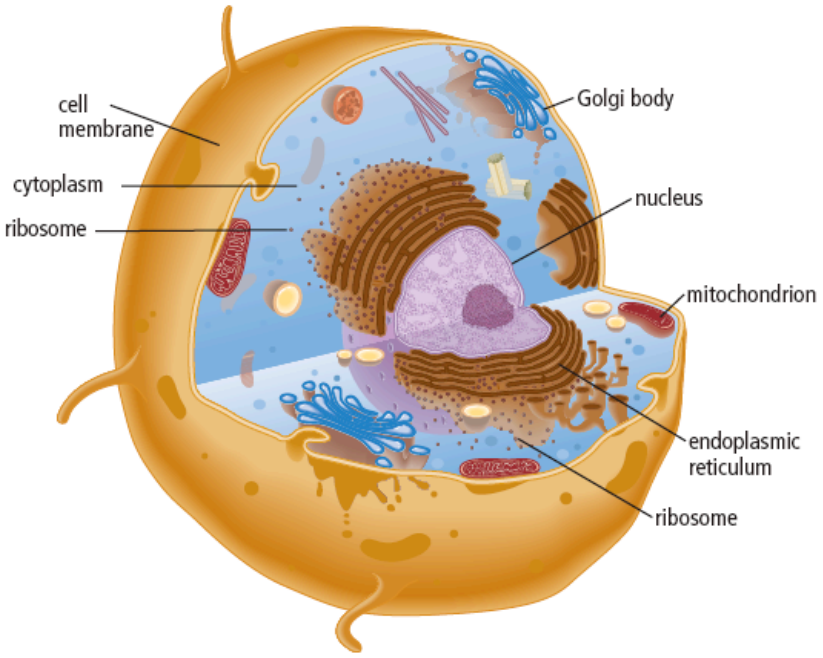
Chapter 4 - The nucleus controls the functions of life

4.1 The Function of the Nucleus within the Cell

Cell Parts and Organelles



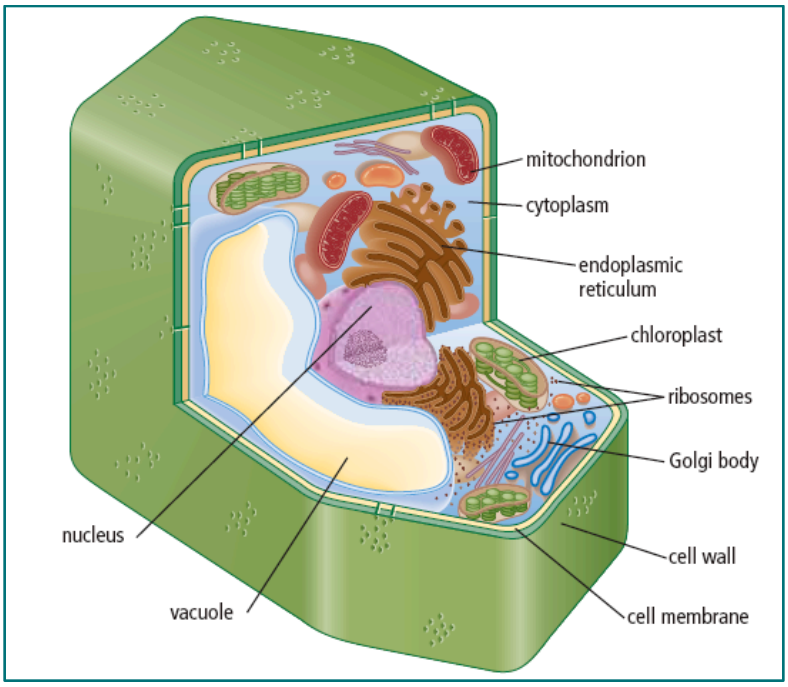
Animal Cells

- Animal cells are equipped with many structures that allow the cell to perform a variety of functions.

Animal Cell Parts (also found in plant cells)

- **cell membrane** - thin covering that controls the flow of materials in and out of the cell.
- **cytoplasm** - jelly-like substance contains the organelles (specialized cell parts)
- **mitochondria** - provide energy for cells
- **ribosomes** - manufacturing plants for proteins
- **endoplasmic reticulum** - membrane-covered channels that act as a transport system for materials made in the cell

- **vesicles** - membrane-covered sacs formed by the endoplasmic reticulum. Vesicles transport new proteins to the Golgi body.
- **Golgi body** - sorts and packages proteins for transport
- **nucleus** - controls all cell activities
- **nucleolus** - membrane-free organelle that makes ribosomes
- **nuclear membrane** - protects the contents of the nucleus
- **Nuclear pores** - openings in the nuclear membrane that allow only certain materials to pass
- **vacuoles** - membrane-bound storage containers



Plant Cells

- Plant cells are equipped with some structures that animal cells do not have.

