Introduction to Biology Week 4

Introduction:

Welcome to week #4. This week you will be introduced to the basic unit of living things, the cell. The topic for this week is the structures known as cells. Cells are the smallest structural units capable of performing all the processes characteristic of living things. This makes cells very special in the hierarchy of biological organization. All living things are composed of one or more cells. These units were first described and named by Robert Hooke in 1665. He was looking at a slice of cork, which comes from the bark of certain types of oak trees, under an early version of the microscope. It wasn’t until nearly 200 years later, in 1839, that cells were recognized as the basic structural unit of life. (This is roughly the same amount of time between the Lewis and Clark expedition and today.) This recognition came from two German biologists, Schleiden and Schwann, who proposed the “cell theory”, that is, that all living things are composed of cells. Note that this is a scientific “theory”. Be sure you understand the meaning of this term in this context as contrasted with popular usage of the term. Also, I think your appreciation of these things called cells will be increased if you visit the Cells Alive Web site listed below in the Assignment section.

Course Outcomes
Describe the major characteristics of living organisms
Identify the major components of a cell and describe their function.

Learning goals:
After studying this material you should be able to:

1. Be able to relate the scientific method to your own life.
2. Describe the unique characteristics of something alive.
3. Explain how a single cell meets the basic criteria that differentiate living organisms from nonliving objects or chemical reactions.
4. Describe the structure of common prokaryotic plant and animal cells.
5. Given a diagram, label the membrane systems, organelles, and other components of each type of cell.
6. Describe the role of membranes in determining the organization of cells and their organelles.
7. Describe how molecules get into and out of cells.
8. Describe the function of each of the cellular organelles.

Assignments:
These will be found in the Week 4 Classroom (In the Assignment folder).

1. Read Chapters 4 and 5 in your text.
2. Visit the following Web site and read the Introduction and Chapter 4 & 5.

   http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookCELL1.html
   http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookCELL2.html
   http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBooktransp.html

   This site is an encapsulation of the Maricopa site.

   http://www.rit.edu/~has7647/Chapt5.html

   This site is less illustrated than Maricopa but has great information

   http://faculty.nl.edu/jste/biocourse.htm
Excellent review of phospholipids.

http://ntri.tamuk.edu/cell/lipid.html

This web site provides an overview of the role lipids play in membrane formation. The narrative is brought to life with associated graphics. Pay attention to the pictures. I highly recommend this site. The Arizona site is a tutorial with questions. If you can answer these questions you are doing well.

http://www.biology.arizona.edu/cell_bio/problem_sets/membranes/index.html

http://www.bact.wisc.edu/microtextbook/bacterialstructure/membraneGen.html

http://www.bact.wisc.edu/microtextbook/index.html
I. Cell theory

A. The smallest biological entity that still retains the characteristics of life

B. Tents of the cell theory
   1. All organisms are composed of one or more cells
   2. The cell is the basic unit of life
   3. New cells arise only from cells that already existed

II. Aspects of the Cell

A. Cell structure and function

   1. Plasma membrane
      a. separates the cell from the environment
      b. permits flow of molecules across the membrane
      c. contains receptors that affect the cell’s activities

   2. Cells contain DNA the genetic information necessary for protein synthesis

   3. The cytoplasm contains
      a. membrane systems
      b. particles
      c. filaments (the cytoskeleton)
      d. semifluid substance

B. In nature there are 2 kinds of cells
   1. *Prokaryotic* cells - bacteria with no nucleus
   2. *Eukaryotic* cells -- contains organelles and membrane bound nucleus

C. Cell membrane structure and function

   1. Plasma membrane - lipid bilayer
      a. forms a boundary between inside and outside of cell
      b. subdivides the cytoplasm into compartments
      c. regulates the entry and exit of substances

   2. Plasma membrane bound protein
      a. Serves as channels and receptors

D. Surface-to-volume constraints on size and shape of the Cell

   1. Most cells are too small to see without a microscope
   2. Small size permits efficient diffusion across the plasma membrane
   3. Surface area increases to the square of the diameter
      volume increases to the cube of the diameter

