

# Chapter 12 Lecture

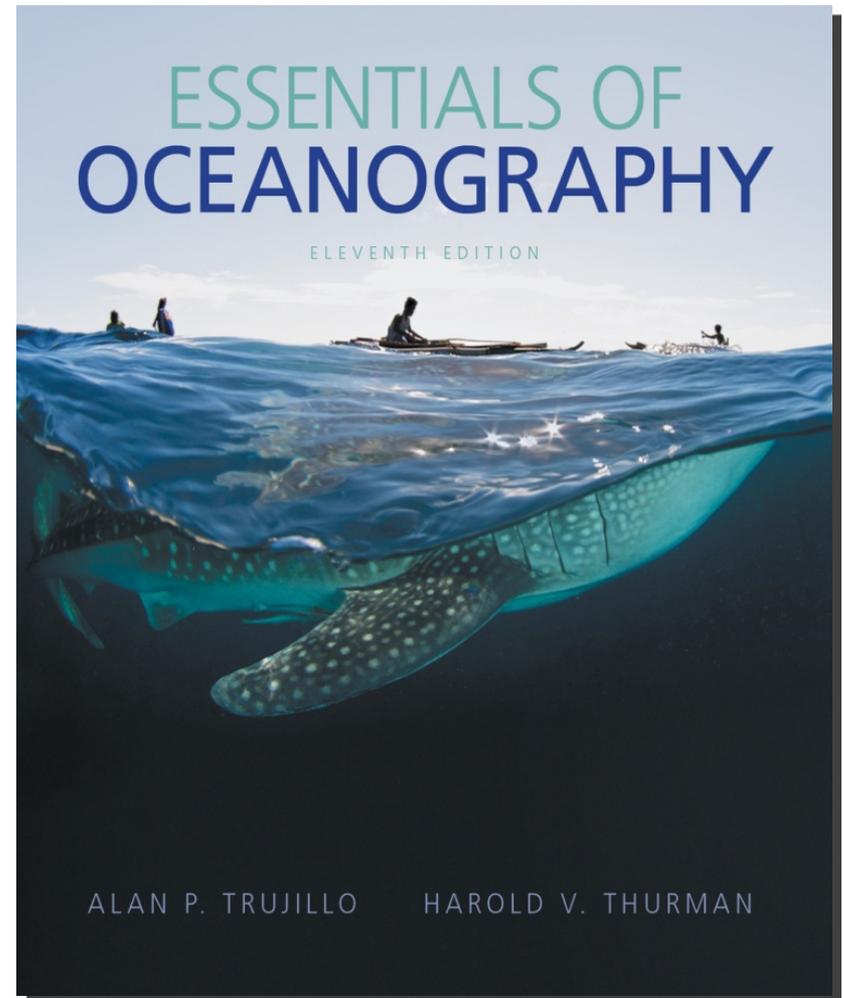
# Essentials of Oceanography

Eleventh Edition

## Marine Life and the Marine Environment

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# Chapter Overview

- Living organisms, including marine species, are classified by characteristics.
- Marine organisms are adapted to the ocean's physical properties.
- The marine environment has distinct divisions.

# Classification of Life

- Classification based on physical characteristics
- DNA sequencing allows genetic comparison.

# Classification of Life

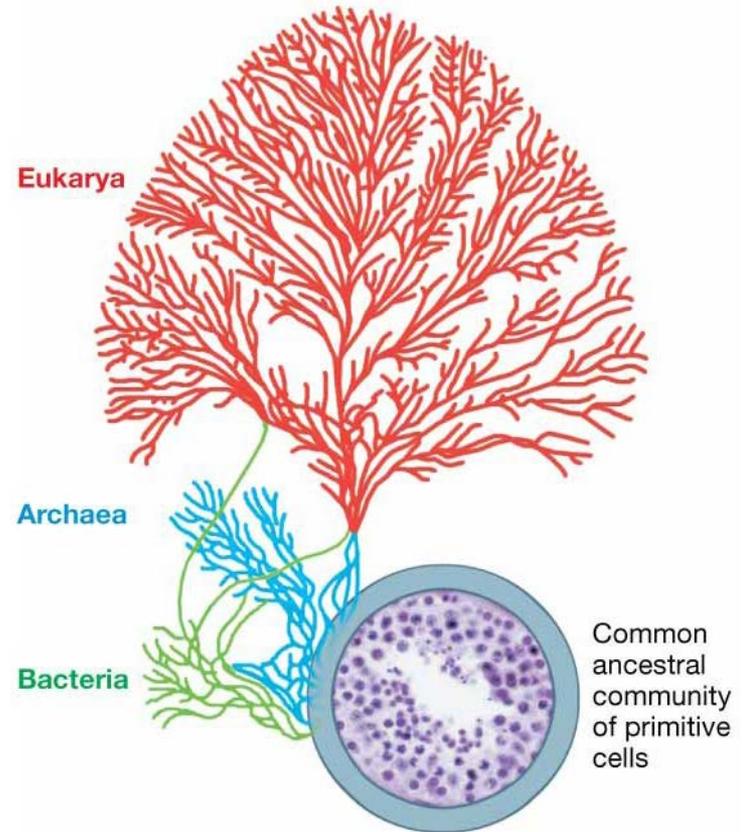
- Living and nonliving things made of atoms
- Life consumes energy from environment.
- NASA's definition encompasses potential for extraterrestrial life.

# Classification of Life

- Working definition of life
- Living things can
  - Capture, store, and transmit energy
  - Reproduce
  - Adapt to environment
  - Change over time

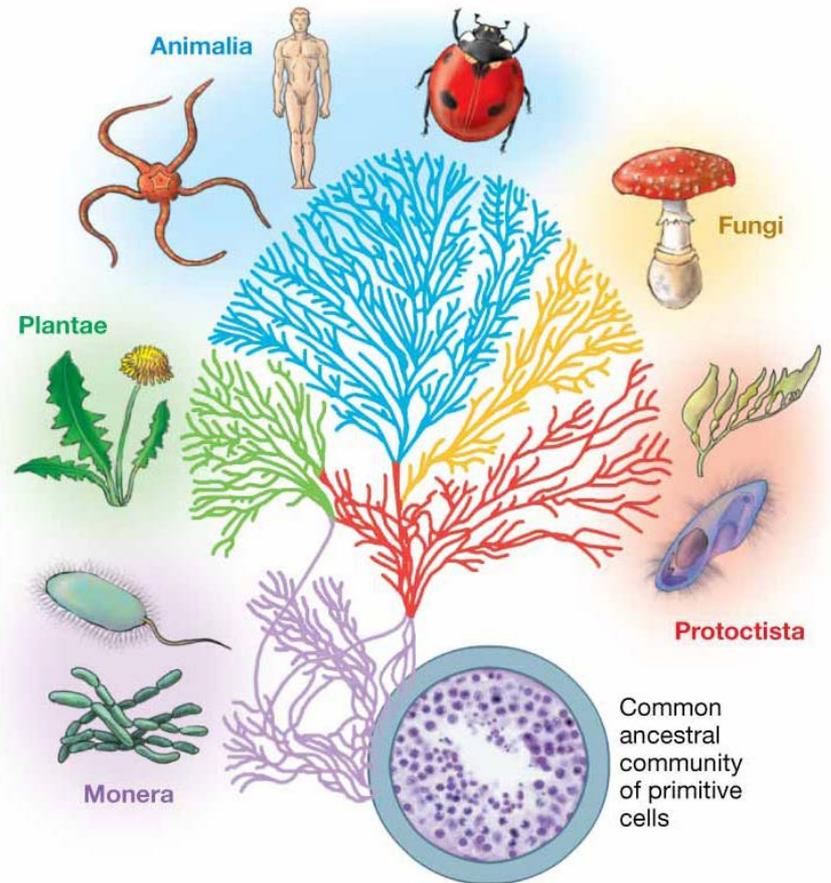
# Classification of Life

- Three domains or superkingdoms
- **Bacteria** – simple life forms without nuclei
- **Archaea** – simple, microscopic creatures
- **Eukarya** – complex, multicellular organisms
  - Plants and animals
  - DNA in discrete nucleus



# Classification of Living Organisms

- Five kingdoms
  - Monera
  - Protocista
  - Fungi
  - Plantae
  - Animalia



# Five Kingdoms of Organisms

- **Monera**
  - Simplest organisms, single-celled
  - Cyanobacteria, heterotrophic bacteria, archaea
- **Protoctista**
  - Single- and multicelled with nucleus
  - Algae, protozoa
- **Fungi**
  - Mold, lichen

# Five Kingdoms of Organisms

- **Plantae**
  - Multicelled photosynthetic plants
  - Surf grass, eelgrass, mangrove, marsh grasses
- **Animalia**
  - Multicelled animals
  - Range from simple sponges to complex vertebrates

