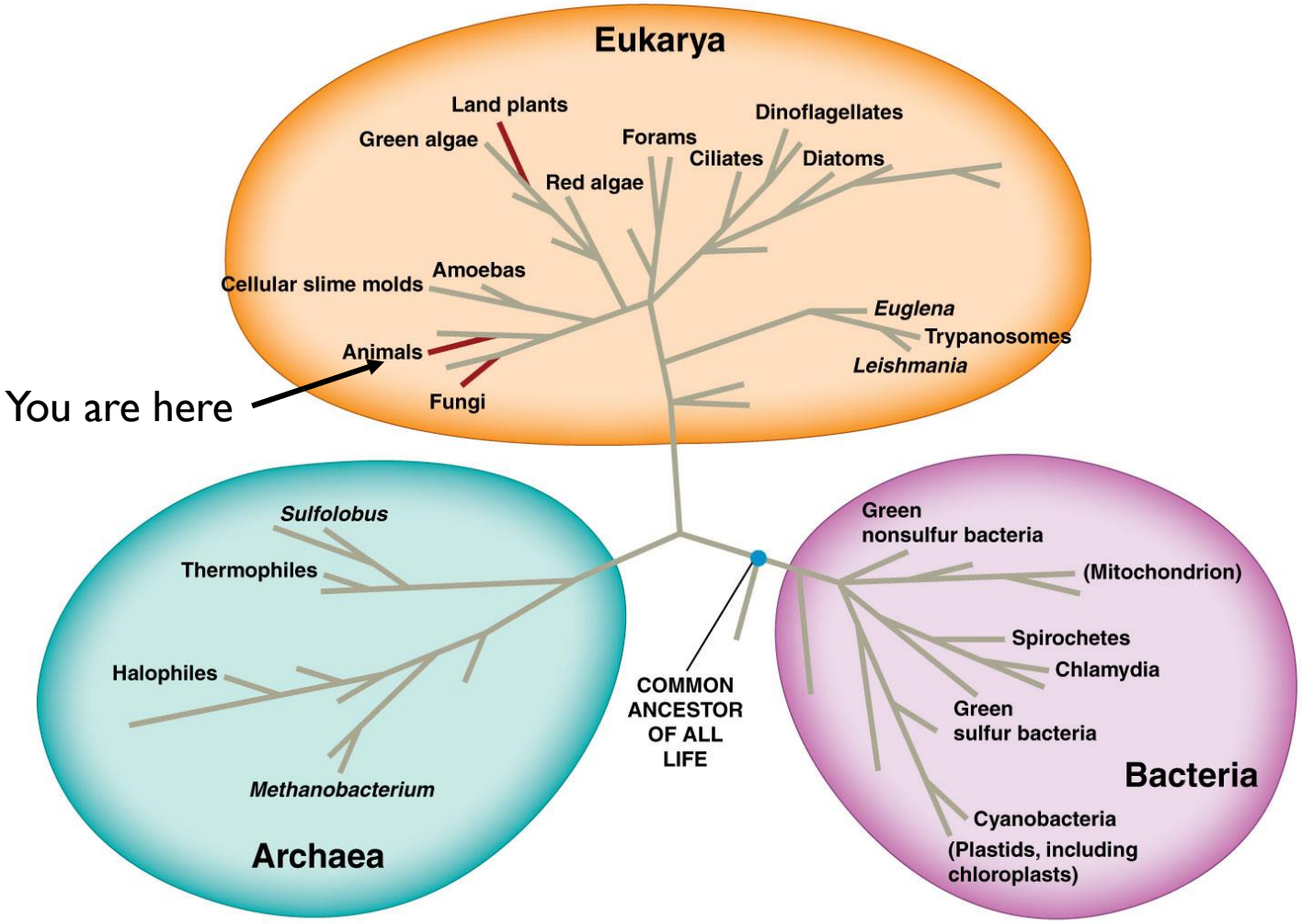
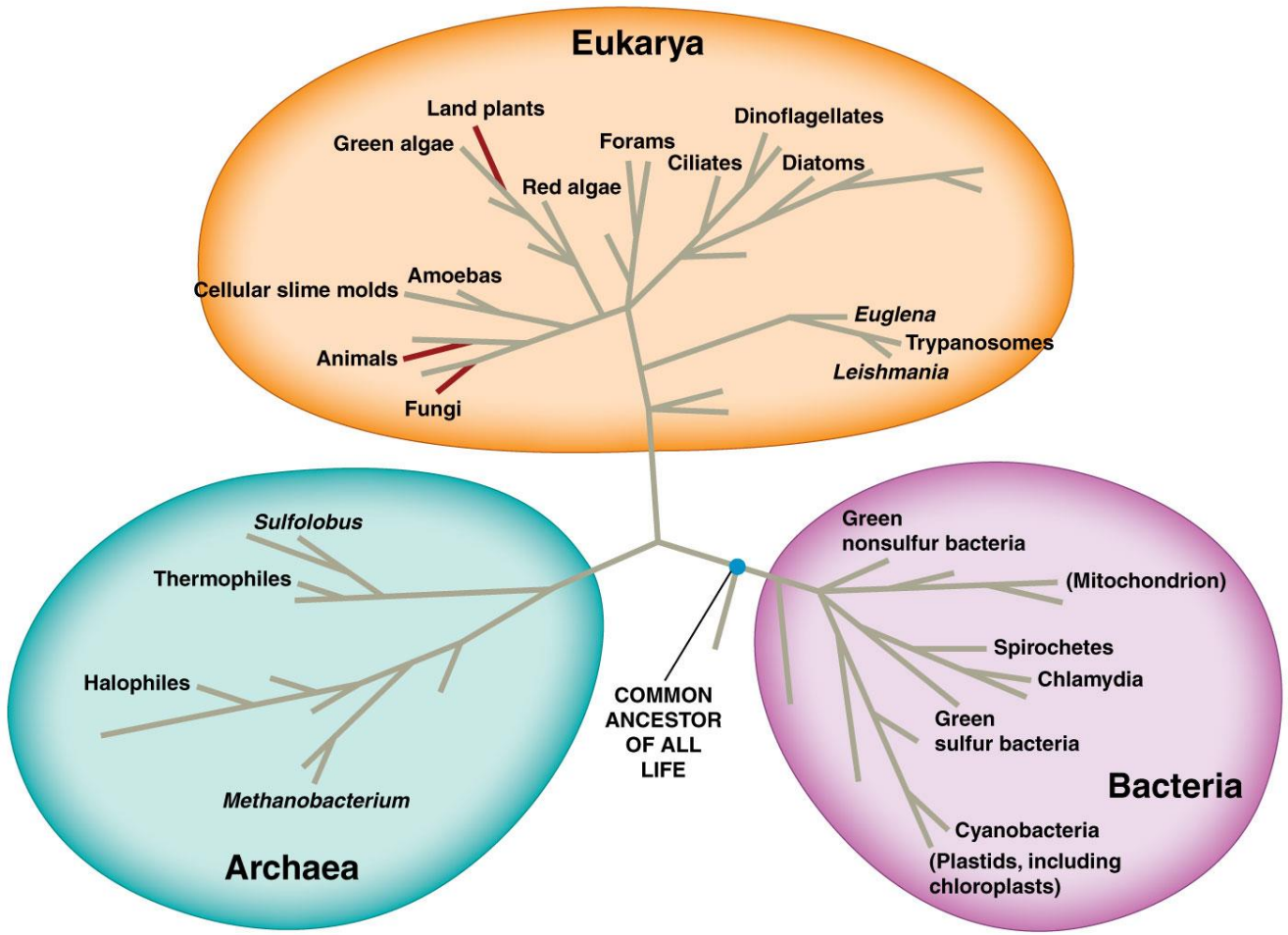
Primary producers and Estuaries

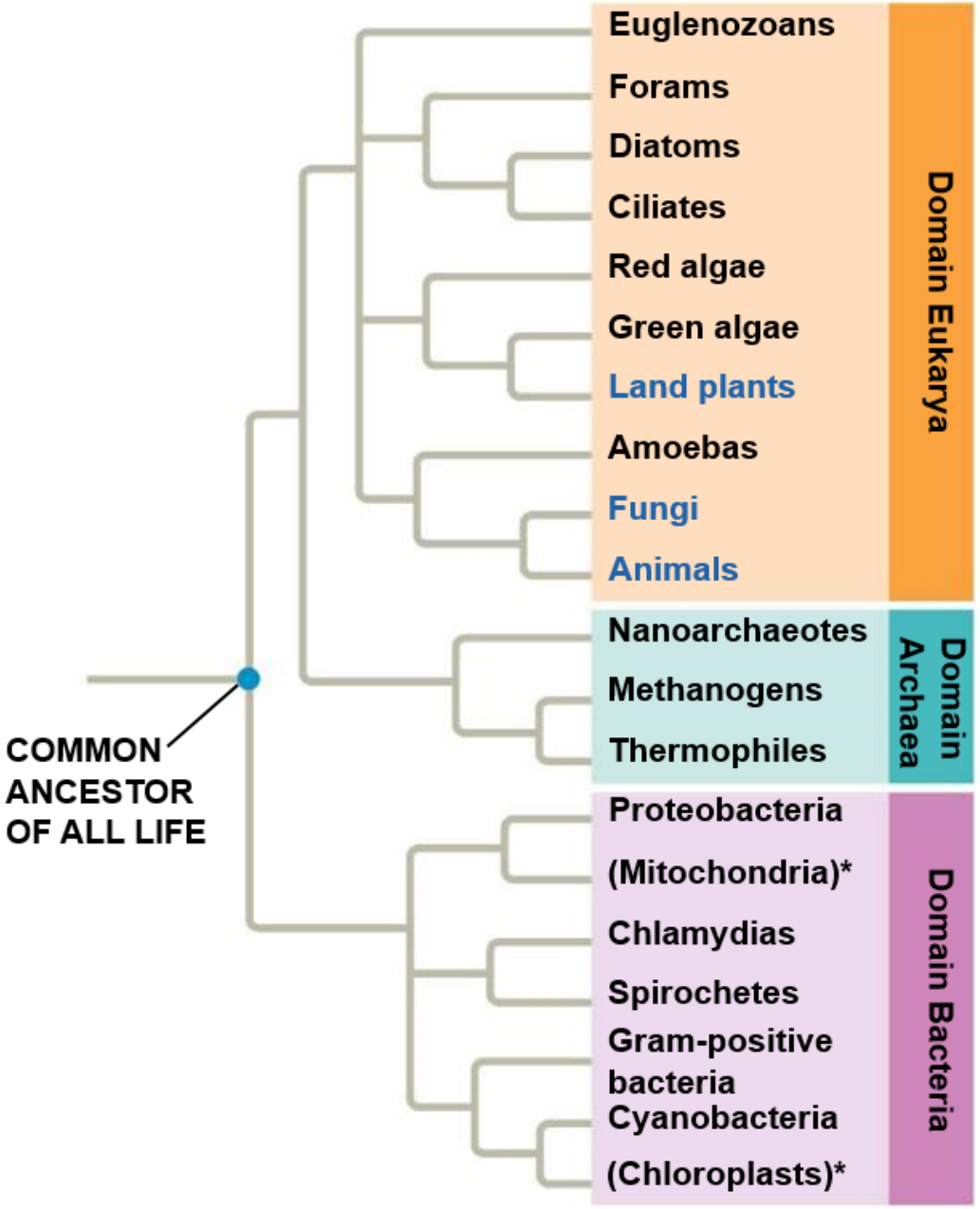
Lab 2

Domains of Life

- **Bacteria**
  - Unicellular prokaryotes
- **Archaea**
  - Unicellular prokaryotes
    - Extremophiles
- **Eukarya**
  - Unicellular and <u>multicellular</u> eukaryotes
    - Protists
    - Fungi
    - Plants
    - Animals

