OCEANOGRAPHY

Chapter 14

Animals of the Benthic Environment

Notes from the textbook, integrated with original contributions

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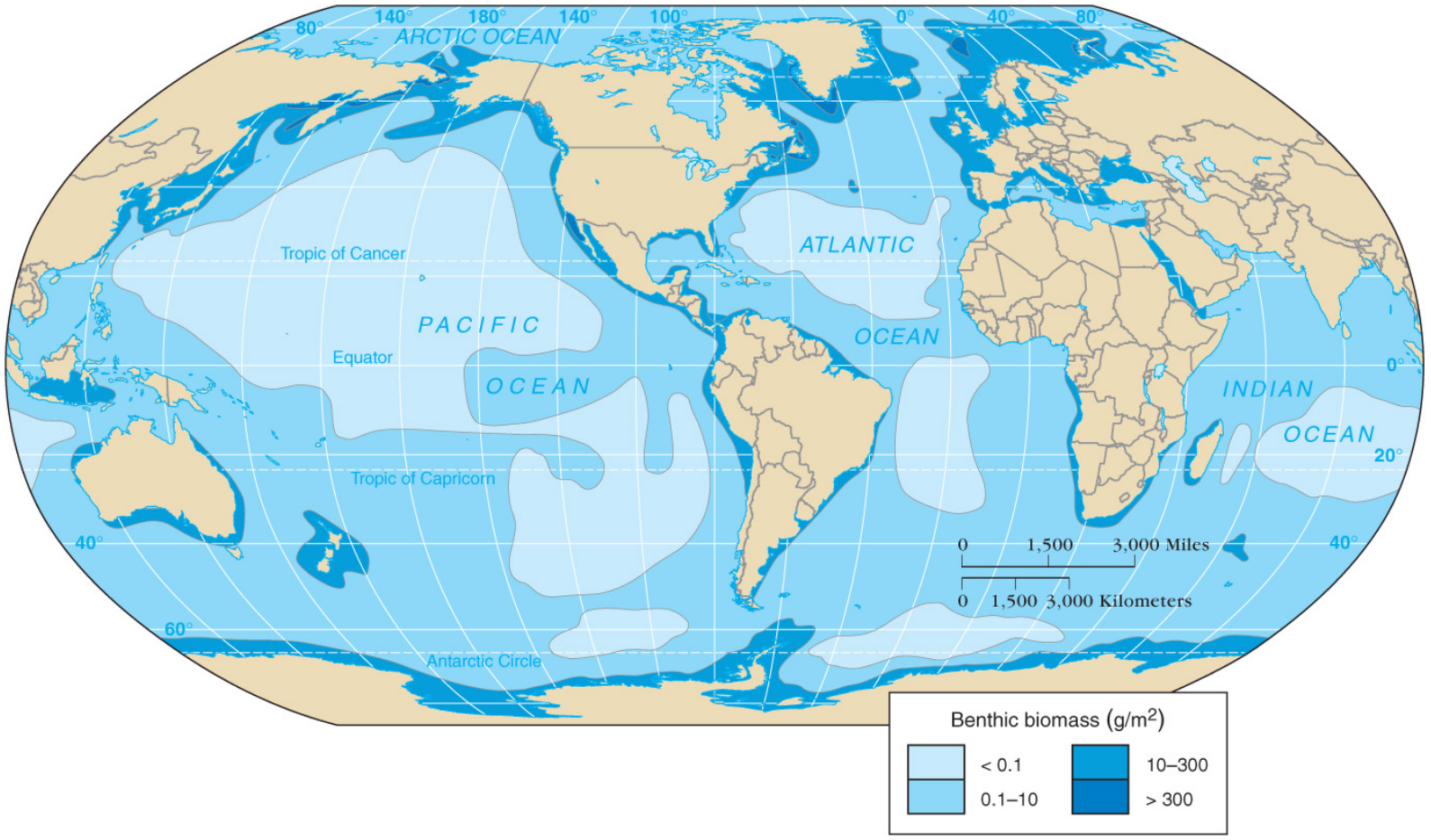
Introduction

- 98% of all marine species live in or on the ocean floor (**benthos**)
  - Do not confuse the number of species (more abundant in benthonic forms) with the biomass (more abundant in pelagic waters)
- Benthic communities include a variety of habitats
  - Corals need specific environmental conditions.
  - Hydrothermal vents support diverse communities that rely on chemosynthesis
- The distribution of the benthic biomass closely matches the distribution of chlorophyll in surface waters
- Most benthic organisms live on the shelf, at a depth shallower than the photic zone
- Ocean currents determine affect coastal temperatures and, as a consequence, species diversity

Distribution of Benthic Organisms



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Introduction

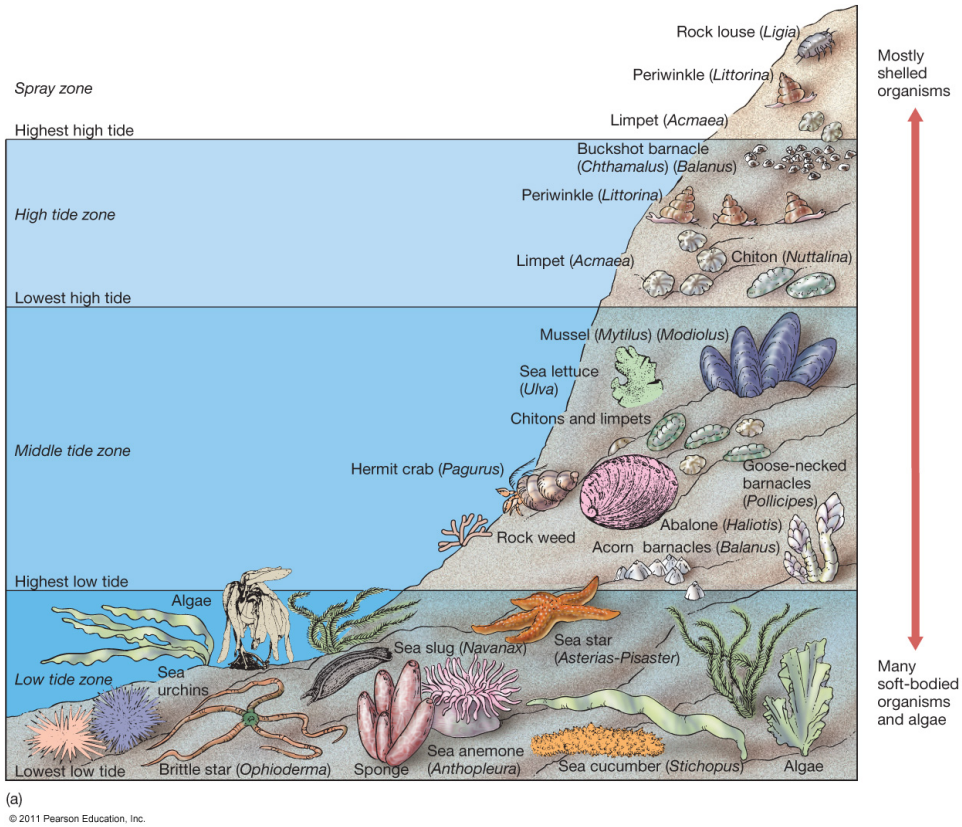
- This chapter describes:
  - Benthic communities that thrive along rocky shores
  - Benthic communities that thrive along soft sediment-covered shores (sand and mud)
  - Benthic communities that thrive on the shallow offshore ocean floor
  - Benthic communities that thrive on the deep ocean floor