Plant Cell Parts

- **chloroplasts** - trap energy from Sun to make glucose, food for the plant
- **cell wall** - tough, rigid structure that surrounds cell membrane, provides protection and structural support

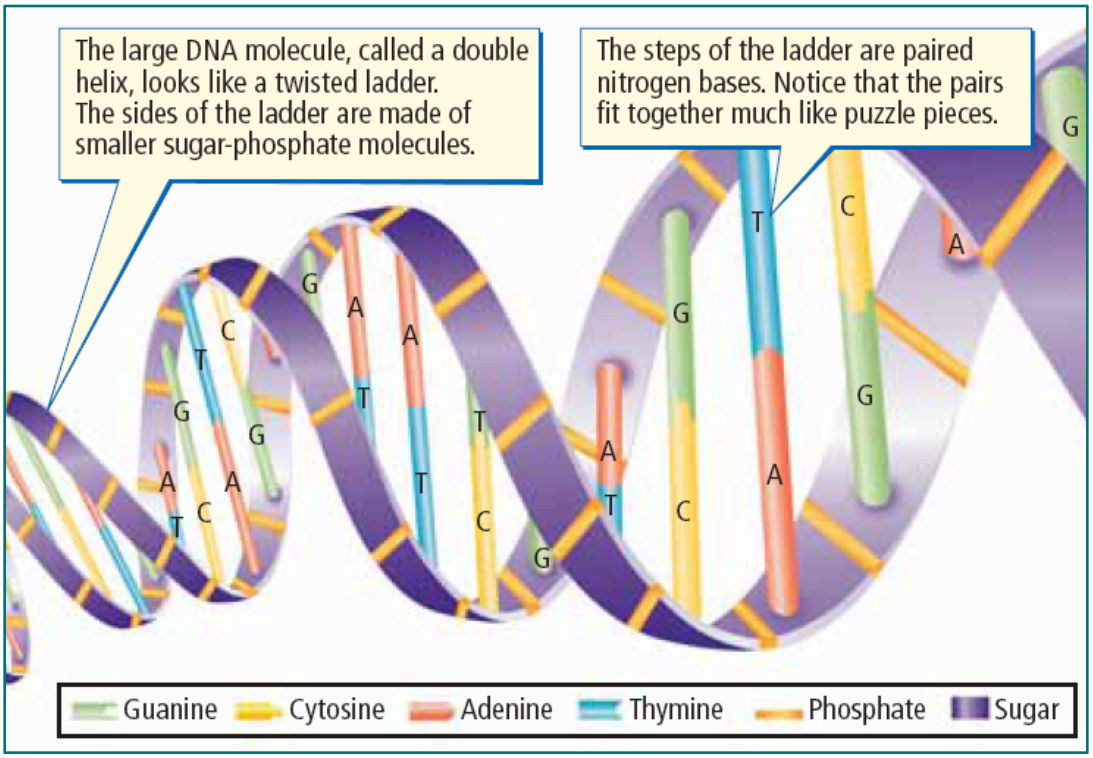
- **large vacuoles** - plant cells are equipped with a large vacuole for storing water

The Nucleus and DNA

- The nucleus contains **DNA** (**deoxyribonucleic acid**); DNA is the molecule has the master set of instructions for how cells function, what they will produce, and when they will die