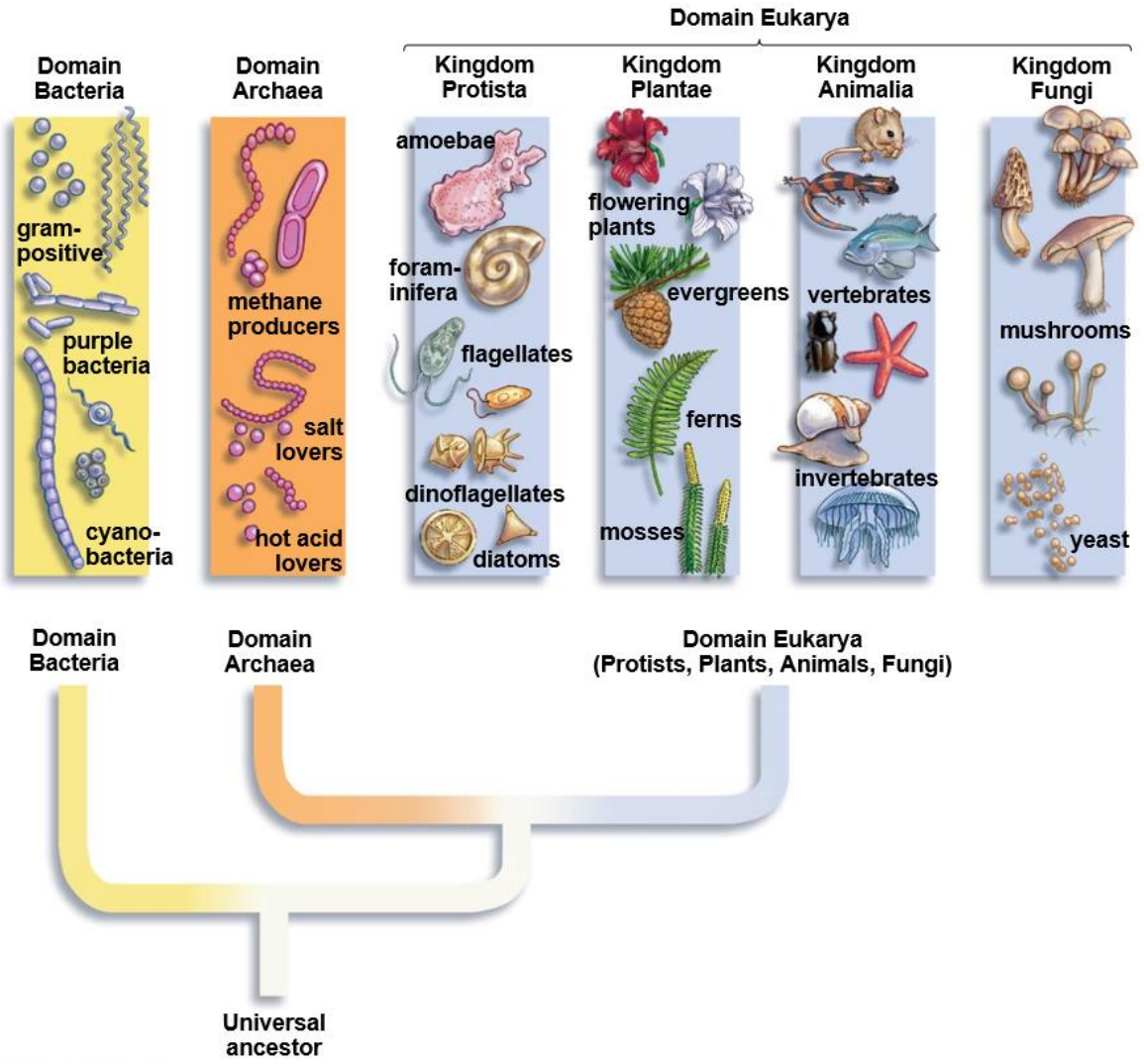






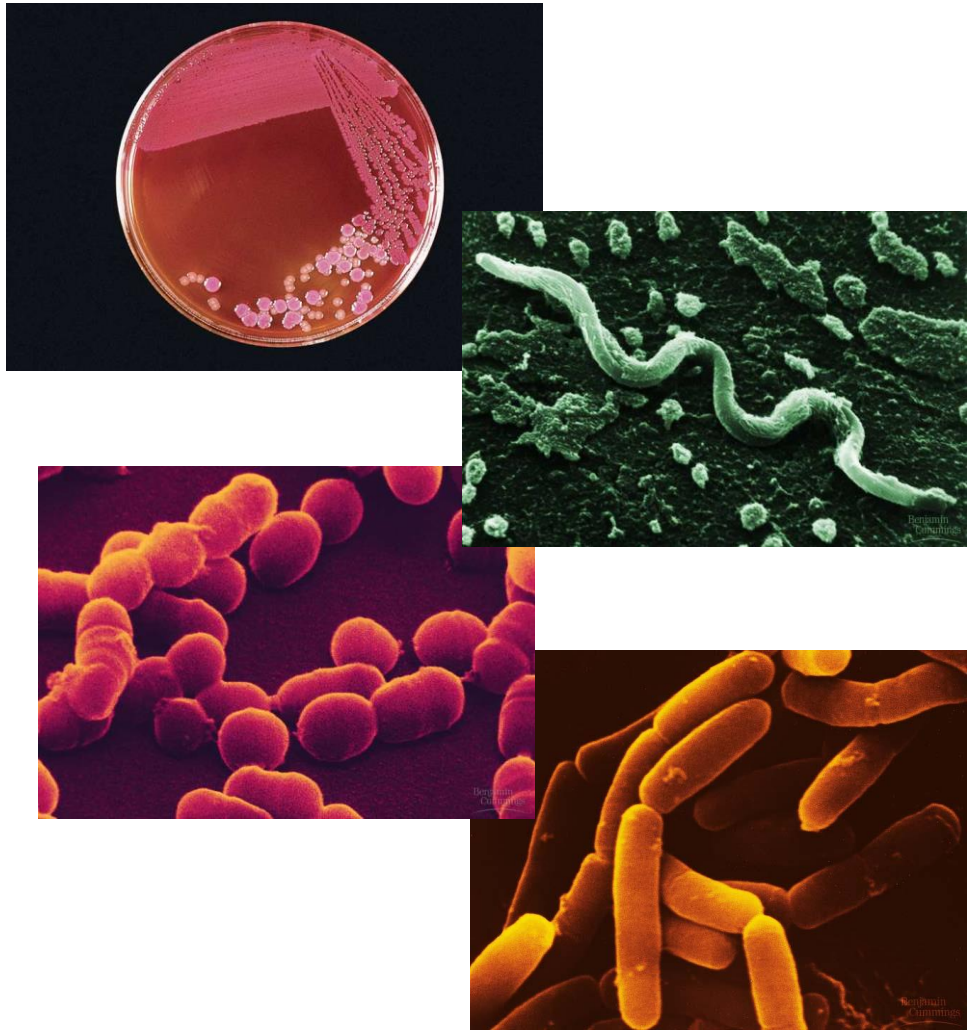
Domains and Kingdoms of Life

- Earth – 4.6 BYA
- Prokaryotes – 3.8 BYA
- Eukaryotes – 2.0 BYA
- First Animals – 635 MYA



Domain: Bacteria

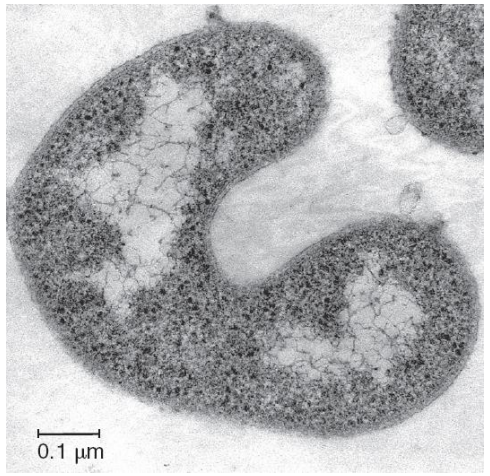
- No membrane bound nucleus or organelles
- Single-celled organisms
- Various shapes
  - Ex: Round = coccus
- <u>Peptidoglycan</u> in cell wall separates bacteria from archaea

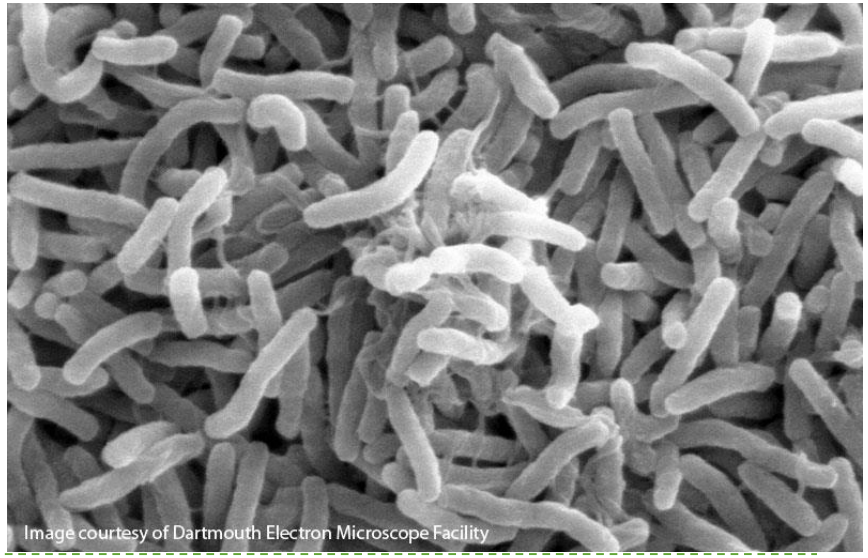


Domain: Bacteria

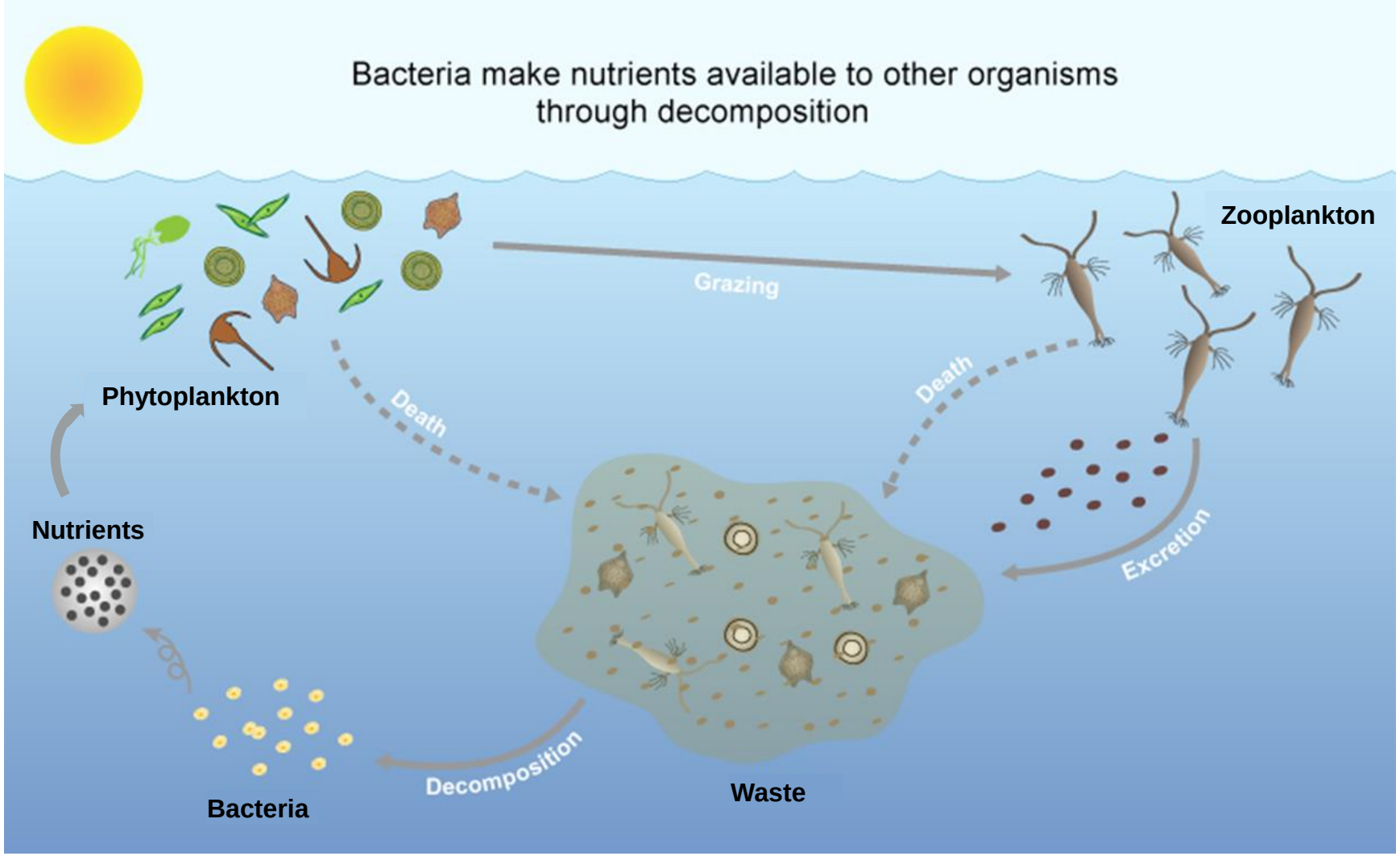
Heterotrophic bacteria: obtain energy from organic matter

- Found everywhere in the ocean
- Important decomposers that recycle nutrients in food webs
- Provides food for bottom-dwelling organisms





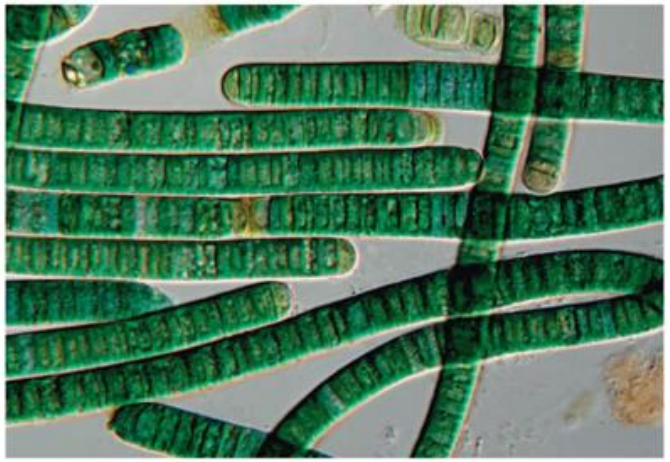
Role of Marine Bacteria



Bacteria: Cyanobacteria

Autotrophic bacteria: obtain food energy through photosynthesis.

