EVOLUTION CONNECTION - Endosymbiotic Theory

We have mentioned that both mitochondria and chloroplasts have a double plasma membrane and contain their own DNA and ribosomes. Strong evidence indicates that endosymbiotic relationships between cells explains these characteristics.

Symbiosis is a relationship in which organisms from two separate species live in close association and typically exhibit specific adaptations to each other. **Endosymbiosis** (*endo-*= within) is a relationship in which one organism lives inside the other. Microbes that produce vitamin K live inside the human gut. This relationship is beneficial for us because we are unable to synthesize vitamin K and need it to produce blood-clotting proteins. It is also helpful for microbes because they are protected from other organisms and are provided a stable habitat and abundant food.

Scientists have long noticed that bacteria, mitochondria, and chloroplasts are similar in size. We also know that mitochondria and chloroplasts have DNA and ribosomes, just as bacteria do. When the DNA found in these organelles was analyzed, it was found to resemble the DNA of current-day bacteria. Scientists hypothesize that host cells and bacteria formed a mutually beneficial endosymbiotic relationship when the host cells ingested aerobic bacteria and cyanobacteria but did not destroy them. Through selection, these ingested bacteria became more specialized in their functions, with the aerobic bacteria becoming mitochondria and the photosynthetic bacteria becoming chloroplasts (Figure 4.30). Although at one time these bacteria would have been able to live on their own, this is no longer possible because of the immense amount of specialization that has occurred.

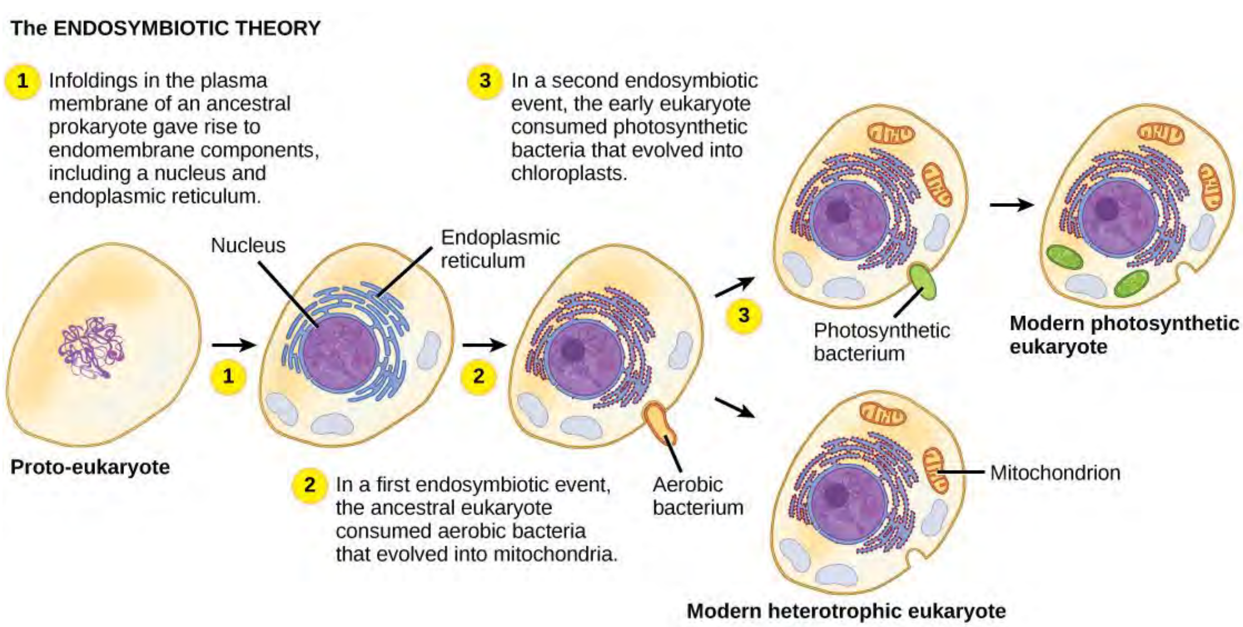

Figure 4.30 The first eukaryote may have originated from an ancestral prokaryote that had undergone membrane proliferation, compartmentalization of cellular function (into a nucleus, lysosomes, and an endoplasmic reticulum), and the establishment of endosymbiotic relationships with an aerobic prokaryote. (credit: Fowler et al. / Concepts of Biology OpenStax)

Much data has been collected that supports that the mitochondria and chloroplasts originated from free-living bacteria. Scientists have drawn similar conclusions that ingested bacteria became more specialized in their functions, lost their ability to live on their own, and are now organelles that help their host cells generate energy. This concept is now known as the **endosymbiotic theory**.