Communities on Rocky Shores

- Epifauna
  - Sessile: Attached to substrate (e.g., marine algae)
  - Mobile: Move over seafloor (e.g., crabs, snails)
- Moderate diversity of species
  - Greatest animal diversity at tropical latitudes
  - Greatest algae diversity at mid-latitudes

Intertidal Zonation

- Rocky shore:
  - Spray zone
    - above spring tide zone (supratidal)
  - Intertidal zone
    - High tide zone
    - Middle tide zone
  - Low tide zone



Spray Zone

- Supratidal zone
  - Organisms:
    - Avoid drying out
    - Many animals have shells
    - Few species of marine algae

(b)

Intertidal Zone Organisms

- High tide zone
  - Animals have shells to avoid drying out
  - Marine algae—rock weeds with thick cell walls

(d)

(e)

Intertidal Zone Organisms

- Middle tide zone
  - More types of marine algae
  - Soft-bodied animals

(g)

Intertidal Zone Organisms

- Low tide zone
  - Abundant algae
  - Many animals hidden by sea weed and sea grass
  - Crabs abundant in all intertidal zones

(i)

Communities on Sediment-Covered Shores

- In presence of soft sediments, life requires very different adaptations than on rocky shores, even if the intertidal zones are somehow similar
- There is less diversity but more individuals
- Most animals in this environment live buried in sediment (**infauna**)
- Microbial communities are also common, particularly when the soft sediment is mud and not sand

the physical environment of sediment

- Sediment-covered shores include
  - Coarse boulder beaches
  - Sand beaches
  - Salt marshes
  - Mud flat

- These are progressively lower-energy environments that are composed by progressively finer sediments
  - Particle size becomes smaller
  - Slope angle decreases
  - Sediment stability increases

- Along high-energy sandy beaches, a large quantity of water from breaking waves sinks into the sand
  - This water brings **oxygen** and nutrients to the animals that live there
  - Oxygen also enhances decomposition of dead tissues by bacteria

- In salt marshes and mud flats oxygen does not find a way to penetrate sediment
  - Decomposition occurs more slowly, or might even be absent (black muds), and these areas develop a characteristic “rotten egg” from hydrogen sulfide (H_2S) gas

Intertidal zonation

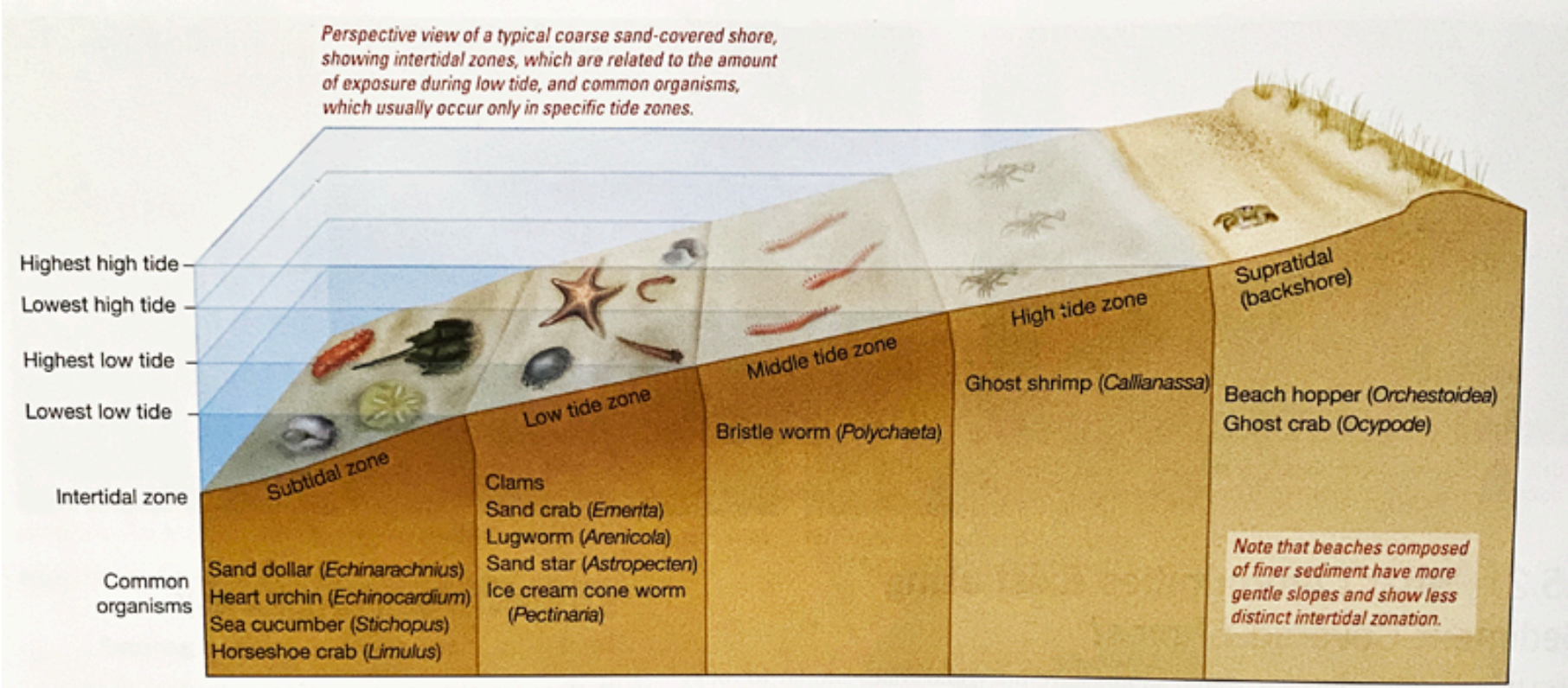


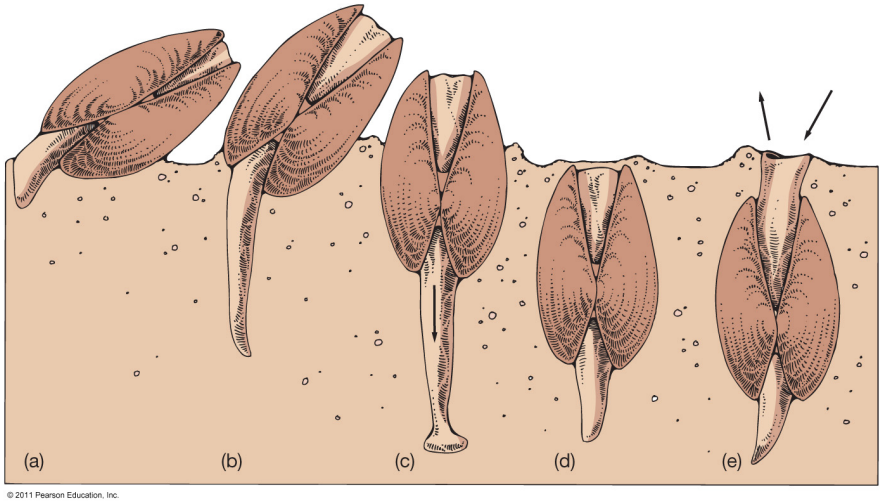
Figure 15.8 Intertidal zonation and common organisms of sediment-covered shores.

