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2006 Laser Line Scan Expedition

Architects of the Coral Reef

(adapted from the 2003 Gulf of Mexico Deep Sea Habitats Expedition)

Focus
Reproduction in Cnidaria

Grade Level
5-6 (Life Science)

Focus Question
What are corals, and how do they reproduce?

Learning Objectives
Students will be able to identify and describe at least five characteristics of Cnidaria.

Students will be able to compare and contrast the four classes of Cnidaria.

Students will be able to describe typical reproductive strategies used by Cnidaria.

Materials
❒ Drawing materials for making posters

Audio/Visual Materials
❒ Chalkboard, marker board with markers, or overhead transparencies for group discussions

Teaching Time
One 45-minute class period, plus time for student research, making posters, and student presentations

Seating Arrangement
Groups of 2-4 students

Maximum Number of Students
30

Key Words
Cnidaria
Nematocyst
Zooxanthellae
Medusa
Polyp
Planula
Anthozoa
Hydrostatic skeleton

Background Information
Coral reefs are one of the most biologically productive ecosystems on Earth, and benefit humans in a variety of ways that include protecting shorelines from erosion and storm damage, supplying foods that are important to many coastal communities, and providing recreational and economic opportunities. In addition, these highly diverse biological communities are proving to be very promising sources of powerful new antibiotic, anti-cancer and anti-inflammatory drugs. Most drugs in use today come from nature. While almost all of these drugs are derived from terrestrial plants and microbes, 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. For more information about drugs from the sea, see "More About Drugs from the Sea" below. You may also want to visit the Ocean Explorer Web site for the 2003 Deep Sea Medicines Expedition (http://oceanexplorer.noaa.gov/explorations/03bio/welcome.html).

Even though they provide 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 damage the physical structure of reefs as well as the coral animals that build them. Careless tourists and boat anchors also cause mechanical damage. 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 20 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 rises 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. 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 (NURP). Using high-resolution satellite imagery and Global Positioning Satellite (GPS) technology, 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.

While these maps show where various reef habitats are located, they are unable to provide detailed information needed for effective management of complex coral reef systems. Side-scan sonar techniques are able to cover large areas, but cannot distinguish individual organisms in communities of fish, algae, and invertebrates. Video and photographic data can be collected by divers in areas shallower than 20 to 30 meters, and by towed cameras, remotely operated vehicles, and manned submersibles in deeper waters. None of these methods, though, are able to collect the large amounts of visual data needed to make detailed maps of coral reef habitats.

A new technology called laser line scan (LLS) may provide a bridge between broad-scale approaches such as side-scan sonar and fine-scale video and still photography. LLS systems can detect objects as small as about one centimeter. This is much better resolution than is possible with side-scan sonar, but not quite as good as video. While LLS systems are unable to cover as much area as side-scan sonar, these systems provide two to five times the coverage of video. One of the most publicized uses of LLS was in the search for wreckage from TWA Flight 800, which went down off Long Island in 1996. In 2001, the Ocean Explorer program and NURP co-sponsored a field test of a commercial LLS system for imaging seafloor habitats. Results from this test confirmed the potential of LLS technology for mapping benthic habitats. The laser images revealed details of low relief sediments such as sand waves and ripples, and showed a variety of fishes, salp chains, sea anemones, sea pens, kelp and other macro-algae. These images allowed scientists to identify fish and invertebrate species within a given habitat, and to observe the relationships of these animals to their habitats. The purpose of the 2006 Laser Line Scan Expedition is to test the ability of LLS technology to provide detailed information about a variety of coral reef habitats in the Hawaiian Archipelago.

In this activity, students will explore characteristics of Cnidarians and typical reproductive strategies used by members of this phylum.

Learning Procedure

1. To prepare for this lesson:
   - Read the introductory essays for the 2006 Laser Line Scan Expedition at http://oceanexplorer.noaa.gov/explorations/06laserline/.

   If you are not already familiar with coral reefs, you may also want to review the coral reef tutorials at http://www.nos.noaa.gov/education/welcome.html.

2. Tell students that corals are members of the phylum Cnidaria, and that their assignment is to
   (a) Prepare a written report that will include:
   - At least three characteristics of Cnidarians;
   - Description of the four classes of this phylum, with drawings or photographs of a typical animal of each class; and
   - Description of different reproductive strategies used by Cnidarians; and

   (b) Prepare a poster illustrating one class of Cnidaria, and how this class reproduces.

   You may want to suggest that students visit http://www.vims.edu/bridge/otherinverts.html as a starting point for their research.

