

Single-celled Primary Producers

Diversity of Primary Producers

- Includes all three Domains
 - Bacteria – Some bacteria photosynthetic (other autotrophic bacteria are chemosynthetic), Cyanobacteria
 - Archaea – Primarily chemosynthetic
 - Eukaryota –
 - Kingdom Protista – singled celled organisms
 - Plant-like - Bacillariophyta, Dinoflagellata, Chrysophyta
 - Animal-like – Foraminafera, Polycystina, Ciliophora

Diversity of Primary Producers (graphic)

Differences of Taxa (graphic)

Size of Producers

- Prokaryotes and Protista are single-celled
- Range of sizes - some are so small they are difficult to collect in numbers
 - Picoplankton - $<2 \mu\text{m}$ (10^{-6})
 - Ultraplankton - 2-5 μm
 - Nanoplankton - 5 -20 μm
 - Microplankton - 20-200 μm
- Most important are nanoplankton or smaller

Prokaryotes

- Single celled with cell wall
- Lack membrane bound organelles including nucleus
- Lack chloroplasts
- Circular chromosome
- Asexual reproduction by mitosis (cell fission) and other means

Bacteria

- Heterotrophic (decomposers)
 - Abundant in sediments
 - Recycle nutrients
- Autotrophic
 - Photosynthetic with chlorophyll but chemistry may be different including production of sulfur instead of oxygen
 - Chemosynthetic - energy conversion from hydrogen, ammonia, sulfur or iron compounds
- Cyanobacteria (blue-green algae)

Bacteria (graphic)

Cyanobacteria

- Most less than 5 μm
- Abundant in intertidal and estuarine and typically benthic

- Contain chlorophyll a and phycocyanin; may also contain phycoerythrin (red)
- Produce oxygen
- In some, population blooms
 - *Oscillatoria* causes red for Red Sea
- May aggregate to form strands or dense mats
 - Long strands of *Lyngbya*

More Cyanobacteria

- Reproduce by cell fission (usually)
- Some are nitrogen fixators (like legumes)
 - Utilized gaseous N₃
- Some symbiotic relationships with other marine organisms, even diatoms
 - Nitrogen fixing species with turtle grass (as an epiphyte) providing nutrient source

Archaea

- Heterotrophic decomposers producing a variety of chemical products including methane
- Autotrophic producers living in extreme environments (e.g. hydrothermal vents)
- DNA evidence shows dramatic difference from Bacteria

Photosynthetic Eukaryotes

- Membrane bound organelles including nucleus
- Have photosynthetic organelles - chloroplasts
- Contain chlorophyll a and accessory pigments
- Kingdom Protista - may be single-celled or multicellular (algae)
 - Lack leaves, stems and roots

Phylum Bacillariophyta

- Diatoms
- Unicellular, but may aggregate in strands or clusters
- Cell wall with pectin and silica (frustule)
 - Include two overlapping halves
- Typically 50-500 µm in size
- Shape either radially symmetrical (centric diatoms) or bilateral (pennate diatoms)
 - Pennates can move by undulation of cytoplasmic surface (typically in sediments or attached to plants or animals)

Diatom Structure (graphic

More Phylum Bacillariophyta

- Chloroplasts with chlorophyll a and c, and carotenoids giving golden color
- Asexually reproduce by cell division
 - Can reproduce rapidly (1 million daughter cells in 3 weeks)

- May reproduce sexually resulting in resistant auxospore
- Important primary producers in open ocean in temperate and polar regions
- Diatomaceous earth

Reproduction in Centric Diatoms (graphic)

Phylum Dinoflagellata

- Unicellular with large nucleus
- 25 - 1000 μm
- Typically with two flagella
 - One flagellum around transverse groove
 - One longitudinal flagellum
- Cell wall usually made from cellulose
- Reproduce asexually by cell division
 - Produce water coloration due to blooms
- Most photosynthetic with small chloroplasts
- Important primary producers in warm water

More Phylum Dinoflagellata

- Certain genera (*Noctiluca* & *Ceratium*) are bioluminescent
 - Luciferin is oxidized by luciferase, releasing energy in the form of light
- Some produce toxins that increase in concentration during blooms and are concentrated by successive trophic levels
 - Red tides and neurotoxic shellfish poisoning (*Ptychodiscus*)
 - Paralytic shellfish poisoning or saxitoxin (*Alexandrium*)
 - Ciguatera fish poisoning (*Gambierdiscus*)

Even More Phylum Dinoflagellata

- A few (zooxanthellae) have a significant symbiotic relationship with other organisms including hermatypic corals (reef building corals), giant clams, anemones and some flatworms
- One (*Pfiesteria*) “blooms” in response to pollution causing harm to fishes and certain invertebrates

Phylum Chrysophyta

- Silicoflagellates
- Photopigments include chlorophyll *a*, *c* and xanthophyll
- Internal siliceous deposit
- One or two flagella with limited mobility
- Reproduce by cell fission

Phylum Chrysophyta (graphic)

Phylum Haptophyta

- Coccolithophorids
- Photopigments include chlorophyll *a*, *c* and xanthophyll
- Flagellated with limited mobility

- Numerous calcareous plates in cell wall (coccoliths)
- May play valued role in total photosynthesis, particularly in tropical regions
- Reproduce by cell fission

Phylum Haptophyta (graphic)

Planktonic Adaptations

- Predation - spines
- Sinking (staying in the photic zone) - increased surface to volume ratio, asymmetrical shape, gas or -filled vesicles
- Seasonal light or nutrient limitations - more chloroplasts, use of stored molecules or absorb them from environment, formation of cysts (low metabolic demand)