Cellular Organelles

1. Organelles
   a. Some of the organelles found in eukaryotic cells come from endosymbiosis
      i. Cells often ingest other cells and digest them for food.
      ii. Sometimes the ingested cell is not digested, but the 2 cells learn to live together for mutual benefit. This is called endosymbiosis.
      iii. Mitochondria and plant chloroplasts are believed to have originated in this way. They have their own DNA and their membranes are lipid bilayers.
   b. Cytosol
      i. Cytosol is the liquid filling the cell. It is a watery solution containing a lot of proteins, salts, dissolved molecules, *etc*.
      ii. The term cytoplasm refers to the cytosol in addition to the organelles, but excluding the nucleus.
   c. Cell membrane
      i. The cell membrane (also called the plasma membrane) separates the contents of the cell from its environment and regulates the passage of molecules into and out of the cell.
      ii. The cell membrane provides a barrier to the movement of things in and out of the cell, allowing some things to pass through while excluding others. We call this a selectively permeable membrane - *i.e.*, some things are able to pass through the membrane while others are not. Because the middle of the membrane is non-polar, hydrophobic molecules pass through it more readily than hydrophilic ones.
   d. Nucleus
      i. The nucleus contains the molecule of heredity - DNA. DNA does not leave the nucleus. DNA contains instructions needed to produce proteins that control all cell activities.
      ii. The nucleus is surrounded by a membrane that has pores in it to allow materials to pass in and out.
      iii. In prokaryotes the genetic material is a single, circular molecule of DNA and is not contained in a membrane-bound nucleus. In eukaryotes, the genetic material is inside the membrane-bound nucleus
   e. Cytoskeleton
      i. An internal system of protein rods determines the shape of the cell.
      ii. These proteins form a framework that:
         (1) Give the cell its shape.
         (2) Are used to transport structures within the cell.
         (3) Are involved in movement of the whole cell.
         (4) Anchor organelles in location.
   f. Mitochondria (singular, mitochondrion)
      i. The mitochondria release energy from the food we eat in a process called cellular respiration. The equation is glucose + oxygen → carbon dioxide + water + energy
      ii. The energy the cell produces is in a chemical form called ATP.
      iii. Mitochondria have two membranes, an inner and an outer. All the equipment the cell needs for cellular respiration is on the inner membrane. To maximize the amount of energy produced, the inner membrane is highly folded to provide lots of surface area.
      iv. **Would all cells have the same number of mitochondria?**

v. Because these organelles have their own DNA (which is different from eukaryotic DNA) and can multiply independent of the cell, it is believed that they probably originated from bacteria by endosymbiosis.

vi. In many endotherms, about 36% of the energy in food is turned into ATP. The rest is turned into thermal energy and is used to keep the individual warm.

g. Ribosomes

i. Cells are largely protein and so need a constant supply of new proteins to replace those that are lost or damaged.

ii. Proteins are made by the ribosomes.

iii. Some ribosomes are free in the cytosol, while others are attached to the ER

(1) Proteins that are secreted by the cell or which go to other organelles are made by ribosomes attached to the rough ER.

(2) Proteins that stay in the cytosol are made by free ribosomes.

h. Endoplasmic reticulum (ER)

i. The ER is made up of a series of membrane canals that extend throughout the cell.

(1) Rough ER

(a) Rough ER is rough because it has ribosomes attached to it.

(b) Cells that secrete lots of protein (*e.g.*, stomach cells, pancreas cells) have lots of rough ER.

(2) Smooth ER

(a) Smooth ER has no ribosomes attached to it.

(b) Smooth ER also makes lipids and detoxifies drugs, including alcohol.

ii. Vesicles are small membrane sacs that pinch off the endoplasmic reticulum or Golgi apparatus and transport molecules to other parts of the cell.

i. Golgi apparatus

i. Some proteins need some modifications before being sent to their final destination. The Golgi receives vesicles that contain molecules from the ER. Chemical reactions within the Golgi complex modify the molecules. Processed molecules are pinched off in a vesicle and sent to appropriate location in or out of the cell.

ii. The Golgi apparatus is a set of stacked, flattened membranes found near the nucleus.

iii. After modifying them, the Golgi ships proteins to the right destination in the cell.

j. Lysosomes

i. Lysosomes are like little recycling centers that digest materials within the cell. A vesicle containing molecules to be recycled fuses with the membrane of the lysosome so that the vesicle contents can be broken down.

ii. They contain digestive enzymes that break down large molecules like proteins, lipids, *etc*. into their basic building blocks to be reused by the cell. They also break down and recycle defective or worn out cells and cell parts.

iii. Small particles ingested by phagocytosis are digested by lysosomes.

iv. Cells also use lysosomes to kill themselves. This important process occurs during the removal of the webbing between our fingers during embryonic development, the reduction in the size of a tadpole tail as it matures, and the dropping of tree leaves in the autumn.

k. Vacuoles
    i. A vacuole can be thought of as a small bubble enclosed by a membrane. They are like vesicles but larger.
    ii. Cells contain small vacuoles for storing materials such as nutrients, minerals, lipids, sugars, *etc*.
    iii. Plant cells have an enormous vacuole which fills most of the cell.
    iv. Some simple eukaryotes have a contractile vacuole which, when filled with water, can contract to squeeze that water from the cell.
l. Cilia and flagella
    i. Hair-like cilia (singular, cilium) and tail-like flagella (singular, flagellum) are projections from the cell.
    ii. By repetitive beating (like a bending motion), they cause the cell to move cause cell to move. Think of oars in a boat. Flagella can propel the cell by waving back and forth.
    iii. If a cell is fixed in place, they can also cause water to move across the surface of a cell.
    iv. In humans, sperm have flagella and the cells of our respiratory tract have cilia.
m. Cell wall
    i. The cell wall of the plant is made of a strong carbohydrate called cellulose. This gives the plant cell strength. The cell wall is like an external skeleton for the plant.
    ii. When a plant cell absorbs water, it swells and the cell membrane pushes against the cell wall. This is called turgor pressure and allows the plant to stay upright. Otherwise, the cell could burst.
    iii. The cell wall remains after the cell dies and in trees we call this wood.
    iv. Some bacteria have cell walls made of peptidoglycan and fungi have cell walls made of chitin.
n. Chloroplasts
    i. Chloroplasts use energy from sunlight to make sugar from CO_2 and water.
    ii. This is photosynthesis and the equation is $CO_2 + H_2O \rightarrow \text{glucose} + O_2$
    iii. Like mitochondria, chloroplasts have double membrane and their own DNA.