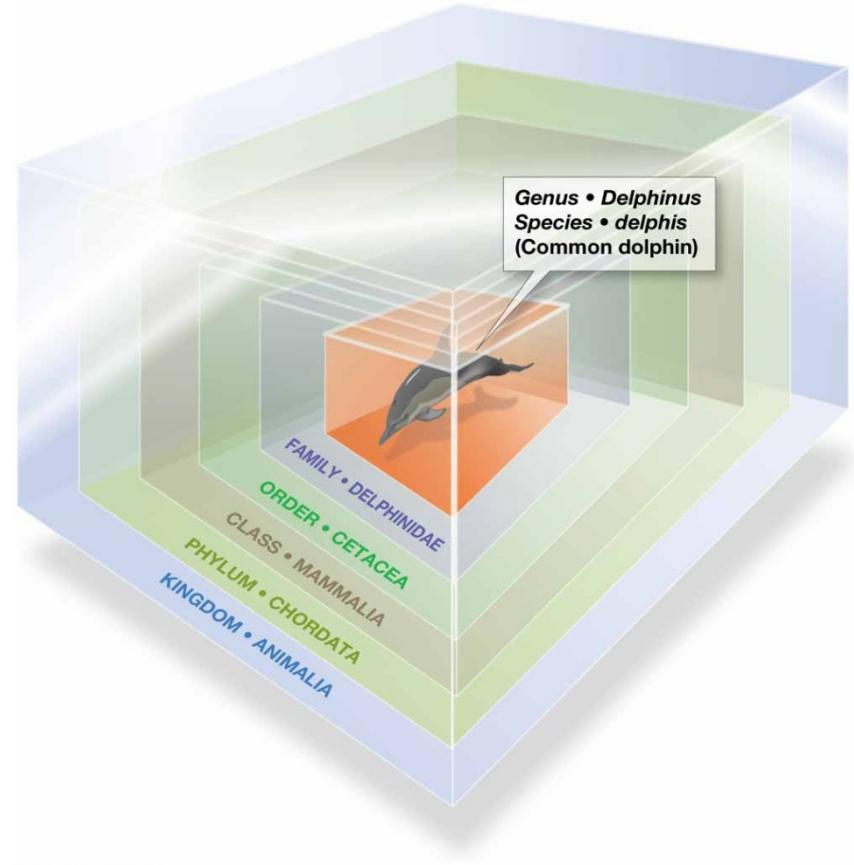
# Taxonomic Classification

- **Carolus Linnaeus** – 1758
  - Developed basis of modern classification of organisms
- **Taxonomy** – systematic classification of organisms
  - Physical characteristics
  - Genetic information



# Taxonomy

- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species
  - Fundamental unit
  - Population of genetically similar, interbreeding individuals



# Taxonomic Classification

**TABLE 12.1 TAXONOMIC CLASSIFICATION OF SELECTED ORGANISMS**

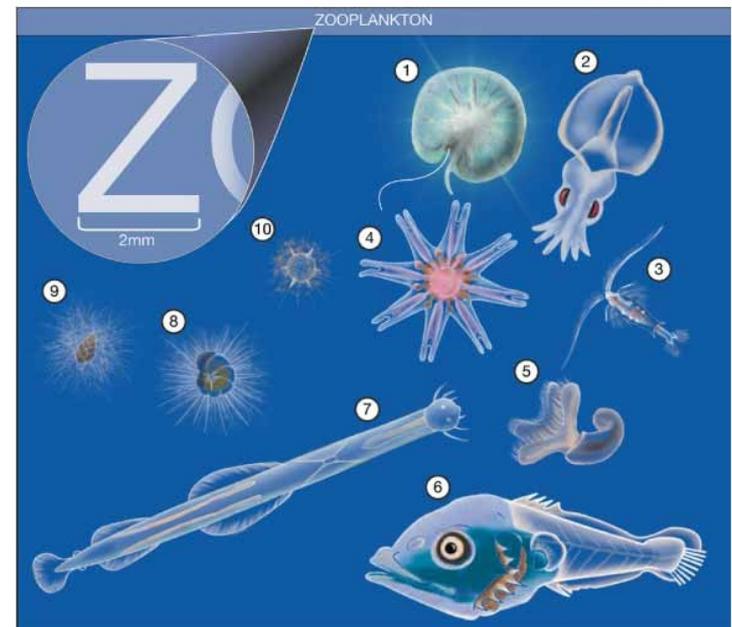
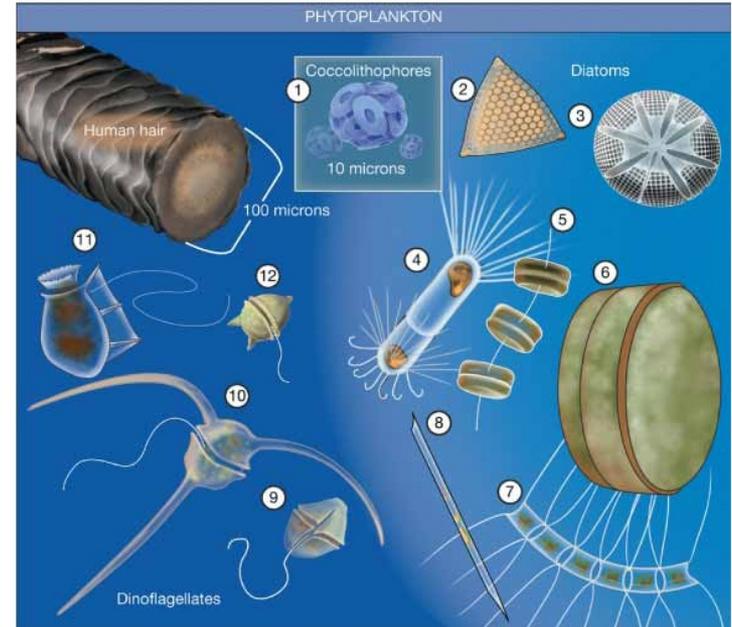
Category	Human	Common dolphin	Killer whale	Bat star	Giant kelp
<b>Kingdom</b>	Animalia	Animalia	Animalia	Animalia	Protoctista
<b>Phylum</b>	Chordata	Chordata	Chordata	Echinodermata	Phaeophyta
<b>Subphylum</b>	Vertebrata	Vertebrata	Vertebrata		
<b>Class</b>	Mammalia	Mammalia	Mammalia	Asteroidea	Phaeophyceae
<b>Order</b>	Primates	Cetacea	Cetacea	Valvatida	Laminariales
<b>Family</b>	Hominidae	Delphinidae	Delphinidae	Oreasteridae	Lessoniaceae
<b>Genus</b>	<i>Homo</i>	<i>Delphinus</i>	<i>Orcinus</i>	<i>Asterina</i>	<i>Macrocystis</i>
<b>Species</b>	<i>sapiens</i>	<i>delphis</i>	<i>orca</i>	<i>miniata</i>	<i>pyrifera</i>

# Classification of Marine Organisms

- **Plankton** (floaters)
- **Nekton** (swimmers)
- **Benthos** (bottom dwellers)

# Types of Plankton

- Most **biomass** on Earth consists of plankton.
- **Phytoplankton**
  - **Autotrophic** – can photosynthesize and produce own food
- **Zooplankton**
  - **Heterotrophic** – relies on food produced by others



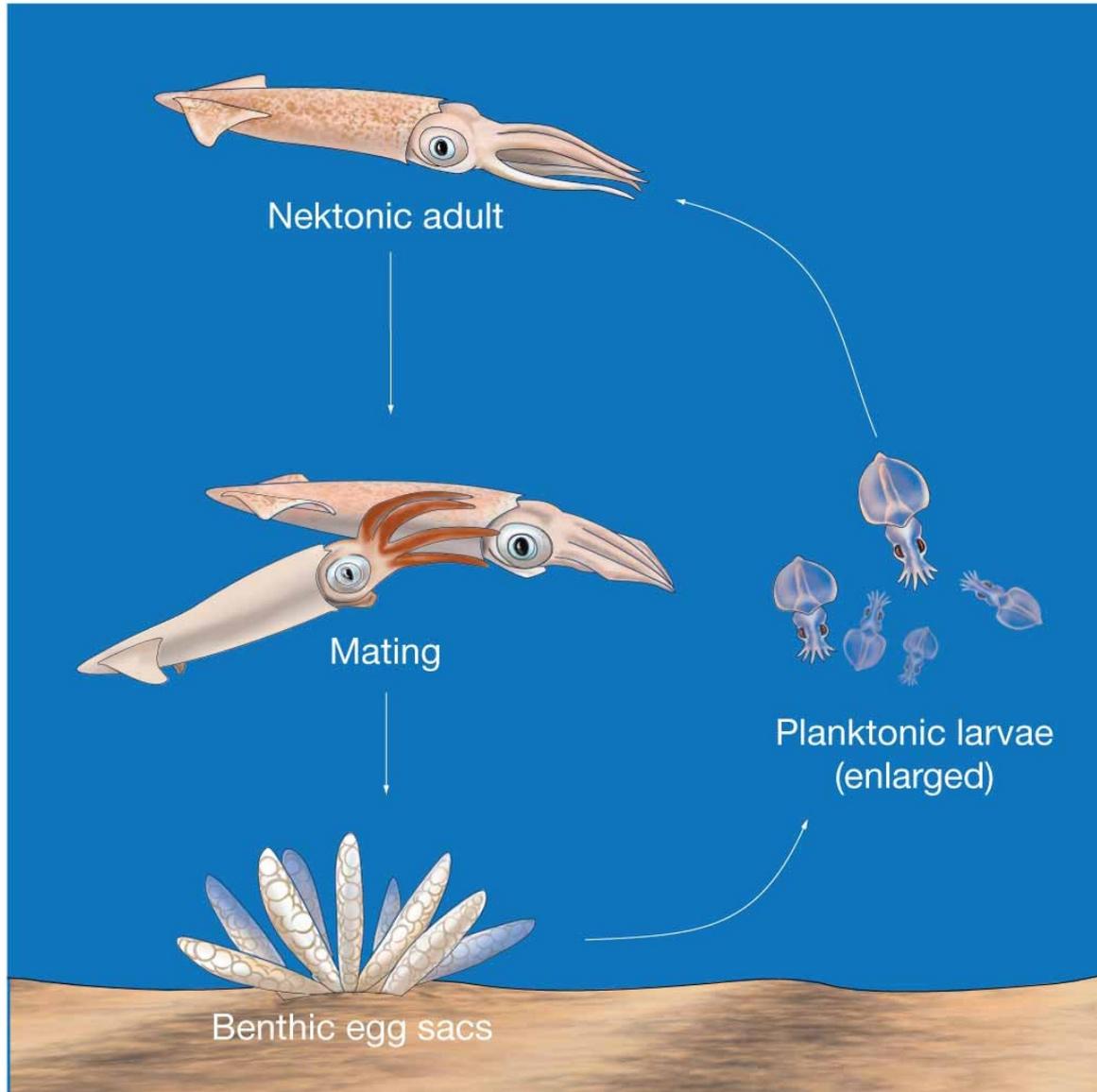
# Other Types of Plankton

- **Bacterioplankton**
  - Very small
  - At least half the ocean's photosynthetic biomass
  - Likely most abundant photosynthetic organism
- **Virioplankton**
  - Smaller than bacterioplankton
  - Not well understood, may limit abundance of other plankton through infection
- **Holoplankton**
  - Entire lives as plankton