Central Vacuole

If you look at Figure 4.31, you will see that plant cells each have a large, central vacuole that occupies most of the cell. The **central vacuole** plays a crucial role in regulating the cell's concentration of water in changing environmental conditions. Have you ever noticed that if you forget to water a plant for a few days, it wilts? That's because as the water concentration in the soil becomes lower than the water concentration in the plant, water moves out of the central vacuoles and cytoplasm. As the central vacuole shrinks, it leaves the cell wall unsupported and appears to wilt. The central vacuole also supports the cell's expansion. When the central vacuole holds more water, the cell becomes larger without having to invest considerable energy in synthesizing a new cytoplasm.

The central vacuole also functions to store proteins in developing seed cells, has digestive enzymes, and acts as a storage site for waste materials.

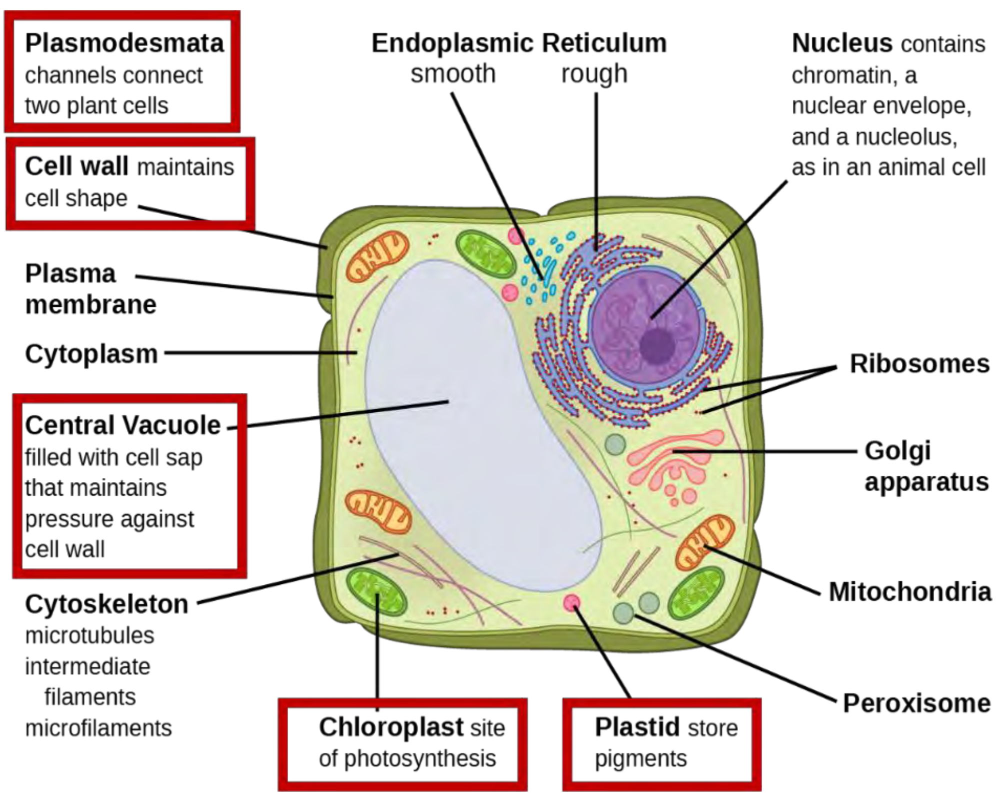

Figure 4.31 These figures show the major organelles and other cell components of a typical eukaryotic plant cell. (credit: Modified by Elizabeth O'Grady original work by Clark et al. / Biology 2E OpenStax)

Intercellular Junctions

Cells can communicate with each other by direct contact, referred to as intercellular junctions. Although both animal and plant cells communicate, there are some differences in the way that this communication is done. Plasmodesmata (singular = plasmodesma) are junctions between plant cells, whereas animal cells use tight junctions, gap junctions, and desmosomes, a type of anchoring junction (Figure 4.32).