- 1st photosynthetic organisms on Earth
  - Increased oxygen in atmosphere
  - Accounts for most primary production in open oceans
  - Likely evolved into chloroplast in eukaryotic cells
- Contains Chlorophyll A, phycocyanin (blue pigment), and phycoerythrin (red pigment)
- Only organism that can <u>fix nitrogen and release oxygen</u> (product of photosynthesis)

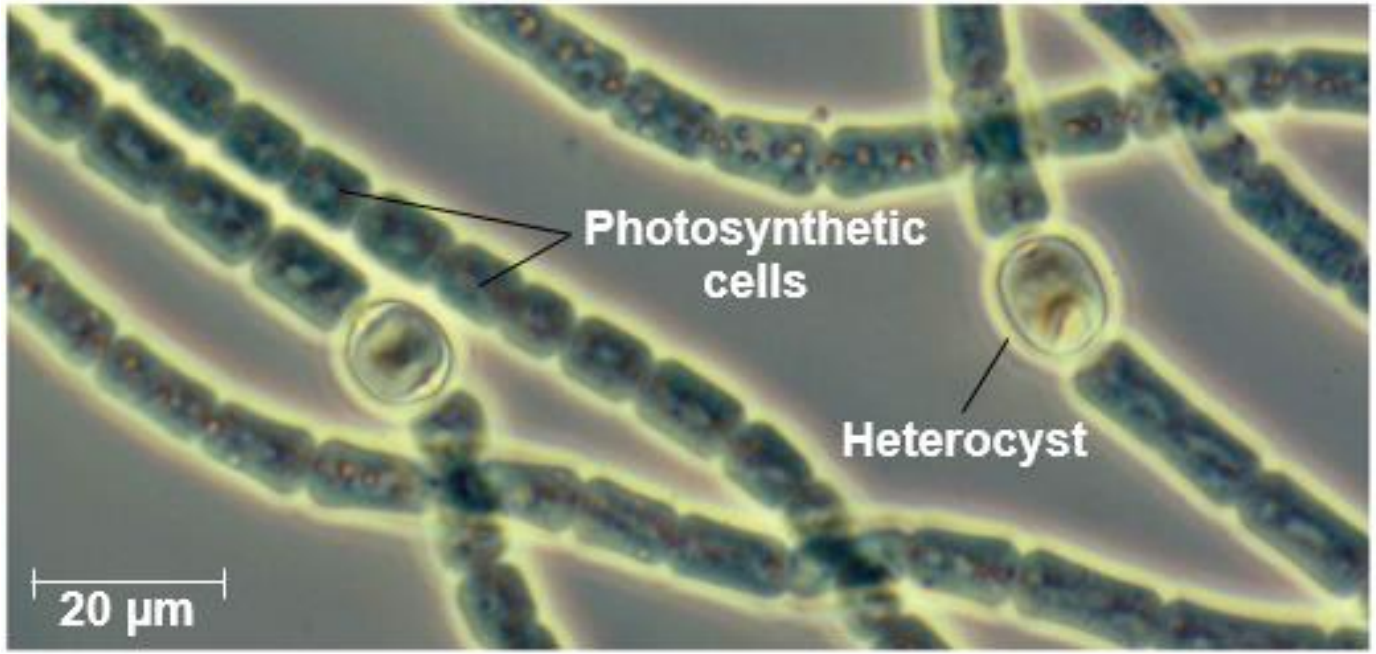


Oscillatoria

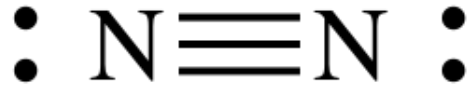
Nitrogen Fixation

Nitrogen fixation: conversion of atmospheric nitrogen (N_2) to ammonia (NH_3)

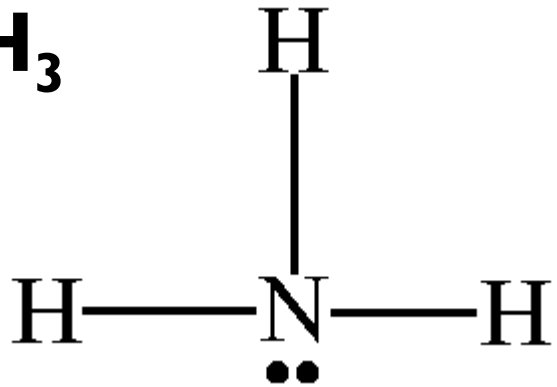
- Heterocysts carry out nitrogen fixation
- Nitrogen used in formation of proteins and organic compounds



N_2

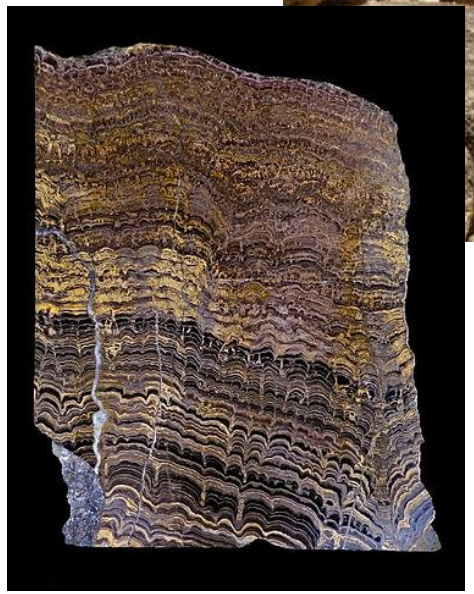


NH_3



Domain: Bacteria

<u>Stromatolites</u>: layered bio-chemical structures formed through the cementation of bio-films produced by cyanobacteria



- Oldest known fossils
  - 3.5 billion years old
- Only organisms for a 1.5 billion years
- Found in shallow seas

Domain: Eukarya, Kingdom: "Protista"

Protists: similar appearing but diverse phyla that are not related through an exclusive common ancestor, which have different life cycles, trophic levels, modes of locomotion and cellular structures.

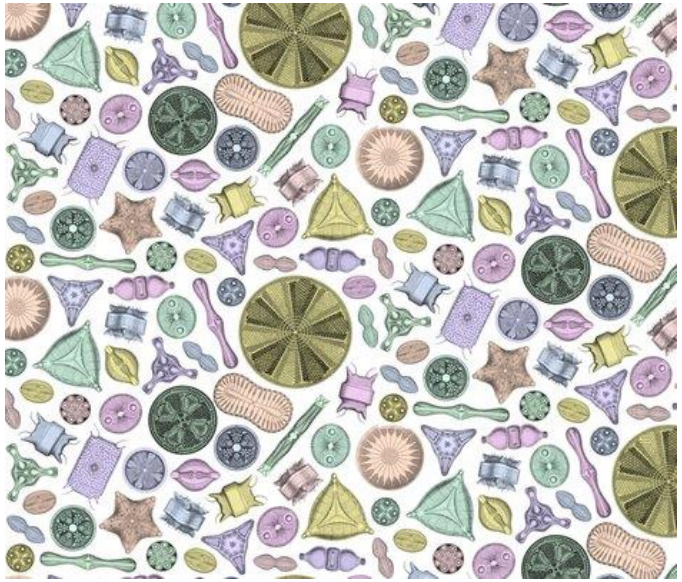
- Under constant debate and revision

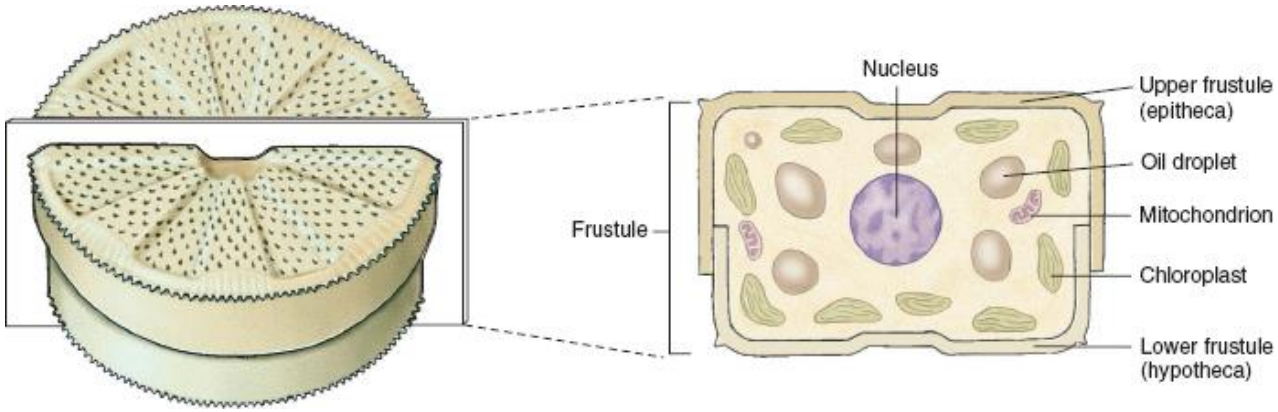
- Eukaryotic organisms that are not plants, animals, or fungi
- Most are unicellular
- Without <u>true tissue</u>
- First eukaryotes arose ~1.5 bya
- Photosynthetic plant-like protists (algae) and heterotrophic animal-like protists

Kingdom: Protista, Phylum Bacillariophyta

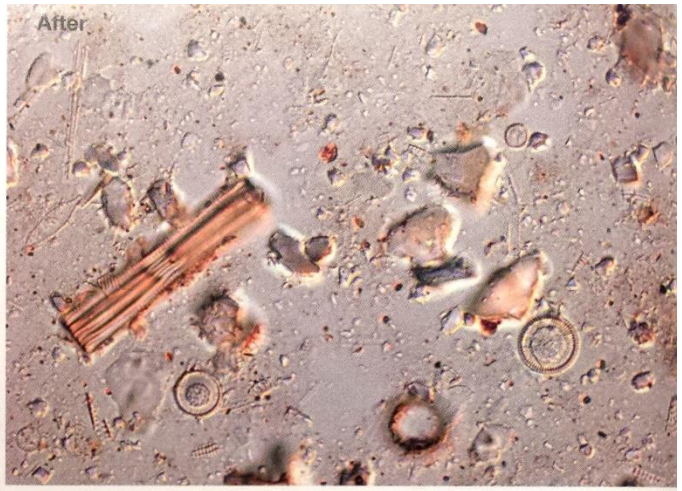
Diatoms

- Planktonic
- Unicellular, but often form chains
- Cell walls made of silica (glass-like material) called frustule
  - Diatomaceous Earth
- Carotenoids (yellow and brown pigments)
- Important primary producers





Diatoms in the Food Web



Greedy Mussels

Quagga mussel (2X actual size)

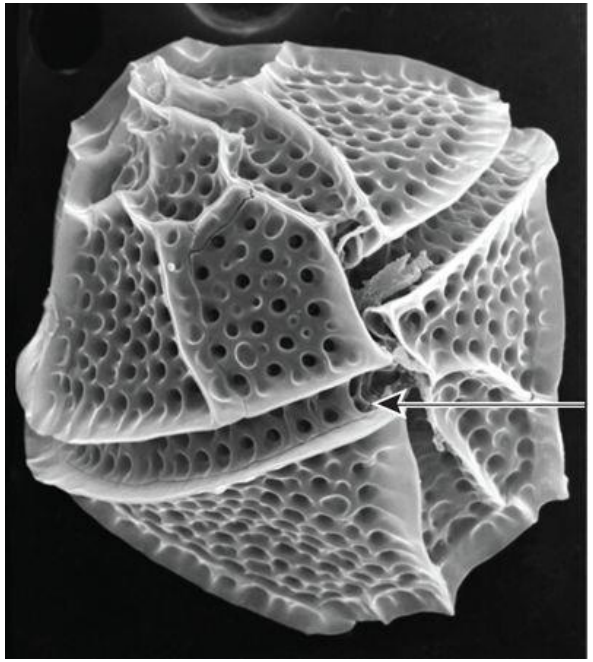
The quagga mussel might be no bigger than a thumbnail, but it's altering the Great Lakes' food web and affecting the lakes' four-to-seven-billion-dollar recreational and commercial fishing industry. Native to Ukraine, the quagga now infests the lakes in even greater numbers than its invasive-species cousin the zebra mussel. Both are believed to have entered North America in the ballast of ships.

