**Cytology**

**Definition** – the study of cells

**History**

- 1660: Leeuwenhoek - microscope
- 1665: Hooke - viewed cork cells
- 1831: Brown - nucleus
- 1838: Schleider & Schwan - cell theory
- 1846: Purkenje & Mohl - protoplasm
- 1888: Schneider - chromosomes
- 1898: Golgi - golgi bodies
- 1931: Knoll & Ruska - electron microscope

**Cell Theory**

Until the 1600's, scientists only saw living systems as whole units. Only after the microscope was invented did they see that all living organisms are composed of cells. Robert Hooke coined the term “cell” when he observed cork under a microscope. The little compartments he observed reminded him of the monk’s cells in a monastery.

There are 3 main points in Cell Theory

1. Cells are the basic unit of structure in all living organisms. *(All living things are made up of cells)*
2. Cells are the basic unit of function in all living organisms. *(Life occurs because of chemical reactions in cells)*
3. All cells come from pre-existing cells.

**Cell Structure and Function**

A living cell is like a miniature factory. There are many different parts that do many different jobs. These small parts, or organelles, are for the most part very similar in all types of cells, but differences do occur.

Scientists generally divide cells into 2 main groups.

1. **Eukaryotes** – contain a membrane bound nucleus e.g. plant cells, animal cells
2. **Prokaryotes** – do not have a “true” nucleus e.g. bacteria

**Cell Organelle Functions**

1. **Cell membrane** – controls movement of materials in and out of the cell.
2. **Cell Wall** – protects and supports plant cells. (plants only)
3. **Chloroplast** – responsible for photosynthesis. (plants only)
4. **Cytoplasm** – all material in the cell except the nucleus (main functioning area of cell)
5. **Endoplasmic reticulum** – responsible for the making and transporting of cell products
6. **Golgi apparatus** – storing, packing and transporting materials
7. **Lysosome** – contains enzymes for digesting food or cell parts (animal cells only)
8. **Mitochondrion** – energy producers
9. **Nucleus** – general control area of the cell
10. **Nucleolus** – makes ribosomes and helps with protein synthesis
11. **Nuclear membrane** – controls movement of materials in and out of the nucleus
12. **Ribosomes** – make protein
13. **Vacuole** – storage for food, water, waste etc. (large ones in plants only)
14. **Centrosome** – helps with cell division (animal cells only)
15. **Chromatin** (chromosomes) threadlike structures that contain all the information about the cell (DNA)
16. **Flagellum** – helps move the cell

**Diversity and Unity in Cells**

All living organisms are variations on a basic cell structure. All cells and living organisms must:

a) absorb nutrients to survive and grow
b) convert nutrients to usable energy
c) be able to reproduce
d) eliminate wastes

Organisms may be

1) **unicellular organisms** (only one cell) – these cells must perform all the above functions
2) **multicellular organisms** (multiple cells) – these organisms often have specialized cells to carry out certain functions. These cells cooperate with each other to carry on life.

**Cell Transport**

In order to survive, cells must move materials in and out of themselves. Movement of materials in and out of the cell can occur by a number of different methods.

**Cell Membrane**

Surrounds the cell. Some particles are able to pass through the cell membrane and others are not. Because of this, we say the cell membrane is **semi-permeable**.

The cell membrane is a bilipid layer (2 fat layers thick) and is described as a fluid mosaic surface. Fluid because it can bend and flex, mosaic because it contains many different bodies (proteins) embedded in it.
A. Passive Transport
Movement of materials across the cell membrane that requires no energy from the cell. Particles are generally smaller and uncharged (neutral) and move from high to low concentration.

1. Simple Diffusion – the movement of materials from an area of higher concentration to an area of lower concentration. (CO₂, O₂ can diffuse through cell membrane between the fat molecules or through a non-specific protein channel)
2. Facilitated Diffusion – particles that are too big to go through the membrane are moved through a specific protein “carrier molecule” in the cell membrane.
3. Osmosis – the diffusion of water across the cell membrane. If some particles (e.g. ions) cannot pass through the cell membrane, then water may pass in or out of the cell to balance the concentrations.

Tonicity refers to the concentration of ions (salt for example) inside a cell relative to the concentration of ions outside the cell in the surrounding solution. Three situations can exist.
1) Hypertonic - a cell is placed in a salt solution stronger in concentration than itself.
2) Hypotonic - a cell is placed in a salt solution weaker in concentration than itself.
3) Isotonic - a cell is placed in a salt solution equal in concentration to itself.

