What is Biology?

What is Biology?

Biology is the study of **living things**.

There are many branches or divisions of biology, each specializing in the study of a specific group of living things.

Division	Area of Specialty
ecology	study of ecosystems
microbiology	study of cells
ethology	animal behaviour
entomology	study of insects
ichthyology	study of fish

What is a living thing?

In order for something to be considered alive it must show certain characteristics. Living things:

- are composed of cells
- require energy (for movement, repair etc…)
- grow
- respond to the environment
- have a limited life span
- produce waste (heat, carbon dioxide, urine etc…)
- produce offspring like themselves
- evolve or change over time

TEST YO!

Living things will show all of these characteristics but there are some exceptions. For example, **a horse + a donkey = a mule**.

Non-living things may show one or a few of these characteristics but not all.

Development of the Cell Theory

Throughout history people have wondered what causes life and how life is maintained. It was not until the invention of the microscope and improvements on the microscope that we were able to look at living tissues and make detailed observations.

With these observations scientists came up with a formal cell theory that is used to explain observations of living things.

1. All living things are composed of one or more cells.
2. Cells are the basic units of structure and function in all organisms.
3. All cells come from previously existing cells.

Test yo!

Historical Look at the Cell

Aristotle - Classified all known organisms into two kingdoms: plant and animal; visualizes a "ladder of life" with plants on the bottom rungs; writes that organisms can arise spontaneously from non-living matter (c334 BC)

Zachary Janssen – this Dutch eyeglass maker invented the first compound microscope, by lining up two lenses to produce extra-large images (1590)

Robert Hooke - Observed tree bark lining with a compound microscope; described the magnification as "empty room-like compartments or cells" (1665)

Anton Van Leeuwenhoek - Reports living "beasties" as small as 0.002 mm observed with a simple single lens microscope (1674)

Carl Linnaeus - Focused on discovering, naming and classifying new species from all over the world (1753)

Robert Brown - First to consider the nucleus as a regular part of the living cell (1831)

Matthias Jacob Schleiden - "All plants are made of cells" (1838)

Theodor Schwann - "All animals are made of cells" (1839)

Carl Heinrich Braun - "The cell is the basic unit of life" (1845)

Rudolph Virchow - "Cells are the last link in a great chain [that forms] tissues, organs, systems and individuals… Where a cell exists, there must have been a pre-existing cell…Throughout the whole series of living forms… there rules an eternal law of continuous development" (1858)

Loiuse Pasteur - Demonstrates that living organisms cannot arise spontaneously from non-living matter (1860)

Microscope Calculations

What every Biologist needs to know…

1. How to use a microscope
2. Estimating size using a microscope
3. Drawing scientific diagrams
4. Examining cells
5. Parts of the cell

Estimating Size Using a Microscope

Magnification

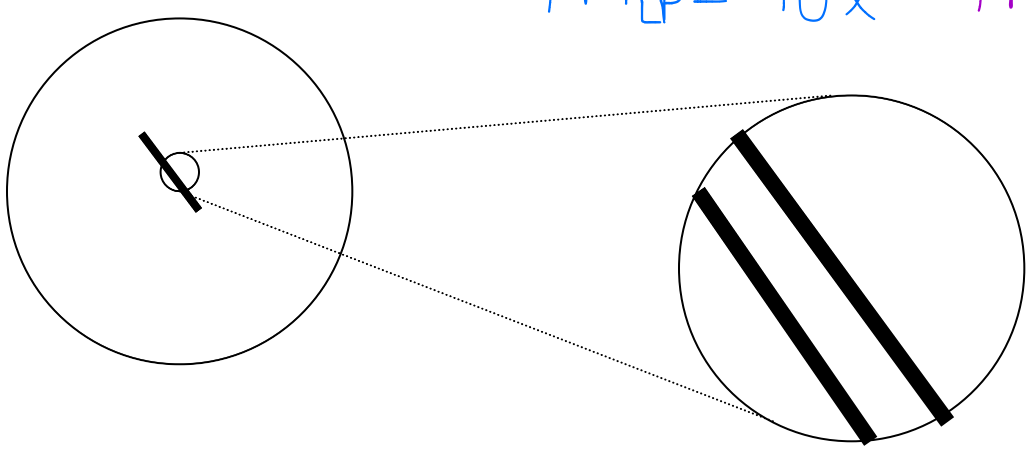
Refers to how many times bigger an object appears under the microscope

10x low 4x medium 10x High 40x

Total Magnification = ocular lens power X objective lens power

$TM_{LP} = 40x$ $TM_{MP} = 100x$

$TM_{HP} = 400x$

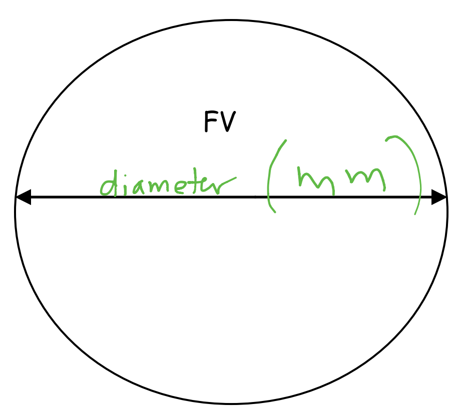


A strand of hair under two different magnifications

Field of View (FV)

Refers to the area you see through the microscope.

You can determine the FV under low power by using a ruler and measuring the area that you can see.



To determine the FV under medium and high power, you must use the following formulas:

$$FV_{MP} = FV_{LP} \times \frac{M_{LP}}{M_{MP}}$$

OR

$$FV_{HP} = FV_{LP} \times \frac{M_{LP}}{M_{HP}}$$

FV = Field of View
M = Magnification
HP = Higher power
MP = Medium power
LP = Lower power

OR: $$\frac{FV_{HP}}{FV_{LP}} = \frac{M_{LP}}{M_{HP}}$$

Example calculation

Calculate the high power field of view (x) for a microscope with:

- eyepiece lens = 10x
- low power lens= 4x
- high power lens = 40x → 1000 x
- low power field of view = 4.1 mm (= 4100 um)

$$\checkmark_1 \quad FV_{HP} = FV_{LP} \times \frac{M_{LP}}{M_{HP}}$$

$$= (4100\,\mu m) \times \frac{(40)}{(400)}$$

$$= 4100 \times \frac{1}{10}$$

$$\checkmark_2 \quad = 410\,\mu m$$

$\checkmark_3$ ∴ the FV_{HP} is 410 μm

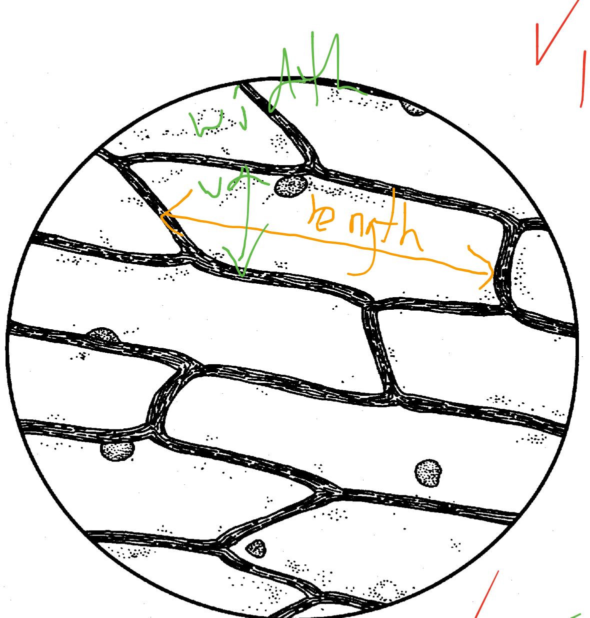
Estimating Length & Width

To estimate the size of an object under the microscope you can use the following equations:

$$\text{Estimated Size} = \frac{FV}{\# \text{ fit}}$$

Example calculation

Estimate the length and width of an onion cell below. The cells were observed under high power using the same microscope in the previous example.