III. The Bacteria Prokaryotic Cell

A. *Prokaryotic* -- means (“before the nucleus”)
   1. DNA is clustered in distinct region of the cytoplasm call the **nucleoid**
B. Bacteria - the smallest and simplest of cells
   1. Flagella - project from membrane and permit rapid movement
   2. Cell wall supports the cell and surrounds the plasma membrane
      a. Regulates transport into and out of the cell
   3. Ribosomes -- protein assembly sites --
      a. dispersed throughout the cytoplasm

IV. Eukaryotic Cells
   A. Function of Organelles
      1. Eukaryotic cells contain a true nucleus
      2. Organelles form compartmentalized portions of the cytoplasm
      3. organelles separate reactions
         1. with respect to time
            a. Allowing for the proper sequence of reaction
         2. space
            a. allowing incompatible reactions to occur in close proximity
   B. Components of the Eukaryotic cell
      1. Nucleus
         a. controls access to the DNA
         b. packing of DNA during cell division
      2. Endoplasmic reticulum (ER)
         a. modifies proteins
         b. involved with lipid synthesis
      3. Golgi bodies
         a. modifies protein
            1) sorts and ships proteins
         b. involved in lipids secretion or internal use
      4. Lysosomes
         a. intracellular digestion
      5. Transport vesicles
         a. between organelles and to and from the cell surface
      6. Mitochondria
         a. ATP formation
      7. Ribosomes
         a. Function in protein synthesis
         b. Free or attached to the E.R.
      8 Cytoskeleton
         a. determines cell shape
         b. provides for motility
      9. Plastids
         a. present in photosynthetic cells
            1) Function in food production and storage
      10. Central vacuoles and cell wall
         a. Found in many protistans fungi and plants
            1) In plants: Central sap vacuole or water vacuole

V. THE NUCLEUS
   A. The nucleus isolates the DNA for ribosomes in cytoplasm where proteins will be assembled
B. Components of the nucleus
1. Nucleolus
   a. The region where subunits of ribosomes are prefabricated

2. Nuclear envelope
   a. consists of lipid bilayer
      1) with pore complexes
      2) ribosome studded outer surface

3. Chromosomes
   a. Composed of DNA and associated proteins
      1) Some proteins serve as enzymes while other act as support proteins
   b. Chromatin - Total collection of DNA and protein

VI. CYTOMEMBRANE SYSTEM

A. Endoplasmic Reticulum (E.R.)
1. Endoplasmic Reticulum
   a. A collection of interconnected tubes and flattened sacs
      1) begins with nucleus and winds through the cytoplasm

2. Two kinds of Endoplasmic Reticulum
   a. Rough
      1) Consists of stacked flattened sacs with attachment of ribosomes
         a) Assembly site of polypeptide (protein synthesis)
   b. Smooth Endoplasmic Reticulum E.R.
      1) No attached ribosomes
      2) Lipid synthesis
      3) vesicles carrying proteins and lipids budded off from here
      4) Inactivation of harmful chemicals
         a) Liver cells

C. Peroxisome
1. Small vesicles contain enzymes that use oxygen
   a. degrades fatty acids and amino acids
   b. Alcohol degraded by animal liver cell peroxisome

2. Hydrogen peroxide converted to water

3. Glyoxisomes found in seeds, peanuts, contains enzymes
   a. converts fats and oils to sugars necessary for rapid growth

D. Golgi bodies
1. Golgi bodies are flatten sacs -- like pancakes--
   a. edges break away as secretory vesicles

2. Proteins and lipids undergo final processing, sorting and packaging
   prior to targeting of items to various location within the cell
E. Lysosomes

1. These vesicles bud from Golgi bodies

2. Vesicles carry powerful enzymes that can digest
   a. contents of other vesicles
      1) Polysaccharides, proteins, nucleic acids and some lipids
   b. worn-out cells parts
   c. bacteria
   d. foreign particles or other cellular parts

   1) Example: The tail of the Tad pole is digested and absorbed as it turns into a frog