Sandy Beach Organisms and Adaptations

- Burrowing animals
- No stable, fixed surface
- Burrowing provides more stable environment
  - Less risk of temperature extremes and drying out

Sandy Beach Organisms and Adaptations

- Bivalve mollusks
  - Soft body, hard shell
  - Example: clams and mussels
  - Greatest number in low tide regions
- Annelid worms

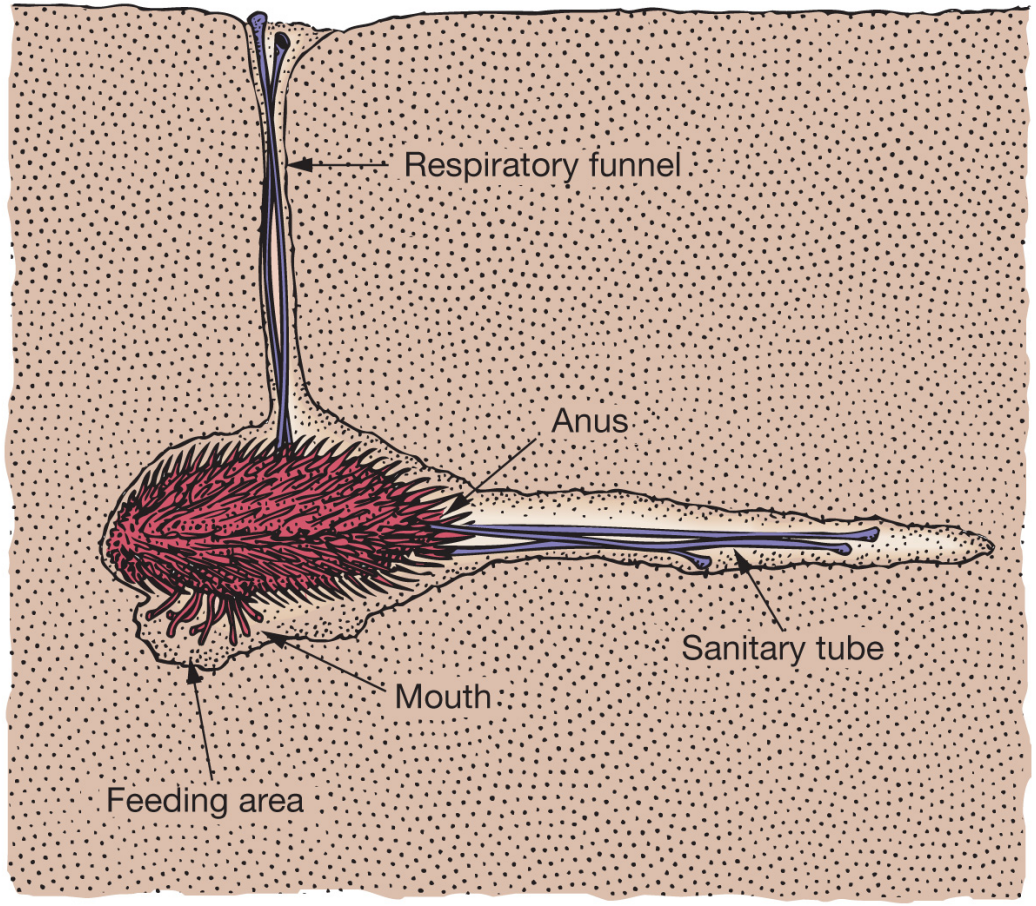


Sandy Beach Organisms and Adaptations

- Crustaceans
  - Segmented body, hard exoskeleton, paired jointed limbs
  - Example: crabs, lobsters

Sandy Beach Organisms and Adaptations

- Echinoderms
  - Spiny skin
  - Five tapered legs
  - Example: starfish and heart urchin
- Meiofauna
  - Small, feed on bacteria



Mud Flats

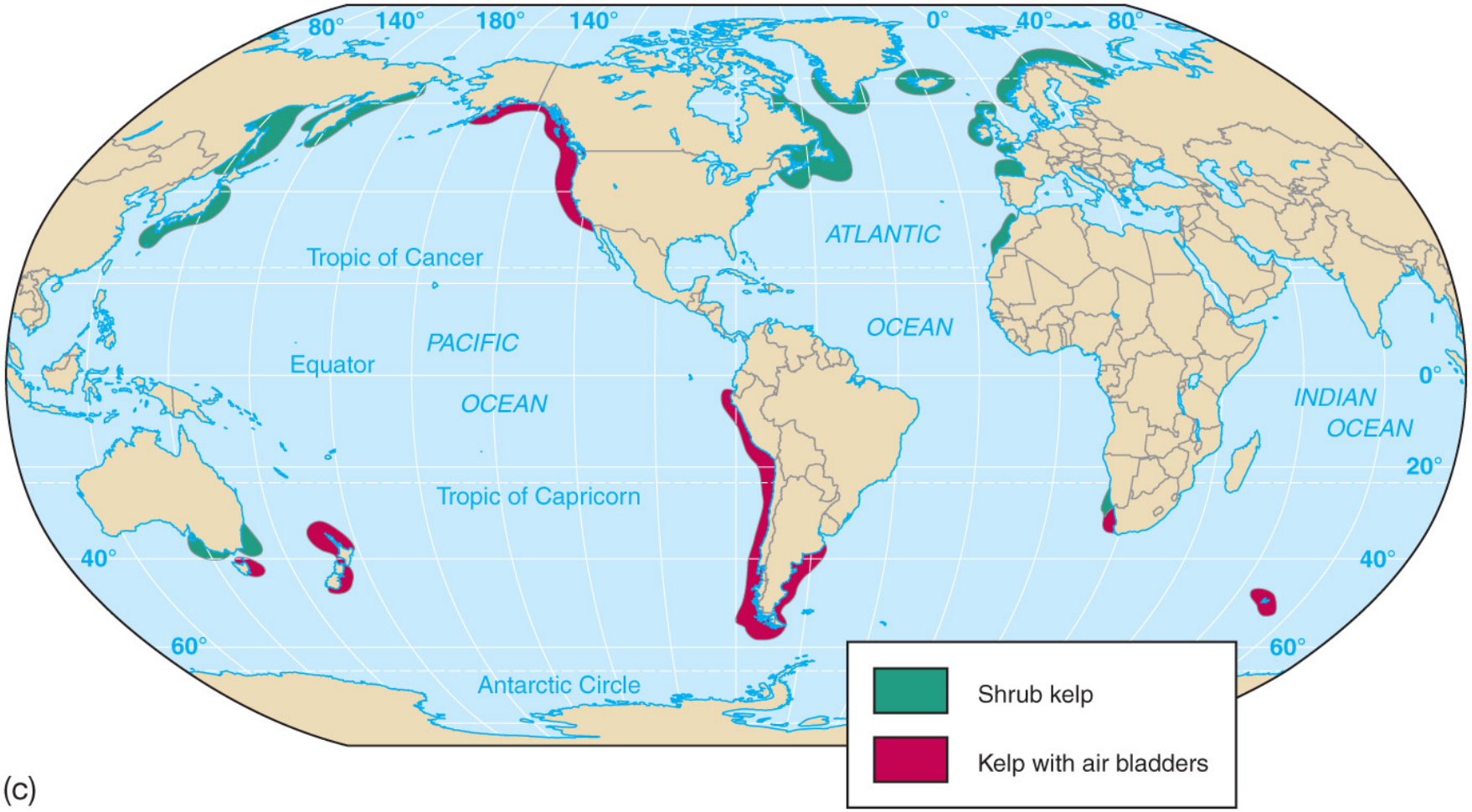
- Eelgrass and turtle grass common
- Bivalves and other mollusks
- Fiddler crabs