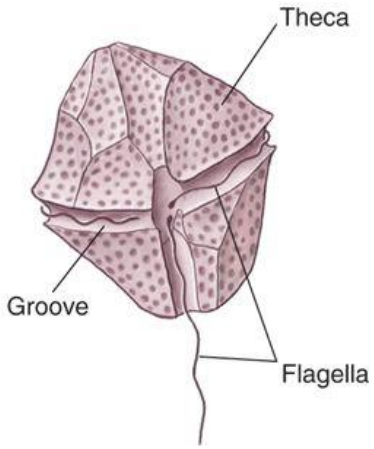
Like zebra mussels, quaggas feed by filtering lake water. Under the right conditions, the trillions of them in Lake Michigan can filter as much water as the lake contains every one to two days, removing algal species they prefer. Magnified 750 times, sediment samples from the lake show the base-of-the-food-web shifts that have resulted from this mussel invasion. The water once teemed with the large, lipid-rich diatom algae called *Stephanodiscus* and *Aulacoseira* (above left) that nourished Lake Michigan's extensive food web. Now that the mussels are hogging the choice algae, that food web is reorganizing to survive on fewer algae of the smaller varieties that are left, such as *Cyclotella* (above right). —*Bill McGraw*

Kingdom: Protista, Phylum Dinophyta

Dinoflagellates

- Planktonic
- Unicellular
- Many are mixotrophic
  - **Mixotroph**: organisms that perform photosynthesis but are also heterotrophic
- Cell wall made of cellulose plates
- Two flagella
- Some are bioluminescent
- Algal blooms (red tides)
- Domoic acid

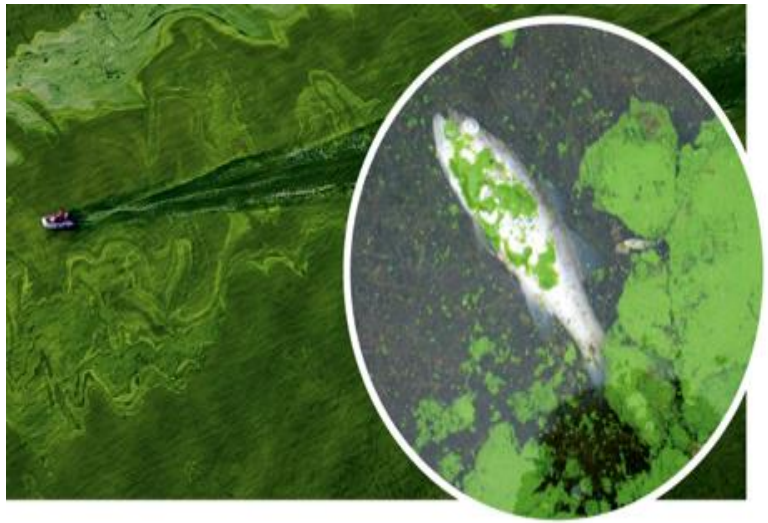


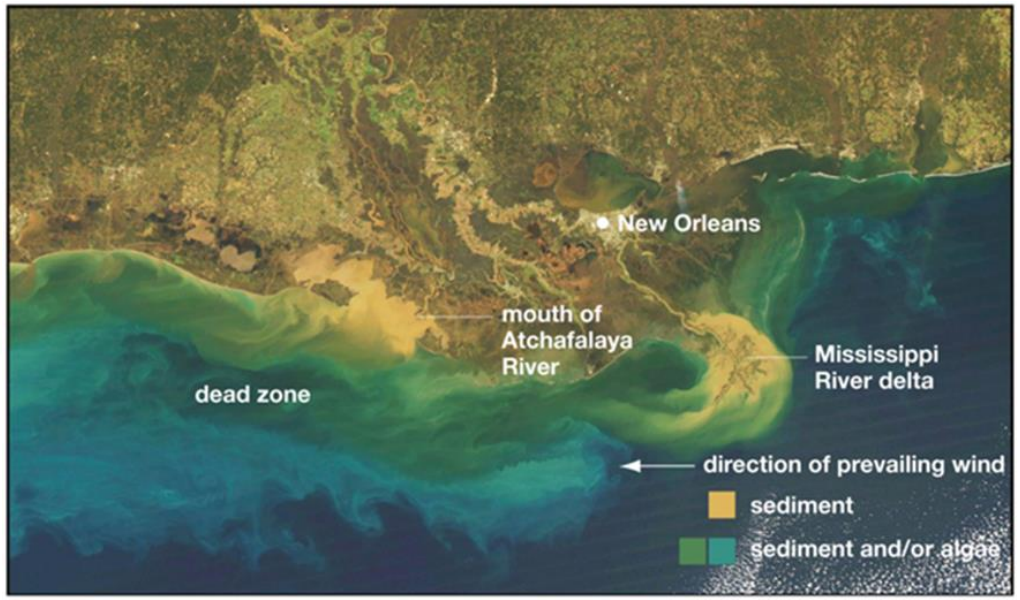


Algal Blooms

<u>Eutrophication</u>: excessive richness of nutrients in a body of water, frequently due to runoff from agricultural areas on land

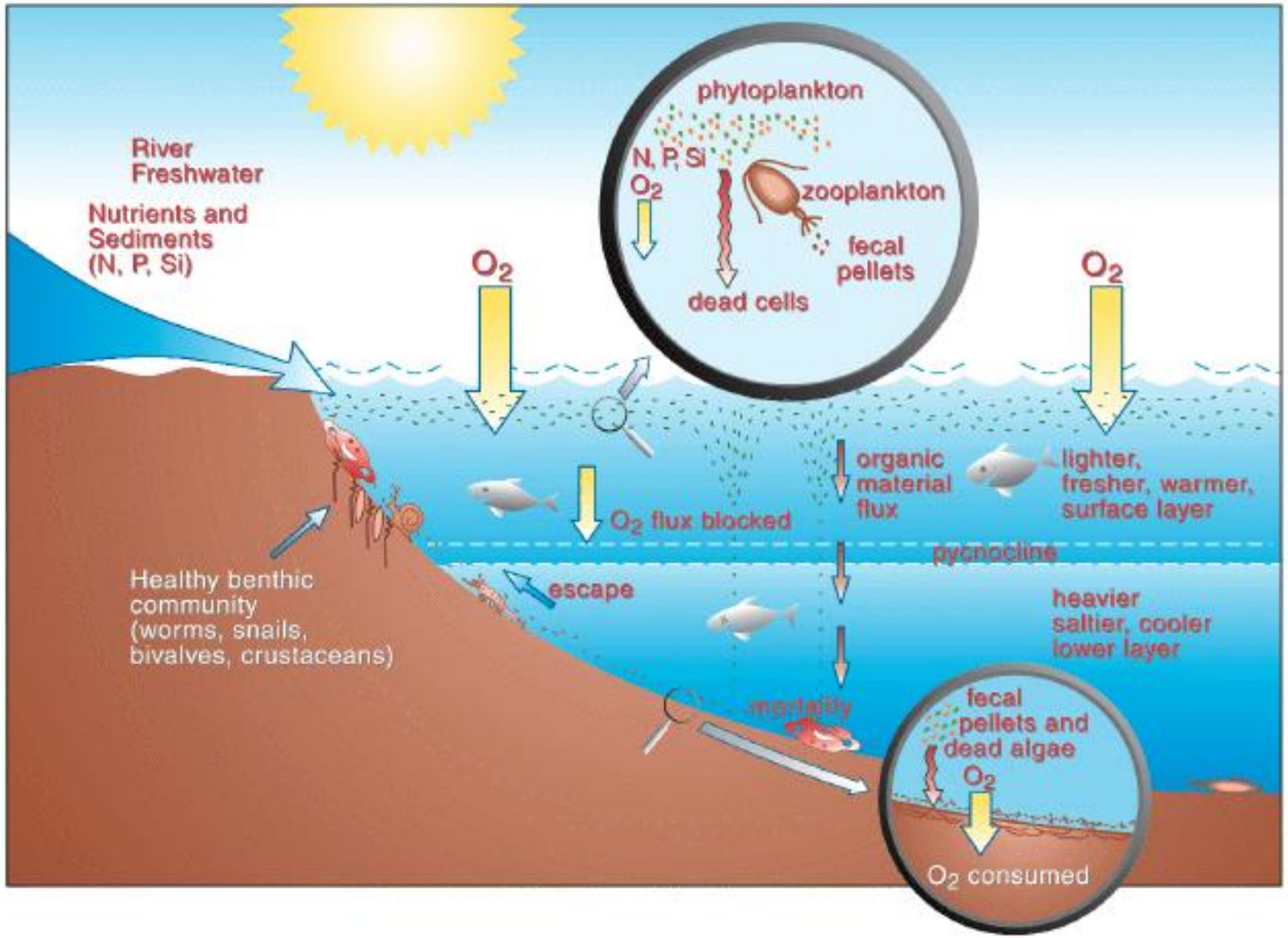
- Can cause algal blooms, which is the dense growth of algae and bacteria that can result in <u>dead zones</u> where animals die from lack of oxygen (hypoxia).





What Causes Dead Zones?

1. During the summer months nutrient rich runoff from land enters the oceans resulting in eutrophication
2. Eutrophication along with abundant solar energy leads to massive algal blooms
3. Dead algae sink to the bottom where bacteria aid in decomposition
4. Heterotrophic bacteria deplete oxygen available to other organisms forming a hypoxic environment



Algal Blooms and Toxins

Algal Blooms and Toxins

A California Sea Lion at a rescue center bites her newborn calf. This behavior is due to brain damage caused by toxic algae.

TOLL: Bleeding from the nose is one indication that this manatee died of toxic algae poisoning. State scientist Andy Garrett views its carcass.

Algal Blooms and Bioluminescence

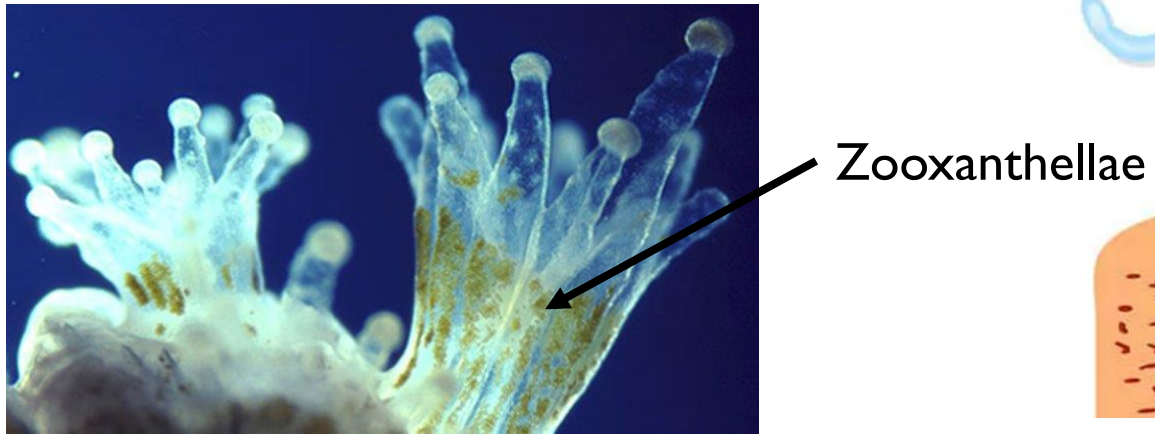
- Bioluminescence in dinoflagellates is produced by a chemical reaction in the organism

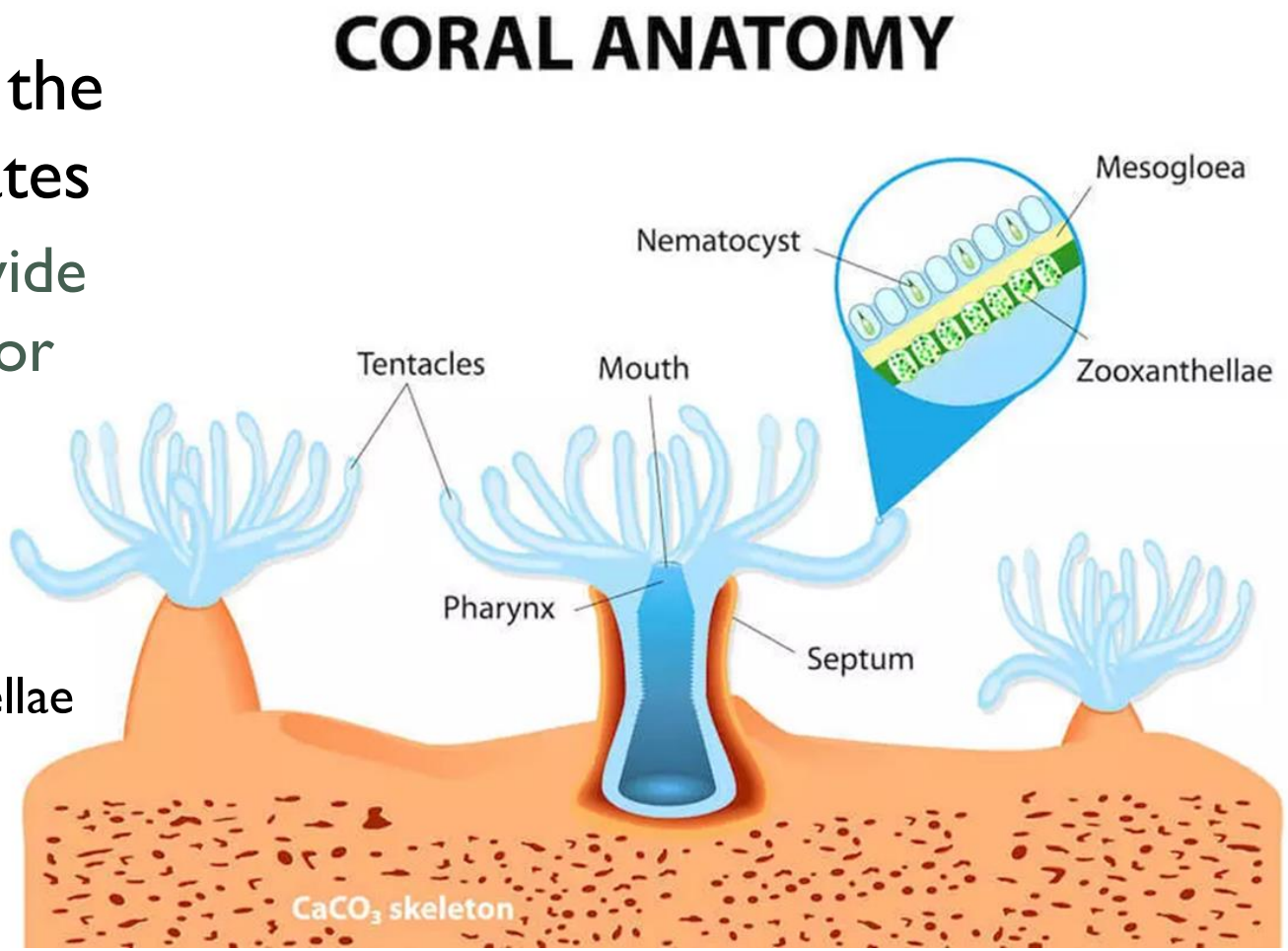
$$\text{Luciferin} + O_2 \xrightarrow{\text{Luciferase}} \text{Oxyluciferin} + \text{Light}$$