# Other Types of Plankton

- **Meroplankton**
  - Part of lives as plankton
  - Juvenile or larval stages
- **Macroplankton**
  - Large floaters such as jellyfish or *Sargassum*
- **Picoplankton**
  - Very small floaters such as bacterioplankton

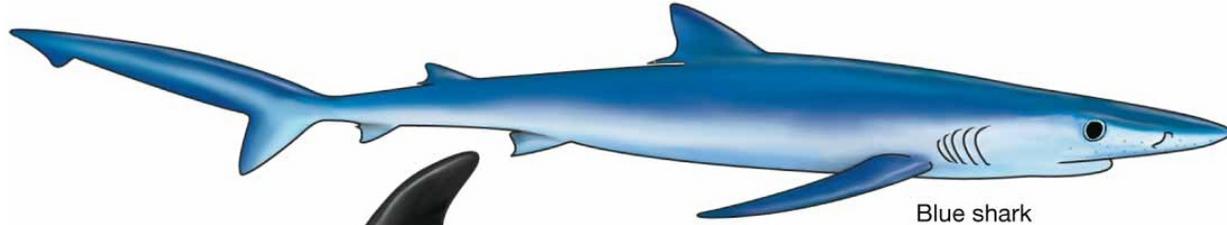
# Life Cycle of a Squid



# Nekton

- Independent swimmers
- Most adult fish and squid
- Marine mammals
- Marine reptiles

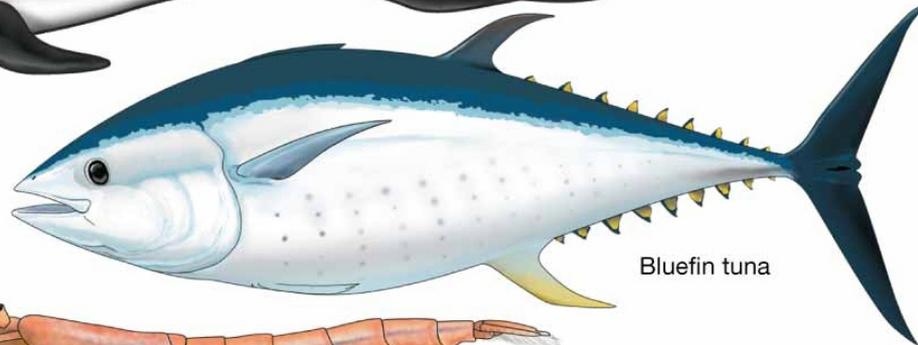
# Nekton



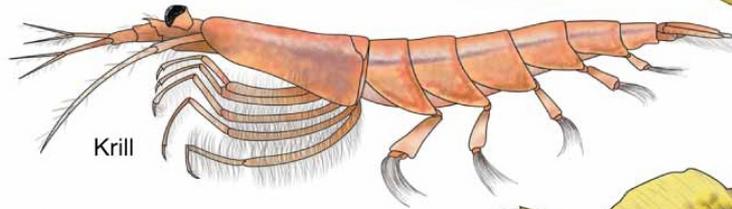
Blue shark



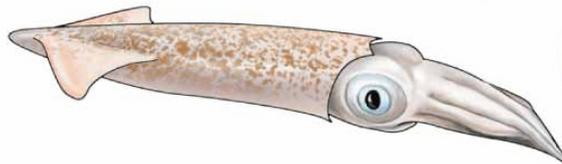
Hourglass dolphin



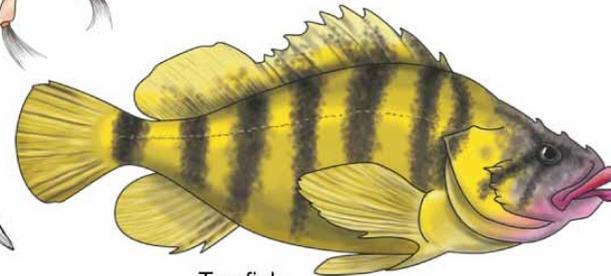
Bluefin tuna



Krill



Market squid

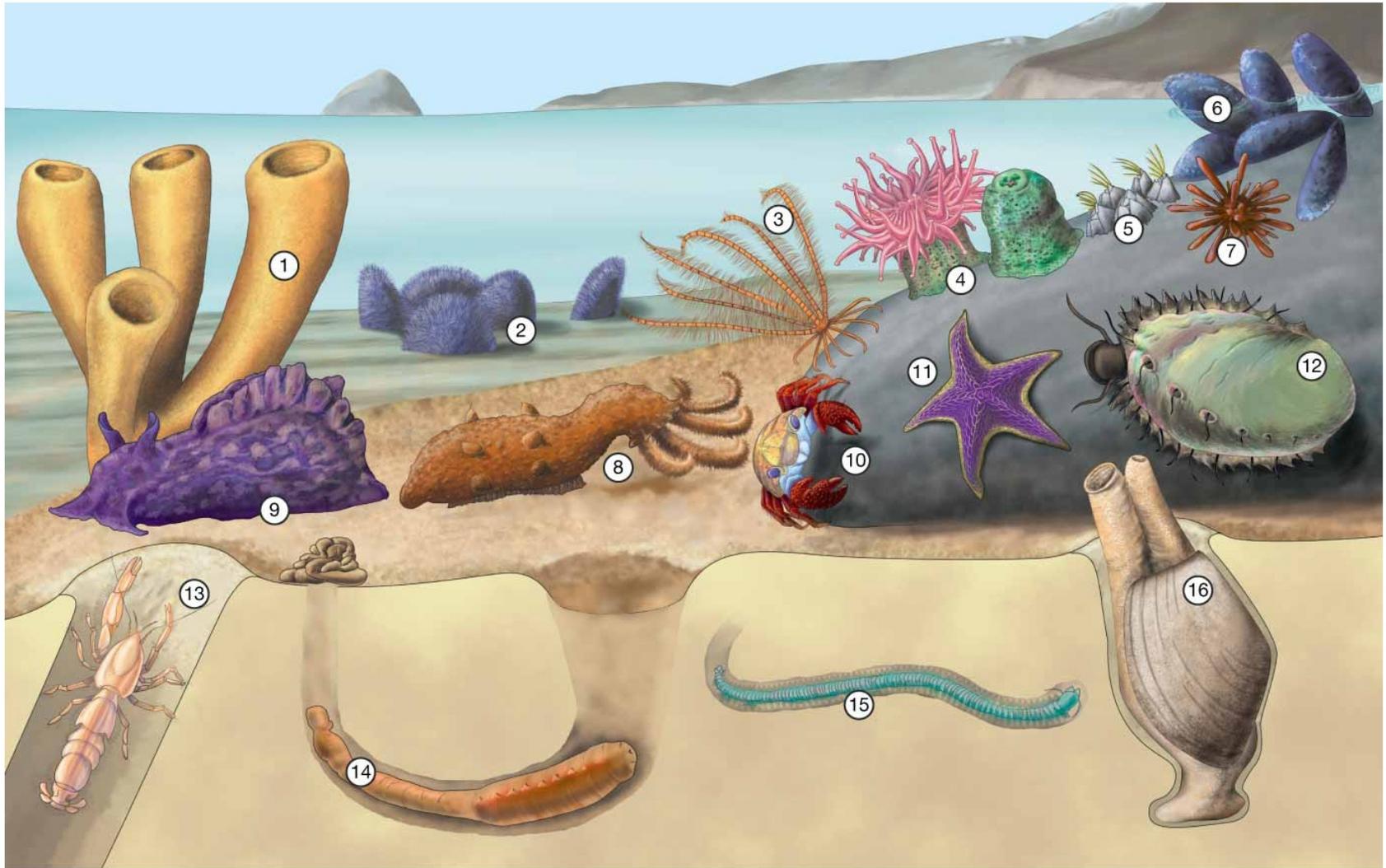


Treefish

# Benthos – Bottom Dwellers

- **Epifauna** live on the surface of the sea floor.
- **Infauna** live buried in sediments.
- **Nektobenthos** swim or crawl through water above the seafloor.
- Benthos are most abundant in shallower water.
- Many live in perpetual darkness, coldness, and stillness.

# Benthos



# Hydrothermal Vent Communities

- Abundant and large deep-ocean benthos
- Discovered in 1977
- Associated with hot vents
- Bacteria-like archaeon produce food using heat and chemicals.