Shallow Offshore Ocean Floor Communities

- Rocky bottoms (subtidal)
  - Kelp and kelp forests
    - Attaches to rocky bottoms
    - Can grow up to 0.6 meters (2 feet) per day
    - Productive ecosystems
    - Provides shelter for other organisms

(b)

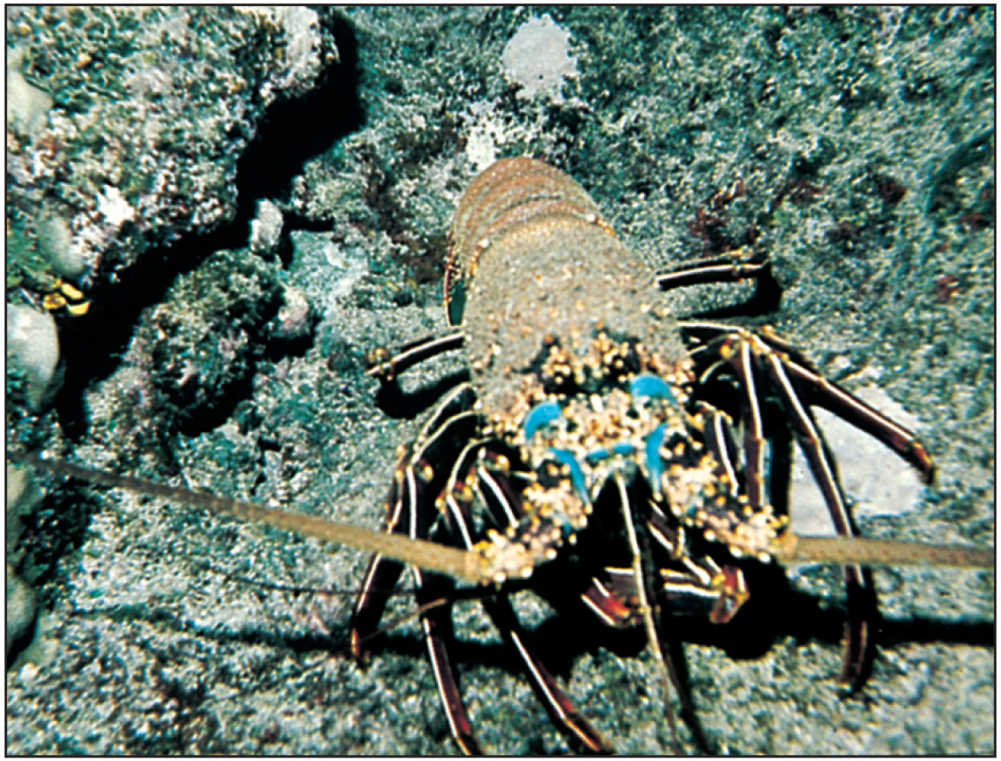
Kelp Distribution



(c)

Rocky Bottom Shallow Offshore Ocean Floor Communities

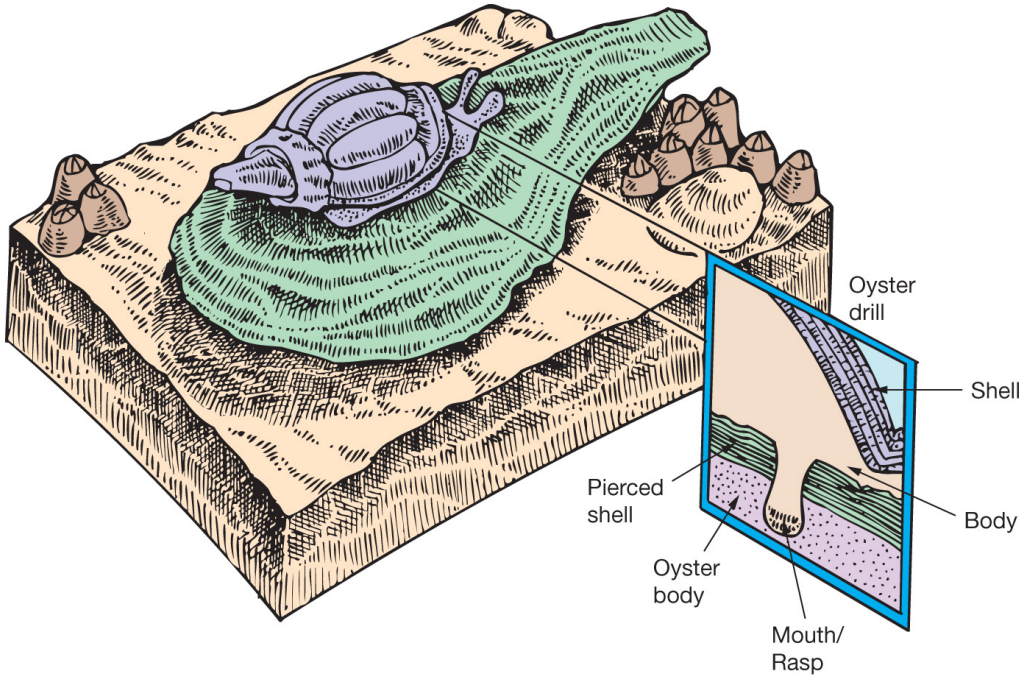
- Lobsters
  - Large, spiny antennae
  - Live in water deeper than 20 meters (65 feet)
  - Scavengers
  - Also feed on live animals



