CHAPTER 5: The Cell

Sect. 5.1: Cells are The Smallest units of life

I. All living things are made of tiny units called cells.

Cytology – study of cells; "**cyte**" = ***cell***

a. Unicellular – organism made up of **one cell**
b. Multicellular – organism made up of **many cells**; trillions of cells
   - cells are specialized for specific functions, ie. nerve cells are different then muscle cells, etc. ***See fig. 5.1, page 116.**

II. Cell theory– various ideas about cells; est. 1700-1800's; *Biology Today*;pge117

1. all orgs. are made of cells
2. all cells come from "parent cells" ; cells reproduce

- *Hooke* – 1665; first described cells as small compartments in cork; he called them "cellulae"
- *Antonie Van Leeuwenhoek* – first to describe the cell; he called them tiny organisms "animalicules"
- *Schleiden* - made 1st statement of cell theory - plants
- *Schwann* -made a statement about cell theory -animals
- *Virchow* – 1855; said that all cells come from other cells, ie, they reproduce.

Sect. 5.2: Biologists use microscopes to study cells.

I. Types of microscopes: *See Figs. 5.2 & 5.3, page 118 - 119

1. Light microscope - ~100 yrs. old; enlarge up to 1500x
   - dyes/stains are used to see cell structures, eg. methyl blue, congo red
2. Phase contrast – allows you to see light & dark areas
3. Electron microscope – to see very tiny structures enlarged 10^6 times (micrometers)
4. Scanning electron microscope – to see the surface of cells

Sect. 5.3: Cells are of two basic types

I. All living cells are separated into 1 of 2 groups:

1. Prokaryotes – bacteria (1-10 microns in diameter)
- evolved ~3.5 billion yrs. ago; 1st life forms
- do not have true membrane organelles; or nucleus, but does have DNA
- See fig. 5.4, page 119

2. Eukaryotes – plants, animals, fungi, are made of this cell type. (10-100 microns in diameter)
- 10-100 microns in diameter
- evolved from prokaryotes ~1.5 billion yrs. Ago
- have a membrane bound nucleus w/ DNA in it
- has true organelles, egs. mitochondria, nucleus

* See Figure 5.5, page 120 - 121

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Sect. 5.4: Membranes organize Eukaryotic cells
[remember! that each type of cells in an org. has a specific role, but all have the same basic structure, ie, muscle cell vs. a nerve cell]

I. 3 basic regions of a cell
1. Cell/Plasma Membrane – outer barrier of the cell and the organelles.
2. Nuclear region – inside the nucleus; houses DNA
3. Cytoplasm – a fluid area inside the cell memb., but outside the nucleus. Houses the organelles.

II. Membranes: The workbenches of the Cell
- all are a *Phospholipid Bilayer* w/ proteins embedded.
- acts as a security guard for the cell and organelles.
- "selectively permeable" to certain molecules.
- involved w/ cell to cell communication and cell identification, ie. has receptors and ID tags on it.

Sect. 5.5: The Eukaryotic Cells

I. Cellular Boundaries:

A. Cell membrane – (all cells) phospholipid bilayer
All cells have an outer boundary such as the cell membrane **"selectively permeable"**, but some cells have an additional boundary covering the cell membrane ….. a **Cell Wall!**

B. Cell Wall – a rigid wall that surrounds the cell membrane and adds additional support and protection to the cell.
Found in plant, fungi and bacteria cells. It is made of **cellulose "roughage" = complex carbohydrates**

II. Organelles of the eukaryotic cell are found in the cytoplasm suspended in the cytoskeleton (like a fish net):

A. Organelles that control the cell:
Nucleus – "the control center of the cell". **It regulates what the cell's job is** and what it will make such as certain proteins, example: bone cells are programmed by DNA to make collagen fibers and calcium salts (found in your skeleton). It contains the genetic information (DNA).

Ribosomes – "protein factories of the cell". The ribosomes are the sites where **amino acids are assembled into proteins and enzymes** made by the cell. There are different types of ribosomes that are involved with protein synthesis, eg. **free ribosomes** and those attached to the ER, ie. rough ER

B. Organelles that assemble, transport, and store stuff:
Endoplasmic reticulum (ER) – "the work bench of the cell". A series of highly folded "transportation channels" which increase surface area for many chemical reactions to take place.
There are two types of ER:
a. Rough ER – an ER w/ ribosomes attached to the outside. It produces **proteins to be exported to outside the cell**.
b. Smooth ER – an ER w/out ribosomes attached to it. It acts as transportation channels for materials made by the cell.
eg, Carbohydrates or lipids that are made by the cell.

Golgi Apparatus – "the UPS of the cell". A flattened stack of membranes that **sort and package molecules** that are made by the cell, eg. proteins, lipids, and carbos.

Vacuoles – "the warehouse of the cell". A **storage compartment for food, enzymes, and waste products**. Plant cell vacuoles are much bigger than animal cell vacuoles.