$$ES_L = \frac{FV}{\# \text{fit}}$$

$$= \frac{410 \mu m}{1.5}$$

$$\doteq 27\overline{3.3} \mu m$$

$$ES_W = \frac{FV_{HP}}{\# \text{fit}}$$

$$= \frac{410 \mu m}{5}$$

$$= 82 \mu m$$

∴ the cell is 273.3 µm long x 82 µm wide

Drawing Magnification

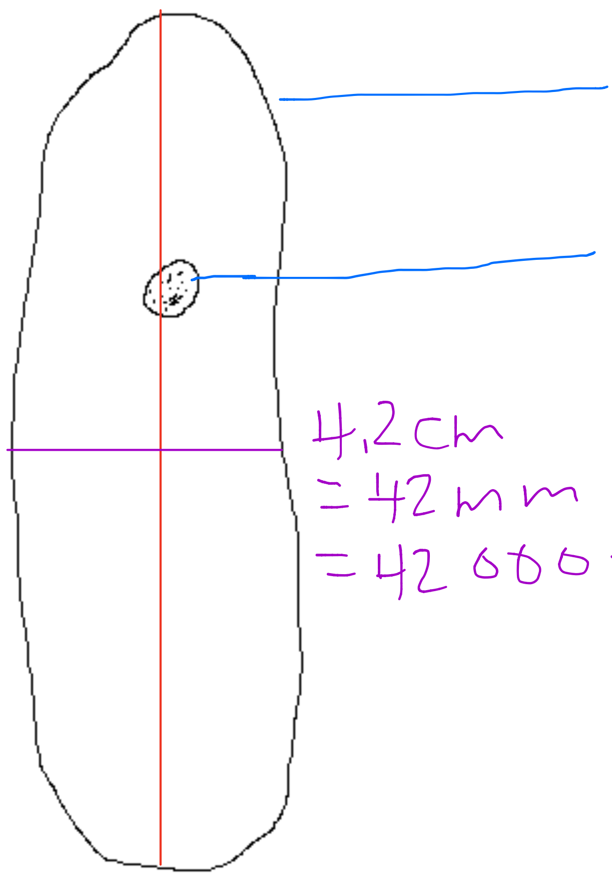
The drawing Magnification represents how big your diagram is in relation to the actual cell size. Example: a model car

$$\text{Drawing Magnification} = \frac{\text{dimensions of cell diagram}}{\text{dimensions of actual cell}}$$

DM

You must use either length or width for your dimensions.

Onion Cell under high power



4.2 cm
= 42 mm
= 42 000 μm

15.7 cm
= 157 mm
= 157 000 μm

$$DM_L = \frac{CD_L}{AC_L}$$

$$= \frac{157000\,\mu m}{273.3\,\mu m}$$

$$= 574.46\,X$$

$$DM_W = \frac{CD_W}{AC_W}$$

$$= \frac{42000\,\mu m}{82\,\mu m}$$

$$= 512.19\,X$$

How to Prepare a Wet Mount

1. Place the specimen in the centre of a clean slide.

2. Using a medicine dropper, add a drop of water directly over the specimen.

3. Position a cover slip at a 45° angle to the slide so that the edge of the cover slip is touching the water.

4. Slowly and carefully lower the cover slip over the specimen. Make sure not to trap any air bubbles under the cover slip.

5. To add some stain to your sample, place a drop of stain on one side of the cover slip and a piece of paper towel on the opposite side. Capillary action will draw the stain across the specimen.

SNC2DI
SCIENTIFIC DRAWINGS

The main requirements in scientific drawing are that a student be able to produce neat accurate outline drawings that show:

(a) Accurate shape (b) Accurate proportions (c) Accurate spatial relationships (d) Organization

A drawing is a communication from the drawer to the viewer... In order to aid the view, the following are required of your drawings:

1. Substantial size i.e. ½ - 1 page.

2. Labels neatly arranged and aligned down the right margin.

3. Structures that are drawn but that cannot be identified should be labeled as "unknown" (since they were present they must be shown).

4. Magnification should be indicated in the title and the lower right corner.

5. A descriptive, underlined title should be used above each drawing.
   Example: <u>Onion Cells on Low Power Using Iodine Stain</u>

6. All work including labels must be in <u>PENCIL</u>. This allows for corrections and reduces blurs and smudges.

7. Remove smudges and errors completely, with a good eraser, when they occur.

8. Always work on blank paper. This adds clarity and is generally less distracting.

9. Use a ruler whenever required - label lines, underlining, guiding pencil in a straight line when printing labels. NEVER use a ruler to draw parts of your diagrams unless they contain absolutely straight lines (in Biology this will not occur for microscope work).

10. Use straight thin label lines <u>without arrowheads</u>. Do not cross label lines.

11. Draw in <u>magnified form</u> exactly what you see (with regard to shape, size, nearby objects (spatial. relationships).

12. Do not underline labels.

13. Use small printed "clarification" notes in the lower left corner of diagrams to record information about the diagrams that cannot be shown on the diagram

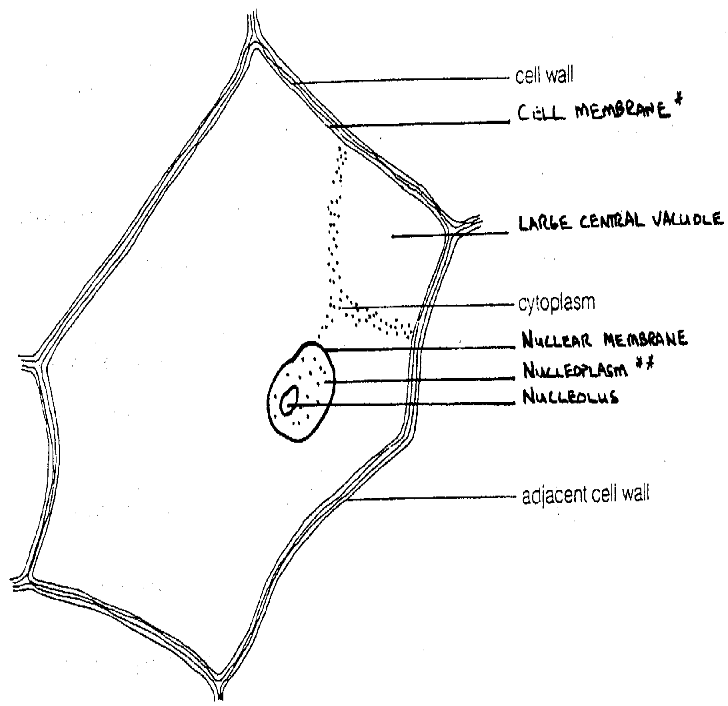
Examples: slide staining, colour(s), actual measured size of structures when measuring required.

Sample Proper Scientific Diagram
Marking Scheme

1. Is the diagram done in pencil?	0 1
2. Does the diagram include a descriptive title?	0 1
3. Does the diagram include "clarification" notes?	0 1
4. Are all labels neatly arranged and aligned down the right margin?	0 1
5. Is the microscope magnification, drawing magnification and size of the object present and correct?	0 1 2 3
6. Is all appropriate identification information present ? (-1 mark per label missing)	0 1 2 3

TOTAL /10

SINGLE ONION CELL SHOWN UNDER HIGH POWER WITH IODINE STAIN



NOTES:

1. *CELL MEMBRANE NOT ACTUALLY SEEN, TOO THIN, AGAINST CELL WALL.
2. **CHROMOSOMES NOT INDIVIDUALLY VISIBLE IN NUCLEOPLASM.

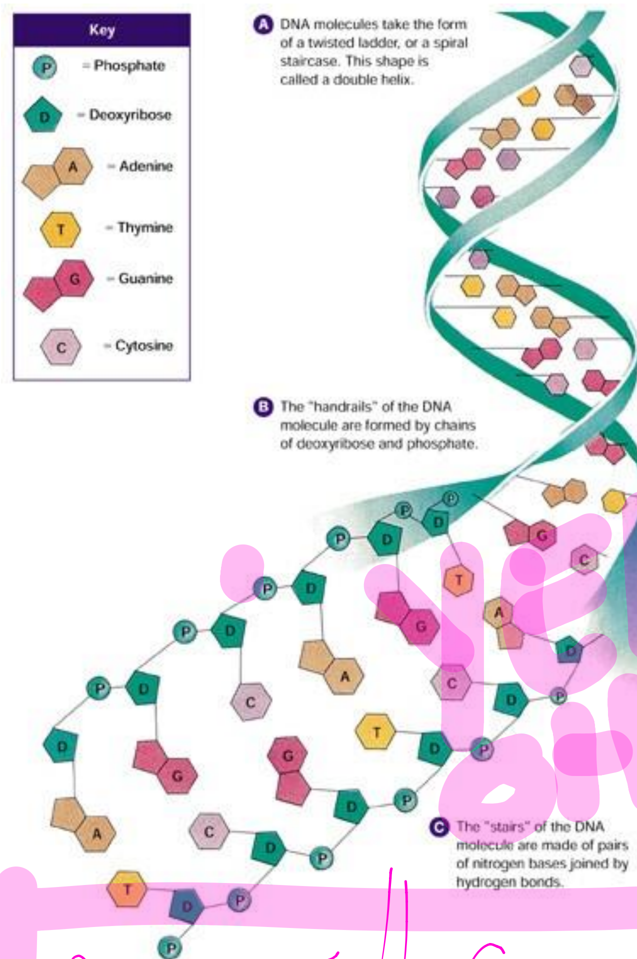
(3. DESCRIPTION OF STAIN COLOUR FOR VARIOUS ORGANELLES)

MICROSCOPE MAGNIFICATION:
DRAWING MAGNIFICATION: 9

What is DNA?

