Nature’s Gardens: Coral Reefs

Building a Reef: Symbiosis

Types of Reefs

Life on a Reef

Coral Reefs and the Future

Reading: 12.20-12.22

15.5
16.15, 16.21
17.26

Graphic: Coral reef, courtesy of NOAA.

Cnidaria - Carnivorous Stinging Animals

Jellyfish, anemones, corals

- Simple digestive system (single sac with wastes expelled through mouth)

- Stinging cells (cnidoblasts) shoot
  upward from tentacles penetrate,
  entangle or disable prey

- Two forms
  - free swimming
    medusa (jellyfish)
  - anchored polyp
    (anemones, coral)

Graphics: Top left: Anemone.
Collection of Dr. J.P. McVey,
Bottom left Garrison, Fig. 15.6b
So What is a Coral Reef?
- Largest animal-built structures on Earth (Great Barrier Reef = 2500 km long)

- Composed of coral animal skeletons, which accumulate, gradually forming a reef

- Reefs grow slowly (1 cm/yr) and are sensitive to changes in sea level and temperature

Coral Reefs and Environmental Conditions
Reefs require:
- abundant light
- warm water temperature
- typical ocean salinity
- sediment-free water
- high oxygen

Where are Coral Reefs Found?
Reefs are found in clear, shallow tropical waters with moderate wave action

Coral Reef Communities
Coral reefs are "oases" within the "biological desert" of the tropical oceans
Coral animals - about half of reef biomass

Coralline algae (plants) - form crusts that "cement" the reef together

Most other animal groups inhabit reefs forming a complex food web

Graphic: Garrison, Fig. 16.12.

**Biodiversity and Competition on a Reef – Survival of the Fittest**
Coral reefs are 0.17% of Earth's surface area but home to 4-5% of all species
Fast-growing coral can overgrow slower-growing species, restricting access to light and food
Long sweeper tentacles can inject venom into adjacent competing coral colonies
Dispersal of toxic water-borne chemicals can deter neighbors

Graphics: (top) Red Sea, M. Al Momany, photographer, courtesy of NOAA, (middle) Gulf of Aqaba, Red Sea, Al Momamy, photographer, courtesy of NOAA. (bottom) Coral reef, photo courtesy of NOAA.

**Self-Defense on the Reef**
- Toxic venoms and distasteful substances are common among coral, fish and other animals on the reef
- Bright colors serve as warnings to other species – many poisonous species are brightly colored
- Camouflage and confusing coloration helps some species hide from predators

Graphic: Brightly colored coral and fish on a North Carolina reef, C. Liipfert, photographer, courtesy of NOAA/NURP and Univ. N.Carolina at Wilmington.

**The Value of Coral Reefs**
- 500 million people globally rely on coral reefs for food, coastal protection, resources, etc
- 30 million people depend exclusively on reefs for food
- In the U.S., reefs provide billions of dollars to the economy through tourism, fisheries, and recreation

Home to 1 million+ species

“Medicine cabinets” of the
21st century

(treatments for heart disease, arthritis, cancer and HIV)

Graphics:
(top) Diver enjoying a reef slope, courtesy of NOAA, (bottom) A deepwater reef community that was the focus of a recent expedition in search of new pharmaceuticals from the sea, photo courtesy of NOAA. Info from U.S. Coral Reef Task Force, NOAA.

Threats
Under current pressures, 60% of coral reefs could die by 2050

Natural threats:
- hurricanes, storms
- changes in climate
- disease
- predators

Human threats:
- poor fishing practices (e.g., cyanide and "blast" fishing)
- pollution
- overexploitation (for recreation and commerce)

What Causes Coral Bleaching?
Large-scale bleaching, across wide swaths of the tropics, is caused by elevated ocean temperatures (1-2 °C higher than usual)

High temperatures damage the cells of zooxanthellae, interfering with their ability to use light for photosynthesis

Locally, bleaching can also be caused by disease, sediment, cyanide fishing, pollution and changes in salinity

Coral Bleaching and Climate Change
Bleaching affects the ecology of the entire reef (if coral die, organisms dependent on them are at risk)
There is concern among scientists for the long-term health of coral reefs due to increasing ocean temperatures due to climate change.


**Ocean Acidity (pH) and Reef Health**
For many species, the ability of corals to generate the hard parts of a reef depends on the acidity (pH) of the ocean.

