CELLS: LECTURE OUTLINE

I. DEVELOPMENT OF THE CELL THEORY

1. In 1663, Robert Hooke observed empty cell walls of cork, and coined the term "cell". He later observed living cells.
2. During the 19th century, Theodor Schwann concluded that all living things are made of cells.
3. Spontaneous generation (life from non-life or "abiogenesis") was the prevailing view of the era.
4. In 1858, Rudolf Virchow said that cells could arise only from preexisting cells.
5. In 1859, Louis Pasteur conducted experiments that finally laid the idea of spontaneous generation to rest.
6. During the 20th century, tenets of the modern cell theory emerged.

II. The Cell Surface

A. The Plasma Membrane
1. Electron microscope revealed that the cell (plasma) membrane (also called unit membrane) is made up of 2 layers.
2. The current model of membrane structure is called the fluid-mosaic model.
   It suggests that the plasma membrane is made up of mobile globular proteins in a layer of phospholipids.
3. Membrane Lipids
   a. Phospholipids are amphiphilic (amphipathic), with a hydrophilic phosphate-containing head and two hydrophobic fatty acid tails.
   b. In the plasma membrane, the phospholipids are oriented with heads out, and tails to the inside, forming a phospholipid bilayer. The phospholipids are not fixed into position.
   c. Twenty percent of membrane lipids are cholesterol, which lends stability to the phospholipids.
   d. Another 5% of membrane lipids are glycolipids, which appear only on the exterior of the membrane.
   e. The plasma membrane can readily repair itself.
4. Membrane Proteins
   a. Membrane proteins can span the membrane (integral or transmembrane proteins), or lie on one side (peripheral proteins).
   b. Functions of membrane proteins include these groupings: receptors (receive chemical messages); channel proteins, motor molecules (cause movement within the cell); and cell identity markers (identify the cell).
B. The Glycocalyx
1. The glycocalyx consists of the carbohydrates moieties of the membrane glycolipids and glycoproteins. It is chemically unique in each individual.
2. The glycocalyx helps cells adhere to one another as well as identifies cells as "self". The glycocalyx can also assist in cellular uptake of substances from the extracellular fluid.

C. Extensions of the Cell Surface
1. Microvilli
   a. Microvilli act to increase the cell's surface area, and occur in areas specialized for absorption (intestines and kidneys).
   b. They appear as a brush border, with stiff filaments of actin inside.
   c. On cells of the taste buds and inner ear, cells with microvilli serve sensory functions.

2. Cilia
   a. Cilia are hair like extensions that are usually motile, and move materials past the cell in the respiratory tract and uterine tubes.
   b. Cilia beat in waves in the same direction (power stroke) then recover (recovery stroke).
   c. A cilium contains a core called an axoneme made up of microtubules in a 9 + 2 arrangement. Peripheral microtubules contain dynein arms that use energy to cause the cilium to beat back and forth.
   d. A basal body, anchors the cilium to the cell. (triplet arrangement of microtubules)

3. Flagella
   a. A flagellum is a long, whiplike structure with an axoneme identical to that of the cilium.
   b. In humans, flagella can be found in sperm.

III. THE CELL INTERIOR
A. Organelles
1. The Nucleus
   a. Of the organelles in the cell that are surrounded by a double unit membrane, the nucleus is the largest. Its nuclear envelope contains pores.
   b. The nucleus houses DNA, the genetic information for the cell.

2. Rough Endoplasmic Reticulum
   a. Rough endoplasmic reticulum (ER) is a system of branching channels continuous with the outer plasma membrane. Each channel contains a space called the cisterna. Rough endoplasmic reticulum has ribosomes (sites of protein synthesis) associated with it.

3. Ribosomes
   Ribosomes are small granules of protein and RNA that read the messages encoded in mRNA. Attached to rough endoplasmic reticulum OR free in cytoplasm.

4. Golgi Complex and Vesicles
   a. The Golgi complex looks like a series of cisternae with swollen edges. Its function in the cell is to receive polypeptide chains from the rough ER, modifies them, and packages them into vesicles. Some vesicles become secretory vesicles.
   b. The Golgi complex is also a carbohydrate factory, and in addition, synthesizes some hormones and lipids.

5. Lysosomes
   a. A lysosome is a package of hydrolytic enzymes enclosed by a single unit membrane.
   b. Many cells exhibit a programmed cell death in which contents of the lysosomes digest cell contents. Lysosomes also exhibit autophagy when they digest worn out cell contents.

6. Peroxisomes
   a. Peroxisomes contain different enzymes than lysosomes, and are abundant in the liver and kidney.
   b. Peroxisome enzymes detoxify alcohol and other drug; also neutralize free radicals.
III. **THE CELL INTERIOR CONT.**

A. Organelles

7. **Mitochondria**
   a. The *mitochondrion* is surrounded by a *double unit membrane.*
      The *folded portions* of the *inner mitochondrial membrane are called cristae.*
   b. Within the mitochondria, *energy is extracted from organic compounds and stored in ATP.*
   c. The mitochondrial *matrix* lies *between the cristae* and contains mitochondrial DNA.