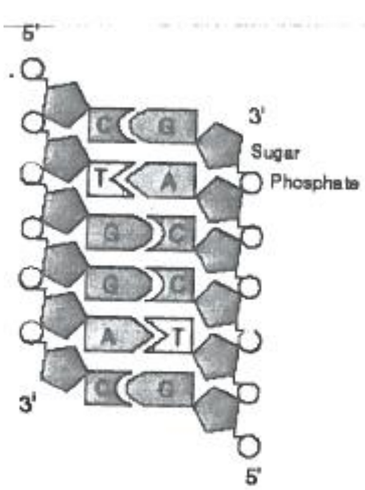
DNA stands for **deoxyribonucleic acid**. It is a large molecule that is used as a storage site for genetic information and contains all of the instructions needed for the proper **development**, **structure** and **function** of an organism.

DNA is found within the **nucleus** and comes in a few different forms, most notably in the form of a **chromosome**. Every plant and animal species has a specific number of chromosomes in the nucleus of each cell. Human cells have **46** chromosomes in each body cell; 23 that originated from the mother's **egg** and 23 from the father's **sperm**.



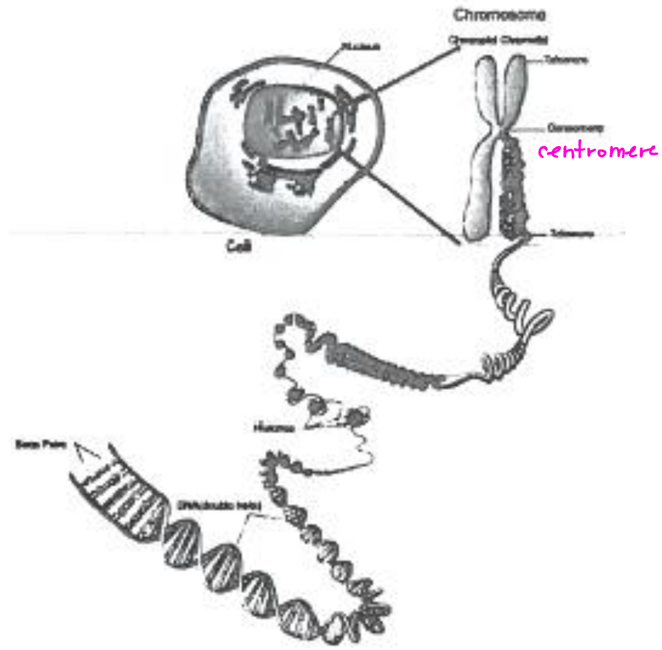
DNA is made up of paired **nucleotides**, which are arranged into a **double helix** structure. A nucleotide is composed of three parts; a **sugar** molecule, a **phosphate** molecule and a **nitrogenous** base. There are 4 different types of nitrogenous bases found in DNA; **adenine**, **thymine**, **cytosine** and **guanine**.

The structure of DNA is similar to a twisted **ladder**. Alternating sugar and phosphate components make-up the "**backbone**" of the DNA double helix.

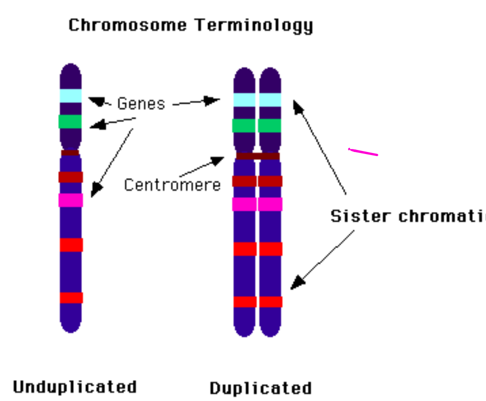


The nitrogenous bases pair-up to make what looks like **rungs on a ladder**. The nitrogen bases fit together like **puzzle** pieces. Adenine will always pair with thymine, while guanine will always pair with cytosine. This means if you know what one strand of the double helix is, you can determine the **complementary strand**. It is the **order** of A, G, C and T that will determine the type of **protein** that is produced.

If the DNA contained in one single human cell was stretched out it would be about **2m** long. In order to fit into the cell, DNA coils up into a tight structure called **chromatin**. When cells are preparing to divide, they make an exact copy of their DNA through a process called DNA **replication**. The DNA then arranges into **chromosomes** in which two pieces of tightly wound DNA associate together and are attached at the centre by a structure called a **centromere**.



DNA is separated into sections called **genes**. Genes are located in specific places on a DNA molecule and provide the instructions for making **proteins**. Therefore, DNA and genes control a cell's activities by controlling what proteins are made when. Humans have approximately **20 000** genes. One of the first animal's sequenced back in 2000, was the fruit fly and it has approximately **13,000** genes.



Each individual human has a unique sequence of DNA from all other humans (except identical twins), however **99.9%** of our DNA is the same. All human DNA is arranged into the same set of genes, however there are small differences in the **pattern** of nitrogen bases within these genes that result in differing traits. Between humans and one of our closest related species, the chimpanzee, approximately **98%** of our DNA is the same.

Cell Division

You are made up of approximately 100 trillion cells. This is amazing considering that all these cells started from one fertilized egg. Even now cells are dividing in your body! Cell division is needed for:

3

1. Growth - **organisms increase in size by creating more cells**
2. Repair and Regeneration - **old and damaged tissue is replaced by new cells**
3. Reproduction – **single celled organisms reproduce by splitting in two**

How does cell division occur?

Cell division occurs in three stages:

1. Replication – **Making an exact copy of DNA**

   The replication process must be relatively **quick** and it must be **accurate** for cells to survive. Remarkably, cells are able to duplicate their DNA in a few **hours**, with an error rate of approximately **one** per **billion** nucleotide pair!

2. Mitosis - **The division of chromosomes in the nucleus**
3. Cytokinesis - **The division of the cytoplasm and cell organelles**

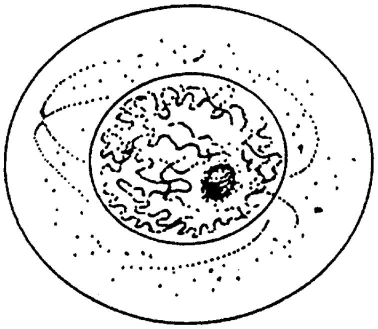
The end result of these stages are **TWO identical cells** from one original cell.

daughter

In order to describe the events of the cell cycle, the process has been divided into several phases:

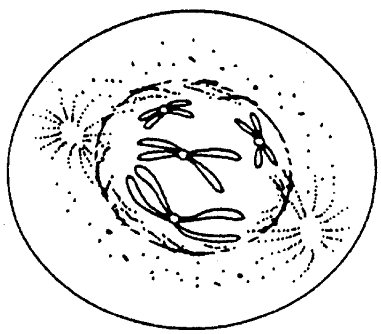
IPMAT

INTERPHASE:



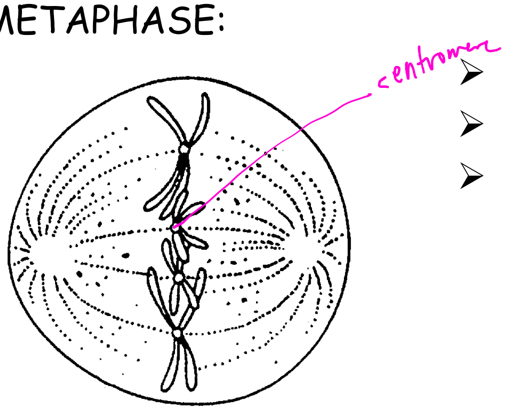
- The cell is doing its **job** (normal cell activities)
- **DNA** in the form of **chromatin** – cannot be seen
- Cell grows
- At the end of interphase the DNA has **replicated**
- Most of the cell's life is spent here

PROPHASE:

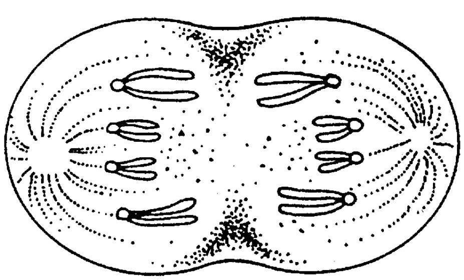


- **Nuclear membrane** disappears
- **Nucleolus** disappears
- DNA **shortens** and **thickens** and becomes visible - **chromsomes**
- **Spindle fibres** form and can be seen
- **Centrioles** move apart

METAPHASE:



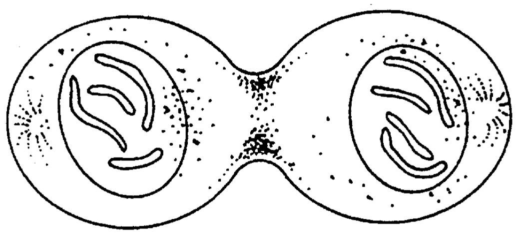
- Chromosomes line up at **equator** of cell
- Centrioles are located at **poles**
- Spindle fibres attach to **centromeres** and centrioles



ANAPHASE:

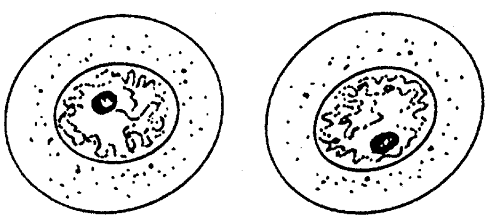
- Centromeres **split** and single-stranded **chromatid** move to opposite poles
- Pulled by spindle fibres

TELOPHASE:



- Opposite of **prophase:**
  - **Nuclear membrane** reappears
  - **Nucleolus** reappears
  - **Spindle fibres** disappears
  - Chromatid become **longer** and **thinner** and cannot be seen (**chromatin**)

FINAL RESULT OF CELL DIVISION:



- **Cytokinesis** occurs (division of cytoplasm)
- Two **genetically identically daughter** cells are produced

Cancer

The DNA in the **nucleus** of each of the cells in your body is **identical**. DNA is like software that determines what you look like. It also controls all of the **functions** within the cells and in your body. The information encoded in this software comes from both of your **parents**. Usually, the software runs smoothly and the program works as it should. However, sometimes "**bugs**" develop in the software and problems occur.