(a)

Rocky Bottom Shallow Offshore Ocean Floor Communities

- Oysters
  - Sessile bivalve mollusks
  - Thick shell
  - Start life as plankton

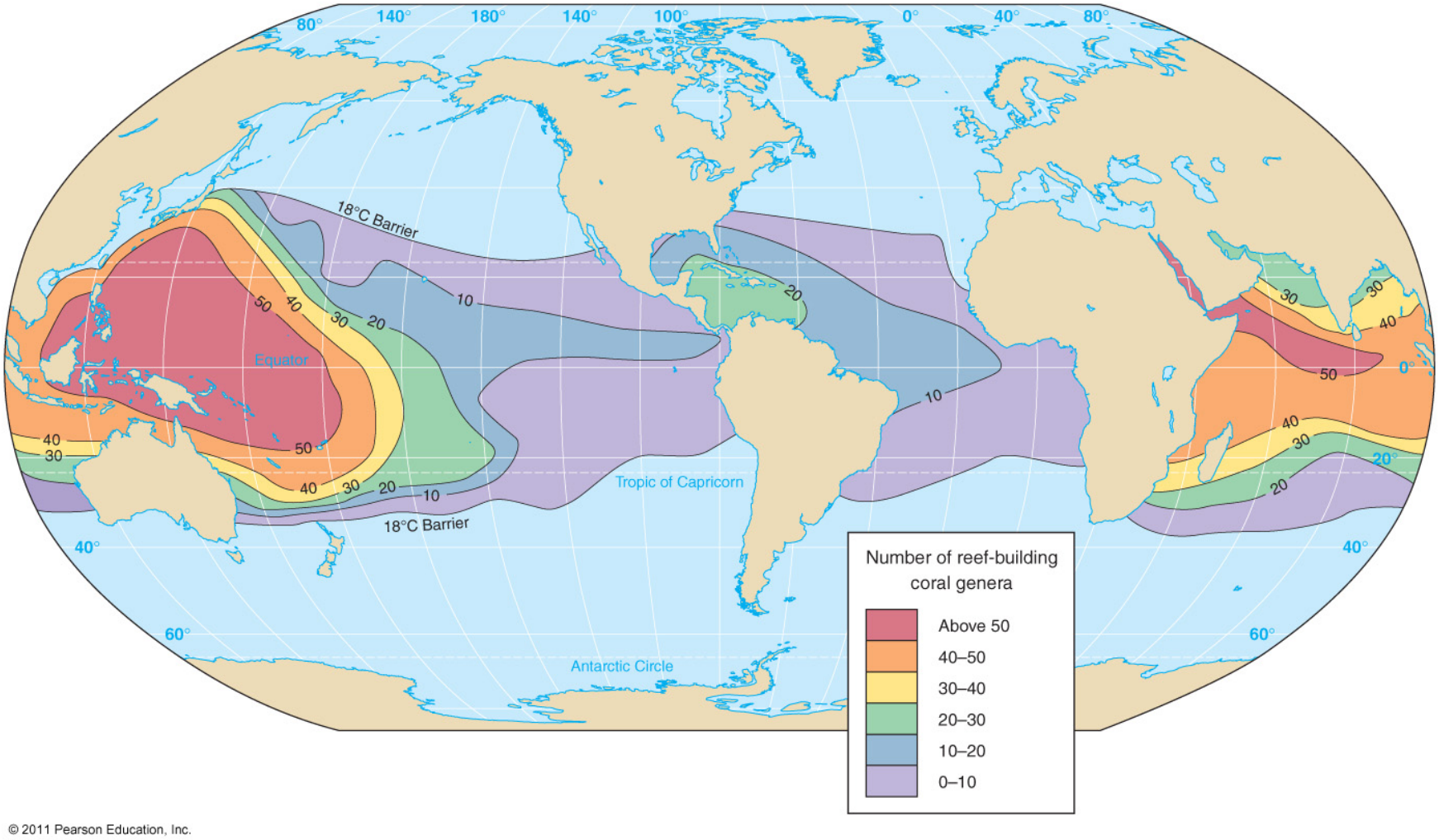


Coral Reefs

- Reefs – shallow water communities restricted to tropics
- Polyps – individual corals

(a)

Coral Reef Distribution



Conditions for Coral Reef Development

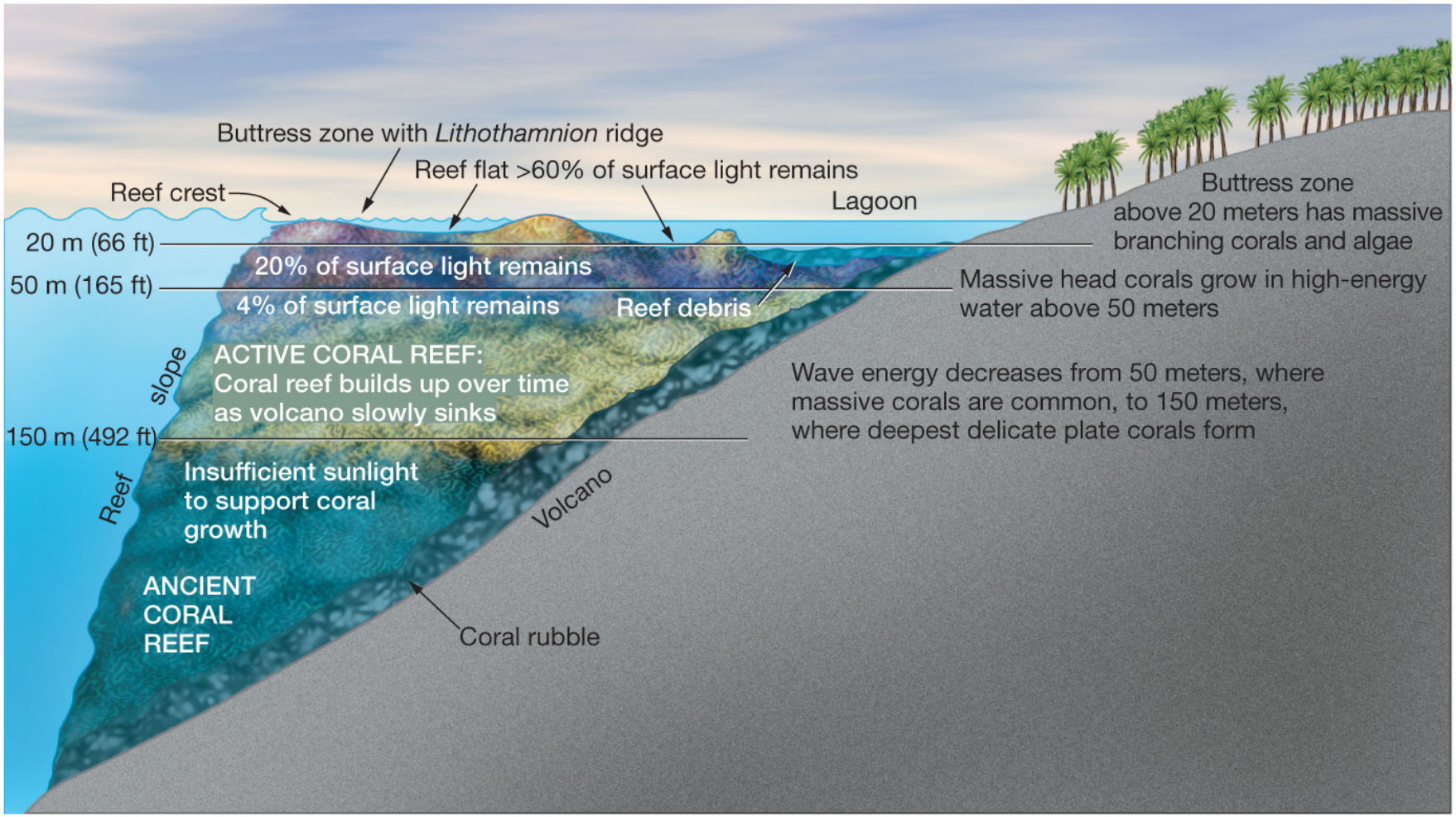
- Warm (but not hot) seawater
- Sunlight (for symbiotic algae)
- Strong waves or currents
- Clear seawater
- Normal salinity
- Hard substrate

