Structural and biochemical adaptations help seaweeds survive and reproduce at the ocean's margins

- The largest marine algae, including brown, red, and green algae, are known collectively as *seaweeds*.
- Seaweeds inhabit the intertidal and subtidal zones of coastal waters.
  - This environment is characterized by extreme physical conditions, including wave forces and exposure to sun and drying conditions at low tide.
- Seaweeds have a complex multicellular anatomy, with some differentiated tissues and organs that resemble those in plants.
  - These analogous features include the **thallus** or body of the seaweed.
  - The thallus typically consists of a rootlike **holdfast** and a stemlike **stipe**, which supports leaflike photosynthetic **blades**.
- Some brown algae have floats to raise the blades toward the surface.
  - Giant brown algae, known as kelps, form forests in deeper water.
  - The stipes of these plants may be 60 m long.
- Many seaweeds are eaten by coastal people, including *Laminaria* ("kombu" in Japan) and *Porphyra* (Japanese "nori") for sushi wraps.
- A variety of gelforming substances are extracted in commercial operations.
  - Algin from brown algae and agar and carageenan from red algae are used as thickeners in food, lubricants in oil drilling, or ***culture media in microbiology***.

Rhodophyta: Red algae lack flagella

- Red algae (Rhodophyta) are the most common seaweeds in the warm coastal waters of tropical oceans.
  - Others live in freshwater, still others in soils.
- Some red algae inhabit deeper waters than other photosynthetic eukaryotes.
  - Their photosynthetic pigments, especially phycobilins, allow some species to absorb those wavelengths (blues and greens) that penetrate down to deep water.
    - One red algal species has been discovered off the Bahamas at a depth of over 260m.
- Most red algae are multicellular, with some reaching a size to be called "seaweeds".
  - The thalli of many species are filamentous.
  - The base of the thallus is usually differentiated into a simple holdfast.

Chlorophyta: Green algae and plants evolved from a common photoautotrophic ancestor

- **Green algae** (chlorophytes and charophyceans) are named for their grass-green chloroplasts.
  - These are similar in ultrastructure and pigment composition to those of plants.
- The charophyceans are closely related to land plants.
- Most of the 7,000 species of chlorophytes live in freshwater.
  - Other species are marine, inhabit damp soil or snow, or live symbiotically within other eukaryotes.
    - Some chlorophytes live symbiotically with fungi to form **lichens**, a mutualistic collective.
- Chlorophytes range in complexity, including:
  - biflagellated unicells that resemble gametes and zoospores
  - colonial species and filamentous forms
  - multicellular forms large enough to qualify as seaweeds.
- Large size and complexity in chlorophytes has evolved by three different mechanisms:
  (1) formation of colonies of individual cells (*Volvox*)
  (2) the repeated division of nuclei without cytoplasmic division to form multinucleate filaments (*Caulerpa*)
  (3) formation of true multicellular forms by cell division and cell differentiation (*Ulva, or sea lettuce*).
- Most green algae have both sexual and asexual reproductive stages.

Many protists use pseudopodia for movement and feeding

- Three groups of protists use **pseudopodia**, cellular extensions, to move and often to feed.
  - Most species are heterotrophs that actively hunt bacteria, and other protists.
  - Other species are symbiotic, including some human parasites.
- Rhizopods (**amoebas**) are all unicellular and use pseudopodia to move and to feed.
- Pseudopodium emerge from anywhere in the cell surface.
- To move, an amoeba extends a pseudopod, anchors its tip, and then streams more cytoplasm into the pseudopodium.
- Amoebas inhabit freshwater and marine environments
  - They may also be abundant in soils.
- Most species are free-living heterotrophs.
- Some are important parasites.
  - These include *Entamoeba histolytica* which causes amoeboid dysentery in humans.
    - These organisms spread via contaminated drinking water, food, and eating utensils.

Actinopoda (Heliozoans and Radiolarians)

- Actinopod, means "ray foot," and refers to slender pseudopodia (axopodia) that radiate from the body.
  - Most actinopods are planktonic.
- Most **heliozoans** ("sun animals") live in fresh water.
- The term **radiolarian** refers to several groups of mostly marine actinopods.
- Foraminiferans, or **forams**, are almost all marine.
  - Most live in sand or attach to rocks or algae.
  - Some are abundant in the plankton.
  - Forams have multichambered, porous shells, consisting of organic materials hardened with calcium carbonate.
- Pseudopodia extend through the pores for swimming, shell formation, and feeding.
  - Many forams form symbioses with algae.
- Over ninety percent of the described forams are fossils.
  - The calcareous skeletons of forams are important components of marine sediments.
  - Fossil forams are often used as chronological markers to correlate the ages of sedimentary rocks from different parts of the world.

Mycetozoa: Slime molds have structural adaptations and life cycles that enhance their ecological roles as decomposers

- **Mycetozoa** (slime molds or "fungus animals") are neither fungi nor animals, but protists.
  - Any resemblance to fungi is analogous, not homologous, for their convergent role in the decomposition of leaf litter and organic debris.
- Slime molds feed and move via pseudopodia, like amoeba, but comparisons of protein sequences place slime molds relatively close to the fungi and animals.
- The **plasmodial slime molds** (Myxogastrida) are brightly pigmented, heterotrophic organisms.
- The feeding stage is an amoeboid mass, the **plasmodium**, that may be several centimeters in diameter.
  - The plasmodium is not multicellular, but a single mass of cytoplasm with multiple nuclei.
- The **cellular slime molds** (Dictyostelida) straddle the line between individuality and multicellularity.
- The feeding stage consists of solitary cells.
- When food is scarce, the cells form an aggregate ("slug") that functions as a unit.
  - Each cell retains its identity in the aggregate.

Multicellularity originated independently many times

- The origin of unicellular eukaryotes permitted more structural diversity than was possible for prokaryotes.
- This ignited an explosion of biological diversification.
- The evolution of multicellularity also gave rise to fungi, plants, and animals.