The cell cycle is controlled by a communication system that involves **chemical** signals. If a cell ignores a signal to stop dividing, unchecked cell **growth** can result…called a **Tumor**.

A **mutation** is a permanent change in a cell's **DNA**. All tumours start with a mutation that affects a cell's response to division signals. This mutation is passed on to other cells during **mitosis**.

Mutations may be:

(i) **Inherited** (i.e., breast cancer)
(ii) **Random**
(iii) A result of exposure to **environmental factors** (i.e., UV light and radiation)
(iv) Due to exposure to **chemicals** (i.e., cigarettes, alcohol, drugs)
(v) **Viruses** (i.e., HPV)

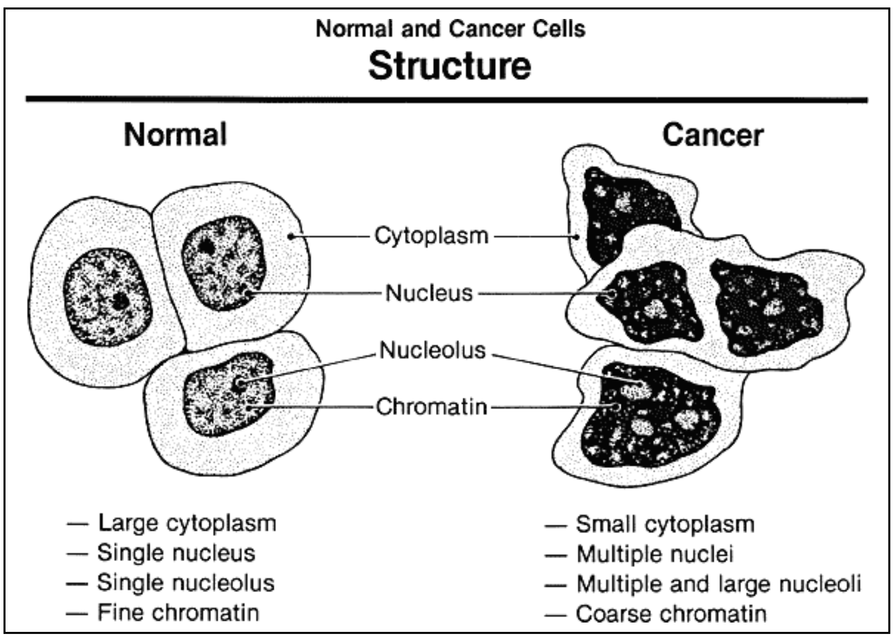
Normal body cells **grow and divide and then eventually die**. Cancer cells just **continue to grow and divide rapidly**. Some mutations are **BENIGN** (not life-threatening), while others are **MALIGNANT** or cancerous.

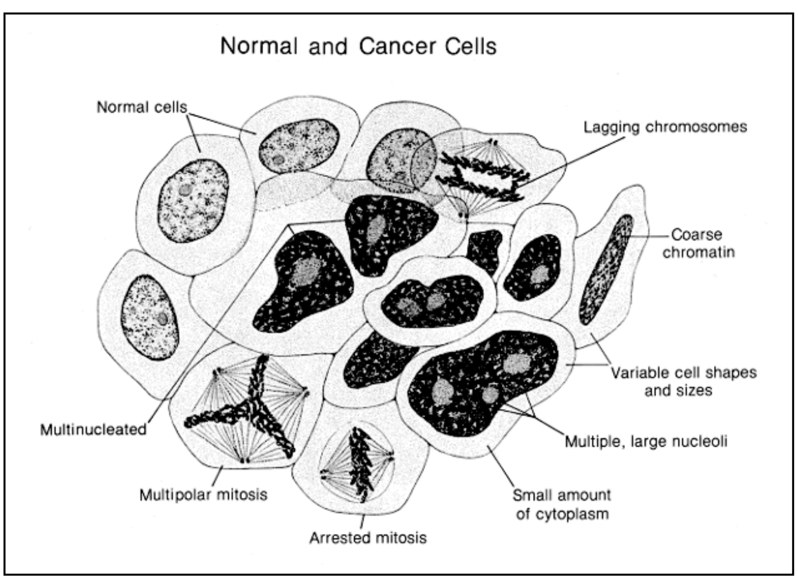
Tumour	Characteristics
Benign	• Cell division is **unchecked** and proceeds at a **moderate** rate • Does **not invade** surrounding cells, but may **push** nearby cells out of the way • Does **not spread** to other parts of the body • Relatively **harmless** unless found in a part of the body, such as the brain, where it may press on other cells
Cancer (Malignant Tumour)	• Cell division is **unchecked** and occurs very **quickly**. Cells spend little time in **interphase** • **Damages and destroys** surrounding cells by invading them • Can **spread** to other parts of the body • May **interfere** with the function of other cells, sometimes resulting in death if the tumour is not destroyed or removed

Cancer Cells

Cells are usually in **contact** with other cells and tend to **stick** together. This contact is required for cells to divide. **Normal** cells **cannot** divide when they are **separated** from one another, but **cancer cells can**. Another problem with cancer cells is that they **do not** stick together or stick to normal cells very well. Cancer cells may separate and move and begin dividing in other parts of the body. This makes cancer **hard to control**.

There are many different types of cells in the body. Each type carries out a **specialized function**. One important difference between cancer cells and normal cells is that **cancer cells do not become specialized** as they grow. They **use up energy** from food but do not carry out the work of normal cells. Also, if a tumour grows large enough, it can **interfere** with the normal function of other **cells, tissues, and organs**.





Cell Specialization and Stem Cells

Cell Specialization

Single celled organisms, like the amoeba, are simple organisms and are able of carrying out all of the essential life functions to survive on their own. Complex, multicellular organisms, like plants and animals divide the tasks needed for survival into groups of **specialized cells**.

Following cell division, each new daughter cell that is created is an exact copy of each other. Each cell contains a **complete** copy of **identical DNA** and the ability to perform any function within the organism. ***So what determines how each cell will become specialized?***

In animals, three main factors influence the differentiation of cells:

1. ➢ **the contents of the cell's cytoplasm - greater vacuoles, greater energy as it grows**
2. ➢ **environmental conditions - example, temperature**, pH
3. ➢ **the influence of neighbouring cells**

When a cell becomes specialized, some of the non-essential **genes** (coding areas of DNA) get, "**turned off**". Those genes that are required to carry out their specific job (ex. muscle cell) remain "turned on" and will remain that way for the cells entire life. It does not normally change to become a different type of cell.

Stem Cells

Stem cells are **unspecialized** cells that can produce various types of specialized cells.

Some animals like the starfish or salamander have stem cells that allow them to **regenerate** some body parts. Humans can replace only a small amount of **tissue**, such as that needed for **bone** and **skin repair**. Human organs are formed in the **embryo** and the body cannot produce new ones.

As embryos, humans have **totipotent** stem cells, which can become **any kind** of cell in the body. As the embryo develops, its stem cells become **pluripotent**. Theses cells are **less versatile** and can produce many, but not all types of cells. After birth, humans have **adult stem cells** which can produce only **specific kinds** of cells. Adult stem cells can be found in various places in the body, but are abundant within the **bone marrow** (interior of large bones where blood is produced).

The use of **embryonic** stem cells has enormous potential for **research** and **medical treatments**, however the means by which they are obtained are considered **unethical** by many.

Levels of Organization

The human body is structured into **systems**. Recall that cells are the smallest units of life. Cells that are similar in **shape** and **function** work together as **tissue**. The human body has four primary kinds of tissue:

Epithelial tissue – covers and protects the body, organs and body cavities

Connective tissue – provides support and holds the body together
Examples: cartilage, bone, fat and blood

Muscle tissue – contains sheets or bundles of muscle cells to produce movement

Nervous tissue – provides communication between all body structures

Different types of tissues work together to form **organs**, which carry out particular functions. Examples include, **heart**, **liver**, **pancreas** and **stomach.**

Organs cannot do all of the necessary work to sustain the body on their own. They must work together with other organs with related functions (**physiology**) or structures (**anatomy**). This is referred to as an **organ system**.