VII. MITOCHONDRIA

A. Primary organelles for transferring carbohydrate energy to the production of ATP
   1. These processes take place in oxygen atmosphere (aerobic conditions)

B. Membranes of mitochondria consist of an outer and inner folded membrane commonly referred to

   ------ singular - crista --- or cristae for many folds

   1. Between the outer and inner membrane system a compartment is formed

   2. Hydrogen ions and electrons move between this compartment structure during ATP production

C. Origins of Mitochondria

   1. Thought to be an ancient bacteria engulfed by predatory cells.

   2. Mitochondria have their own DNA

VIII. SPECIALIZED PLANT ORGANELLES

A. Chloroplasts and other plastids
   1. Chloroplasts are oval or disk shaped
      a. Double membrane structure
      b. Stacked disks called grana
         1) traps light energy to form ATP
      c. Chlorophyll give chloroplasts their green color

   2. Chromoplasts
      a. Contains plant red and brown pigments
         1) Give colors to petals, fruits and roots

   3. Amyloplast
      a. Store starch granules
IX. CYTOSKELETON

A. Scaffolds for cell shape and internal organization

1. Interconnected system of bundled fibers, slender threads, and lattices extends from nucleus to plasma membrane

2. The main components of the cytoskeleton
   All assembled from protein subunits
   a. Microtubules
      1) Hollow strands
   b. Microfilaments
      1) Solid strands
   c. Intermediate filaments
      1) Found in animals

3. Transient microtubules
   a. “Spindle” microtubules
      1) Facilitating chromosome movement during cell division

4. Permanent microtubules
   a. Functions in muscle contraction

B. Internal Movement

1. Controlled assembly and disassembly subunits of microtubule and microfilament allow attached structures
   a. To be pushed or dragged through the cytoplasm
   b. Microtubules and microfilaments active slide past one another

2) Cytoplasmic streaming -- Cyclosis

3) In muscle and amoeboid motion

Paramecium move by what means?? cilia or flagella??

Relatively speaking Cilia are short and flagella are long.

Paramecium movement is accomplished by microtubules

Cut radially a flagella have a 9 + 2 cross-sectional array of microfilaments useful in propulsion.

Our intestinal track and lungs use cilia to move objects along.

C. Microtubule Organizing Center (MTOC)

1. Sites of origin of microtubules

2. MTOC near the nucleus of animal cells includes a pair of centrioles
   a. govern the plane of cell division
   b. Centrioles serve as patterns for the assembly of basal bodies
      which organize flagella and cilia microtubules
X. CELL SURFACE SPECIALIZATION

A. Cell walls and cell junctions in plants
   1. Cell walls are found in plants, bacteria and fungi and not in animals
      a. Composed of carbohydrates
   2. Cell wall has numerous junctions or pores
      a. Plasmodesmata

B. Intercellular material in Animals
   1. Components include
      a. collagen
      b. fibrous proteins
      c. glycoproteins
      d. polysaccharide

Material secreted from cell to cell forming “ground substance”

C. Cell junctions in animals
   1. Tight junction
      a. between cells of epithelial tissue
      b. cytoskeletal strands of one cell fuses with strands of neighboring cell
   2. Adhering junctions
      a. are like spot welds at the plasma membrane between two adjacent cells
   3. Gap junctions
      a. small open channels directly linking the cytoplasm of adjacent cells
I. Membrane Definitions for chapter 5

A. Fluid mosaic model - the membrane is composed of a phospholipid bilayer interspersed with integral proteins which pass through the membrane and peripheral proteins which attach to either the inner or outer surface

1. Phospholipids are amphipathic having a polar "head" and a nonpolar "tail"
   a. the polar heads are directed outward to interact with the water molecules
   b. the non-polar tails are directed toward each other

2. Movement within membrane bilayer
   a. Sideways, spin, flex their tails to prevent close packing
   b. Different sides of the membrane may have different arrangement of molecules (asymmetric)

3. Glycolipids - carbohydrates are attached to the head portion of the phospholipid

4. Glycoproteins - carbohydrates are attached to the proteins of the membrane

5. Cholesterol - steroid inter spaced within the phospholipid bilayer and is involved with maintaining the fluidity of the membrane