# Number of Marine Species

- Total cataloged species on Earth about 1.8 million
- Many marine species not yet identified due to exploration difficulties
- As many as 2000 new marine and terrestrial species discovered each year

# Number of Marine Species

- More land species than marine species
- Ocean has relatively uniform conditions
- Less adaptation required, less speciation
- Marine species overwhelmingly benthic (98%) rather than pelagic (2%)

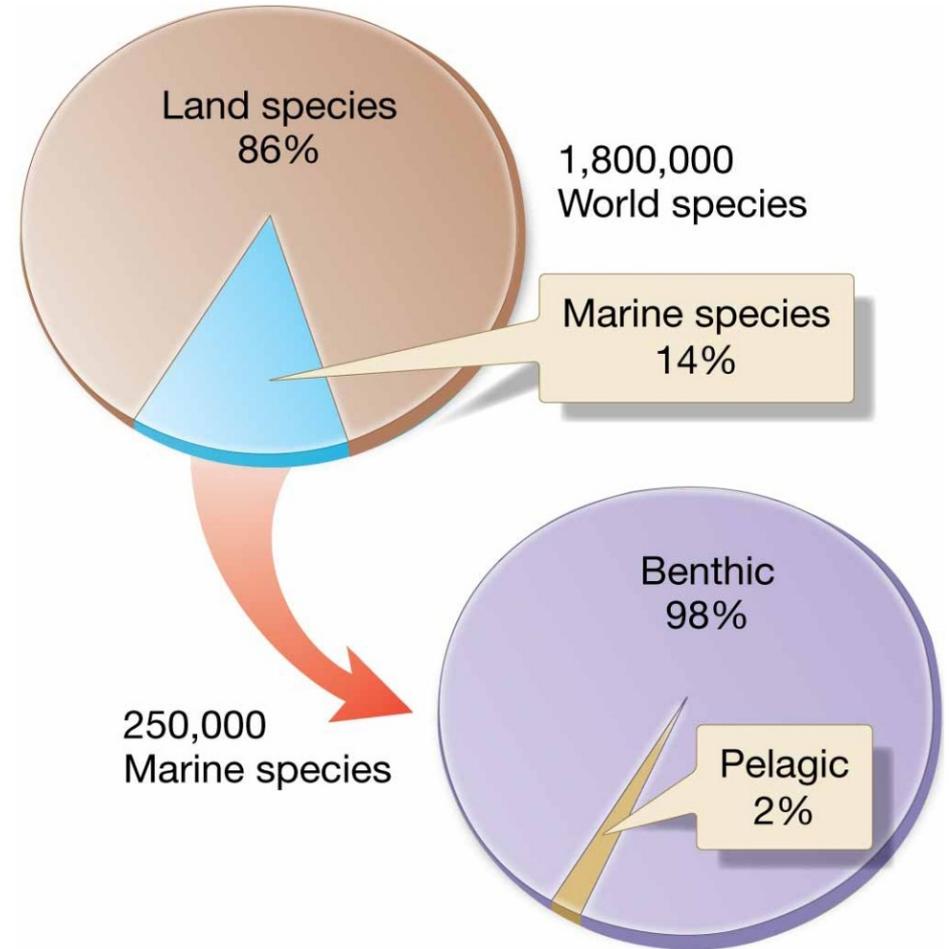
# Number of Marine Species

- Census of Marine Life (CoML) -- \$650 million 10 year program completed in 2010
- Discovered at least 1200 new marine species including yeti crab
- Assessed diversity, distribution, and abundance of marine organisms



# Number of Marine Species

- Currently 250,000 documented marine species

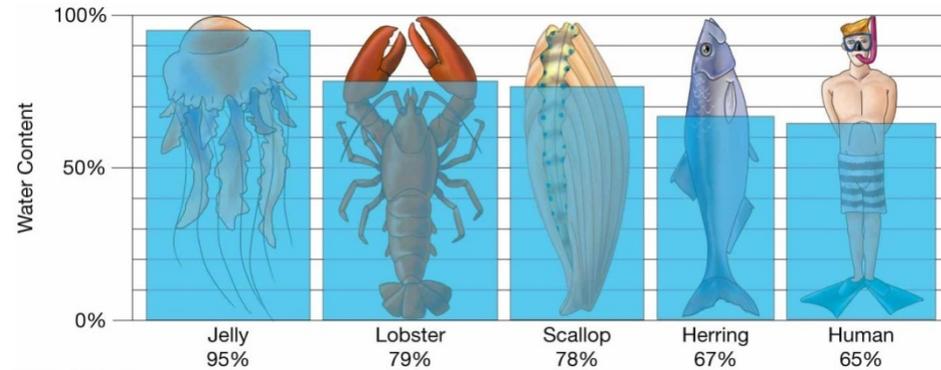


# Adaptations of Marine Organisms

- The marine environment is more stable than land.
- Organisms in the ocean are less able to withstand environmental changes.

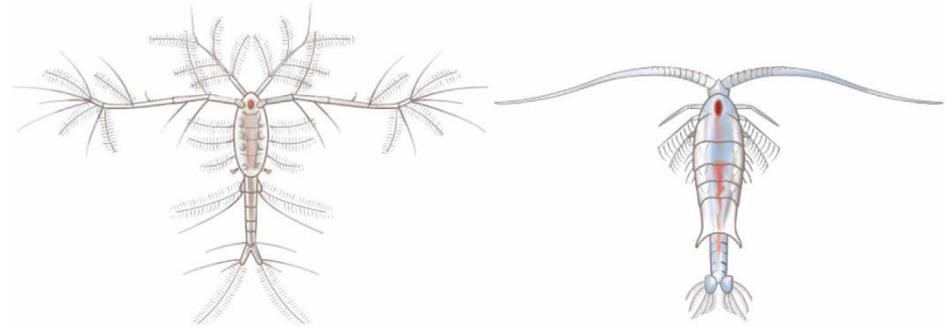
# Adaptations of Marine Organisms

- **Protoplasm** – substance of living matter
  - More than 80% of mass is water
- Marine animals do not risk desiccation.



# Adaptations of Marine Organisms

- Physical support
  - Buoyancy
  - How to resist sinking
  - Different support structures in cold (fewer) rather than warm (more appendages) seawater
    - Changes in water **viscosity** with temperature
  - Smaller size



# Adaptations of Marine Organisms

- High surface area to volume ratio
- Cube a – greater resistance to sinking per unit of mass than cube c
- Phytoplankton benefit from being small

Dimensions of Cube a

$$\begin{aligned}\text{Side} &= 1 \\ \text{Surface} &= 6 \\ \text{Volume} &= 1^3 = 1 \\ \frac{S}{V} &= \frac{6}{1} = 6\end{aligned}$$



Oxygen diffusion across skin



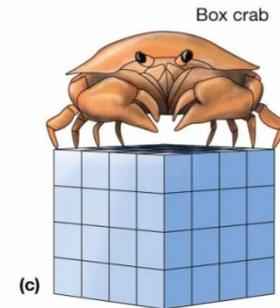
Dimensions of Cube b

$$\begin{aligned}\text{Side} &= 2 \\ \text{Surface} &= 2^2 \times 6 = 24 \\ \text{Volume} &= 2^3 = 8 \\ \frac{S}{V} &= \frac{24}{8} = 3\end{aligned}$$



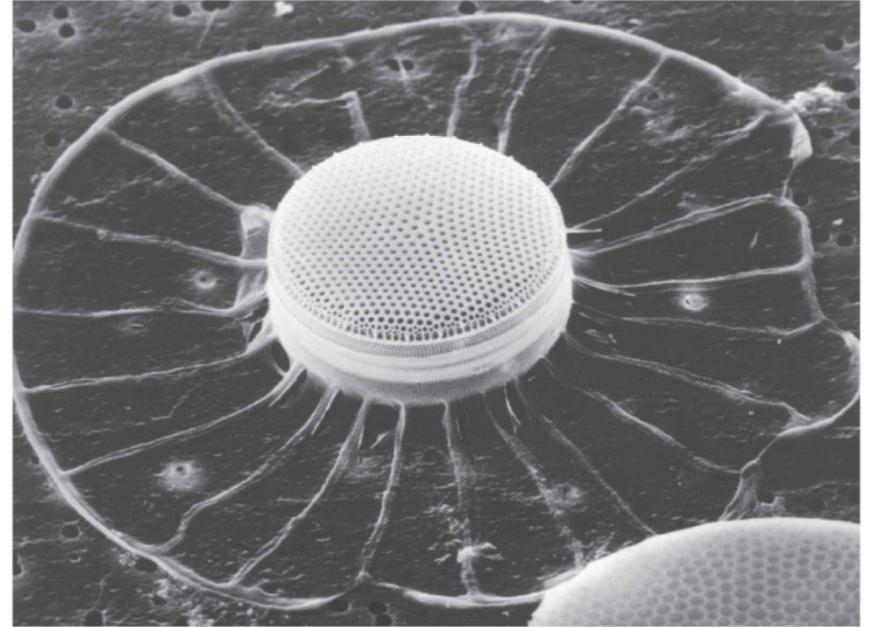
Dimensions of Cube c

$$\begin{aligned}\text{Side} &= 4 \\ \text{Surface} &= 4^2 \times 6 = 96 \\ \text{Volume} &= 4^3 = 64 \\ \frac{S}{V} &= \frac{96}{64} = 1.5\end{aligned}$$



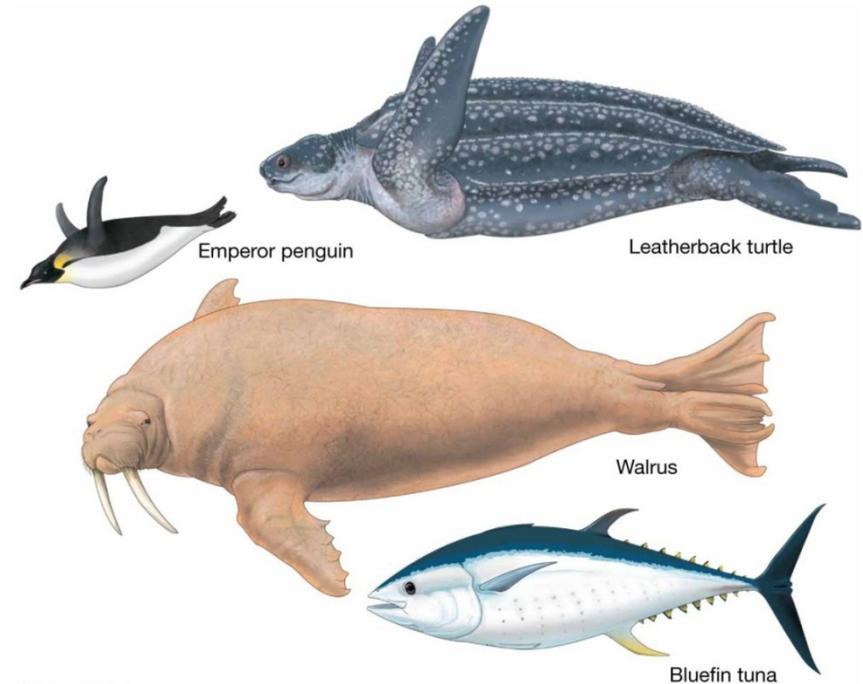
# Adaptations of Marine Organisms

- Unusual appendages to increase surface area
- Oil in micro-organisms to increase buoyancy