The following is a list of the body's major organ systems and their functions:

Organ System	Major Organs	Major Function
Digestive	Esophagus, stomach, intestines, liver, pancreas	Physical and chemical breakdown of food
Circulatory	Heart, blood vessels	Transportation of nutrients, gases and waste; defence against infection
Respiratory	Lungs, trachea, blood vessels	Gas exchange
Reproductive	Testes, vas deferens, ovaries, uterus, fallopian tubes	Sexual reproduction
Excretory	Kidney, bladder, ureter, urethra	Removal of waste
Locomotion	Bones, muscles	Movement of body and body parts
Endocrine	Pancreas, pituitary gland, adrenal glands	Coordination and chemical regulation of body activities
Nervous	Brain, spinal cord, eyes, ears, nose, tongue, nerves	Response to environment; control of body activities

Human Organ Systems

Digestive System

Digestion is a complex process, which results in food being broken down into its component molecules. It involves:

1) Mechanical (Physical) Digestion

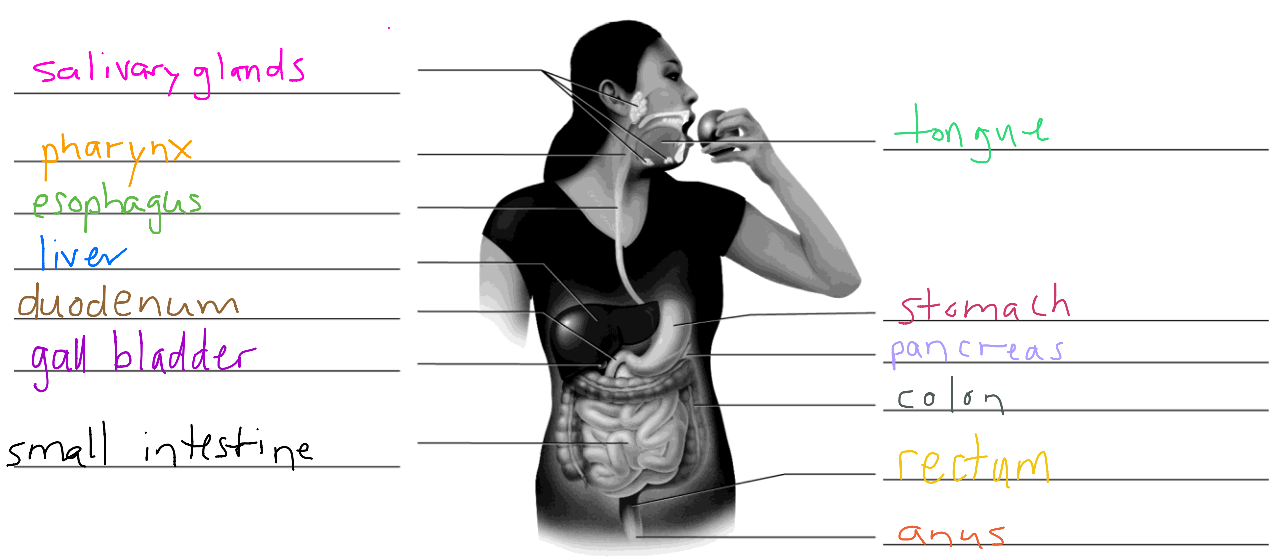
- **Physically breaking the food into small pieces and mixing it with liquids**
- **No enzymes are necessary and no energy is released**

2) Chemical Digestion

- **Digestive enzymes help split specific chemical bonds holding the food molecules together**
- **Once split up, molecules must be small enough to be absorbed into the bloodstream and, in turn, into the cells of the body**

*In humans, the digestion process takes about **24-33** hours and requires passage through an extremely long tube system **(alimentary canal),** separated into distinct regions that perform specific functions.*

Parts of the Digestive System



Functions of the Digestive System

Part	Function
Salivary glands	- Secretes saliva - Assists in chemical digestion and lubricates food
Esophagus	- Moves food to stomach by peristalsis
Stomach	- Mechanical digestion and chemical digestion
Small Intestine	- Complete chemical digestion and absorb nutrients
Large Intestine Rectum Anus	- Reabsorb water and minerals - Feces stored in rectum - Elimination of waste

The Mouth (Ingestion)

Both **physical** breakdown and **chemical** digestion occur in the mouth. The teeth are important for **physical** digestion.

Human teeth

Type of Tooth	Number	Function
Incisor	8	Cutting
Canine	4	Tearing
Premolars	8	Grinding
Molars	8	Crushing
Wisdom	4	Crushing

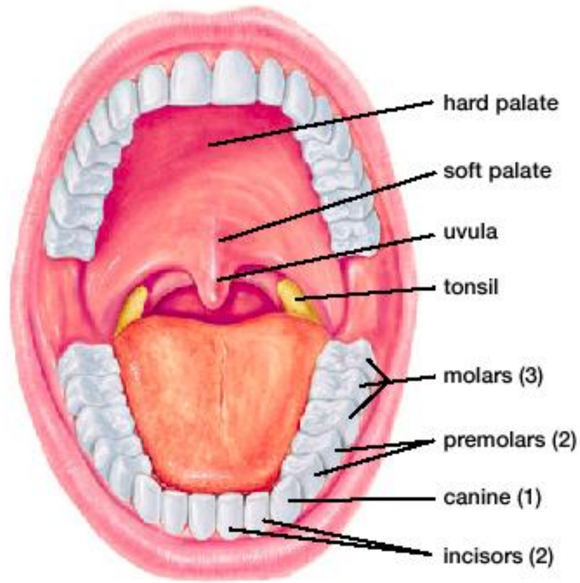


Figure 10.11 This illustration of the human mouth shows the number, type, and arrangement of the teeth, plus other details.

Chemical digestion begins as food is chewed, and it begins to mix with **saliva** produced by the three salivary glands.

Some functions of saliva include:

- It wets and **lubricates** so food can be swallowed easier
- It causes the food particles to stick together to form a food mass, or **bolus**
- It contains a digestive enzyme **salivary amylase**, which breaks down starch into simple carbohydrates

The Esophagus

No digestion, neither physical nor chemical occurs in the esophagus. It secretes **mucin,** a lubricant which aids the bolus of food in its journey to the stomach.

The movement of food down the digestive tube is aided by rhythmic muscle contractions called **peristalsis**.

The Stomach

The stomach is the site for temporarily storage of **food**. Both **physical** breakdown and **chemical** digestion occurs here. Physically the stomach has a **J-shaped** appearance and can hold up to **1.5 L** of food.

In the stomach, food is broken down mechanically into smaller particles by the **contractions** of the **muscular** stomach walls (**oblique** muscles). This is referred to as **churning**. The food mass is mixed with **hydrochloric acid** (**HCl**). The lining of the stomach is covered by a layer of **mucus** to protect it from the acidic environment.

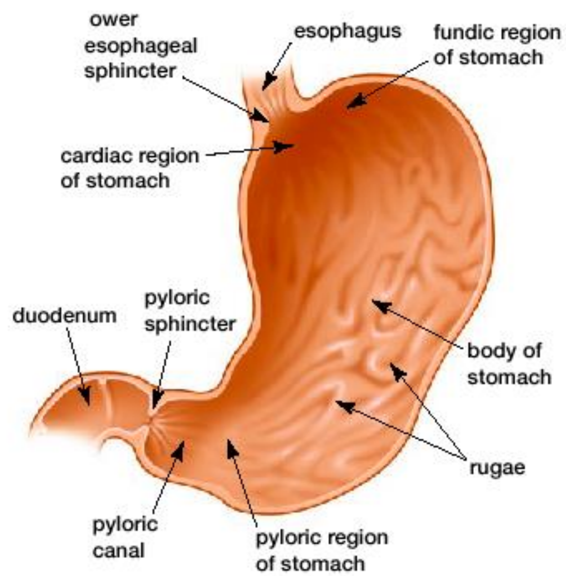


Figure 10.13 A cross sectional view of the stomach. Note the multitude of folds called rugae on the inner walls, and the esophageal and pyloric sphincters.

The Small Intestine

Most **chemical** digestion and almost **all absorption** of nutrients occur here. After food leaves the stomach, it enters the first part of the small intestine called the **duodenum**. At this stage, the partially digested food is called **chyme**. When chyme reaches the duodenum, it stimulates the production of enzymes from the **pancreas** and **liver** that aid in chemical digestion. These enzymes empty into the duodenum. The **pancreas** produces the **most enzymes** need for digestion, along with the hormones **insulin** and **glucagon** which help to regulate **blood-sugar levels**. The **liver** produces **bile,** an **emulsifying** agent needed for the physical digestion of **fats.**

↳ breaks down fat

The remainder of the small intestine (ileum and jejunum) is where the **absorption** of **nutrients** occurs.

The Large Intestine

Undigested and **unabsorbed** materials pass from the small intestine into the large intestine. No digestion occurs in this portion of the digestive system.