B. Functions of the cell membrane (aka plasmalemma)

1. Transport proteins
   a. Selective permeability - the membrane only allows certain substances through (proteins serve as channels and transporters)
   b. A channel protein either open or gated serves as a pore through which ions, water and soluble substances can move
      Message transmitted across the nervous system
   c. A carrier protein binds specific substances
      1). Some work passively while others are active requiring ATP to function

2. Receptors and Response
   a. Hormone receptors: stimulus response
      1) Triggers changes in the cell’s activity like - growth or flight response to adrenaline
   b. Chemo receptors: bacterial environmental sensing
      1) Either movement towards or away from environmental stimulus

3. Respiration/Photosynthesis
   a. Mitochondrial, chloroplant and bacterial membranes serve as structure allowing for these processes to take place.

4. Adhesion proteins
   a. Adhesion type protein binding cell within organs to “stick” together.
5. **Recognition proteins**

   a. Glycoproteins serve as self makers within animal systems against self destruction by immune system

C. Transport across membranes

1. **Water Movement**

   a. **Concentration Gradients and Diffusion**

      1) Concentration - the number of molecules in a given volume

      2) Molecules move down a *concentration* gradient (High to Low)

      3) Movement of molecules down this gradient is called --- *diffusion*

         (a) Simple diffusion

             1) Transport from a region of high concentration to a region of low concentration

             2) Passive, or physical, process as no cellular energy is expended

             3) Membrane does not serve as a barrier

             4) Example: oxygen and carbon dioxide move by simple diffusion across the respiratory membrane (alveolar/capillary interface) of lung tissue.

      4) Rate and direction of diffusion controlled by

         a) Electric gradient - differences in charge between to regions -- sodium and chloride atoms

             (1) Small electrically neutral molecules will move across the lipid bilayer membrane

                 (a) H₂O, O₂, CO₂, Ethanol (ETOH)

         b) Temperature - higher temperatures cause increased agitation of molecules

         c) Molecular size

             Small molecules move faster than larger ones

         e) Pressure gradient --

             (1) difference in pressure between two adjoining regions can influence the rate and direction of diffusion

2. **Bulk Flow**

   a. Tendency of different substances in a fluid to move together in the same direction due to a pressure gradient -- (animal circulatory system)

3. **Osmosis**

   a. Transport of water from a region of high water concentration (low solute conc.) to a Region of
lower water concentration (high solute conc.) through special water channels called aquaporins

b. Passive, or physical, process as no cellular energy is expended

c. The plasma lemma serves as a barrier

d. Types of solutions based upon osmotic potential (aka: tonicity = a measure of the concentration of solutes in an aqueous solution)

(1) Isotonic solutions (iso = same)

a) Solute concentration on both sides of the membrane barrier are the same.
b) No net movement of water molecules across the membrane.

(2) Hypotonic solutions (hypo = less than)

a) Solute concentration on the outside of the cell's membrane is less than that of the cytosol. (Therefore, the water concentration is greater outside the cell)
b) Water molecules pass from the exterior into the cell causing it to swell, and eventually to burst.

(3) Hypertonic solutions (hyper = greater than)

a) Solute concentration external to the cell is less than that of the cytosol. (Therefore, the water concentration is less outside the cell)
b) Water molecules pass out of the cell into the exterior causing the cell to shrink (crenation)

3. Facilitated diffusion (transport)

a. Transport of substances from a region of high concentration to a region of low conc.

Carrier proteins -- function in a passive transport manner moving molecules to the side of the membrane where they are less concentrated

Cellular uptake of Glucose (remember glucose is a large polar molecule).

b. The plasmalemma serves as a barrier

c. Protein channels are required

d. Passive, or physical, process as no cellular energy is expended and will continue until solute molecule are equal on both sides

4. Active transport

a. Movement of substances from a low concentration to a high concentration

Requiring ATP energy to move substance across membrane against a gradient

(1) pumping of ions -- Calcium ions to make the cell up to 1000 times lower in Ca$^{2+}$ concentration

b. The plasmalemma serves as a barrier

c. Active, or physiological, process as cellular energy is expended
d. Types of active transport:

(1) Primary active transport - substances are directly pumped across the membrane due to the expenditure of energy from ATP (via ATP-ase activity)

(2) Secondary active transport - substances follow other substances after they have been transported by means of primary active transport

(3) uniport - only one substance is transported across the membrane

(4) coupled transport - more than one substance is transported
   (a) symport - substances are transported in the same direction
   (b) antiport - substances are transported in opposite directions

(5) vesicular transport - formation of a vesicle as substances are brought into or leave a cell
   (a) Endocytosis - substances are taken into the cell
      (1) Receptor mediated endocytosis - a specific membrane protein binds to a specific ligand and thus initiates the vesicle-formation process.
      (2) Phagocytosis - large, solid objects are taken into the cell
      (3) Pinocytosis - tiny droplets of material are taken up into the cell
   (b) Exocytosis - substances are taken out of the cell when secretory vesicles fuse with the plasmalemma

II. Cytoplasm (the term which refers to the cytosol plus all the organelles except the nucleus)

A. The cytosol is 75 -90% water in composition

B. It suspends organelles and solutes (ions, glucose, amino acids, fatty acids, proteins, lipids, ATP, gases, and waste products.)
Complete the following table about the eukaryotic nucleus. Enter the name of each nuclear component described.

<table>
<thead>
<tr>
<th>Nuclear Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>One or more masses in the nucleus; sites where the protein and RNA subunits of ribosomes are assembled.</td>
</tr>
<tr>
<td>b.</td>
<td>Two lipid bilayer membranes thick; proteins and protein pores span the bilayers</td>
</tr>
<tr>
<td>c.</td>
<td>A cell’s total collection of DNA and its associated proteins</td>
</tr>
<tr>
<td>d.</td>
<td>Fluid interior portion of the nucleus</td>
</tr>
<tr>
<td>e.</td>
<td>An individual DNA molecule and its associated proteins in the nucleus</td>
</tr>
</tbody>
</table>

Circle one of two possible answers given between parentheses in each statement.

1. The cytoskeleton gives (prokaryotic/eukaryotic) cells their shape, internal organization, and movement.
2. (Protein/Carbohydrate) subunits from the basic components of microtubules, microfilaments, and intermediate filaments.
3. Microtubules and microfilaments, acting singly or collectively, underlie nearly all the (chemistry/movements) of eukaryotic cells.
4. Colchicine (inhibits assembly and promotes disassembly of microtubules/stabilizes existing microtubules and prevents formation of new ones).
5. The thinnest of cytoskeletal elements are (microtubules/microfilaments).
For question 1 - 20 choose from the following:

a. Mitochondria  B. Chloroplasts  C. Amyloplasts  D. Central vacuole  E. Chromoplast

1. _____ Occur only in photosynthetic eukaryotic cells
2. _____ ATP molecules form when organic compounds are degraded
3. _____ Plastids that lack pigments
4. _____ A muscle might have thousands
5. _____ Plastids that have an abundance of carotenoids but no chlorophylls
6. _____ ATP-forming reactions require oxygen
7. _____ Causes fluid pressure to build up inside a living plant cell
8. _____ Organelles that absorb sunlight energy and produce ATP
9. _____ The source of the yellow-to-red colors of many flowers, leaves, and fruits
10. ____ Inner folds are called cristae
11. ____ May increase so much in volume that it takes up 50 to 90 percent of cell’s interior
12. ____ Plastid with Internal areas know as grana and stroma
13. ____ Plastids that resemble certain photosynthetic bacteria
14. ____ Two distinct compartments are created by a double-membrane system
15. ____ Store starch grains and are abundant in cells of stems, tubers, and seeds
16. ____ Resemble nonphotosynthetic bacteria in terms of size and biochemistry
17. ____ The site of photosynthesis in plant cells
18. ____ Fluid-filled; stores amino acids, sugars, ions, and toxic wastes
19. ____ All photosynthetic and nonphotosynthetic eukaryotic cells have one or more
20. ____ Possess two outer membranes layers that surround a semifluid interior, one membrane
    wrapped over the other
Study the illustration below and match each component of the cytomembrane system with the most correct description of function. Some components may be used more than once.