Lysosomes – "the garbage collectors of the cell".
It breaks down old worn-out cell parts, and invading bacteria & viruses. The lysosomes contain digestive enzymes that break down. Examples: a tadpole loses its tail when it develops into a frog. Human fetal development of the fingers & toes.

C. Energy Transformers: Organelles that produce energy for the cell.
[all cells require energy to do work, eg. muscle contraction, cell reproduction, photosynthesis]

Chloroplasts – "the power plant of the cell". They convert unusable sunlight energy into usable energy, ie, convert sunlight into chemical energy (food). **"PHOTOSYNTHESIS"**. They contain a green pigment called Chlorophyll. Any plant or algae has chloroplasts.
a. Plastids – any organelle that stores pigments, starch or lipids, eg, **Amyloplasts** store starch in potato cells. Chloroplasts are also a type of plastid.

Mitochondria – "the SDG & E of the cell". The mitochondria converts food energy into usable energy for the cell(ATP). This process is called "cellular respiration".

D. Structures for Support and Locomotion:

Cytoskeleton – "the bricks and cement of the cell". Protein fibers(microtubules and filaments) that provide support of the cytoplasm. The organelles are suspended within the cytoskeleton.

Cilia – many short hair-like structures on the outer surface of the cell membrane. They move in a wave-like fashion. They are found in your lungs and wind-pipe; they move debris out of the body. The cell looks like it has a "butch hair cut".

Flagella – 1 or more long hair-like structure that allows the cell to travel, eg. sperm cells and many bacterium.

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Sect. 5.6: Cell Activities Require Energy

I. Cell parts have a specific role in the function of the whole organism, examples:
- Golgi apparatus packages proteins to make bones.
- Mitochondria is critical to muscle cell contraction.
- ALL cells require ENERGY!I

Question? In order to maintain life, what must the cell do?

- Obtain energy from food (chemical energy)
- Transfer energy from food to ATP
- Produce and release waste. eg. CO_2 or lactic acid

II. Metabolism – all the chem. reactions in the cell (see A,B, & C above)
- synthesis & decomposition rxns. in the cell]
- NOTE: not all the energy(calories) from foodis immediately used by the cell. eg. adipose tissue, amyloplasts

Question?
- How do nutrients and waste enter & leave the cell?

III. Structure of the Cell Membrane
- The membrane is "semipermeable" – only certain molecules are able to pass freely, others must be carried by other molecules. eg. O_2 vs. glucose
- Made of a phospholipid bilayer w/ proteins embedded in it

* (See Fig. 5.12; page 127)

A. Functions of membrane proteins:
- Transportation channels for large molecules and ions such as glucose & Na^+ , CL^- , K^+ ions **"the bat cave"**

- Receptor sites on the surface of cells. **"antennas"** ie. the cell receives chemical info. from other cells or other parts of the body, egs. hormones or neurotransmitters
- Cell surface markers. **"ID tags or an address"** ie. serves to identify the cell as "self" or tissue type such as blood type A + or O – etc...

Question?

- Why must an organ recipient take medication in order for their body to accept the new organ?

Sect 5.7 and 5.8: Substances Enter & leave the cell via the Cell Membrane in Many Ways

I. Two mechanisms by which substances move across the cell membrane

1. Passive transport – cell does not expend ATP to move subs. across the cell memb. egs. diffusion , osmosis, and facilitated diffusion.

2. Active transport – cell expends(uses) ATP to move substances across the cell membrane; examples: endocytosis & exocytosis

Definitions:

a. Solvent – a sub. that does the dissolving. eg. H_20
b. Solute – a sub. that gets dissolved by a solvent. eg. Salt
c. Solution – the combination of a solvent & solute. eg. salt water or koolaid
d. Concentration – the amount of solute relative to the solvent. ie. really sweet koolaid has a [↑]

[atoms and molecules are in constant motion; moving in many directions eg. like putting cream in your coffee]

A. Passive transport – no ATP used by the cell.

- Molecules move with the conc. gradient, ie. from [High] to [Low]

1. *Diffusion* – molecules move from an area of high conc. to an area of low conc. until an equilibrium is reached.
Examples: gas exchange between the lungs and blood; spraying perfume or smelling a skunk

2. *Osmosis* – the diffusion of water across membrane from an area of [high] to [low] concentration.

B. Active transport – ATP is used by the cell.

- Molecules move against the conc. gradient, ie. from [Low] to [High]

1. Endocytosis – the cell takes substances into the cell.
(2 ways)

a. *phago*cytosis – cell eating
b. *pino*cytosis – cell drinking

Example: an immune cell engulfing microbes (bacteria).

2. Exocytosis – the cell releases substances to the outside.

Example: nerve cells releasing neurotransmitters

Question?

- Why do cells constantly take in and get rid of substances?

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Sect. 5.9: The Cell's Life is a Cycle

I. Why Are Cells Sooo Small? Cell Size Limitation:

- Eukaryotes are ~ 5 to 20 μm; nerve cells can be up to 1 meter.
- Prokaryotes are 1 to 10 μm

Hey! Why can't organisms be just ONE BIG CELL?