Functions of the large intestine include:

1. Reabsorption of **water** from the food mass
2. Absorption of vitamins **B** and **K** produced by live **bacteria** in the large intestine

Fecal matter (undigested material) is stored in the last part of the large intestine, the **rectum**, and periodically eliminated, or **defecated**, through the **anus**.

Human Organ Systems Continued...

Respiratory System

There are several stages and forms of respiration:

1. **Breathing** - moving air into and out of lungs (inhalation/exhalation)

2. **External Respiration** - exchange of O_2 and CO_2 between air and lungs (blood). (Occurs by diffusion)

3. **Circulation** - movement of dissolved gases by the blood to and from the body cells.

4. **Internal Respiration** - exchange of CO_2 and O_2 between blood and body cells. (Occurs by diffusion)

5. **Cellular Respiration** - nutrients are broken down and released in the mitochondria of cells.

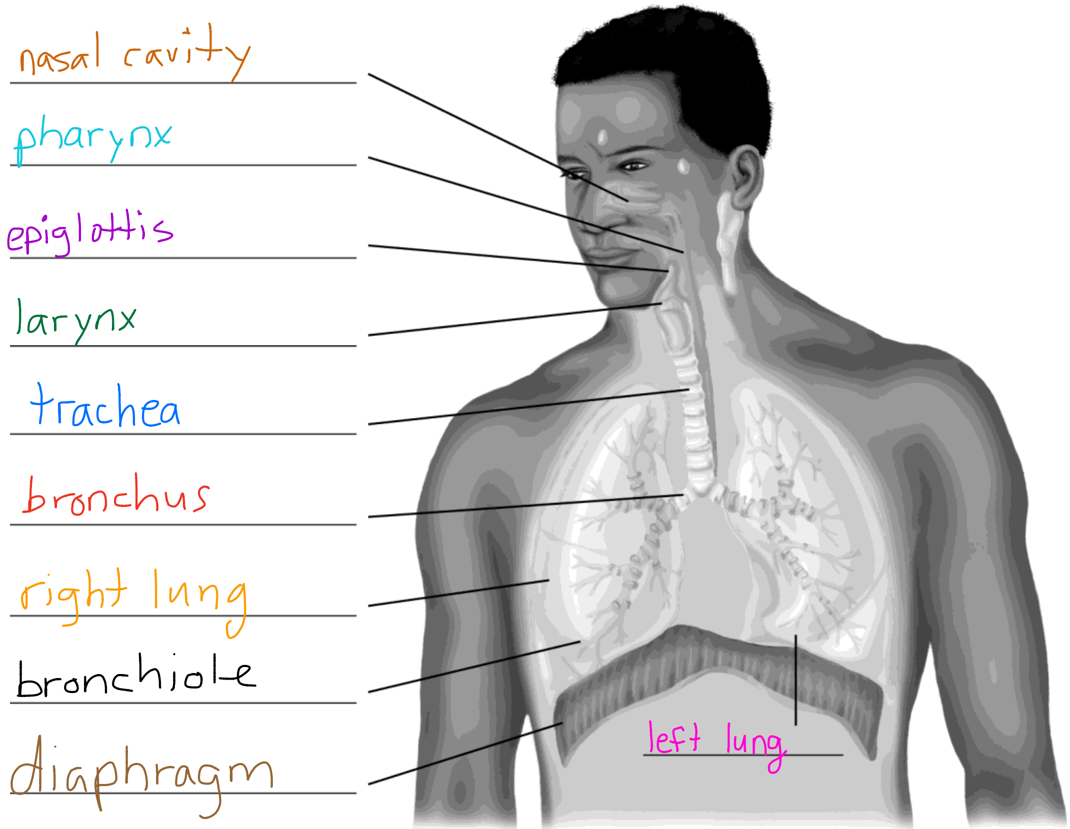
   Glucose + Oxygen → Carbon dioxide + water + Energy (ATP)

The Respiratory Surface

The respiratory surface must have the following characteristics:

- It must be **thin walled** so **diffusion** occurs rapidly
- It must be **moist** so that oxygen and carbon dioxide will **dissolve**
- It must be in contact with an environmental source of **oxygen**
- In most multi-cellular organisms it must be in close contact with a **transport** system
- It must have a large **surface area**

Parts of the Respiratory System



Functions of the Respiratory System

Part	Function
Nasal Cavity	Filters, warms and moistens air
Trachea	Passage of air to the bronchi Surrounded by cartilage Regulated by the epiglottis
Bronchi	Passage of air to broncioles Mucous filters foreign material
Bronchiole	Passage of air to alveoli Extensive branching to increase surface area
Alveoli	Location for gas exchange Thin membrane surrounded by capillaries (blood vessels)
Diaphragm	Thin muscle Regulates the volume of the chest cavity for breathing

Human Organ Systems Continued...

Circulatory System

Circulation is the movement of materials within an organism.

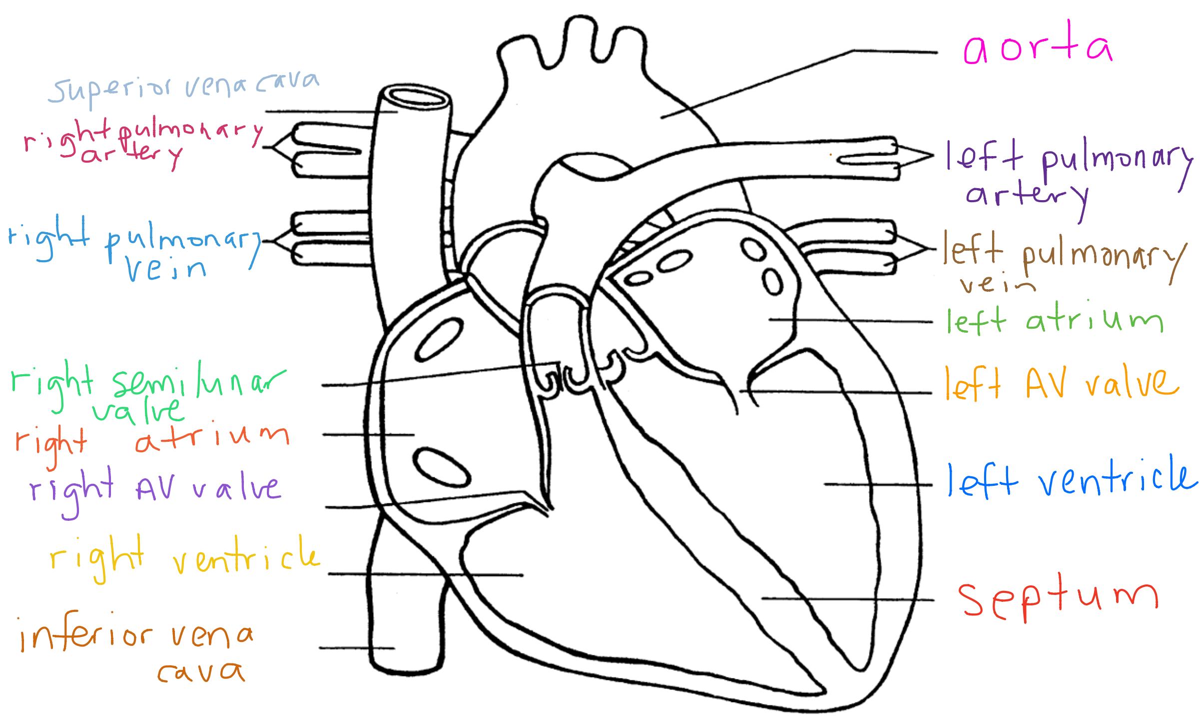
A circulatory system usually consists of:

1) A **fluid** in which materials are **dissolved** (**plasma**)
2) A network of **tubes** or body spaces in which the fluid flows (**vessels**)
3) A means of driving or moving the fluid (**pump**)

Humans (like many other vertebrates) have a **closed**, **double** circulatory system:

The Heart

- The human heart pumps constantly (average of **70** times/minute)
- **90 000** times per day
- With each beat it pumps blood about through about **160 000 km** of vessels



Part	Function
Atria	Chamber of the heart that collects blood flowing into the heart. The right atrium receives blood from the systemic circulation while the left atrium receives blood from the pulmonary circulation
Ventricle	Chamber of the heart that collects blood to be pumped away from the heart. The right ventricle pumps blood to the pulmonary circulation while the left ventricle pumps blood into the systemic circulation
Septum	The wall that separates the right and left ventricles of the heart
Valves	Regulates blood flow
Aorta	The main blood vessel that carries blood from the heart into the systemic circulation
Pulmonary Artery	The artery that carries blood from the right ventricle of the heart to the lungs
Pulmonary Vein	The vein that carries oxygenated blood from the lungs back to the left atrium of the heart
Superior Vena Cava	The main blood vessel that collects blood from the systemic circulation of the body (upper) and returns it to the right atrium of the heart
Inferior Vena Cava	The main blood vessel that collects blood from the systemic circulation of the body (lower) and returns it to the right atrium of the heart

- The route taken by the blood within the heart is called **cardiac circulation.**
- The pathway of the blood from the heart to the lungs is called **pulmonary circulation.**
- The movement from the heart to the rest of the body is called **systemic circulation.**

MC

Blood Vessels

Arteries (usually high O_2, low CO_2)

- Carries blood **away** from the heart to the **body tissues**
- **Thick muscle** layer and **elastic** walls
- When the walls **expand** then **contract**, they help to **propel** blood through the arteries

Veins (usually low O_2, high CO_2)

- Carries blood **to** the heart from **organs** and **tissues**
- **Thin muscle** layer and slightly **elastic** walls
- Contain flap-like **valves** to prevent **backflow** of blood – defective valves can cause blood to pool and result in **varicose veins**
- **Muscle contraction** around the veins help to keep the blood moving back to the heart.