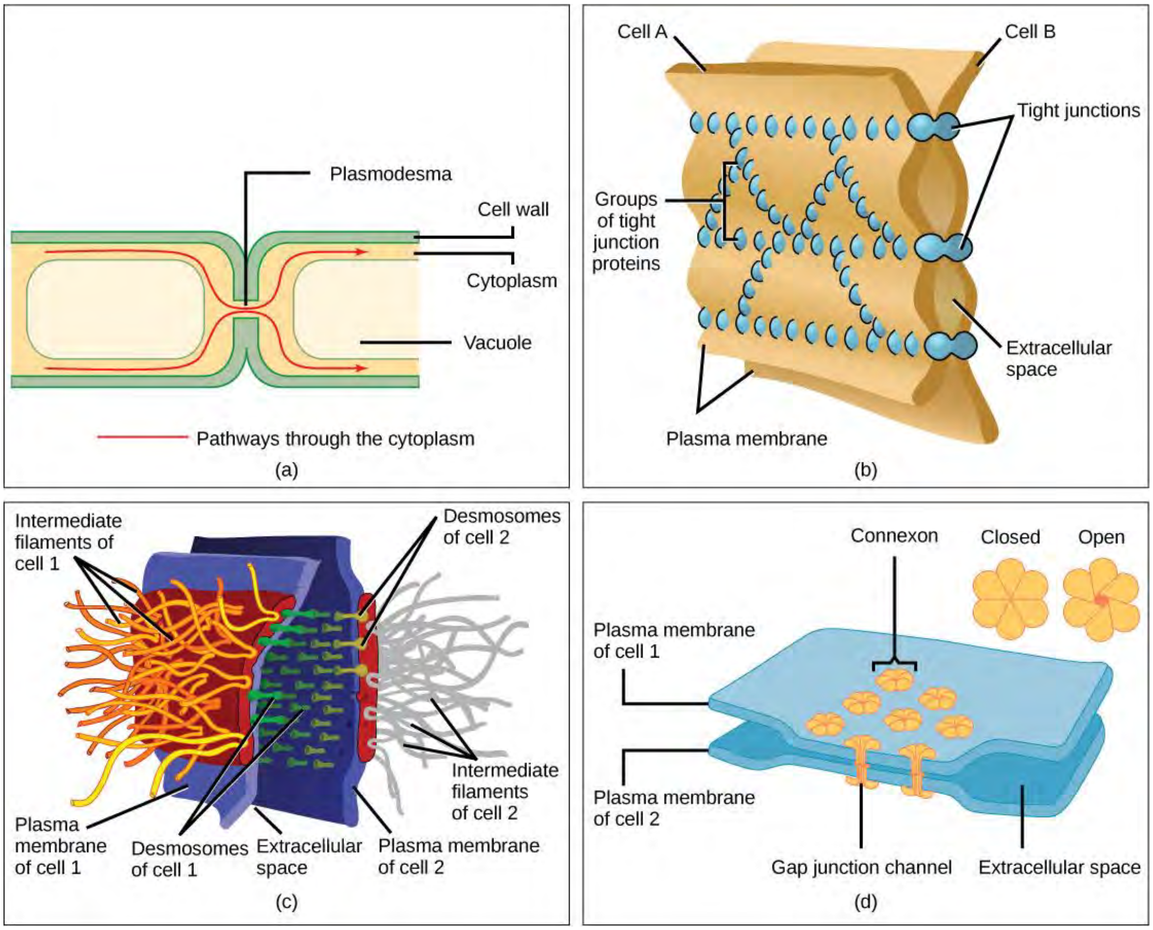

Figure 4.32 There are four kinds of connections between cells. (a) plasmodesma (b) Tight junctions (c) Desmosomes (d) Gap junctions (credit b, c, d: modification of work by Mariana Ruiz Villareal / Concepts of Biology OpenStax)