3. Have each group present a summary of their findings. Tabulate key facts about Cnidaria on a chalkboard, marker board, or overhead transparencies. These facts should include:
   - 'Cnidaria' means 'stinging nettle' in Greek.
   - There are four classes of Cnidaria: Anthozoa (corals, anemones, and sea pens), Cubozoa (highly toxic box jellies), Hydrozoa (hydroids, fire corals, and animals resembling jellyfish like the Portuguese man-of-war), and Scyphozoa (true jellyfish).
   - All Cnidarians live in water.
   - Cnidarians are radially symmetrical.
   - There are two body plans among the Cnidaria: the medusa is the "jellyfish plan" with an umbrella-shaped body having the mouth facing downwards, surrounded by tentacles; the polyp is the "flower plan" with a mouth facing upwards and also surrounded by tentacles; the other end of the polyp is usually attached to a fixed surface.
   - Cnidarians have a distinct upper and lower surface—the surface with the mouth is called the oral surface, and the opposite side is called the aboral surface.
   - Cnidarians have nerve cells and muscles, but do not have organs such as brains, hearts, circulatory or excretory systems.
   - Cnidarians have simple digestive systems without an anus; the mouth is used for output as well as input.
   - Cnidarians have stinging cells called nematocysts (which are the primary distinguishing characteristic of the phylum); these stingers often contain toxins, that account for the sting

of jellyfishes; some box jellies have toxins powerful enough to kill humans.
- Most cnidarians are carnivorous; many feed on small particles of detritus and plankton, but others are able to capture and eat large prey.
- Some cnidarians, including many corals, have symbiotic single-celled algae called zooxanthellae that produce food by photosynthesis; the cnidarians are able to use this food, and provide the zooxanthellae with protection and simple minerals.
- Many cnidarians, including many corals, are colonial, with many individual animals living together as one organism.
- Cnidarians maintain their shape with fluids inside their bodies (this is called a hydrostatic skeleton).
- Some cnidarians also produce a hard internal skeleton of limestone (this is what makes some of the "rocks" that form coral reefs).
- Some corals are used to make jewelry.
- Coral reefs protect many coastal areas from erosion and storm damage, provide habitat and nursery areas for fishes that provide food for many people around the world, and support tourist industries in many countries.
- Some reef-dwelling organisms are the source for important pharmaceuticals.
- The life cycle of many cnidarians includes a polyp phase as well as a medusa phase; in Anthozoa, though, there is never a medusa phase.
- Most Cnidarians release eggs and sperm simultaneously into the water, so fertilization is external.
- In many corals, ova and sperm are located in the same polyp; fertilization takes place inside the gastrovascular cavity, and the larvae are ejected through the mouth.
- A fertilized cnidarian egg develops into a free-swimming larva called a planula.
- Planula larvae are pear shaped and fringed with cilia that give them limited swimming ability.
- Planula larvae eventually settle down and develop into polyps.
- In some cnidarians, polyps may reproduce asexually by budding off more polyps or by budding off medusa forms. These medusae swim off and develop into adults that may eventually produce gametes that develop into planulae. Anthozoa never produce medusae.

The Bridge Connection

http://www.vims.edu/bridge/reef.html; http://www.vims.edu/bridge/otherinverts.html

The "Me" Connection

Have students write a short essay describing ways that cnidarians or coral reefs might be important to their own lives.

Connections to Other Subjects

English/Language Arts, Earth Science

Evaluation

Written reports and posters provide opportunities for assessment.

Extensions

Log on to http://oceanexplorer.noaa.gov to keep up to date with the latest 2006 Laser Line Scan Expedition discoveries, and to find out what researchers are learning about coral communities in the Hawaiian Archipelago.

Other Relevant Lesson Plans from NOAA's Ocean Exploration Program

Keep Away

http://oceanexplorer.noaa.gov/explorations/03mex/background/edu/media/mexdh_keepaway.pdf
(5 pages, 424k) (from the 2003 Gulf of Mexico Deep Sea Habitats Expedition)

Focus: Effects of pollution on diversity in benthic communities (Life Science)

In this activity, students will discuss the meaning of "biological diversity" and compare and contrast the concepts of "variety" and "relative abundance" as they relate to biological diversity. Given information on the number of individuals, number of species, and biological diversity at a series of sites, students will make inferences about the possible effects of oil drilling operations on benthic communities.

Deep Gardens

http://oceanexplorer.noaa.gov/explorations/05deepcorals/background/edu/media/05deepcorals_gardens.pdf
(8 pages, 359k) (from the Florida Coast Deep Corals 2005 Expedition)

Focus: Comparison of deep-sea and shallow-water tropical coral reefs (Life Science)

In this activity, students will compare and contrast deep-sea coral reefs with their shallow-water counterparts, describe three types of coral associated with deep-sea coral reefs, and explain three benefits associated with deep-sea coral reefs. Students will explain why many scientists are concerned about the future of deep-sea coral reefs.

Islands, Reefs, and a Hotspot

http://oceanexplorer.noaa.gov/explorations/02hawaii/background/education/media/nwhi_hot.pdf
(8 pages, 484kb) (from the 2002 Northwestern Hawaiian Islands Expedition)

Focus: Formation of the Hawaiian archipelago (Earth Science)

In this activity, students will be able to describe eight stages in the formation of islands in the Hawaiian archipelago and will be able to describe the movement of tectonic plates in the Hawaiian archipelago region. Students will also be able to describe how a combination of hotspot activity and tectonic plate movement could produce the arrangement of seamounts observed in the Hawaiian archipelago.