Capillaries

- The smallest vessels
- The **arterioles** and **venules** are connected by a network of microscopic capillaries
- **One cell thick** and allow for exchange of materials between cells and the blood by **diffusion**

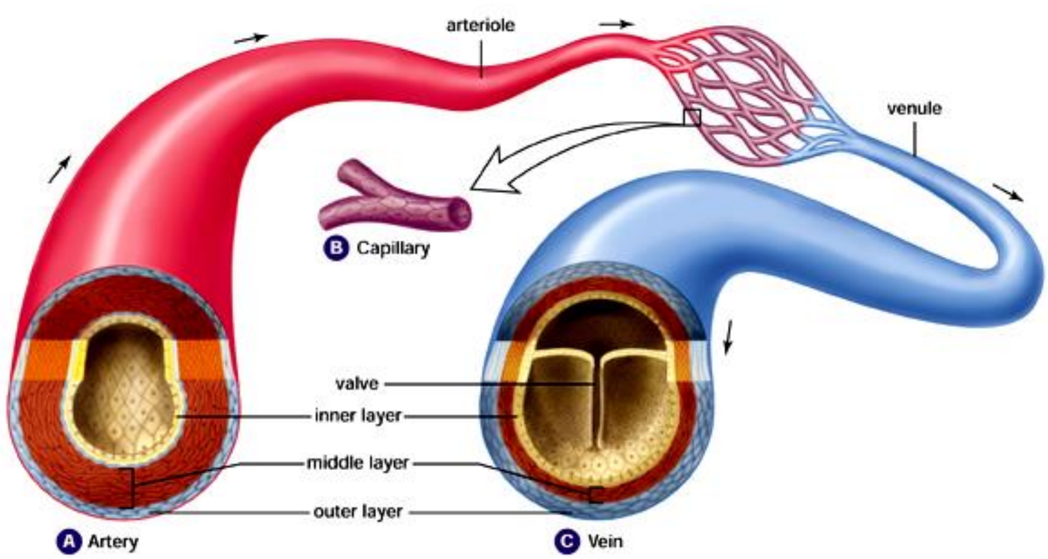


Figure 9.12. Sections through an artery, capillary, and vein. At any given moment, about 30% of the blood in your systemic circulation will be found in the arteries, 5% in the capillaries, and 65% in the veins.

Blood Components

Table 9.2
Cellular components of blood

Point of comparison	Red blood cells	White blood cells		Platelets
		Leucocytes	Lymphocytes	
Origin	red bone marrow	red bone marrow	spleen, lymph glands	red bone marrow, lungs
Cells present per mm^3 of blood (approx.)	5 500 000 (male) 4 500 000 (female)	6000	2000	250 000
Relative size	small (8 µm diameter)	largest (up to 25 µm)	large (10 µm)	smallest (2 µm)
Function	to carry oxygen and carbon dioxide to and from cells	to engulf foreign particles	to play a role in the formation of antibodies	to play a role in the clotting of blood
Life span	120 days	a few hours to a few days	unknown	7–8 days
				

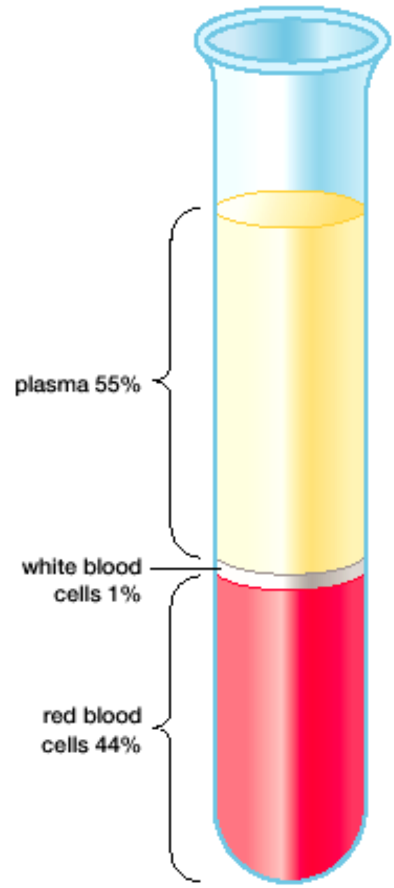


Figure 9.14 A medical device can be used to separate the three main components of the blood. When the blood is separated it settles into layers as shown here.

<u>Plant Tissues</u>

Recall, in Humans:

- There are nerve tissue, connective tissue, muscle tissue and epithelial tissue
- These tissues combine to make up our major organs like the heart, lungs, skin

Plants also have tissues and these tissues make up organs. The tissues of a plant are:

- Epidermal tissue (covering)
- Ground tissue (storing, support, photosynthesis)
- Vascular tissue (transport)

The organs of a plant include:

- The Stems
- The Roots
- The Leaves

Epidermal Tissue

Produces structures such as, the **cuticle** which is a clear outer coating. It protects against water loss, protects against infection and restricts gas exchange.

Produce specialized cells such as **root hairs** for absorption and **guard cells** for gas exchange.

Ground Tissue (internal non-vascular tissue)

There are three types of ground tissue:

a) Parenchyma (storage, photosynthesis)
b) Collenchyma (support)
c) Sclerenchyma (support)

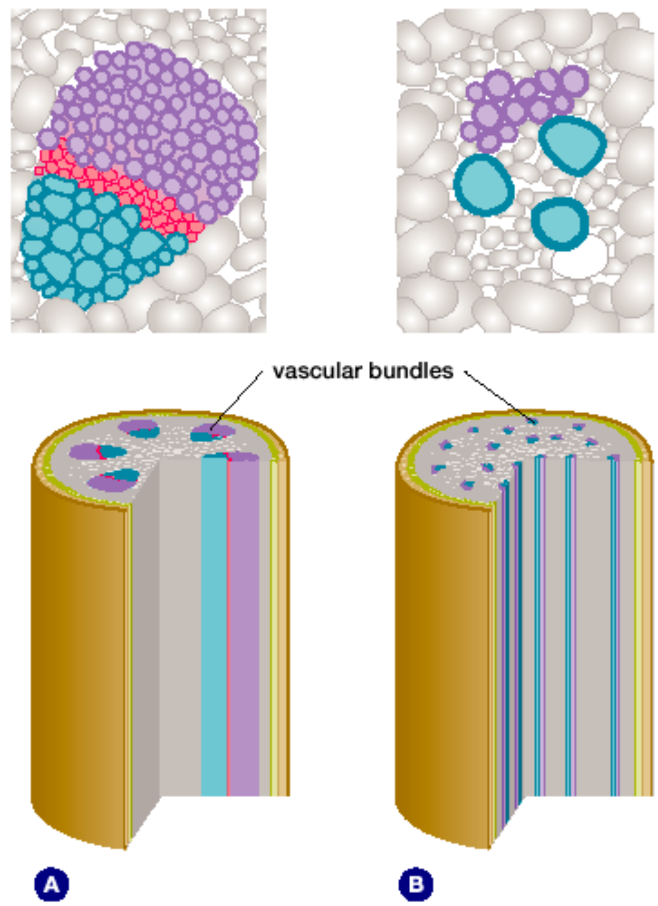


Figure 14.15 Locate the vascular bundles in the stem cross-sections of a typical dicot (A) and a typical monocot (B).

Vascular Tissue

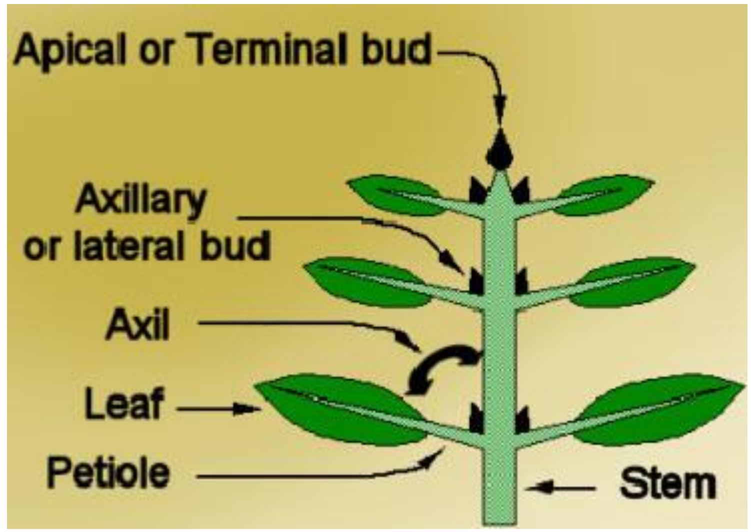
These are specialized tissue for **transporting** material from one location to another. Vascular tissues are located in the **vascular bundles.**

Vascular bundles contain two groups of tissue:

a) Xylem - transports **water** and dissolved **minerals**
b) Phloem - transports sugars in the form of **sucrose**

Specialized Cells and Tissues in Plants

A healthy plant is always growing and making new specialized cells – except when dormant during **cold** or very **hot** weather.