Kingdom: Protista, Phylum Dinophyta

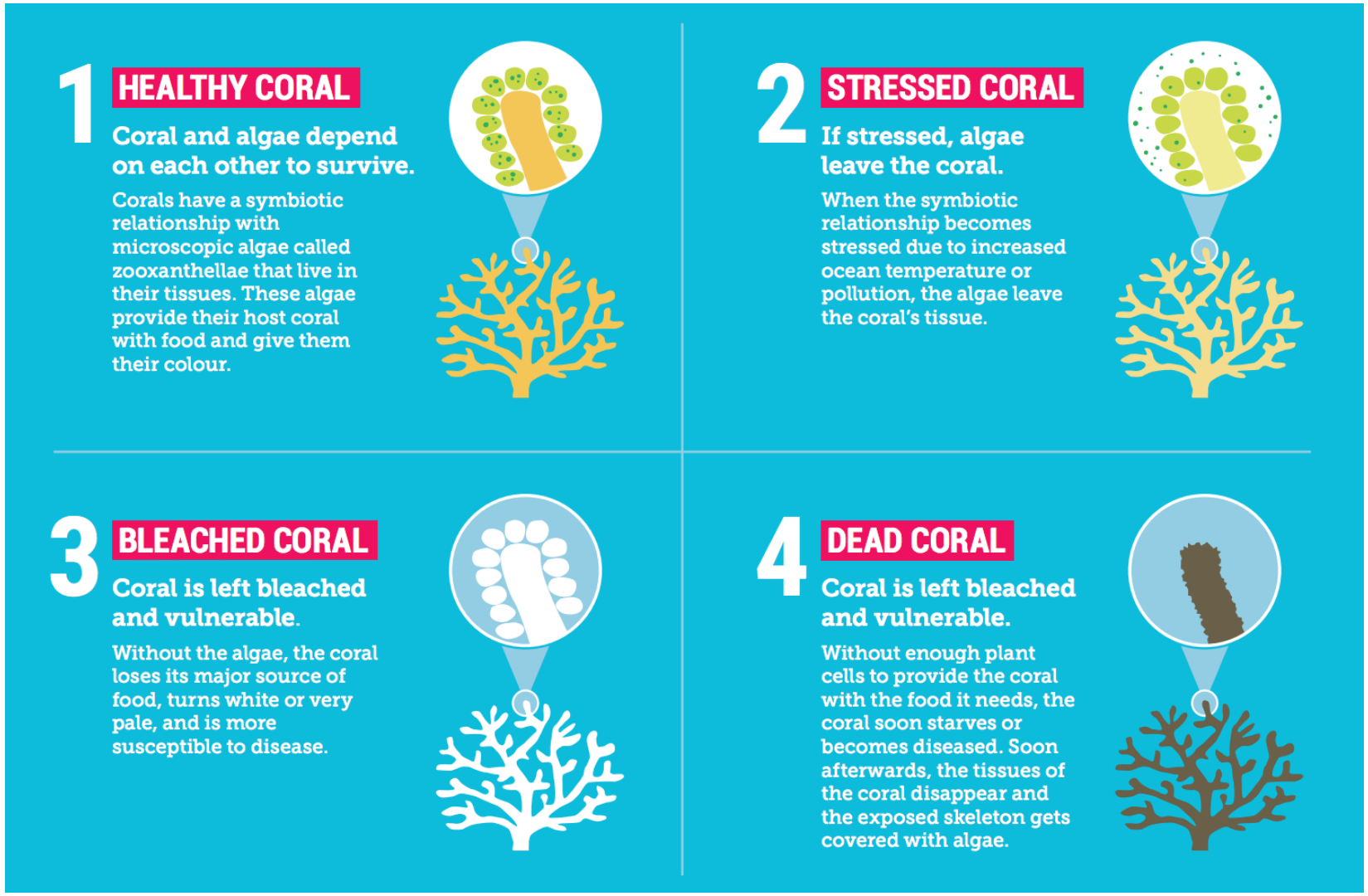
Zooxanthellae

- Symbiotic dinoflagellate found in the tissue of many marine invertebrates
  - Photosynthetic zooxanthellae provide hosts with carbon products used for energy and growth





Zooxanthellae and Coral Bleaching



Multicellular Primary Producers

Macroalgae (seaweeds): multicellular, photosynthetic organisms that lack true tissue, leaves, stems, and roots.

- Classification depends on photosynthetic pigments
  - Green, red, and brown seaweeds
- Wide range of growth forms

Marine plants: multicellular, photosynthetic organisms with true leaves, stems and roots (contain vascular tissue).

- Flowering plants

Structure of Macroalgae

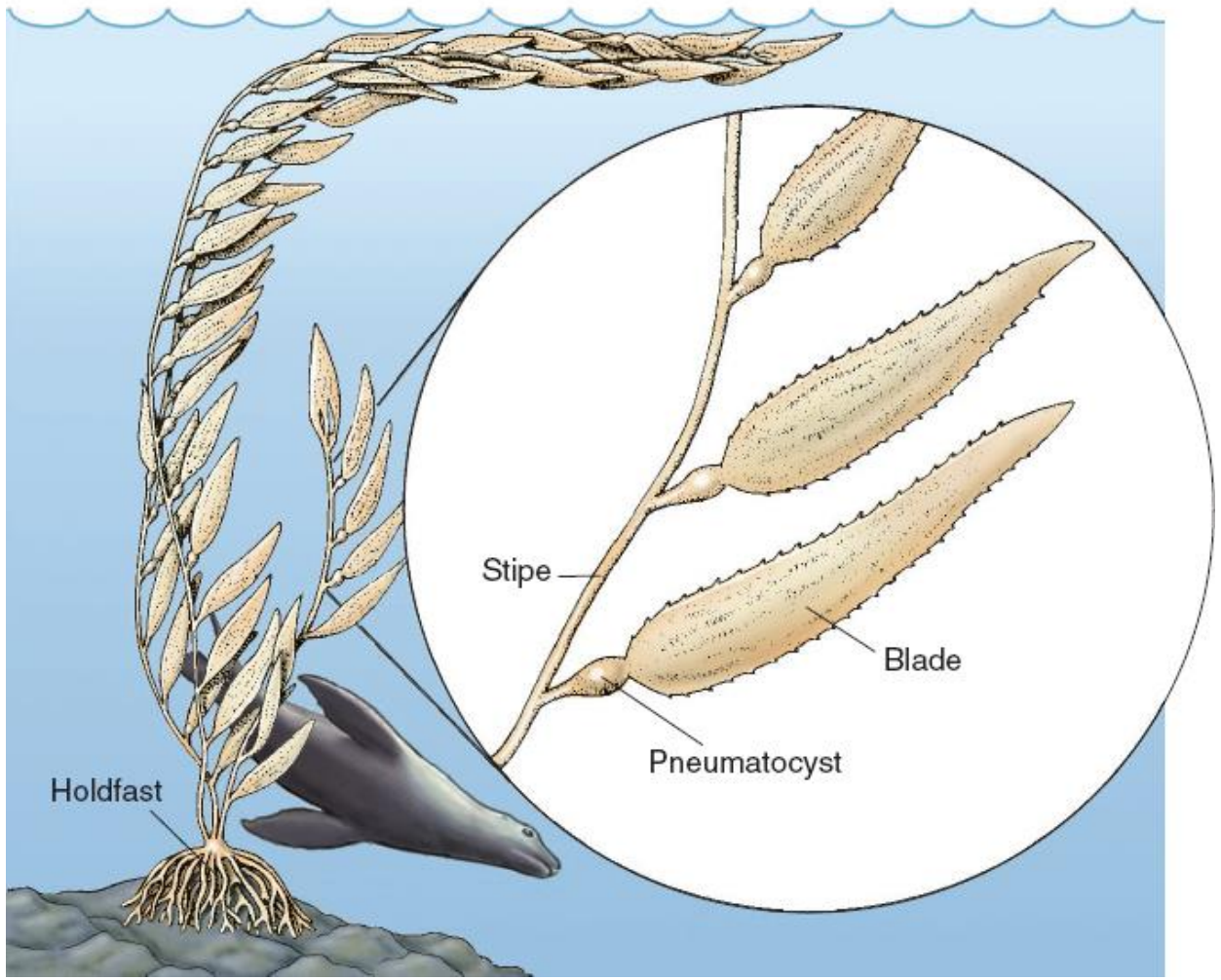
<u>Thallus</u>: entire body of algae

Blades: leaf-like structures that are the main site of photosynthesis

Stipe: stem-like structure that provide support

Pneumatocyst: gas-filled bladders that keep blades near the surface to maximize photosynthesis

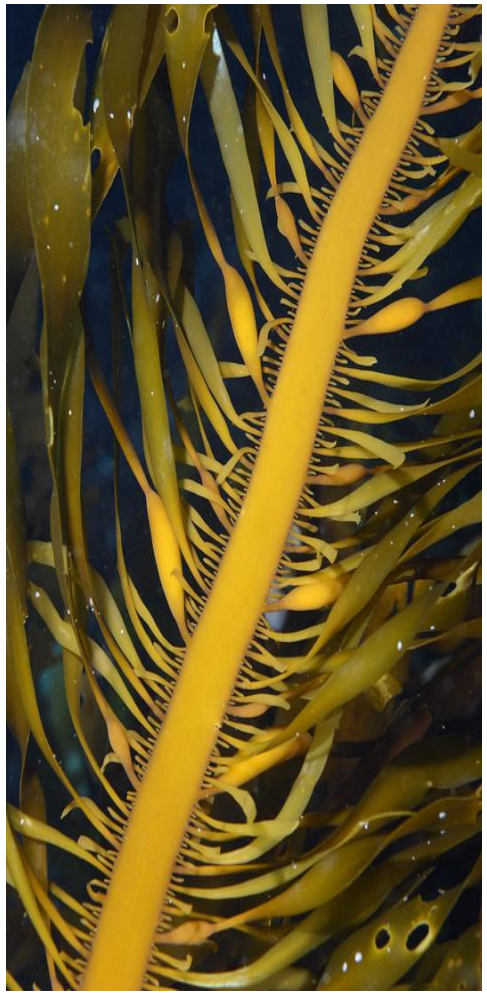
Holdfast: root-like structure that attaches the thallus to the bottom



Kingdom: Protista, Phylum: Phaeophyta

Brown algae

- Largest and most complex seaweeds
  - Rockweeds and Kelps
- Dominant primary producer in temperate and polar rocky coasts
- Photosynthetic pigments
  - Brown and yellow carotenoids
  - Fucoxanthin
- Algin

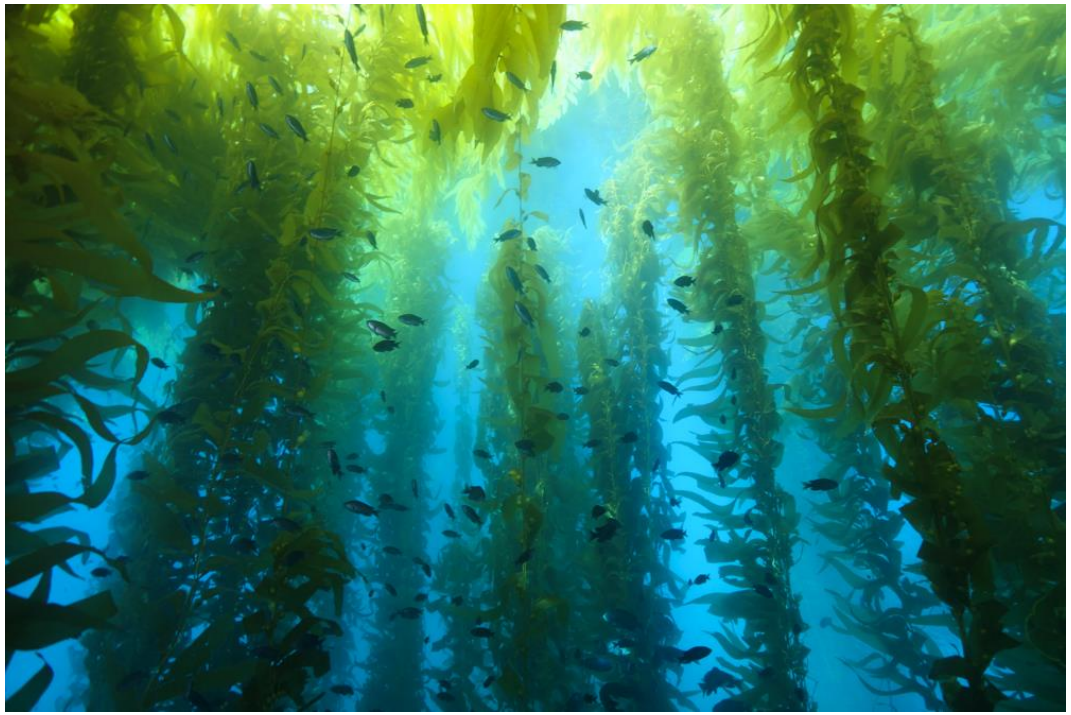


Kingdom: Protista, Phylum: Phaeophyta

Brown Algae

Giant Kelp (*Macrocystis pyrifera*)