Forests of the Deep

http://oceanexplorer.noaa.gov/explorations/04alaska/background/edu/media/GOA04.Forests.pdf
(4 pages, 232k) (from the 2004 Gulf of Alaska Seamount Expedition)

Focus: Deep-sea coral communities associated with seamounts (Life Science)

In this activity, students will be able to explain at least three ways in which seamounts are important to biological communities, infer at least three ways in which deep-sea corals are important to seamount ecosystems, and explain why many scientists are concerned about the future of seamount ecosystems.

A Piece of Cake

http://oceanexplorer.noaa.gov/explorations/03bump/background/edu/media/03cb_cake.pdf
(4 pages, 244k) (from the 2003 Charleston Bump Expedition)

Focus: Spatial heterogeneity in deep-water coral communities (Life Science)

In this activity, students will be able to explain what a habitat is, describe at least three functions or benefits that habitats provide, and describe some habitats that are typical of deep-water hard bottom communities. Students will also be able to explain how organisms, such as deep-water corals and sponges, add to the variety of habitats in areas such as the Charleston Bump.

Easy as Pi

http://oceanexplorer.noaa.gov/explorations/03bump/background/edu/media/03cb_pi.pdf
(4 pages, 252k) (from The Charleston Bump 2003 Expedition)

Focus: Structural complexity in benthic habitats (Life Science/Mathematics)

In this activity, students will be able to describe the importance of structural features that increase surface area in benthic habitats and quantify the relative impact of various structural modifications on surface area in model habitats. Students will also be able to give examples of organisms that increase the structural complexity of their communities.

Other Resources

http://oceanservice.noaa.gov/education/kits/corals/welcome.html – The National Ocean Service Coral Reef Discovery Kit, with a variety of coral reef-related lessons, information, and activities.

http://www.coris.noaa.gov/ – NOAA's Coral Reef Information System

http://www.csc.noaa.gov/benthic/mapping/techniques/sensors/laser-line.htm – Information about laser line scan technology

http://response.restoration.noaa.gov/kids/kids.html – Click on "Coral Reefs and Oil Spills: A Guided Tour" for a basic overview of coral ecology, types of things that can harm coral, and see how resource managers go about response and restoration efforts; from the National Ocean Service Office of Response and Restoration

http://tolweb.org/tree/phylogeny.html – The Tree of Life Web site

Roberts, S. and M. Hirshfield. Deep Sea Corals: Out of sight but no longer out of mind. http://www.oceana.org/index.php?id=699 — Background on deep-water coral reefs

http://www.oceanicresearch.org/ – The Oceanic Research Group Web site; lots of photos, but note that they are very explicit about their copyrights; check out "Cnidarians: Simple but Deadly Animals!" by Jonathan Bird, which provides an easy introduction designed for classroom use

http://www.mesa.edu.au/friends/seashores/index.html – "Life on Australian Seashores" by Keith Davey on the Marine Education Society of Australasia Web site, with an easy introduction to Cnidaria, including their method of reproduction.

http://www-biol.paisley.ac.uk/courses/Tatner/biomedia/units/cnid1.htm – Phylum Cnidaria on Biomedia of the Glasgow University Zoological Museum on the Biological Sciences, University of Paisley, Scotland Web site; includes explanations of the major classes, a glossary of terms and diagrams and photos.

http://www.calacademy.org/calwild/2000fall/stories/seavenoms.html – Article from California Wild: "Stinging Seas - Tread Softly In Tropical Waters" by Gary C. Williams; an introduction to the venomous nature of tropical cnidarians, why and how they do it

Ariadne, D. and D. Diamante-Fabunan. 2000. Coral Bleaching: the Whys, the Hows and What Next? OverSeas, The Online Magazine for Sustainable Seas. http://www.oneocean.org/overseas/200009/coral_bleaching_the_hows_and_whys_and_whats_next.html

http://www.coral.noaa.gov/ – Web site for NOAA's Coral Health and Monitoring Program

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

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
- Reproduction and heredity
- Populations and ecosystems

- Diversity and adaptations of organisms

Content Standard F: Science in Personal and Social Perspectives
- Populations, resources, and environments

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1.
The Earth has one big ocean with many features.
- *Fundamental Concept h.* Although the ocean is large, it is finite and resources are limited.

Essential Principle 5.
The ocean supports a great diversity of life and ecosystems.
- *Fundamental Concept e.* The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.
- *Fundamental Concept f.* Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy." Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

Essential Principle 6.
The ocean and humans are inextricably interconnected.
- *Fundamental Concept b.* From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
- *Fundamental Concept c.* The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.
- *Fundamental Concept e.* Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (such as point source, non-point source, and noise pollution) and physical modifications (such as changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.
- *Fundamental Concept g.* Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Essential Principle 7.
The ocean is largely unexplored.
- *Fundamental Concept a.* The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.
- *Fundamental Concept b.* Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.
- *Fundamental Concept c.* Over the last 40 years, use of ocean resources has increased significantly, therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations.
- *Fundamental Concept d.* New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
- *Fundamental Concept f.* Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers,

geologists, meteorologists, and physicists, and new ways of thinking.

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Please send your comments to:
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