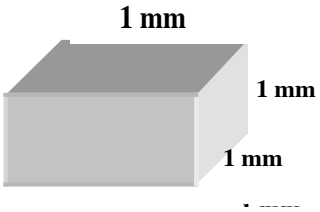
* Substances have to travel through the cell via slow processes (diffusion), so large cells would be less efficient than smaller cells.

A. Surface area- to - Volume Ratio Limits Cell Size:

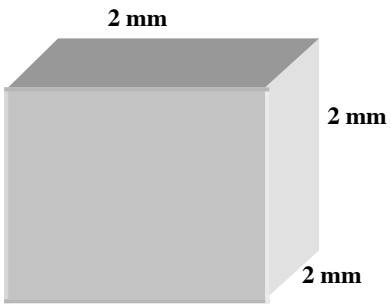
The cell's surface provides interaction w/ their environment.

Surface area (mm^2) = (Length X Width) (6 sides)
Volume (ml^3) = Length X Width X Height

III. Double the cell size (1 mm to 2 mm), and the volume ↑ 8-fold or (increases 8 times)
IV. Double the cell size (1 mm to 2 mm), and the surface area ↑ 4-fold or (increases 4 times)



Surface area = 6 mm^2
Volume = 1 ml^3



Surface area = 24 mm^2
Volume = 8 ml^3

So, with an increase in cell size the cell volume increases much faster than the surface area! There is not enough cell memb. (surface area) to support the amount of nutrient, O_2 & waste (volume inside) to diffuse across the membrane.

* Large cells have less surface area per volume; therefore, it is more efficient to be small for materials to enter & leave the cell.
The cell would die due to lack of nutrients or build up of toxins!
* Solution: Before cells get too big, they divide!

II. Cellular Reproduction: "cell division " - process by which one cell divides into 2 cells (2 daughter cells) each containing a copy of DNA. ** growth & reproduction

- 2 Types:

1. Mitosis - division of body cells (somatic cells); skin, nerves, etc.
2. Meiosis - division of sex cells (gametes); egg & sperm

A. Discovery of chromosomes:

- Chromosomes are tightly coiled DNA molecules that is copied from generation to generation.
- Chromosomes are only visible when the cell is dividing!
- contains: 60% protein; 40%DNA

B. How many Chromosomes in a Cell?

- varies among different species
- *in humans* - each body cell (somatic cell) contains 46 chromosomes, or 23 pairs (half came from each parent).

III. The Cell Cycle in Eukaryotes:

Cell Cycle – all the events that take place in during a cell's growth & reproduction. (see fig. 5.14; page 128)

$$G_1 > S > G_2 > M > C$$

G_1 - growth phase 1; major portion of cycle. Protein synthesis.
High metabolic activity!
S - DNA synthesis (duplication); 2 sister chromatids form.
G_2 - preparation for DNA separation; organelles duplicate.
M - "mitosis"; nuclear division, made up of 4 phases (PMAT).
(1. prophase, 2. metaphase, 3. anaphase, 4. telophase)

C - "cytokinesis"- the physical dividing of the cell into 2 daughter cells.

Sect. 5.10: Mitosis Is a Continuous Process *(See Figure 5.15, page 130)

I. Mitosis - M phase of cell cycle
* the division of body cells.
* DNA undergoes intricate changes & movements
*NOTE: the following phases flow smoothly together!

a. Interphase - "preparation phase of mitosis"- includes $G_1 > S > G_2$. It used to be considered a "resting phase" during cell division!
1. Prophase -
* condensing of chromosomes; become visible.
* nuclear envelope(membrane) breaks down
* spindle fibers(microtubules) appear to help pull the chromosomes to opposite poles

2. Metaphase - "middle"
* chromosomes are lined up in equator (metaphase plate) of cell
* each centromere splits in two, freeing the 2 sister chromatids to be drawn to opposite poles

3. Anaphase -
* separated sister chromatids (chromosomes) are drawn to opposite poles by microtubules (ie. spindle fibers) sliding past one another (energy is supplied by ATP)

4. Telophase -
* spindle fibers (microtubules) are disassembled
* nuclear membrane reforms around each set of chromosomes
* chromosomes uncoil into an extended form
* mitosis is complete!

Cytokinesis - the stage of cell cycle @ which cytoplasmic division is complete.
* cleavage (pinching off) of parent cell into 2 daughter cells
*animal cells - cleavage furrow(no cell wall)
*plant cell - cell plate (cell wall)

Sect. 5.11: Cells Become Specialized During Development

I. Result of Mitosis = a Multi-cellular Organisms
- Two cells genetically identical to the parent cell, eg, skin repair
- In unicellular organisms the new cells remain as single-celled organisms. ie, new offspring of bacteria
- In multicellular organisms the new cells work together to become part of tissue > organs > organ systems > whole organism.

II. Abnormal Cell Division: Cancer?
- cells in some area of the body divide uncontrollably; the excess tissue is called a *tumor, neoplasm* or *growth.*