Symbiosis of Coral and Algae

- Coral reefs made of algae, mollusks, foraminifers as well as corals
- Hermatypic coral – mutualistic relationship with algae
  - Algae provide food
  - Corals provide nutrients
- Mixotrophs – derive part of nutrition from algae

(b)

Coral Reef Zonation



Importance of Coral Reefs

- Largest structures created by living organisms
  - Great Barrier Reef, Australia, more than 2000 km (1250 miles) long
- Great diversity of species
- Important tourist locales
- Fisheries
- Reefs protect shorelines

Humans and Coral Reefs

- Fishing, tourist collecting, and sediment influx due to shore development harm coral reefs.
- Sewage discharge and agricultural fertilizers increase nutrients in reef waters.
  - Hermatypic corals thrive at low nutrient levels
  - Phytoplankton overwhelm at high nutrient levels
  - Bioerosion of coral reef by algae-eating organisms

Crown of Thorns Phenomenon

- Sea star eats coral polyps
- Outbreaks (greatly increased numbers) decimate reef

Coral Reefs in Decline

- 30% healthy today, 41% healthy in 2000
- One third of corals – high risk of extinction
- Humans – greatest threat
- Other threats
  - Hurricanes
  - Global warming
    - Coral bleaching
  - Floods
  - Tsunami

Deep-Ocean Floor Communities

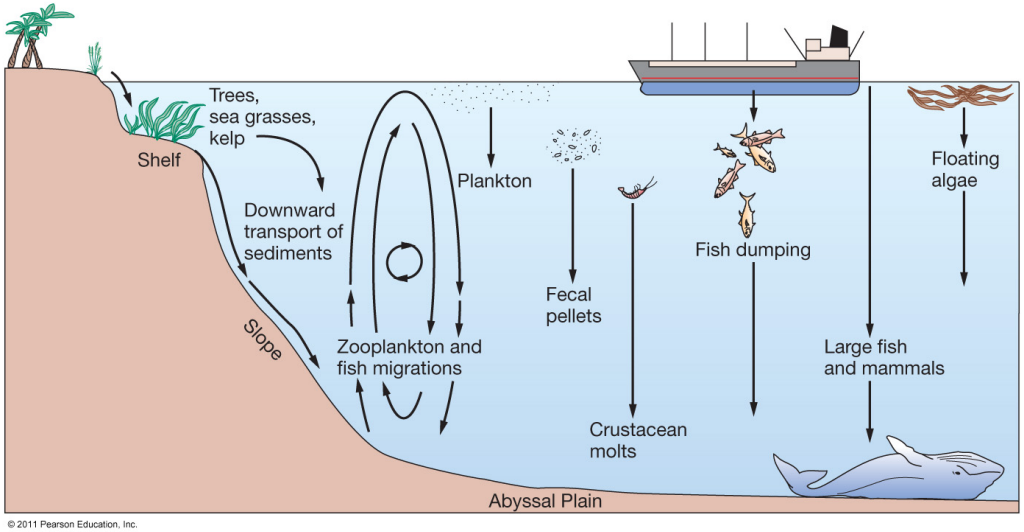
- Less known about than shallower water communities
  - Expensive to explore the deep
  - Limited oxygen
  - Robotic technology for exploration

Deep Ocean Physical Environment

- Bathyal, abyssal, hadal zones
- Light absent below 1000 meters (3300 feet)
- Temperature usually between -1.8°C (28.8°F) and 3°C (37°F)
- High oxygen
- High pressure
- Abyssal storms – affect bottom currents

Deep Ocean Food Sources and Species Diversity

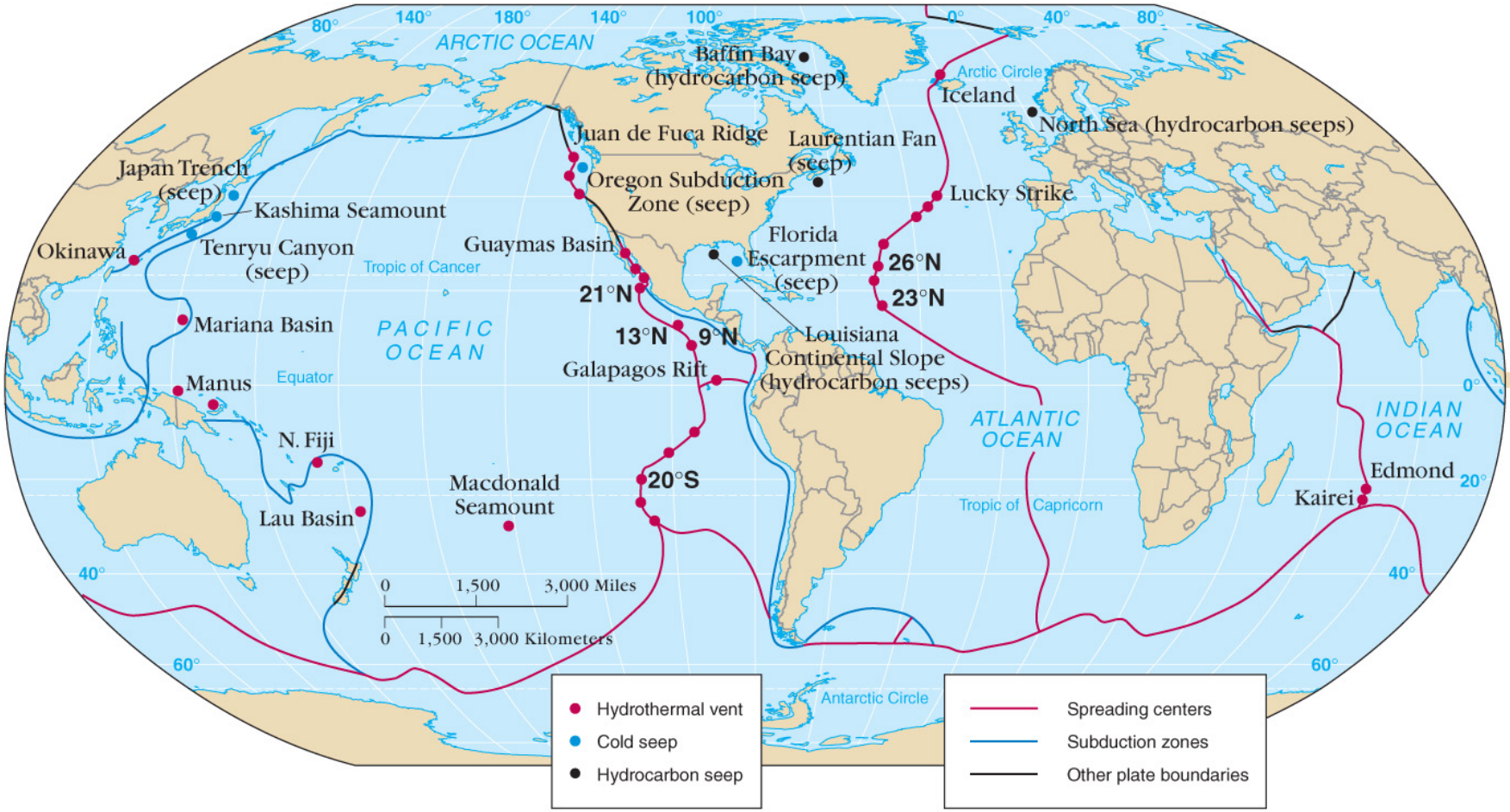
- No primary productivity
- Only 1 – 3% of euphotic food present
- Special adaptations for detecting food
- Species diversity equivalent to rain forest