- Can grow more than 45m long (150ft)
  - Can grow 60cm (2ft) a day
- Single pneumatocysts at base of each blade
- Common in northern pacific Northern California to Alaska, South America, South Africa, New Zealand, and southern Australia
- Large stands make up kelp forests
- Declining due to warming water temps and purple sea urchins



Kingdom: Protista, Phylum: Phaeophyta

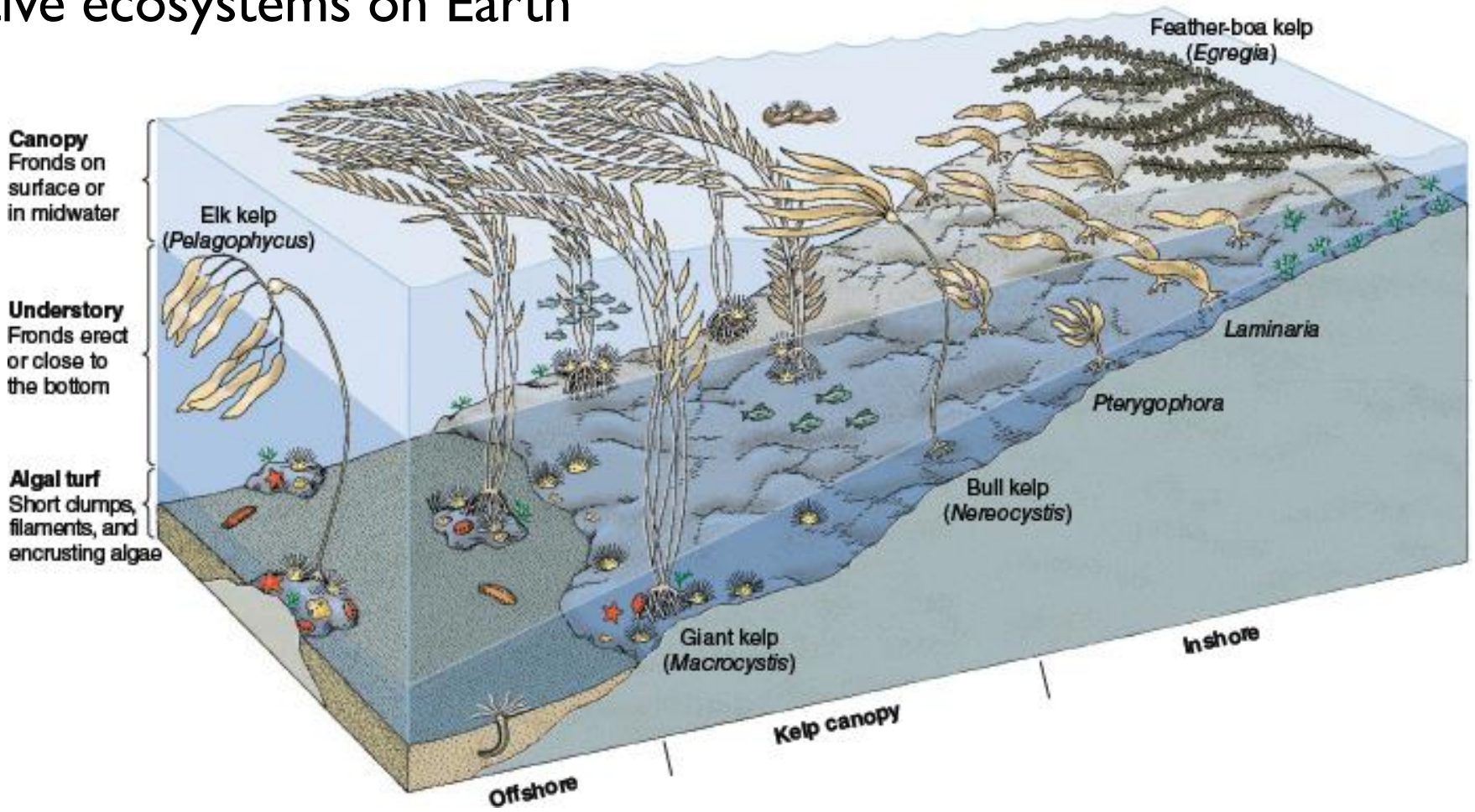
Brown Algae

Bull Kelp (*Nereocystis luetkeana*)

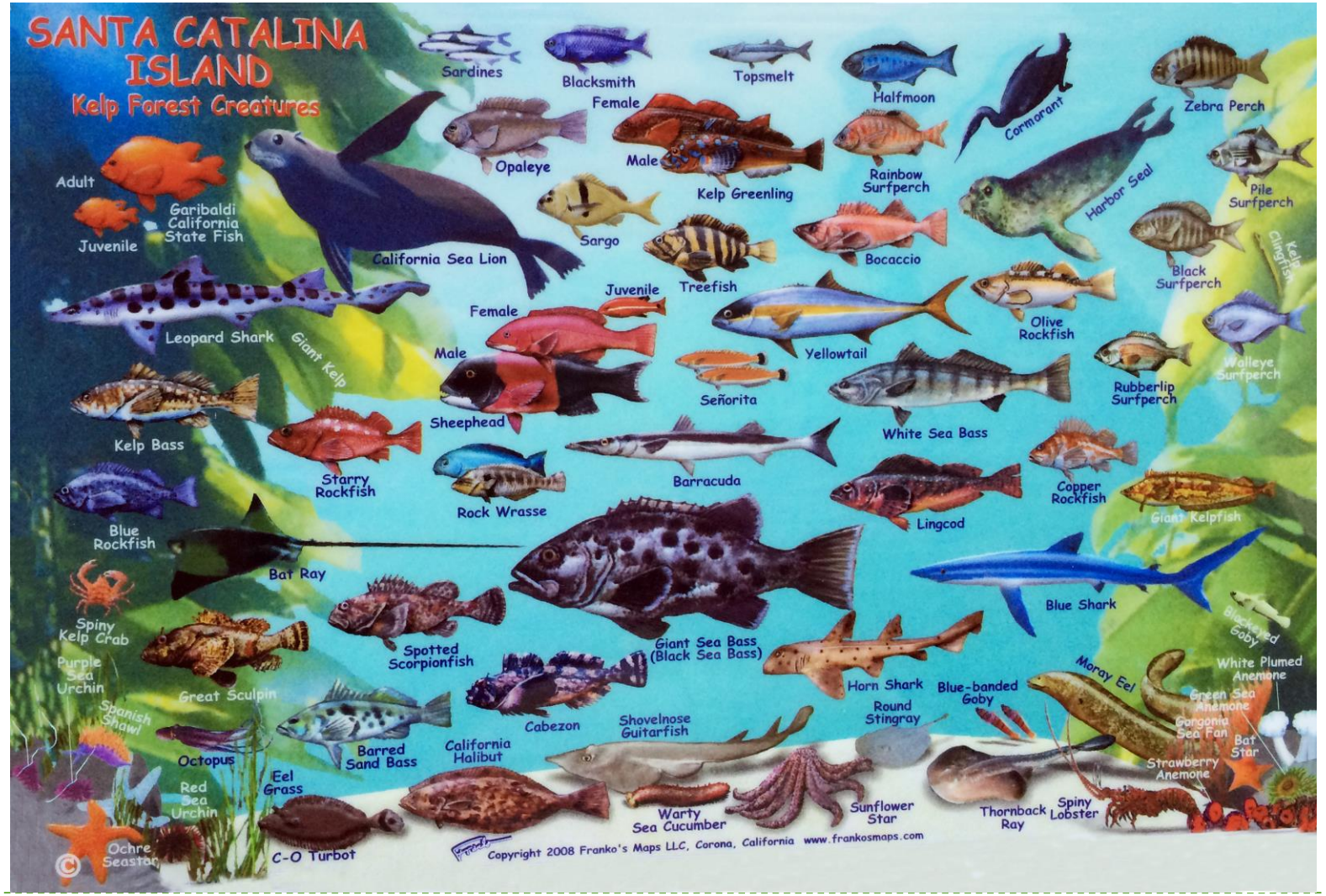
- Stipe can grow to 30m (98ft)
- Large pneumatocysts
- Common in northern pacific
  Northern California to Alaska

Kingdom: Protista, Phylum: Phaeophyta

Kelp forests are made up of various brown algae's and are some of the most productive ecosystems on Earth



Kelp Forest Species



Kingdom: Protista, Phylum: Chlorophyta

Green algae

- Only about 10% are marine
- Most are unicellular
- Photosynthetic pigments
  - Chlorophyll
- Land plants evolved from green algae
- Dominate algae in areas that very in salinity
  - Bays, estuaries tide pools

Caulerpa taxifolia is an invasive green algae common in the aquarium trade. It's sale and distribution is outlawed in California.

Sea lettuce *(Ulva latuca*) and dead man's fingers (*Codium fragile*) are common in intertidal habitats

Kingdom: Protista, Phylum: Rhodophyta

Red algae

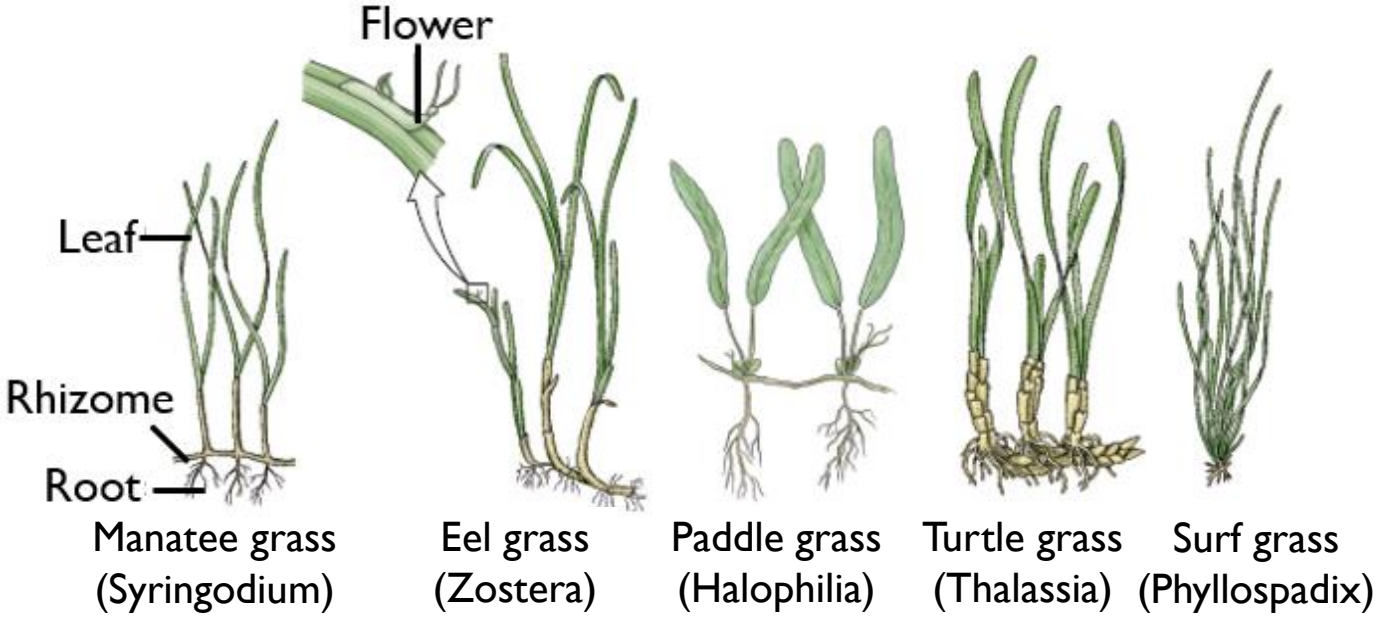
- More marine red algae than green and brown algae combined
- Contains Chlorophyll A, phycocyanin (blue pigment), and phycoerythrin (red pigment)
- Common in shallow marine environments
- Agar

Corallina algae are red algae that deposit calcium carbonate in their cell walls. Warm water corallina species are important in coral reef building

Kingdom: Plantae, Phylum: Anthophyta

Seagrasses

- Not true grasses
- Most are tropical and subtropical
- Horizontal stems called rhizomes
- Sexual reproduction through pollination
- Asexual reproduction trough extending rhizomes
- Eel grass and surf grass common locally



