MacGillivray Freeman's
CORAL REEF ADVENTURE

The coral reef is an entire living system, a structure built by colonies of tiny coral animals over millions of years. Teaming with as much biodiversity as terrestrial rainforests, coral reefs, with their extraordinary beauty, bright palette of colors, and oddly patterned inhabitants, are one of Earth's most important ecosystems.

The biodiversity of the reef system supports a vast interdependent food web, from microscopic plants and animals to humans. However, this life sustaining resource is now seriously threatened by human impact. The possible warming of our climate with associated warming of ocean temperatures, increased sedimentation from development along coastal areas, pollution, and unsustainable fishing methods are only some of the threats to reefs worldwide. As humans change the environment on the surface of the Earth, the conditions underneath the surface of our oceans change accordingly.

Through scientific exploration and discovery at Scripps Institution of Oceanography and other research institutions worldwide, we are learning how the coral reef ecosystem is dependent on the complex interactions of its inhabitants. From the microscopic plants that live within the tissues of the corals to the diversity of invertebrates and fishes that find food and shelter within the colorful caves and crevices, the reef system's millions of species also provide important food resources for sharks, sea turtles and dolphins. Millions of people throughout the world depend directly on the reefs for their livelihood.

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“Rainforests of the Sea”

There are more species of organisms living on coral reefs than in any other environment in the ocean. In fact, despite covering less that 0.2 percent of the total area of oceans, coral reefs are noted for some of the highest levels of total productivity on Earth and house 25% of all marine creatures. Like a rainforest, coral reefs form a habitat where an astonishing array of life thrives. It has been estimated that between 1 and 9 million species live on coral reefs. Reefs are home to thousands of species found nowhere else on Earth. For many it is a hunting ground, a safe place to hide, a place to breed, to raise young, and to grow old. There is a complex and delicate web of close relationships between the many organisms in the coral reef ecosystem.

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More Than Just Colorful Rocks: Corals Are Animals

The corals that form the structure of a coral reef are living animals that feed, fight, reproduce and grow. Corals are invertebrates, animals without a backbone, belonging to the class Anthozoa (AN-THO-ZOA) and the phylum Cnidaria (NI-DARIA). Corals, like other anthozoans, have a simple body structure that has only one body opening, the mouth. They are closely related to other cnidarians such as jellyfish, which float through the water, and anemones that, like corals, attach themselves to a hard surface. The individual coral animal body unit is called a “polyp.” Each polyp has a mouth surrounded by a ring of tentacles leading to the stomach. Coral polyps are connected to other polyps in a colony. A colony is formed of millions of polyps which grew from one original larva that by dividing and budding, and in some cases fusing, became a group of interconnected organisms. As the coral grows, new polyps are formed. Old coral reefs may be over 100 feet thick, but the living part is only a thin veneer of corals and other organisms, perhaps only a few feet thick on the surface. Coral tentacles are armed with stinging structures called nematocysts that the coral uses to capture tiny animals in the ocean water called plankton. The plankton is deposited in the mouth, passes to a cavity where it is digested and nutrients are absorbed. Solid wastes then pass back out through the coral polyp’s mouth. Food is shared with neighboring polyps in a colony through connections between individuals. Space on a reef is limited and corals will fight with their neighbors including other plants and animals to prevent overgrowth. Coral polyps on the edges of colonies may use long “sweeper tentacles,” loaded

with nematocysts, to sting many of their neighbors that grow too close. They can also use long, tubular mesenterial filaments, which are extended from the polyp's stomach cavities to digest away encroaching neighbors. Other corals compete by growing rapidly and shading their neighbors.

On a few nights of each year many of the corals on the reef reproduce in an event called mass spawning. Tens to hundreds of species of corals release their eggs and sperm into the water on the same night. The eggs float to the ocean's surface where they can be fertilized, forming new coral larvae called planulae. The coral planulae swim in the ocean for several days to weeks until they settle on the reef bottom and grow into new corals. Corals can also reproduce asexually by budding. During budding the coral polyp will divide to make a nearly identical copy of itself that will remain attached to the parent polyp. A coral colony will form after repeated rounds of budding and can grow to contain hundreds and even thousands of polyps. As new polyps form they overgrow older polyps that die and add their calcium carbonate skeleton to the foundation of the reef.

There are two main types of coral: non-reef builders (ahermatypic) and reef builders (hermatypic). Ahermatypic corals, such as soft corals and solitary hard corals, do not contribute substantially to the formation of the reef. Solitary corals grow as individual polyps that do not form colonies. Soft corals are colonial corals that have a flexible skeleton and depend on toxic chemicals in their tissues to protect themselves from predators. Hermatypic, or reef building corals, are hard corals that form large colonies from thousands of connected polyps living together, sharing food and energy. Hard corals use zooxanthellae (ZOO-ZAN-THELLY), helper algae, to combine calcium and carbonate from the water and from respiration, to form a strong limestone underlying skeleton, similar to the process used by clams, oysters and snails to create their hard shells. The zooxanthellae are the corals' "solar panels" and provide enough energy to build their skeletons rapidly. Generation after generation of polyps add to the skeleton, forming corals of an incredible array of shapes and sizes. Coral colonies can grow bigger than a small house and can be several hundred years old. Over thousands of years, the skeletons of many coral colonies living together form reefs.