# Viscosity and Streamlining Adaptations

- **Streamlining**  
important for larger organisms
  - Shape offers least resistance to fluid flow
- Flattened body
- Tapering back end



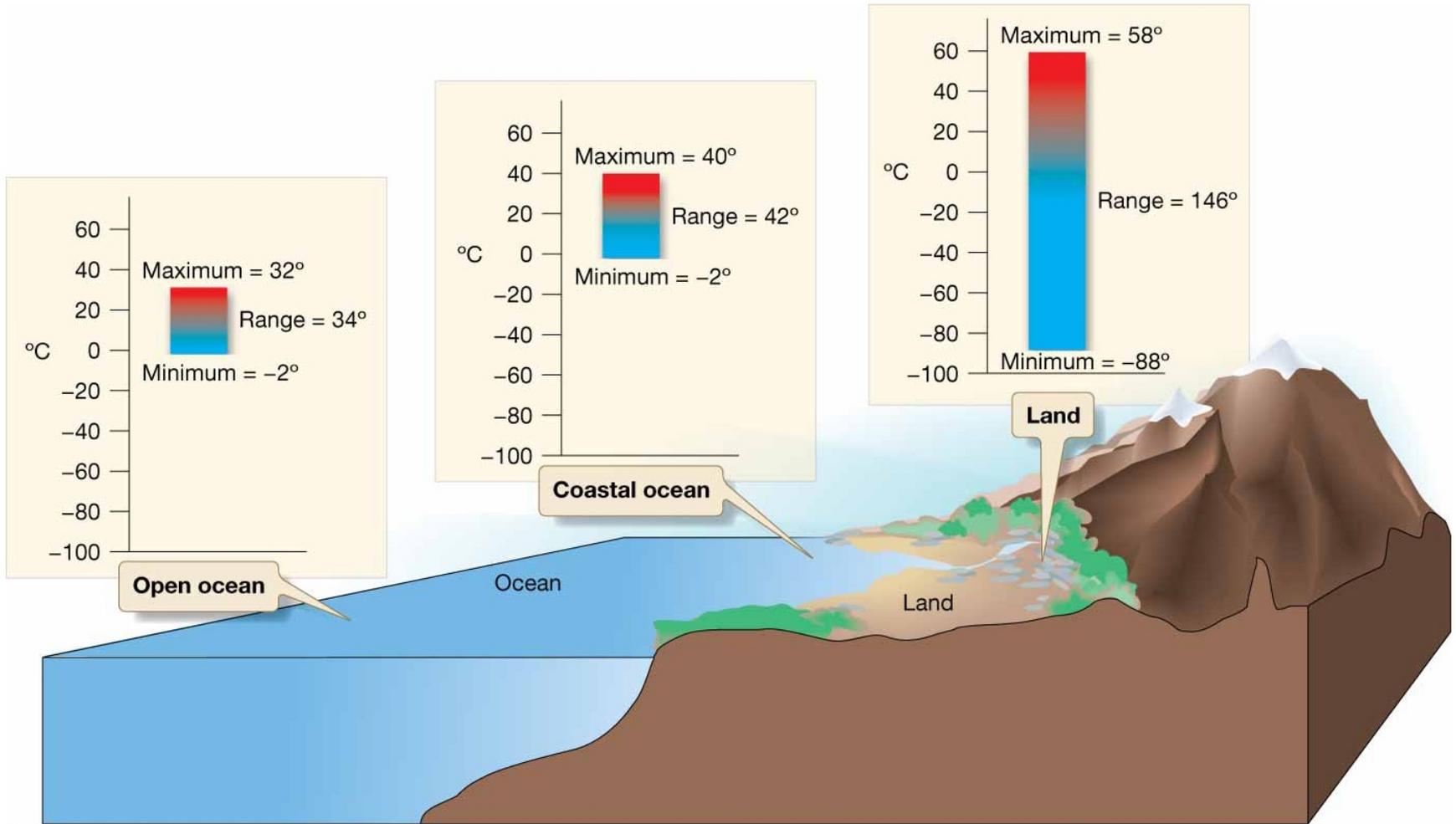
# Reproduction

- **Broadcast spawning** – eggs and sperm directly released into seawater
- Marine organisms take advantage of water's high viscosity to enhance reproduction chances

# Temperature and Marine Life

- Narrow range of temperature in oceans
- Smaller variations (daily, seasonally, annually)
- Deep ocean is nearly isothermal

# Comparison of Ocean and Land Temperatures



# Ocean Temperature

- More stable than land for four reasons
  - Higher heat capacity of water
  - Ocean warming reduced by evaporation
  - Solar radiation penetrates deeply into ocean layers
  - Ocean mixing

# Cold vs. Warm Water Species

- Floating organisms smaller in warmer seawater
- More appendages in warmer seawater
- Tropical organisms grow faster, live shorter, reproduce more often
- More species in warmer seawater
- More biomass in cooler seawater (upwelling)

# Temperature and Marine Organisms

- **Stenothermal**

- Organisms withstand small variation in temperature
- Typically live in open ocean

- **Eurythermal**

- Organisms withstand large variation in temperature
- Typically live in coastal waters

# Salinity and Marine Organisms

- **Stenohaline**

- Organisms withstand only small variation in salinity
- Typically live in open ocean

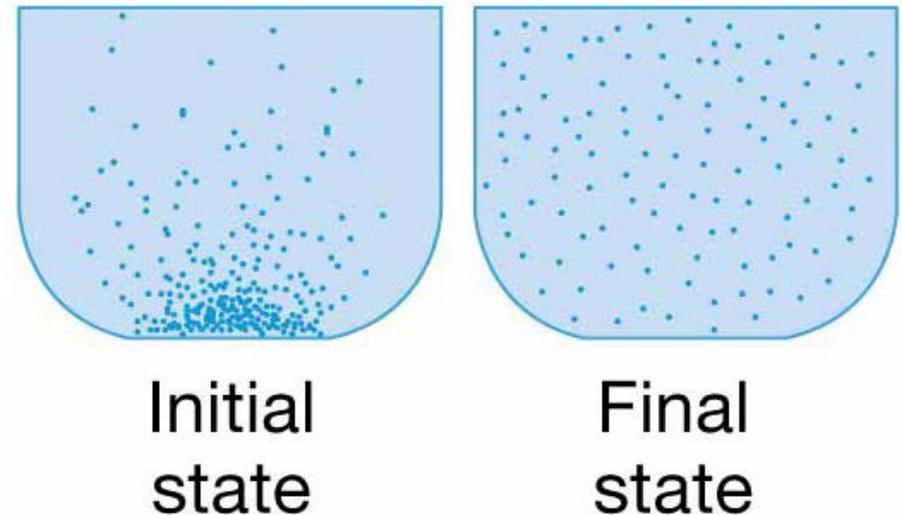
- **Euryhaline**

- Organisms withstand large variation in salinity
- Typically live in coastal waters, e.g., estuaries