Kingdom: Plantae, Phylum: Anthophyta

Salt-Marsh Plants

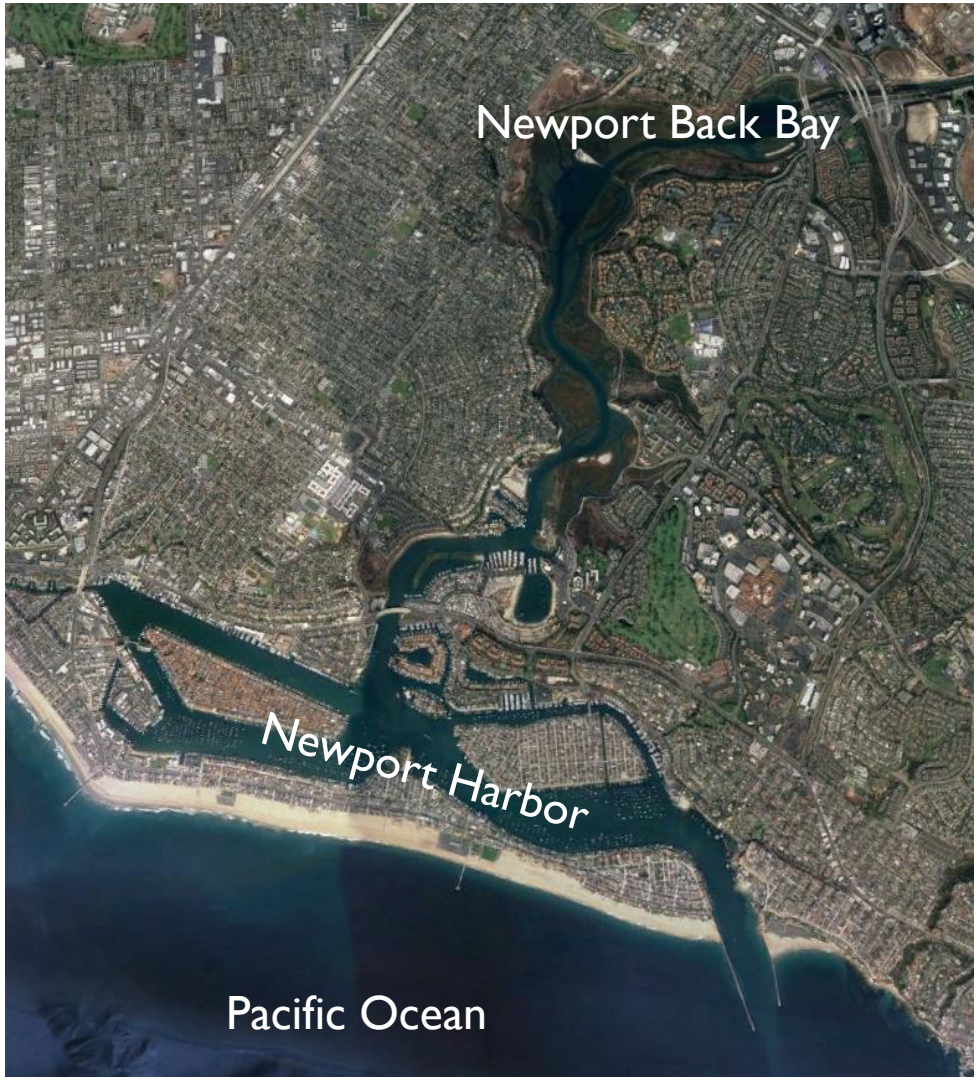
- **Halophytes**: salt tolerant plants
  - Salt glands excrete excess salt
- Typically submerged only during high-tide
- Habitat for many fish and bird species

Saltmarsh bird's beak (*Cordylanthus maritimus*) is a federal and state endangered species that is found in Newport Bay Estuary. Notice the salt crystals excreted by the plant.

Pickleweed (*Salicornia virginica*) and Cordgrass (*Spartina folosia*) are also common in our local estuaries

Estuaries

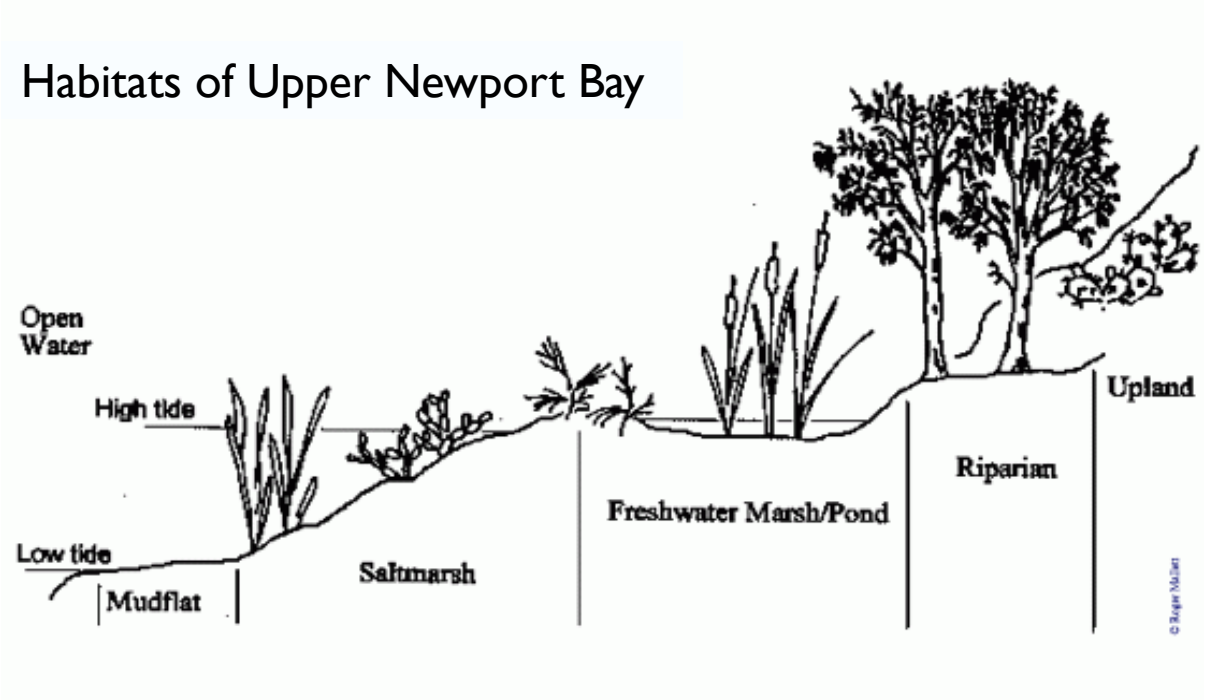
<u>Estuary</u>: a partially enclosed area where a freshwater river or stream meets the ocean resulting in brackish waters.



Estuaries

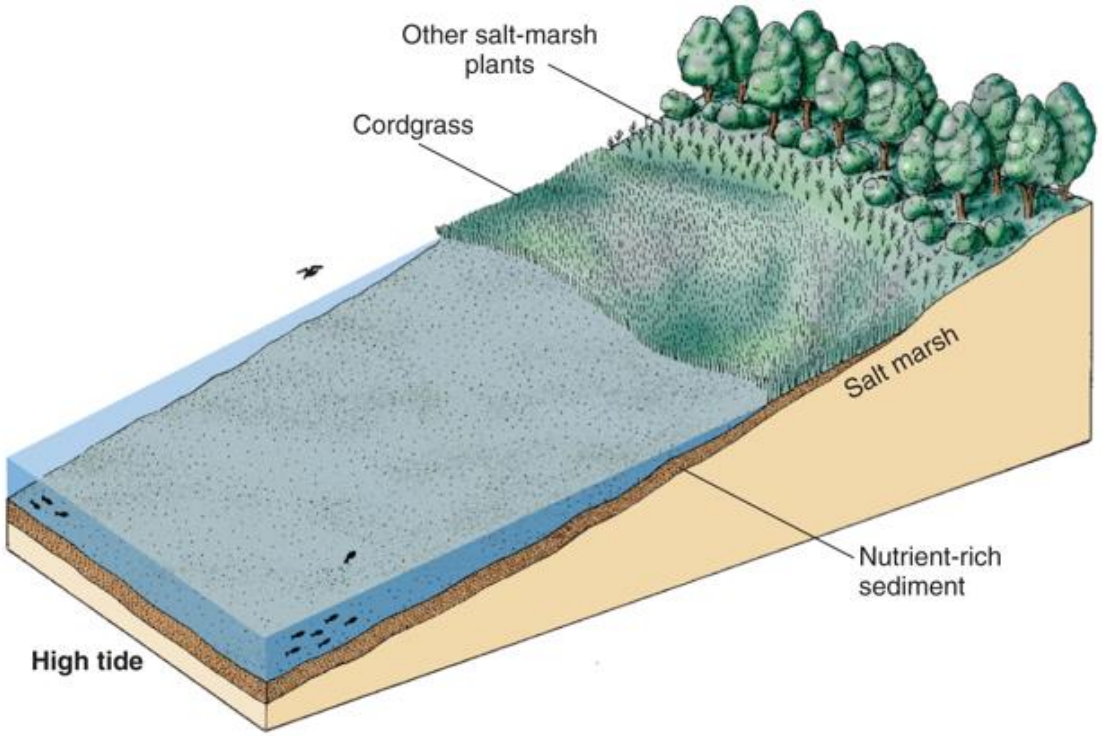
Estuary habitat types:

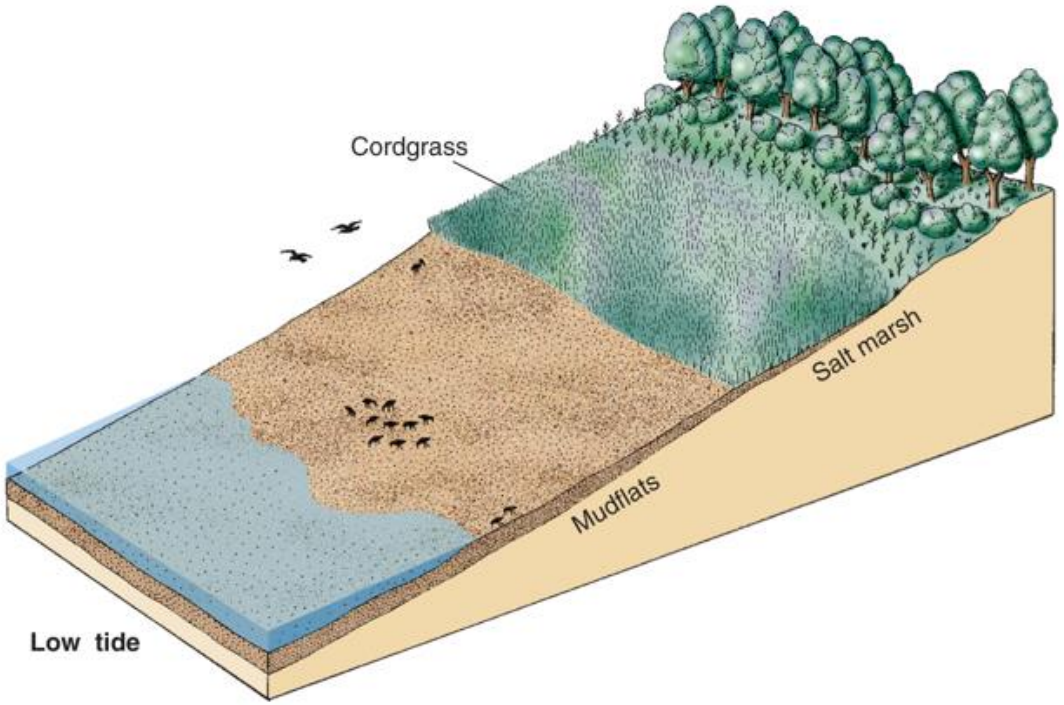
- **Open water**: area covered with water during low tide
- **Mudflats**: areas covered during high tide but exposed during low tide
- **Saltmarsh**: area covered during high tide
- **Freshwater marshes and ponds**: stagnant freshwater habitats
- **Riparian**: terrestrial areas along freshwater habitats
- **Upland**: terrestrial habitats not adjacent to fresh or salt water habitats



Estuaries and Tides

- Mudflats are fully submerged and the salt marsh partially submerged during high tide. The mudflats are exposed during low tide allowing shorebirds to feed on the invertebrate infauna buried in the mud.





Estuary Habitats – Open Water

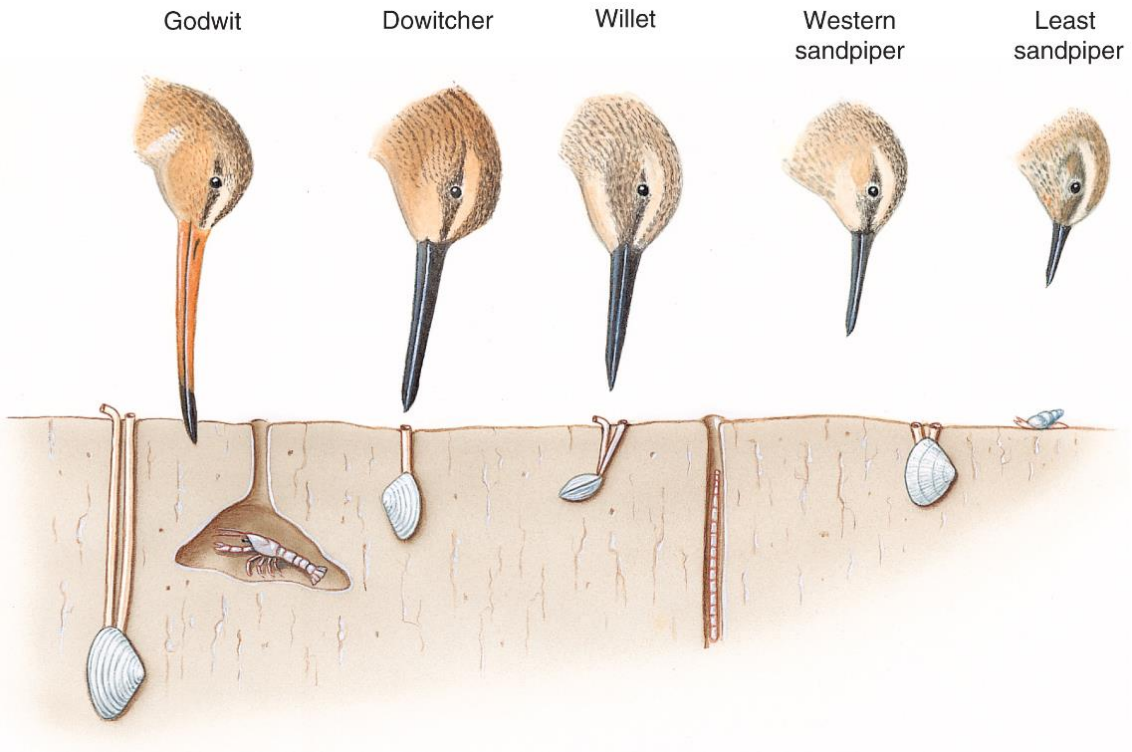
- Tidal cycle brings in plankton and other marine organisms
- Freshwater input and tides affect salinity levels of brackish water
- Nutrients from freshwater input stimulates growth of photosynthetic algae