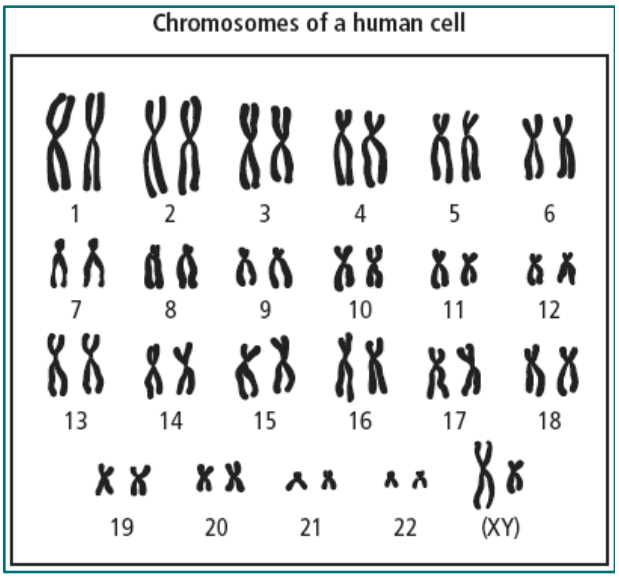
Structure of DNA

- DNA looks like a twisted ladder - two strands wrap around each other in a spiral shape (double helix)
- The sides of the DNA ladder are made of sugar and phosphate.
- The steps of the ladder are made of four nitrogen bases: adenine (A), guanine (G), cytosine (C), and thymine (T).
- The bases join in a specific way:
  - A always joins with T
  - G always joins with C



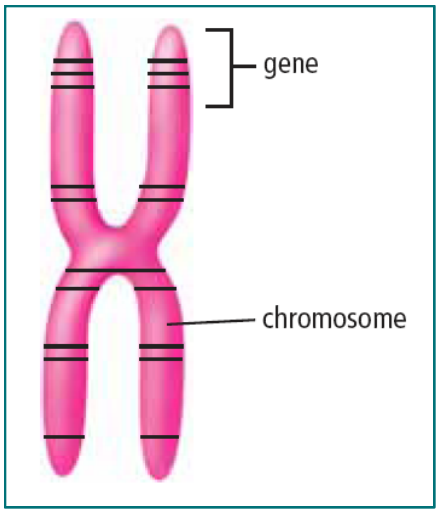
DNA in the Nucleus

- Most of the time DNA is in the form of **chromatin**
- Chromatin coils tightly into X-shaped **chromosomes**
- Every organism has a specific number of chromosomes
- Human cells have 46 chromosomes arranged in 23 pairs
- The 23rd pair determines sex; XX for females and XY for males



Genes

- **Genes** are small segments of DNA located on a chromosome
- Genes store the information needed to produce proteins
- Each chromosome can carry thousands of genes
- All your body cells have the same genes, but only specific genes are “read” in each cell to produce specific proteins



- Specialized proteins called **enzymes** and **hormones** carry out important specific functions in the body

Production of Proteins

- Protein production in the cell involves several important steps:
  1. The nucleus receives a chemical signal to make a specific protein.

2. The DNA message for the protein is copied into a small molecule called RNA.
3. RNA leaves the nucleus through a nuclear pore.
4. The RNA message is delivered to a ribosome, the ribosome makes the protein.
5. The manufactured protein enters the endoplasmic reticulum (ER).
6. A vesicle forms at the end of the ER, and carries the protein to the Golgi body.
7. The Golgi body repackages the protein for transport out of the cell.
8. A vesicle forms off the end of the Golgi body to carry the protein to the cell membrane.
9. The vesicle attaches to the cell membrane, and its protein contents are released out of the cell.

4.2 Mutation

- A **gene mutation** involves a change in the order of bases (A,C,T,G) that make up the gene. There are several types of gene mutation:
  - Deletion (base missing)
  - Addition (extra base added)
  - Substitution (one base substituted for another)
- Gene mutations may produce proteins that are beneficial or harmful to the organism, or may have no effect at all.
- Example: a particular mutated gene produces white coat Kermode bears - they occur as only a small percentage of the population (they are normally black in colour).

Effects of Mutations

- **Positive Mutation**

    - When a gene mutation benefits the individual.
    - Example: Some plants have developed resistance to bacterial and fungal infections.
- **Negative Mutation**
    - When a gene mutation harms the individual
    - Example: Sickle cell genes in affected humans cause blood cells that are abnormally shaped.
- **Neutral Mutation**
    - When a gene mutation has no effect on the individual
    - Example: The white Kermode bear

Mutagens & Mutation Repair

- **Mutagens** are substances or factors that cause mutations
- Environmental mutagens such as mercury, cigarette smoke, X-ray and UV radiation, and certain viruses can cause mutations
- Correcting mutations is difficult, but new techniques such as **gene therapy** offer hope.
- Gene therapy is complicated and experimental:
    - A virus in engineered to carry a normal gene
    - The virus must somehow be targeted to the cells with the defective gene
    - The normal gene must then replace the defective gene
    - The normal gene must then be “switched on” so that the replacement normal gene produces the proper healthy proteins. It is also important that the normal gene make the correct amount of healthy protein.