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Major Types of Coral Reefs

There are three major types of reefs: fringing reefs, barrier reefs and atolls. Fringing reefs form just off the coast of a continent or an island and usually progress from a shallow sandy lagoon to the reef crest where the most wave resistant corals grow, to the reef face where the majority of the coral species are found. Barrier reefs form farther offshore, usually 10-100 kilometers from the coast, and often form massive walls of coral separated from the coast by a large channel or lagoon. Atolls are circular reefs surrounding a lagoon that form when volcanic islands sink into the ocean over millions of years. Coral reefs are found throughout the warm, shallow tropical oceans of the world, mostly between the tropic of Capricorn (23°27') and the tropic of Cancer (23°27'). Since ocean currents can bring warm water to cooler places, reef corals grow in surprising locations such as off Texas and near Tokyo, Japan! There are two major coral reef regions in the world: the Indo-West Pacific and the Western Atlantic. The Indo-West Pacific region spans from the Red Sea through Australia to the Indian Ocean and to Africa. It is the largest coral reef region in the world with the greatest diversity of coral and fish species. The Western Atlantic region spans from Florida to Brazil, and includes the Caribbean, Bermuda, and the Gulf of Mexico. Reefs are also found in the tropical eastern Atlantic and Eastern Pacific, but they are less well developed and diverse.

The Intimate Partnerships of Reefs Reef building corals are dependent on a close relationship with tiny algae (plants) that live within their tissue, the zooxanthellae. The zooxanthellae provide the corals with up to 98% of the food that they produce, allowing the corals to make their skeletons grow faster and form reefs. Corals in turn provide the zooxanthellae with a safe place to live where they receive plenty of sunlight and nitrogen-rich waste products. Corals cannot obtain enough energy from feeding alone to build large colonies and form reefs. Coral reefs are found in the tropics where the warm, clear, shallow water allows enough sunlight to reach the algae living within their tissues.

The relationship between a coral and its zooxanthellae is delicately balanced, however, and small changes in environmental conditions, especially seawater temperature, can disrupt it. With increasing temperature the algae may die or leave the coral tissue, causing the corals to turn white and “bleach.” The bleached corals can only survive for a few weeks without the energy supplied from their algae, and if seawater temperatures don’t return to normal the corals cannot obtain new zooxanthellae and will die. The Earth’s average temperature has been rising at an unprecedented rate, and this global warming may have dire effects on coral reefs. During the last 20 years, bleaching events have increased in severity and massive bleaching events have caused entire reef communities to die. In 1998, coral bleaching was so extensive that thousands of kilometers of reefs were damaged.

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Global Warming and The Greenhouse Effect

The surface temperature for each of the planets in our solar system is determined by its heat budget. The heat budget is balanced, like other types of budgets, if the amount of energy coming in equals the amount going out. Global warming occurs when the incoming energy from the sun (solar radiation) is greater than the energy released back into space as light or heat. Recently the Earth has become abnormally warm. Ocean temperatures have increased by over 1°C over the past century and continue to increase at an even faster rate. In 1995 alone, the average temperature increased by half a degree. The increase in global warming is likely caused by the "greenhouse effect."

The greenhouse effect is the accumulation of gases in the atmosphere that prevent the heat emitted from the Earth to return to space, disrupting the Earth's heat budget. There are several types of greenhouse gases including nitrogen oxides, ozone, carbon dioxide, methane, and chlorofluorocarbons (CFCs). Carbon dioxide is the most significant of the greenhouse gases, accounting for about 64% of the total absorption of infrared energy. Human activities, such as the burning of fossil fuels and deforestation, have caused a steady increase in the concentration of greenhouse gases to levels unprecedented in Earth's recent history. The resulting global warming is increasing the severity and intensity of coral bleaching. Unless we take an active role in reducing greenhouse gases, and slow down global warming, the fate of coral reefs will remain precarious.

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Coral Reefs in Peril

Coral reefs are being lost worldwide at an alarming rate. The Global Coral Reef Monitoring Network estimates that over 16% of the reefs, globally, have already been effectively lost and that up to 40% may be lost by the year 2010. Three billion of the world's 5.3 billion people live in coastal areas. This number is expected to double in the next 50 years with the greatest population increases expected in tropical developing countries. Coral Reef Stewardship Coral reefs depend on our stewardship just as we depend on them. The Fijians have a taboo system run by the Chiefs, which determines when and where certain fishes can be caught. This traditional reef management system has worked well for thousands of years and has allowed the Fijians to survive without over-harvesting their reefs. The reefs provide food, protection from storms and rough seas, income from tourists, and help Fijians become a part of their culture through ceremonies that thank the reefs and waters. The Fijians are just one of hundreds of cultures worldwide that rely directly on the tropical marine system for survival. The loss in fisheries income is increasing and is estimated to be billions of dollars a year if reefs are lost. Coral reefs also act as an important buffer to the tropical coastline protecting the land from waves, storms, and erosion. They serve as a source of novel biomedical resources, and we may be losing potential cures to disease as the biodiversity on reefs disappear. Pharmaceuticals from coral reef organisms are now being developed as potential cures for cancer, HIV, arthritis and other diseases.

The biggest way to reverse the adverse changes to coral reefs is through education. Through films like CORAL REEF ADVENTURE we can learn how our actions affect coral reefs so we can better protect them for the future.

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From the MacGillivray Freeman documentary film website:
http://www.macgillivrayfreemanfilms.com/site/our-films/film-library/coral-reef-adventure.html