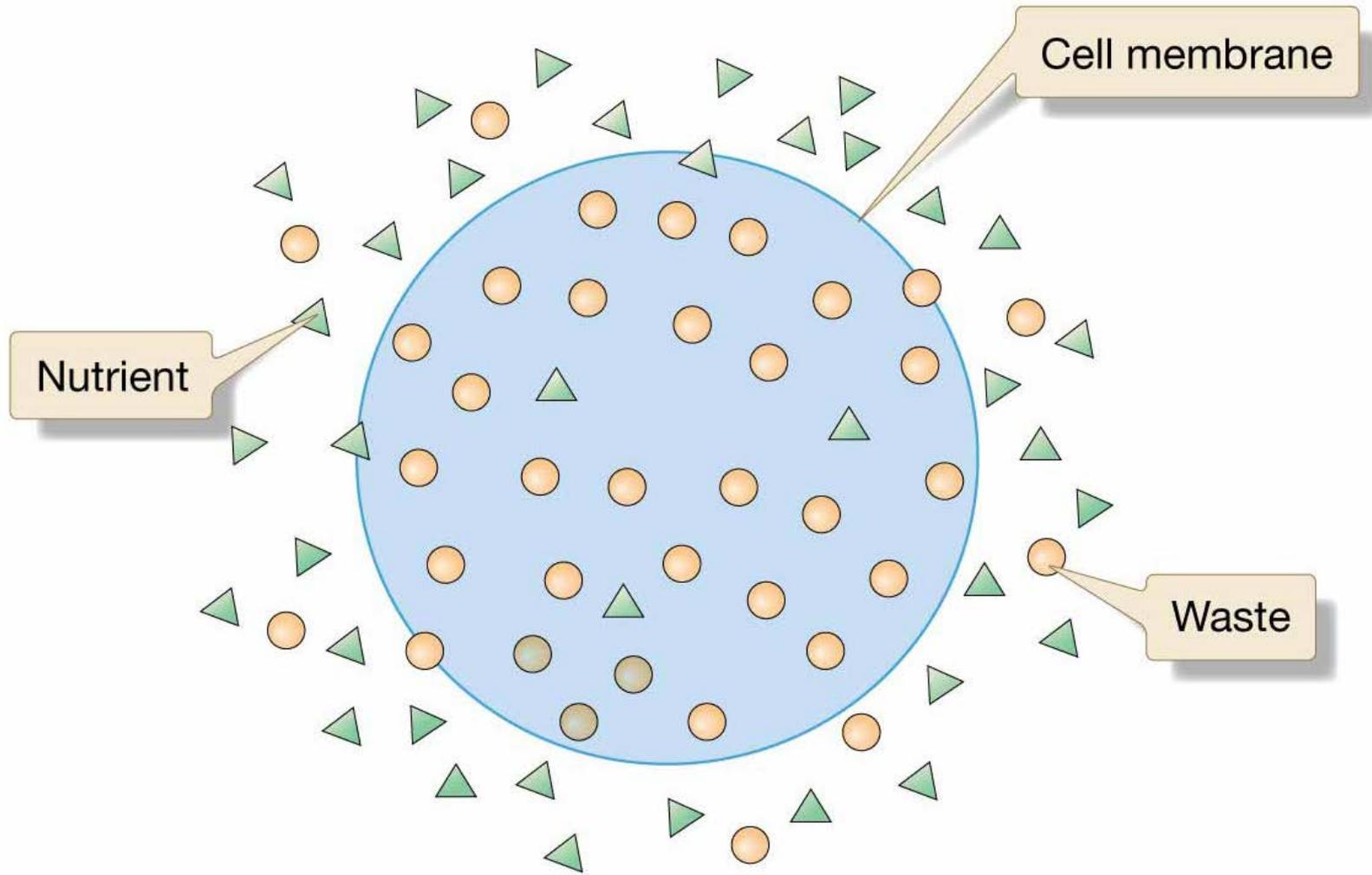
# Salinity Adaptations

- Extracting minerals from seawater
- High concentration to low concentration
  - Diffusion
  - Cell membrane permeable to nutrients, for example
  - Waste passes from cell to ocean

## Diffusion

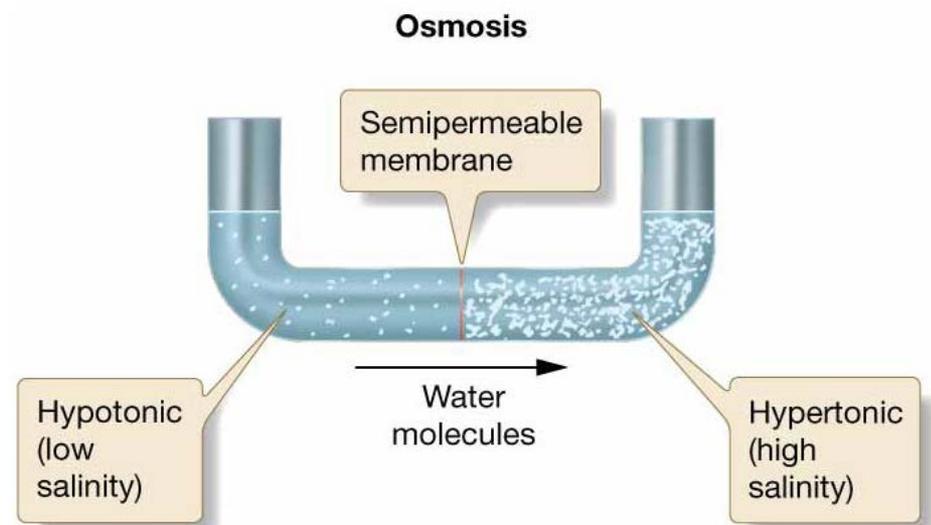


# Diffusion



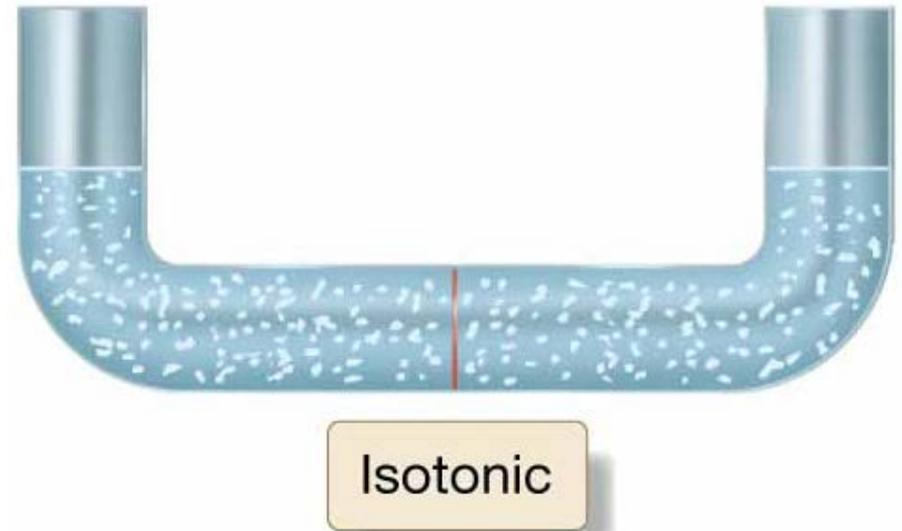
# Osmosis

- Water molecules move from less concentrated to more concentrated solutions
- **Osmotic pressure**
  - In more concentrated solutions
  - Prevents passage of water molecules

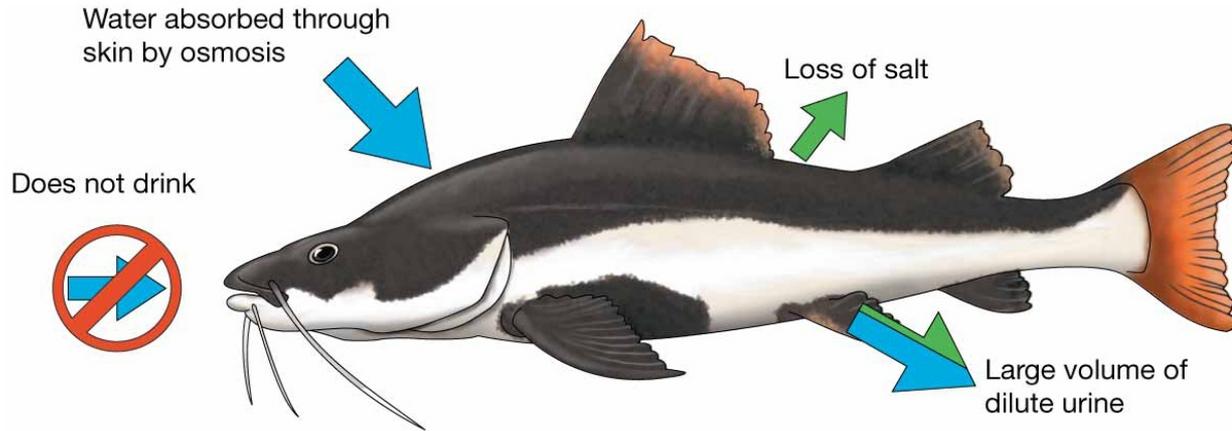


# Osmosis

- **Isotonic** – organism's body fluid salinity same as ocean
- **Hypertonic** – seawater has lower salinity than organism's fluids
- **Hypotonic** – organism's fluids have lower salinity than ocean