Deep-Sea Hydrothermal Vent Biocommunities

- Discovery – *Alvin* in 1977
- Galapagos Rift in Pacific Ocean
- Water temperature 8–12°C (46–54°F)
- Chimney vents, hot acidic water
  - Black smokers

Locations of Hydrothermal Vent Communities



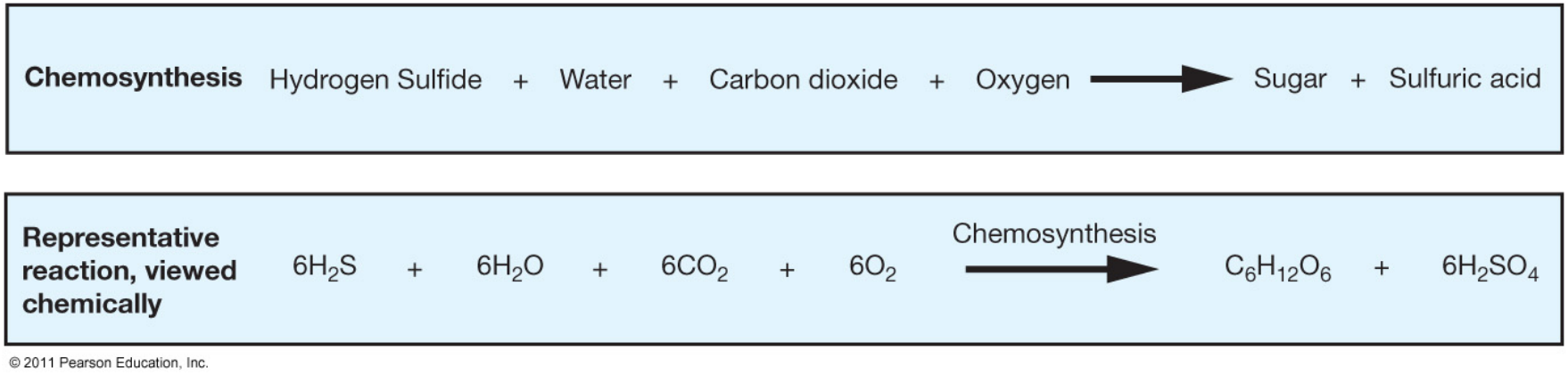
Hydrothermal Vent Species

- Giant tubeworms
- Giant clams
- Giant mussels
- Crabs
- Microbial mats
- Life supported by chemosynthesis

(a)

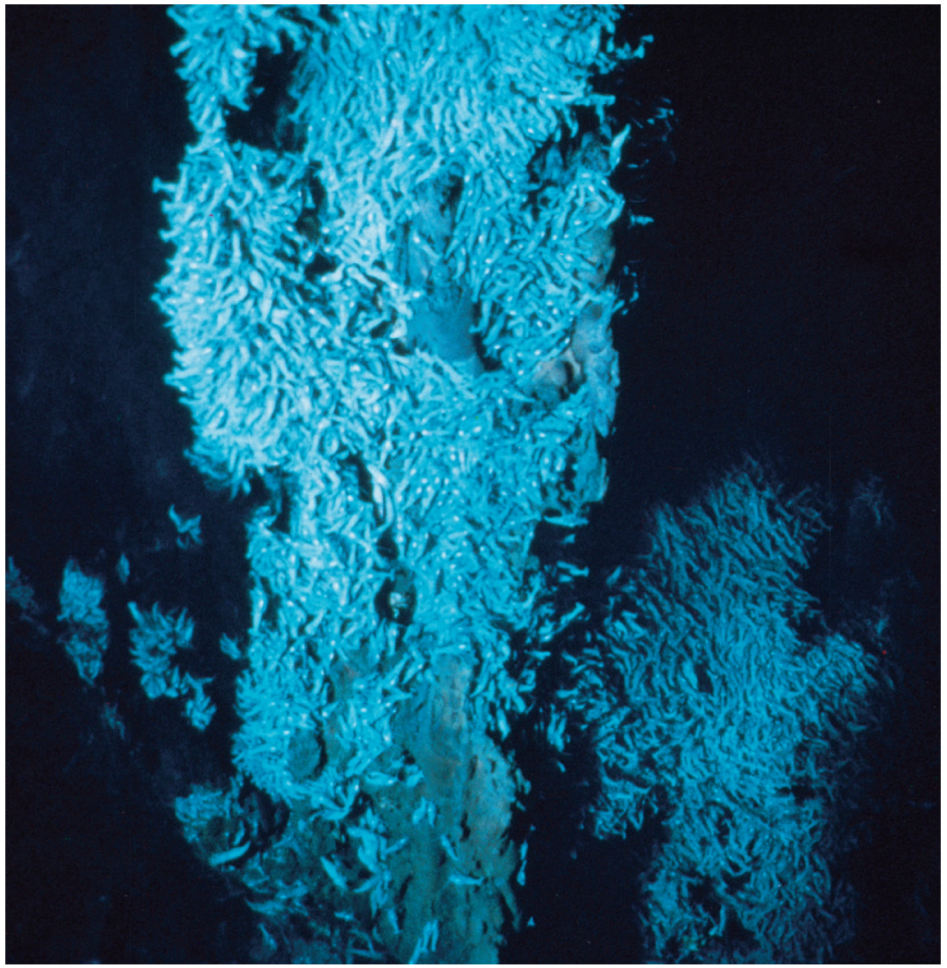
Chemosynthesis

- Microscopic Archaea – thrive on hydrogen sulfide from vents
  - Manufacture sugar, carbon dioxide, and dissolved oxygen
- Base of hydrothermal vent food chain