Plasmolysis – is what happens to a plant cell when placed in hypertonic solution. ie. Celery in salt water.

B. Active Transport
The transport of molecules in and out of the cell requiring energy from the cell. This usually occurs when moving particles from an area of low concentration to an area of higher concentration. Larger charged particles (ions) are moved. In this case a transport protein spins and takes substances across the membrane.

Endocytosis:
The movement of large amounts of materials into a cell (usually nutrients) by the membrane wrapping around the material and “pinching off”.
Pinocytosis – tiny chunks (drinking)
Phagocytosis – larger chunks

Exocytosis
The movement of large amounts of materials (usually wastes) out of the cell by a vacuole moving to the cell membrane. (Opposite of endocytosis)

Cyclosis
Also known as cytoplasmic streaming, cyclosis is the passive movement of the cytoplasm and its contents (various organelles) around in the cell. Cyclosis aids with diffusion of particles within the cell.

Interactive Plant Cell Labelling Game for cell Function, https://www.purposegames.com/game/2bde3fa5
Cell Cycle
The life cycle of a cell is often represented by a circular diagram. See below.
It is important to note, that in order for a cell to compete the cycle and divide into two cells, first the DNA must be copied.
Also note, not every cell completes the cell cycle. In fact, most cells in your body differentiate and become one of the 210 different cell types in your body (skin cell, muscle cell etc.). Once the cell differentiates, it can no longer divide. It remains in a functional phase of Interphase often referred to as G₀. Only special cells called stem cells complete the cell cycle and divide to replace the old worn out cells.

There are 2 main stages to the cells cycle.
1. Interphase
2. Cell Division

Interphase is subdivided into 3 stages.
1. G₁ – cell growth
2. S – DNA is replicated
3. G₂ – cell grows again and prepares for cell division

Cell Division is subdivided into 2 stages.
1. Mitosis (which is nuclear division)
2. Cytokinesis (which is the actual division of the cytoplasm and pinching of the cell membrane into two cells.)

Cell Division (I P P M A T C)

Interphase – the stage before cell division where chromatin (DNA) replicate.
Prophase – the first stage of mitosis – chromatin condense into chromosomes.
Prometaphase – the nuclear membrane breaks down and the spindle fibers attach to the chromosomes.
Metaphase – (M=meta M=middle) chromosomes align along the middle of the cell (equatorial plate).
Anaphase – (A=ana A=apart) sister chromatids separate and are pulled apart to opposite poles.
Telophase – (T=telo T=two new nuclei) chromosomes reach the poles and two new nuclei form. Mitosis is now complete.
Cytokinesis – the cytoplasm and its contents (organelles) are divided in half as the cell membrane pinches together (cleavage furrowing) resulting in two cells.
Cancer
Cancer is a class of diseases characterized by out-of-control cell growth. There are over 100 different types of cancer, and each is classified by the type of cell that is initially affected.

Cancer harms the body when damaged cells divide uncontrollably to form lumps or masses of tissue called tumors (except in the case of leukemia where cancer prohibits normal blood function by abnormal cell division in the blood stream).

Tumors can grow and interfere with the digestive, nervous, and circulatory systems, and they can release hormones that alter body function. Tumors that stay in one spot and demonstrate limited growth are generally considered to be benign.

When a tumor successfully spreads to other parts of the body and grows, invading and destroying other healthy tissues, it is said to have metastasized. This process itself is called metastasis, and the result is a serious condition that is very difficult to treat.

In 2007, cancer claimed the lives of about 7.6 million people in the world. Physicians and researchers who specialize in the study, diagnosis, treatment, and prevention of cancer are called oncologists.

Cause of Cancer
Cancer is ultimately the result of cells that uncontrollably grow and do not die. Normal cells in the body follow an orderly path of growth, division, and death. Programmed cell death is called apoptosis, and when this process breaks down, cancer begins to form. Unlike regular cells, cancer cells do not experience programmatic death and instead continue to grow and divide. This leads to a mass of abnormal cells that grows out of control.

Cells can experience uncontrolled growth if there are damages or mutations to DNA, and therefore, damage to the genes involved in cell division. Four key types of gene are responsible for the cell division process:

1. Oncogenes tell cells when to divide “ON SWITCH”.
2. Tumor Suppressor Genes tell cells when not to divide “OFF SWITCH”.
3. Suicide Genes tell the cell to kill itself.
4. DNA Repair Genes instruct cell to repair damaged DNA.