expel their zooxanthellae.

Briefly explain the purpose and activities of the U. S. Coral Reef Task Force (CRTF), and highlight the monitoring functions that are intended to identify reef areas threatened by thermal stress or algal blooms.

2.

Tell students that their assignment is to investigate possible explanations for zooxanthellae expulsion by corals under stress, and prepare a written report outlining at least one hypothesis that explains this behavior. The report should explain:

- the symbiotic relationship between corals and their zooxanthellae;
- how corals obtain their zooxanthellae; and
- how environmental stress may alter the symbiosis.

If you want to provide a starting point for this research, the following resources will be useful:

http://oceanservice.noaa.gov/education/kits/corals/supp_coral_roadmap.html (Roadmap to Resources: Corals)

http://www.gbrmpa.gov.au/corp_site/info_services/publications/reef_research/issue2_98/2rmn1.html (article: Bleaching The Great Unknown)

http://www.oneocean.org/overseas/200009/coral_bleaching_the_hows_and_whys_and_whats_next.html (article: Coral Bleaching: the Whys, the Hows and What Next?)

http://ioc.unesco.org/coralbleaching/Hughes%20et%20al.pdf (article: Climate Change, Human Impacts, and the Resilience of Coral Reefs)

http://www.crc.uri.edu/download/COR_011.pdf (article: Coral Bleaching: Causes, Consequences and Response)

3.

Lead a discussion of students' research results. Written reports should include most of the following points:

- Zooxanthellae are single-celled motile algae (dinoflagellates).
- Many marine invertebrates in addition to corals have symbiotic algae.
- Photosynthesis by zooxanthellae provides a significant source of nutrition for many host symbionts; as much as 90% of the total energy requirement in some coral and giant clam species.
- Zooxanthellae are also involved in calcium carbonate deposition (skeletal growth) in some corals.
- Some zooxanthellae produce an ultraviolet-absorbing pigment that may act as a sort of "sunscreen" for host corals.
- The mechanism by which corals obtain zooxanthellae (or, from a slightly different perspective, become infected with zooxanthellae) is not known, but sea anemone larvae have been reported to indiscriminantly ingest zooxanthellae along with other particulate materials. The algal cells become incorporated into the larvae's endodermal cells, while other particulate materials are either digested or expelled.
- "Bleaching" has been observed in most marine organisms that host zooxanthellae.
- It is not known whether bleaching happens because the algae leave their host animal or because the host expels the algae.