- High acidity (low pH) degrades calcium carbonate skeletons and shells
- Low pH puts reef ecosystems at risk of catastrophic structural and ecological failure

About 30% of the anthropogenic CO2 produced since the beginning of industrialization has been absorbed by the oceans, reducing ocean pH by 0.1

As the ocean continues to absorb CO2, pH may fall by an additional 0.14-0.35 units by 2100*


Potential Impacts of Acidification on Coral Reefs

**Maintaining Healthy Reefs for the Future**
Research and monitoring
- learn more about how reef systems “work” and their potential vulnerabilities
- determine which reefs are most at risk and why

Educational programs
- targeted at both tourists and local populations

Tackle the challenge of climate change

[Graphics: (top) Landsat satellite images of reefs are used to map and monitor reefs, French Frigate Shoals, Hawaii, courtesy of NOAA, (bottom) a healthy reef, photo courtesy of NOAA.]

**Life in Extreme Environments**

**Hot Vents**

**Cold Seeps**

**Brine Pools**

Reading: 4.15

13.5
The Deep Sea

The deep sea is cold and dark
- The food web is weakly supported by organic matter raining from above
- Photosynthetic production of new organic matter is not possible due to lack of light

Most deep sea communities are adapted to
- sparse food availability
- low population density

Alternative Energy in the Deep Sea
But... Not all ecosystems are fueled by photosynthesis

Methane and sulfur-rich fluids provide energy for chemosynthetic bacteria in some deep sea communities

Photosynthesis, Respiration and Chemosynthesis

Photosynthesis binds energy into large organic molecules...

Carbon dioxide + water + sunlight + nutrients → organic matter + oxygen

Respiration converts organic matter to energy...
Organic matter + oxygen \rightarrow 
Carbon dioxide + water + chemical energy

**Chemosynthesis (An Old Way of Life)**
Chemosynthesis synthesizes organic material from inorganic substances

\[
\text{Carbon + Hydrogen + Oxygen + Water} \rightarrow \text{Carbohydrates + Sulfuric Acid}
\]

\[
\text{Dioxide} \quad \text{Sulfide}
\]

Chemosynthesis can sustain vibrant food webs in the complete absence of sunlight.

**Where Are Chemosynthetic Communities Found?**
Chemosynthesis requires high concentrations of chemicals such as hydrogen sulfide or methane.

These are found where:

- seawater is in contact with the mantle (hydrothermal vents)

- these materials enter the sea due to other processes (cold seeps and brine pools)
Hydrothermal Vent Communities
At hydrothermal vents and cold seeps, chemosynthetic bacteria are at the base of complex food webs

Other organisms:
- tube worms
- giant clams
- mussels

Challenges in a Hydrothermal Vent Community
Most inhabitants must be adapted to life at high temperatures (sometimes over 600 deg F!)
Hydrothermal vents are temporary features – organisms must be able to colonize distant locales

Cold Seep Environments
Tectonic motion can force methane-rich fluids out of sediments to form cold seeps along continental margins

Cold seeps emit chemical-rich fluid slowly over long periods of time
Unlike hydrothermal vents, these are relatively stable environments, home to long-lived organisms

Graphic: Tube worms in a Gulf of Mexico cold seep grow to 2 meters long, C.Fisher, photographer, courtesy of NOAA NURP and Penn. State Univ.

Bottom Graphic: Garrison Fig.4.32

Cold Seep Communities
In many cold seeps, the food web is supported by:
- “mat” forming bacteria
- bacteria that are in symbiotic relationships with animals

Clams and worms derive most of their food from the bacteria

Other animals forage at the seeps (crabs, anemones, gastropods)

Graphic: Mussels, worms and a spider crab at a hydrocarbon seep, I.MacDonald, photographer. Courtesy of NOAA NURP and Texas A&M Univ.

Brine Pools
Along passive margins, salt domes can create brine pools with salinity 4 times greater than seawater

Methane seeping from the edges of the pool creates a diverse community

But.. anything that swims or falls into the hypersaline pool dies

Graphic: (top) Edge of a brine pool, a super salty pond, ringed by mussels. J. Brooks, photographer, courtesy of NOAA NURP and Texas A&M Univ, (bottom) submersible exploring a brine pool, Penn. State, Univ.

The Brine Pool
The brine pool is a crater-like depression filled with water up to four times saltier than seawater

Mussels and other organisms inhabit the region just outside the pool
Extreme Environments - A Model for Extraterrestrial Life?
Hydrothermal vent communities suggest life could be thriving elsewhere in our solar system

Europa (a moon of Jupiter)
- icy surface
- deep saltwater ocean
- tectonic activity
- hydrothermal vents??
- life???

Preview of Next Lecture
Charismatic Megafauna (Marine Mammals)

Review for Final Exam

Reading: 6.24-6.25
15.35-15.38
17.22