Estuary Habitats – Mudflats

- Area exposed during low tide.
- Mud formed by fine particles consisting of silt, clay and detritus deposited by freshwater and marine inputs.
- <u>Highest concentration</u> of living organisms of all estuary habitats
  - Invertebrate infauna are dominant in mudflat habitat
  - Important food source for shorebirds during low tide and fishes during high tide

Estuary Habitats – Mudflats

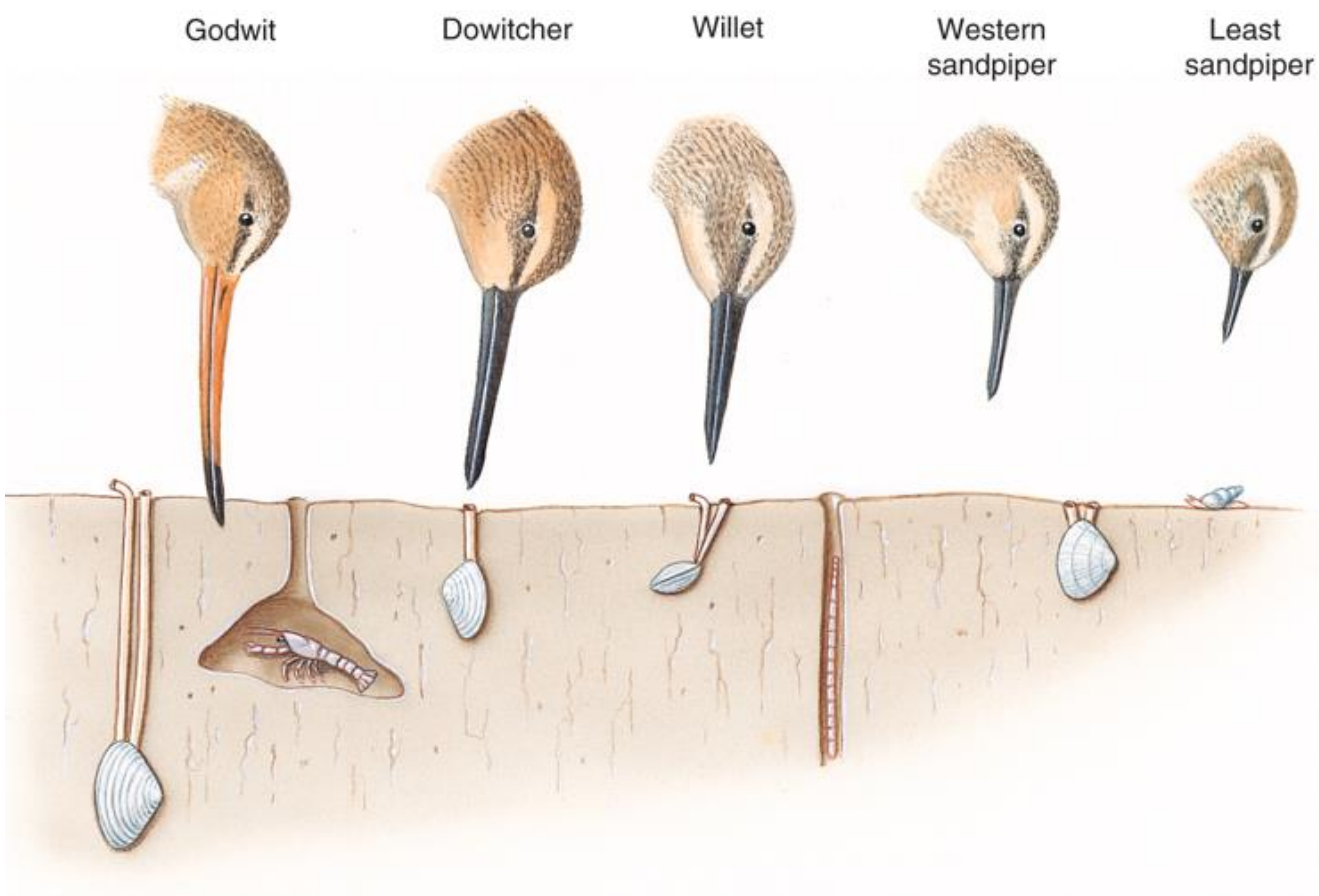
Various bill lengths and shapes of shorebird species are an example of <u>resource partitioning</u>



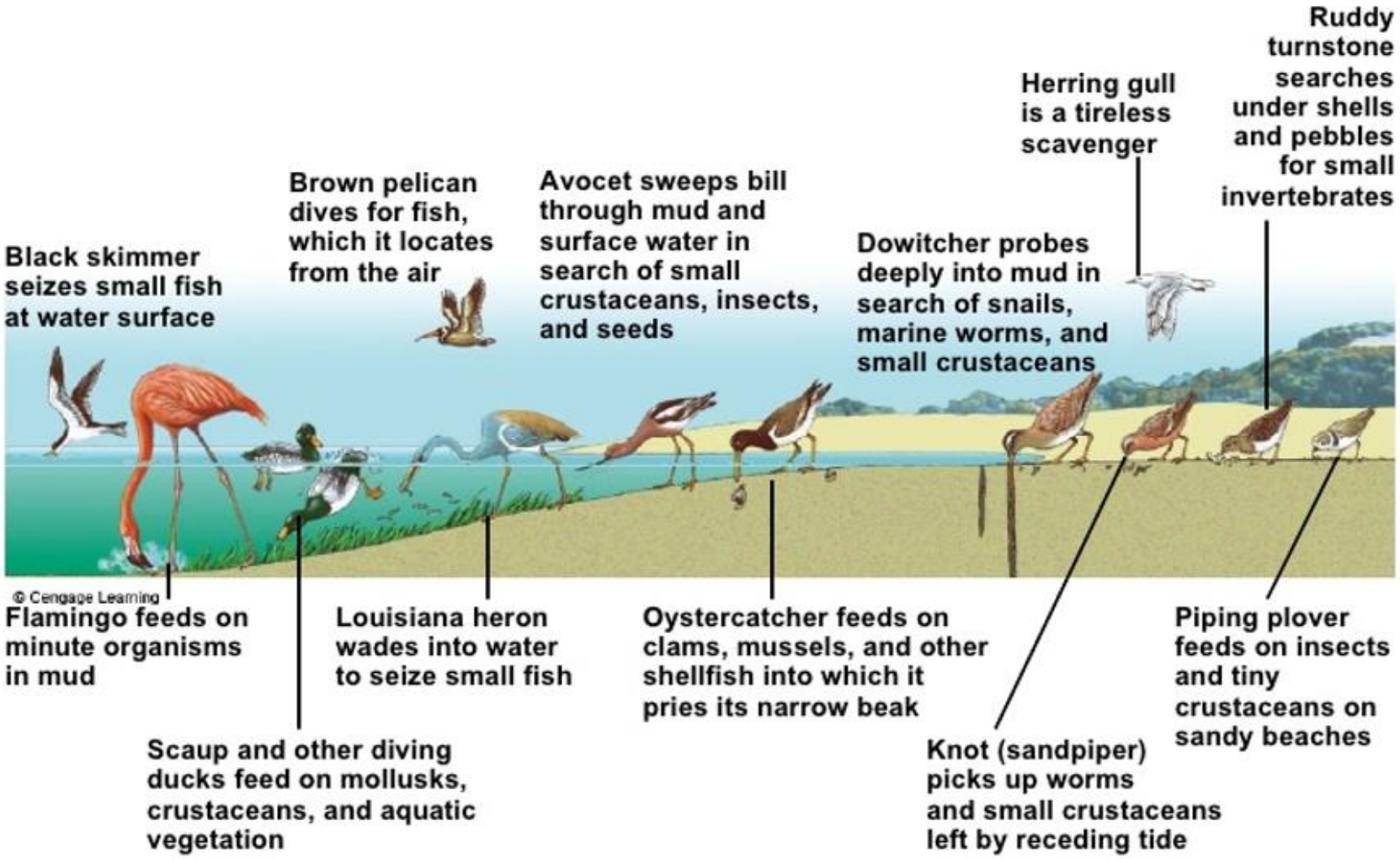
Resource Partitioning

Resource partitioning: when species evolve to occupy different ecological niches to reduce the amount of <u>competition</u> between species

- Different bill lengths in shorebirds allow different species to specialize in different prey types



Resource Partitioning



Estuary Habitats – Salt Marsh

- Areas partially flooded during high tide
  - Saltmarsh plants bordering mudflats mark height of average high tide.
- Temperate and subarctic regions worldwide
- Dominated by <u>halophytes</u> (salt-tolerant plants)
  - Salt grass, cord grass and pickleweed
- Salt marsh plants help stabilize soils by decreasing erosion caused by wave action

Estuary Habitats – Salt Marsh

Salt Grass

- Typically found in middle zone of salt marsh
- Halophytes: salt tolerant plant species
  - Excretes salt from pores crystallizes on the blade forming characteristic square salt shape.
- Asexual reproduction through rhizomes (horizontal stems)
- Used by nesting birds and as a food source for ducks and geese

Estuary Habitats – Salt Marsh

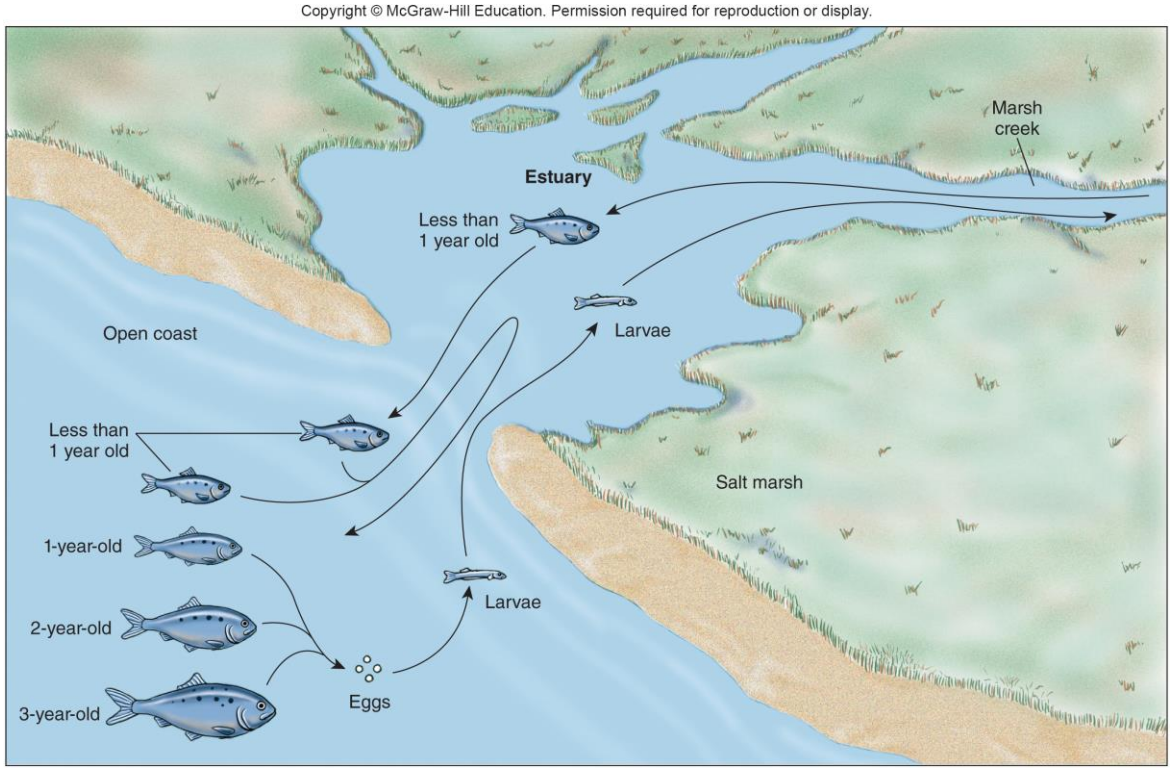
Pickleweed

- Typically found in low to middle zones of salt marsh
- Succulent
- Excess salt is transported to the tips of the plant where the salt containing cells break down and die, turning red in the process
- Important habitat for protected species
  - Belding's savanna sparrow and saltmarsh harvest mouse

Importance of Estuaries

Estuaries act as <u>nurseries</u> for numerous marine organisms

- Fewer predators and rich food sources
- Approximately 90% of the marine commercial catch in northern Gulf of Mexico rely on estuaries for part of their life cycle



Importance of Estuaries

Estuaries act as critical stopovers for many migratory bird species

- Many migratory birds breed in estuaries

Importance of Estuaries

- Estuaries help buffer against <u>flooding and erosion</u> by absorbing excess runoff and slowly releasing it into the ocean.

Importance of Estuaries

- Estuary plants filter silt and nutrients from the water, but also trap trash and other pollutants

- Estuary soils help neutralize toxic pollutants that are on their way out to sea