# Marine vs. Freshwater Fish

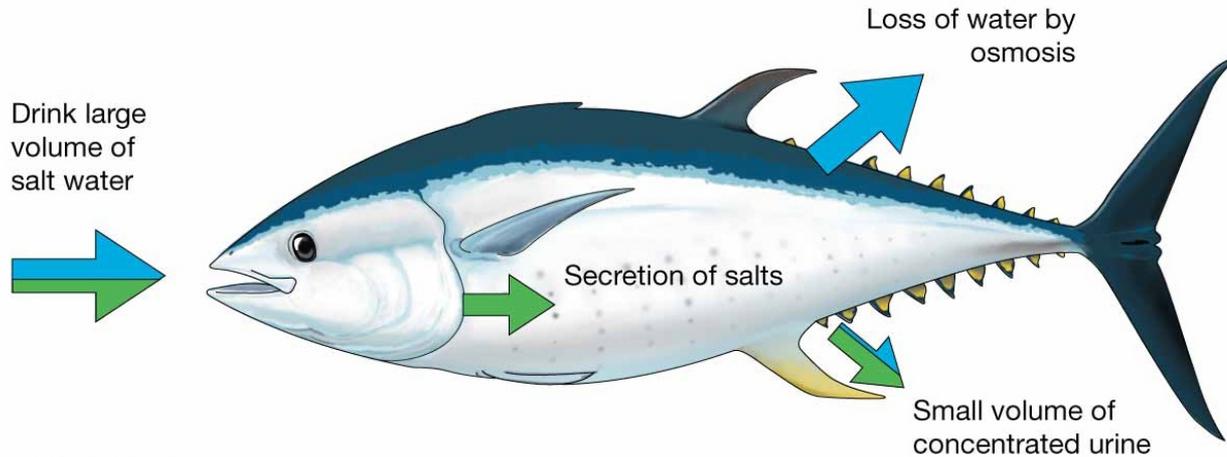


**Freshwater fish**

**Hypotonic = low osmotic pressure**

**Saltwater fish**

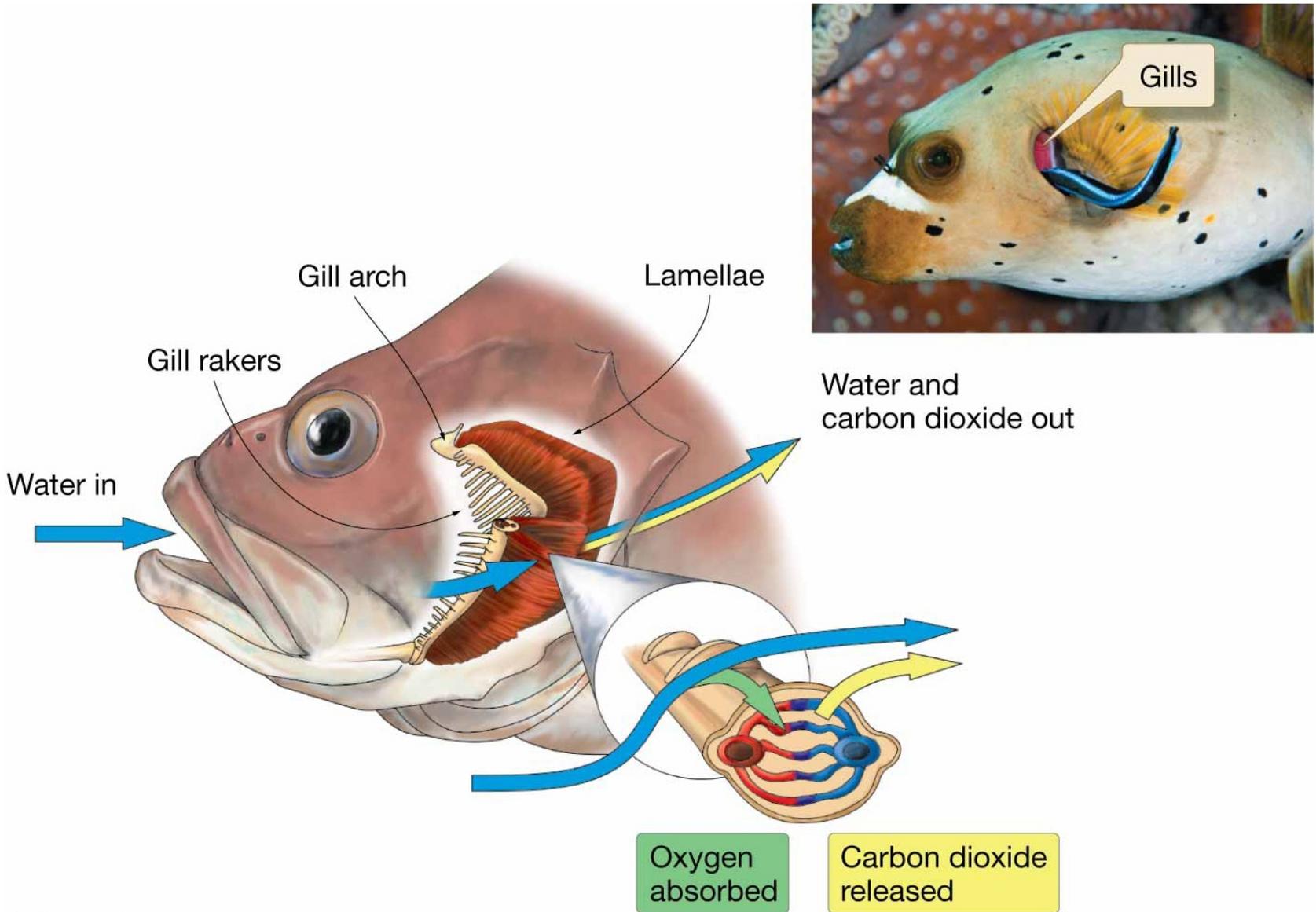
**Hypertonic = high osmotic pressure**



# Dissolved Gases

- Animals extract dissolved oxygen ( $O_2$ ) from seawater through **gills**.
- Gills exchange oxygen and carbon dioxide directly with seawater.
- Low marine oxygen levels can kill fish.
- Gill structure and location varies among animals.

# Gills on Fish



# Water's Transparency

- Many marine organisms see well.
- Some marine organisms are nearly transparent.
  - Elude predators
  - Stalk prey



# Adaptations to Marine Environment

- **Camouflage** through color patterns
- **Countershading** – dark on top, light on bottom

# Camouflage and Countershading



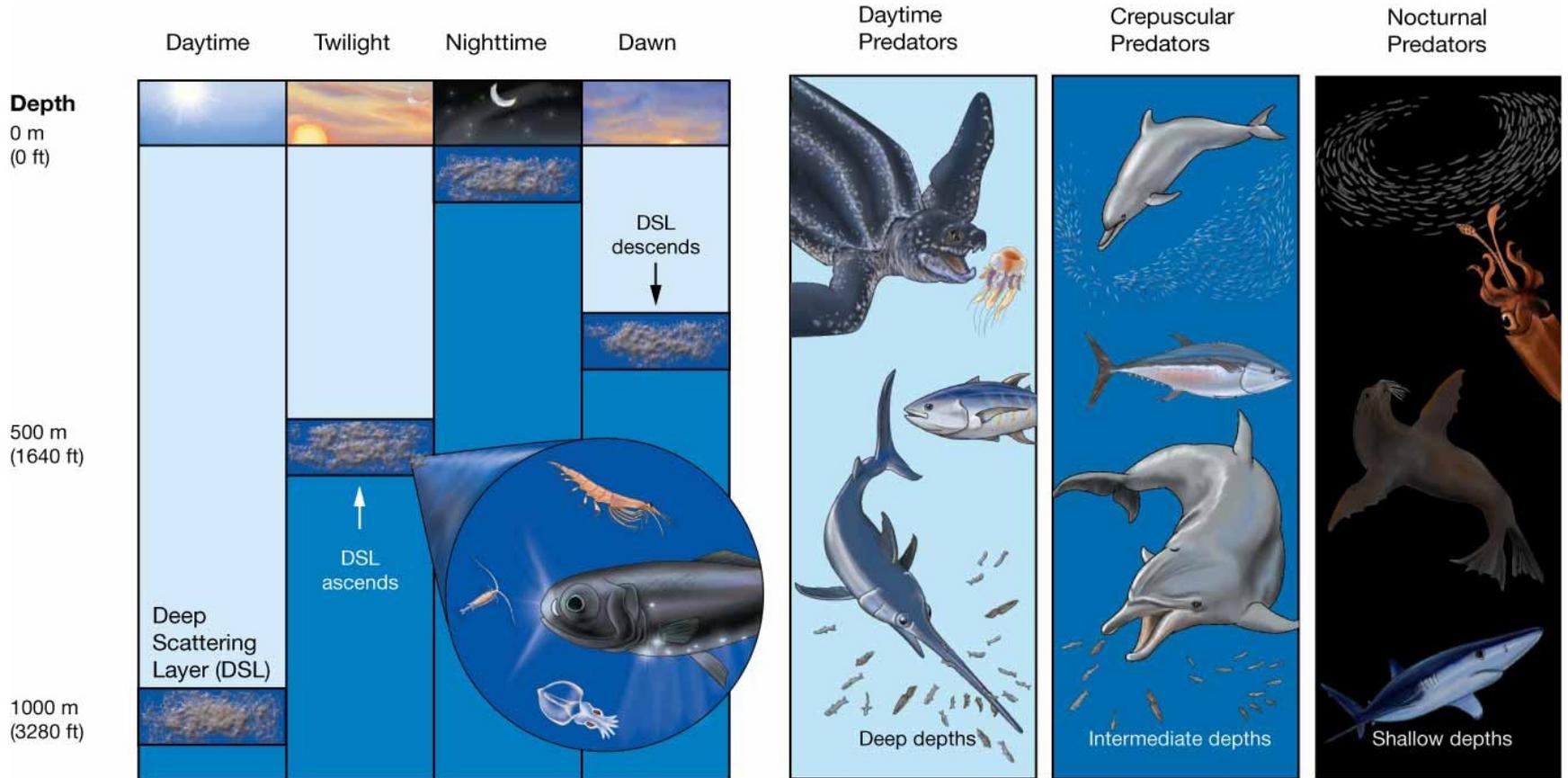
# Camouflage and Countershading



# Deep Scattering Layer

- Daily migration of many marine organisms to deeper, darker parts of ocean
- Dense concentration of organisms creates “false bottom” recorded on sonar readings
- Protection from predators
- Causes increased vertical mixing of ocean waters

# Deep Scattering Layer



# Disruptive Coloration

- Large, bold patterns, contrasting colors make animal blend into background

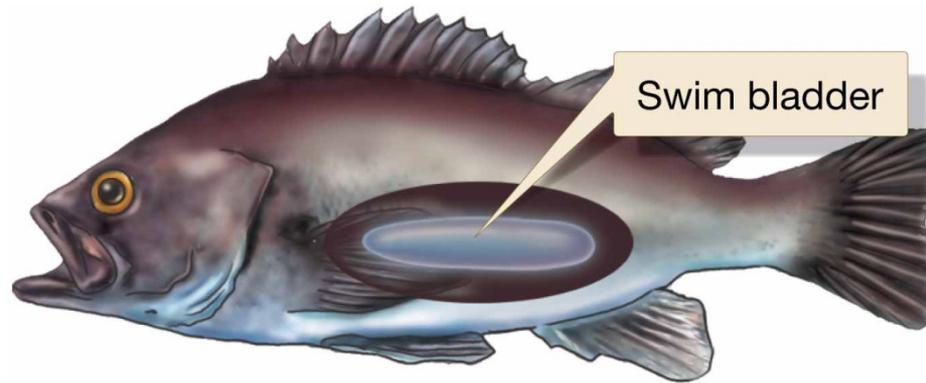


# Water Pressure

- Increases about 1 atmosphere (1 kg/cm<sup>2</sup>) with every 10 meters (33 feet) deeper
- Many marine organisms – no inner air pockets
- Collapsible rib cage (e.g., sperm whale)

# Water Pressure

- Many fish have **swim bladder**
  - Adjusts buoyancy and allows fish to regulate depth