1. ______ Assembly of polypeptide chains
2. ______ Lipid assembly
3. ______ DNA instructions for building polypeptide chains
4. ______ Initiate protein modification following assembly
5. ______ Proteins and lipids take on final form
6. ______ Sort and package lipids and proteins for transport to final destinations following modification
7. ______ Vesicles formed at plasma membrane transport substances into cytoplasm
8. ______ Sacs of enzymes that break down fatty acids and amino acids, forming hydrogen peroxide
9. ______ Special vesicles budding from Golgi bodies that become organelles of intracellular digestion
10. ______ Transport unfinished proteins to a Golgi body
11. ______ Transport finished Golgi products to the plasma membrane
12. ______ Release Golgi products at the plasma membrane
13. ______ Transport unfinished lipids to a Golgi body

A. spaces within smooth membranes of ER
B. nucleus
C. Golgi body
D. vesicles from Golgi
E. vesicles budding from rough ER
F. endocytosis with vesicles
G. exocytosis with vesicles
H. spaces within rough ER
I. ribosome in the cytoplasm
J. vesicles budding from smooth ER
K. lysosomes
L. peroxisomes
33. Membranes consist of
   a. a lipid bilayer
   b. a protein bilayer
   c. phospholipids and proteins
   d. both a and c are correct

34. Which of the following is not found as a part of prokaryotic cells?
   a. Ribosomes
   b. DNA
   c. Nucleus
   d. Cytoplasm
   e. Cell wall

35. Which of the following statements most correctly describes the relationship between cell surface area and cell volume?
   a. As a cell expands in volume, its diameter increases at a rate faster than its surface area does.
   b. Volume increases with the square of the diameter, but surface area increases only with the cube.
   c. If a cell were to grow four times in diameter, its volume of cytoplasm increases sixteen times and its surface area increases sixty-four times.
   d. Volume increases with the cube of the diameter, but surface area increases only with the square.

36. Most cell membrane functions are carried out by
   a. carbohydrates
   b. nucleic acids
   c. lipids
   d. proteins

37. Animal cells dismantle and dispose of waste materials by
   a. using centrally located vacuoles
   b. several lysosomes fusing with a vesicle that encloses the wastes
   c. microvilli packaging and exporting the wastes
   d. mitochondrial breakdown of the wastes

38. The nucleolus is the site where
   a. the protein and RNA subunits of ribosomes are assembled
   b. the chromatin is formed
   c. chromosomes are bound to the inside of the nuclear envelope
   d. chromosomes duplicate themselves

39. The is free of Ribosomes, curves through the cytoplasm, and is the main site of lipid synthesis.
   a. lysosome
   b. Golgi body
   c. smooth ER
   d. rough ER

40. Which of the following is not present in all cells?
   a. Cell wall
   b. Plasma membrane c. Ribosomes
   d. DNA molecules

41. As a part of the cytomembrane system, the modify lipids and proteins to permit sorting and packaging for specific locations.
   a. endoplasmic reticulum
   b. Golgi bodies
   c. peroxisomes
   d. lysosomes

42. Chloroplasts
   a. are specialists in oxygen-requiring reactions
   b. function as part of the cytoskeleton
   c. trap sunlight energy and produce organic compounds
   d. assist in carrying out cell membrane functions

43. Mitochondria convert energy stored in to forms that the cell can use, principally ATP.
   a. water
   b. carbon compounds
   c. NADPH
   d. carbon dioxide
44. Are sacs of enzymes that bud from ER; they produce potentially harmful hydrogen peroxide while breaking down fatty acids and amino acids.
   a. Lysosomes
   b. Glyoxysomes
   c. Golgi bodies
   d. Peroxisomes

45. Two classes of cytoskeletal elements underlie nearly all movements of eukaryotic cells; they are
   a. Desmins and vimentins
   b. Actin and microfilaments
   c. Microtubules and microfilaments
   d. Microtubules and myosin