Hydrothermal Vent Communities

- Vents active for years or decades
- Animals species similar at widely separated vents
- Larvae drift from site to site
- “Dead whale hypothesis”
  - Large carcasses may be stepping stone for larvae

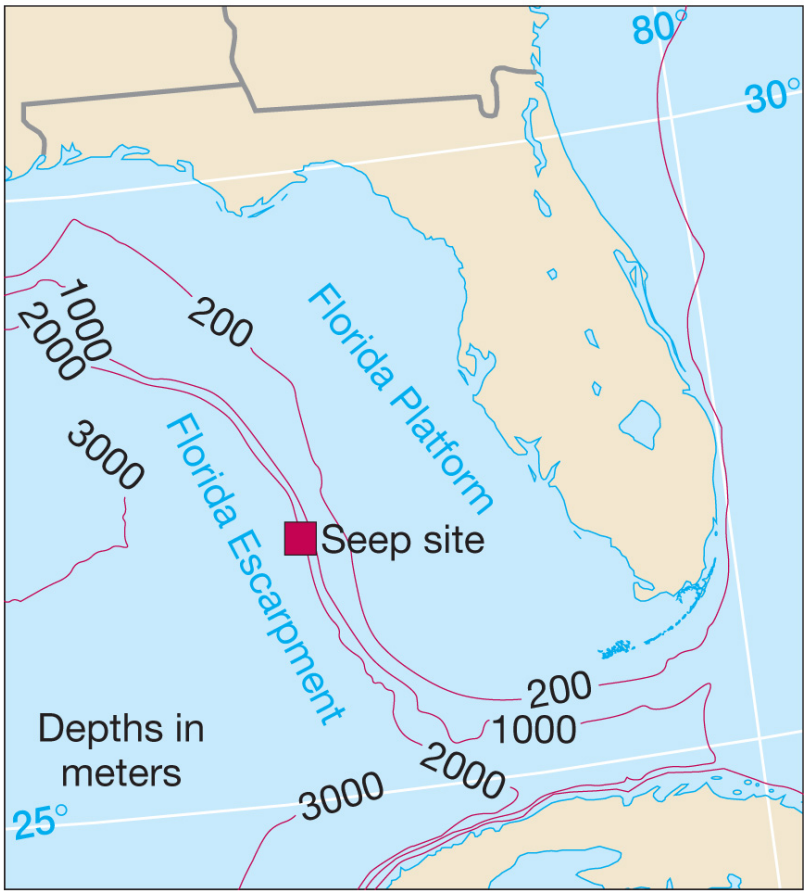


Hydrothermal Vents and the Origins of Life

- Life on Earth may have originated at hydrothermal vents.
  - Uniform conditions
  - Presence of Archaea bacteria
  - Microbes with genes identical to those found in humans

Low-Temperature Seep Biocommunities

- Chemosynthetically support life
- Hypersaline seeps
  - High salinity
  - Florida Escarpment – seeping water from limestone fractures



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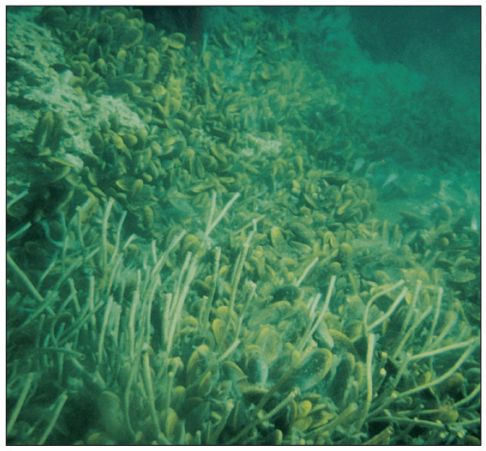
Low-Temperature Seep Biocommunities

- Hydrocarbon seeps
  - Oil and gas seeps
  - Hydrogen sulfide and/o methane

(a)



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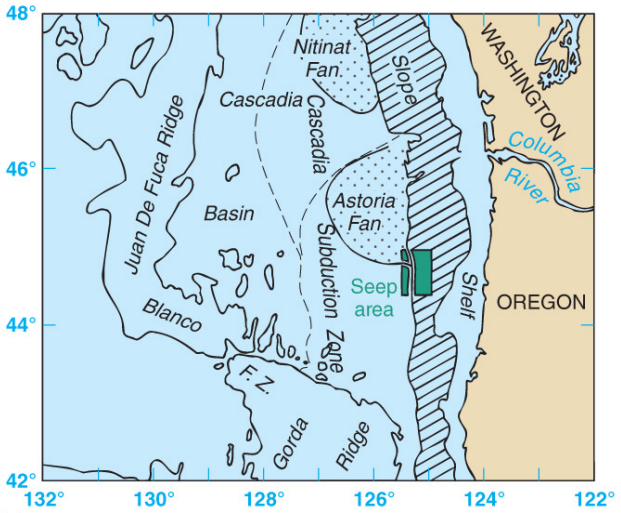
(c)

Low-Temperature Seep Biocommunities

- Subduction zone seeps
  - Juan de Fuca plate
  - Folded sedimentary rocks
  - Methane



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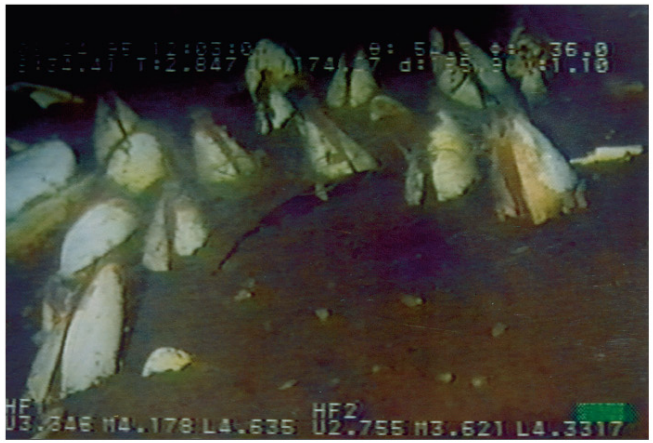

(b)

Beneath the Sea Floor

- A new frontier
- Deep biosphere
- Microbes live in pore fluids
- Might represent much of Earth's total biomass

End of CHAPTER 15
Animals of the Benthic Environment