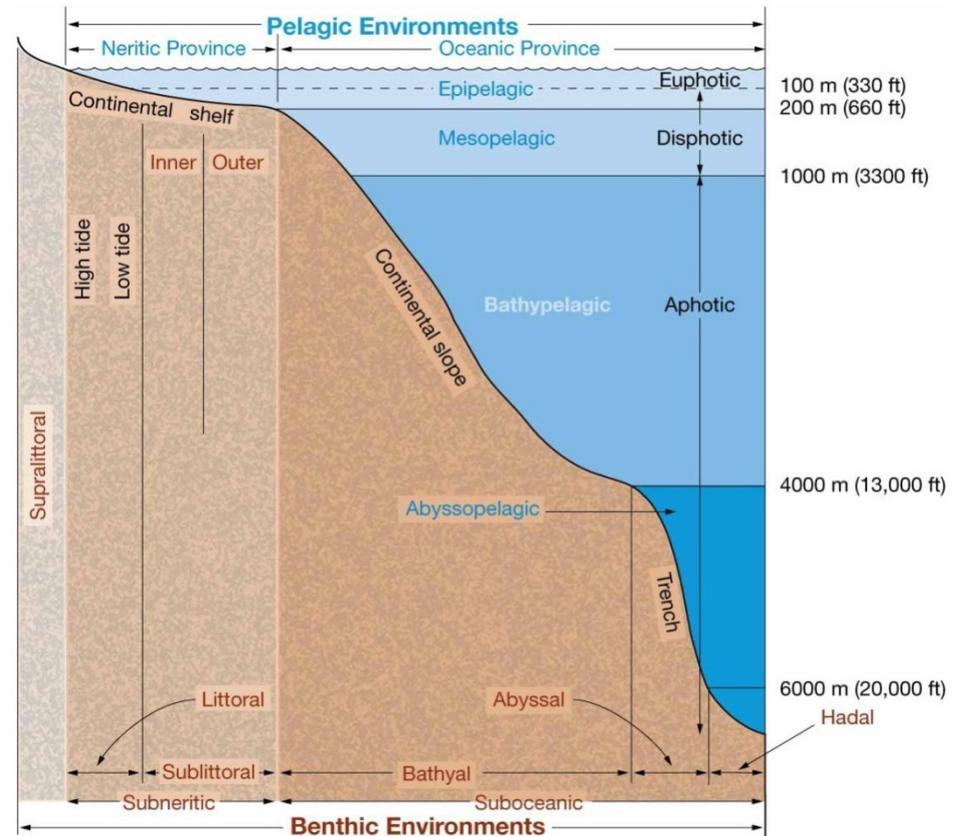


# Divisions of the Marine Environment

- **Pelagic** (open sea)
  - Neritic (< 200 meters) and oceanic
- **Benthic** (sea floor)
  - Subneritic and suboceanic

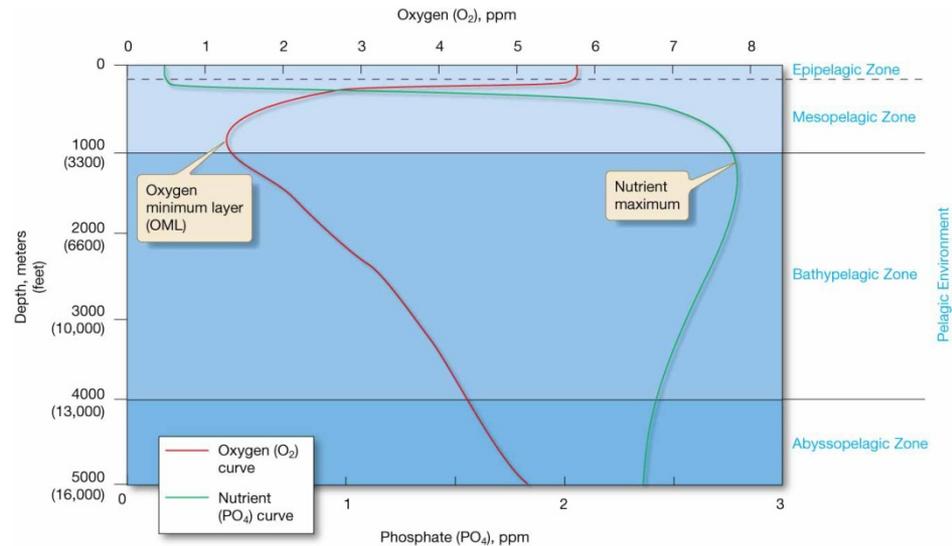
# Pelagic Environment

- Divided into **biozones**
- **Neritic Province** – from shore seaward, all water < 200 meters deep
- **Oceanic Province** – depth increases beyond 200 meters



# Oceanic Province

- **Epipelagic**
  - Only zone to support photosynthesis
  - Dissolved oxygen decreases around 200 meters
- **Mesopelagic**
  - Organisms capable of **bioluminescence** common
  - Contains dissolved **oxygen minimum layer (OML)**



# Ocean Province

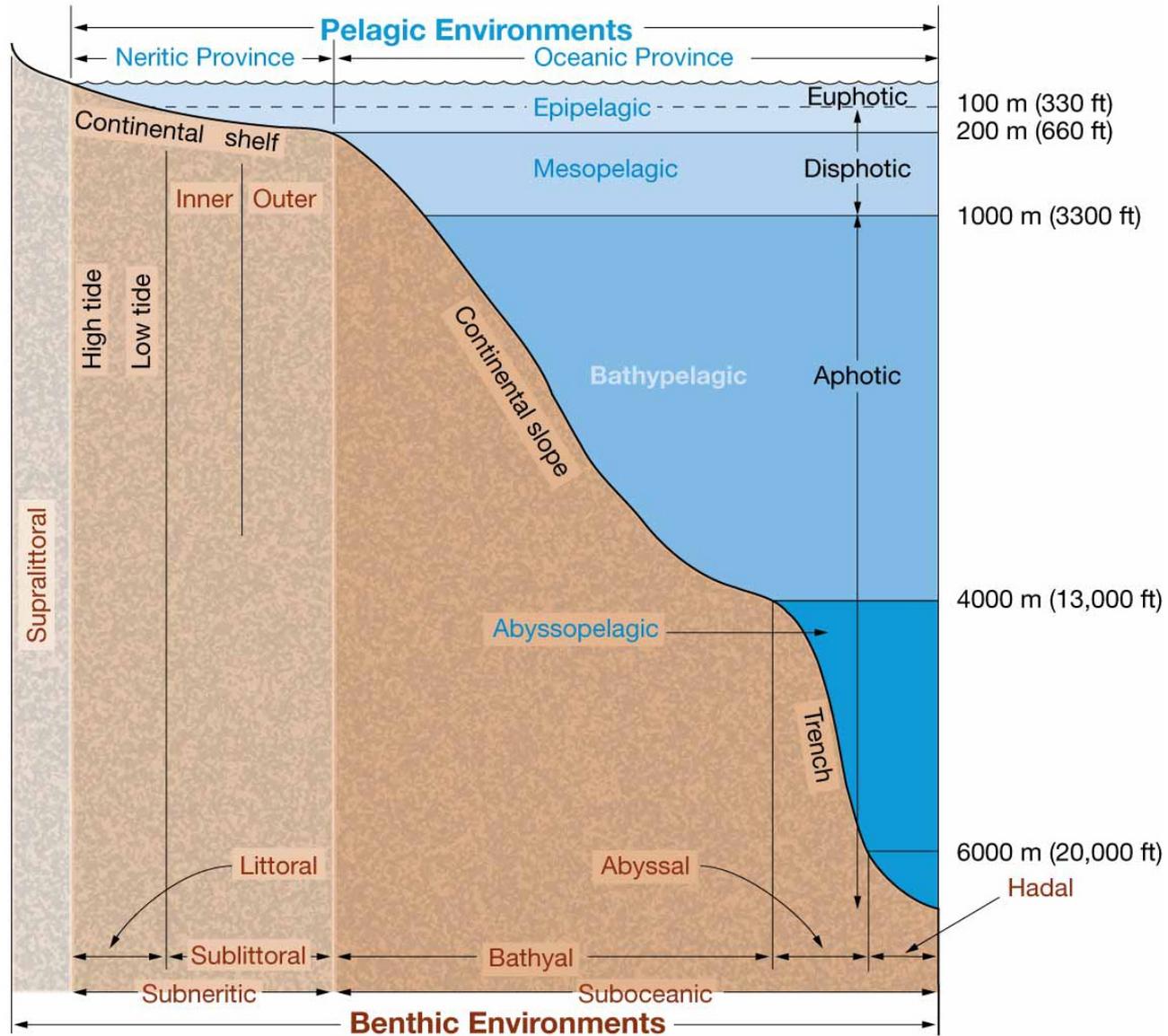
- **Bathypelagic** and **abyssopelagic zones** – 75% of living space in oceanic province
- **Bioluminescence** common in mesopelagic and deeper
  - Ability to biologically produce light
- Detritus feeding shrimp – predators at depth



# Ocean Zones Based on Light Availability

- **Euphotic** – surface to where enough light exists to support photosynthesis
- **Disphotic** – small but measurable quantities of light
- **Aphotic** – no light

# Benthic Environments



# Benthic Environments

- **Supralittoral** – transition from land to sea floor above spring high tide line; spray zone
- **Subneritic** – spring high tide shoreline to 200 m, about  $\frac{1}{2}$  the continental shelf
  - **Littoral** – intertidal zone
  - **Sublittoral** – shallow subtidal zone
    - **Inner** – extends to depth where marine algae no longer grow attached to ocean bottom
    - **Outer** – inner sublittoral to shelf break or 200 m

# Suboceanic Province

- **Bathyal** – continental slope
- **Abyssal**
  - More than 80% of benthic environment
  - Animal tracks in abyssal clay
- **Hadal**
  - Below 6000 m
  - Only deep trenches on continental margins



End of CHAPTER 12  
Marine Life and the Marine  
Environment