8. **Smooth Endoplasmic Reticulum**
   a. Smooth ER is a *network of branching tubules, lacking ribosomes.*
   b. It functions to *detoxify drugs and alcohol, and also synthesizes triglycerides, cholesterol, and steroid hormones.*

9. **Centrioles**
   a. *Centrioles* are *short assemblies of microtubules* arranged in *nine groups of three microtubules.*
   b. The *centrosome* is a place *within the cytoplasm* where *two centrioles lie perpendicular to each other.*
      It *plays a role in cell division.*

B. Cytoskeleton
1. The *cytoskeleton* is a collection of *protein filaments and cylinders* that helps *support* the cell, *organize* and *moves its contents,* and *helps the whole cell move.*
2. *Microfilaments* are 6 nm (1 nanometer = .001 µ) in diameter and composed of *actin.*
3. *Intermediate filaments* (8-10 nm) are *thicker and stiffer than microfilaments* and participate in *junctions* that hold epithelial cells together.
4. A *microtubule* (25 nm) is a cylinder made of *13 parallel strands called protofilaments,* each of which is a long chain of *tubulin.* Microtubules *radiate from the centrosome and hold organelles in place and act like railroad tracks to guide organelles,* plus they participate as the *mitotic spindle during cell division.*
   Microtubules are *not permanent structures.*

C. Inclusions
   *Inclusions* are temporary cellular contents that take on a variety of activities.
   Some contain *glycogen granules,* while others hold *oil droplets, mucus, or pigments.*

IV. **Intercellular Junctions**

A. **Intercellular Junctions**
1. Intercellular junctions occur *between adjacent cells* and help maintain *structural integrity* of tissue as well as allow *communication between cells.*
2. **Tight Junctions**
   a. Tight junctions are formed by a zipper-like fusion of membrane proteins of adjacent cells.
   b. In the intestine, tight junctions keep bacteria out and ensure that nutrients are absorbed into cells, rather than passing between them.
3. **Desmosomes**
   A desmosome is a "spot weld" between cells that holds them together to help the tissue resist mechanical stress.
4. **Gap (Communicating) Junctions**
   Gap junctions are formed by a *ring like structure* made up of membrane proteins.
   *Chemical communication* and *nutrients* can pass from one cell to the next through gap junctions.
V. Membrane Transport - Passive Mechanisms

A. Filtration
1. Filtration: process whereby particles are driven through the selectively permeable membrane of the cell.
2. An example of filtration in the body is when blood pressure forces fluid through the walls of capillaries.

B. Simple Diffusion
1. Simple diffusion involves the movement of particles from an area of greater concentration to one of lesser concentration because of their own kinetic energy. Particles are said to move down a concentration gradient.
2. Diffusion rates increase with increasing temperature, decrease with molecular weight, increase with a steeper concentration gradient and larger surface area of membrane. Permeability of the membrane also influences diffusion rate.

C. Osmosis
1. Osmosis is a special case of diffusion involving water movement from an area where water is more greatly concentrated to an area containing less water.
2. Tonicity (tonicity literally = strength)
   a. The ability of a solution to affect the fluid volume and pressure within a cell is called its tonicity.
   b. Hypotonic solutions are more dilute (less solutes) than the intracellular fluid; hypertonic solutions are more concentrated. Isotonic solutions contain the same quantities of solute.

D. Facilitated Diffusion
1. Facilitated diffusion is the movement of a solute down a concentration gradient with the help of a carrier protein.
2. Carrier-mediated transport: same as facilitated diffusion.

VI. Membrane Transport - Active Mechanisms

A. Active Transport
1. Active transport employs carrier proteins, but uses energy (ATP) to move solutes up (against) their concentration gradients.
2. Active transport is a four-step process. First, the ligand binds to the carrier. Second, the carrier hydrolyzes ATP and becomes phosphorylated. Third, the carrier undergoes a conformational change. Fourth, the carrier releases the ligand on the other side of the membrane and returns to its original shape.

B. Bulk Transport (note: ALL of these are active transport processes!)
1. Bulk transport involves the moving of larger substances (droplets) across a membrane.
2. Exocytosis is the expulsion of material from the cell; endocytosis is the opposite process (brings material IN).
3. Phagocytosis is the process of "cell eating", wherein the cytoplasm flows into pseudopods, surrounds a particle, and traps it into a vacuole or phagosome.
4. Pinocytosis (cell "drinking") employs pinocytotic vesicles to take in droplets of extracellular fluid. Receptor-mediated pinocytosis is more selective, and a clathrin-coated pit forms around a protein receptor that is bound to the target molecule. HIV employs this process to invade healthy cells.

Review: Prokaryotic vs. Eukaryotic cells from BIO 105