Meristematic cells are the **stem** cells of plants. They are undifferentiated cells that can develop into a variety of cell types in the plant and are found in various locations. Unlike animals, plants form new organs periodically throughout their lives.

Meristematic cells in the roots are responsible for elongating the root; deeper or wider underground. In the stem there are **terminal buds** responsible for the plant growing **up** and **lateral buds** for developing new **branches**. A bud is a swelling of the stem that contains new, not yet developed tissues. A plant's most active growth occurs near the **terminal** bud. Plants release a chemical called **auxin** which controls the cells below and behind them.

Just like humans and animals, plant tissues and organs can be attacked by **bacteria** and **viruses**. In addition plants are also susceptible to developing **cancer**. Plant **galls** are similar to **tumors**. Galls are produced by the abnormal growth of cells, usually in response to **infection** by another organism. One major difference between plant and human tumors is that galls do not normally **spread** to other tissues and is seldom **fatal**.

Movement of Water

Water moves through a plant through the **xylem** and is done so in a few different ways. As water flows in through the roots of the plant, **pressure** builds-up in the xylem; this pressure forces the water **up**. Water molecules also tend to stick together **(cohesion)** and to surfaces (**adhesion**) which helps water fight the force of **gravity**.

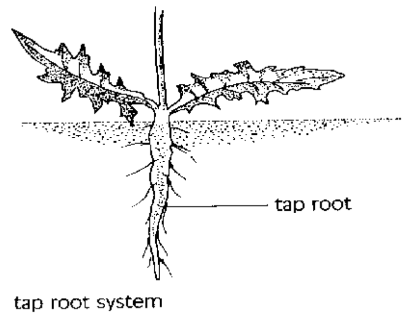
As water reaches the leaves, some of it is used for **photosynthesis** and some is lost in the form of **water vapour**, through the **stomata** during **transpiration**. This process removes the water from the xylem, and helps to **pull** the water up the plant.

Plant Organs

Roots

One of the major roles of the root is to **anchor** the plant in the soil and hold the **stem** in place; by doing so, plants also help to prevent **erosion** of the soil. There are two main types of roots, **tap** roots and **fibrous** roots.

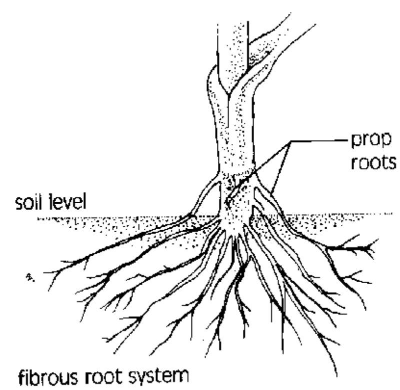
Tap Roots



a) Large main root with smaller lateral roots (**hairs**)
b) Can access water that is **deep** into the ground
c) Good for **storage** of food, water and minerals

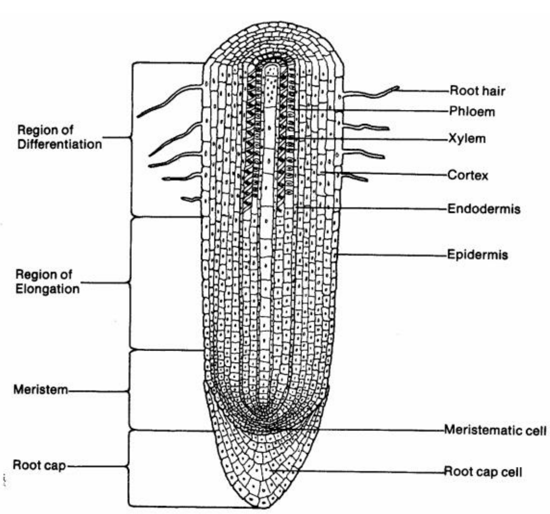
Fibrous Roots

a) Many branched roots of equal size
b) Tend to be shallower then tap roots
c) Holding the soil together, preventing **erosion**
d) Can absorb a great deal of water very **quickly**



The second major role of the root is nutrient transport:

a) Roots absorb water for **photosynthesis**
b) Roots replace water lost by **transpiration**
c) Roots absorb water to maintain **turgor** pressure
d) Roots absorb dissolved **minerals**
e) Roots store **sugars** in the form of **starch**



Root Tip Zones

Root cap – forms a **protective covering** for the delicate meristematic tissues

Meristematic Zone - region of actively dividing **unspecialized** cells (**mitosis**)

Elongation Zone - cells, **enlarge**, pushing the root tip **forward**

Maturation Zone - **cell differentiation; u**nspecialized cells develop into **specialized** cells

Stems

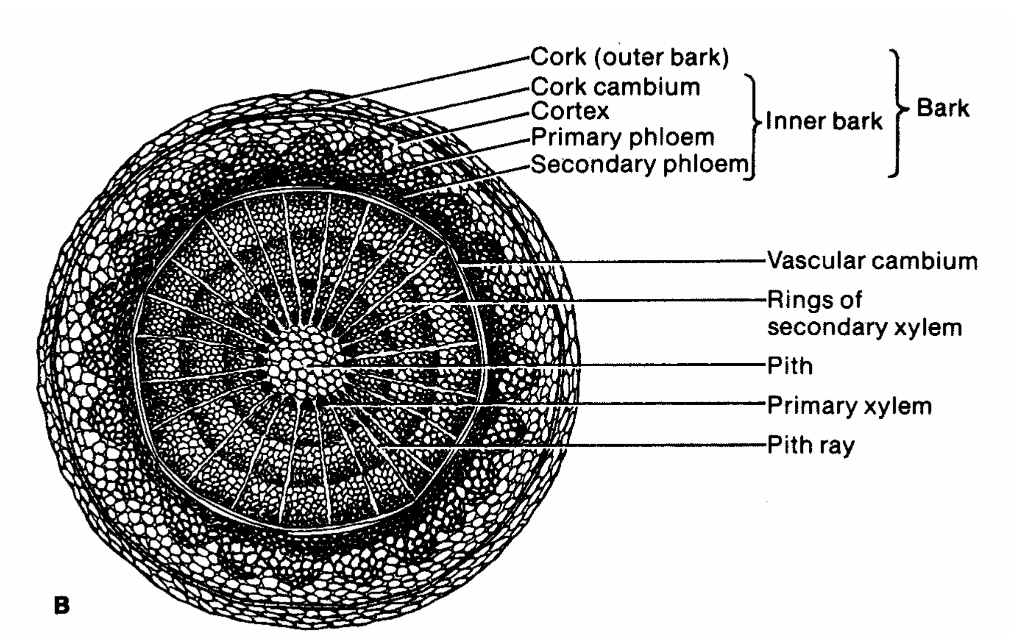
Stems play an important role in the **support** (holding the leaves up to the light) and **transport** (water, minerals and sugars) of the plant.

Like the roots and leaves of a plant, the stem is composed of different **tissue** layers. Stems can come in two other major forms; **herbaceous** or **woody**.

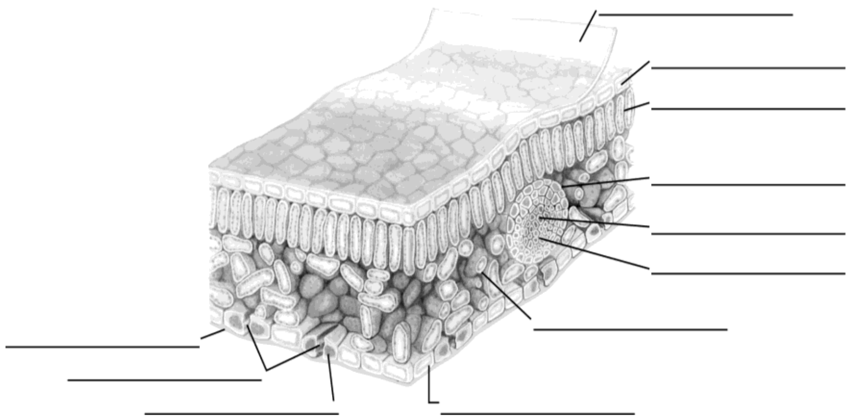
A) Herbaceous Stems (Annual)
- Generally **soft**, **flexible** and **green**
- Must be planted from **seed every growing season**
- Examples include **corn** and **tomato** plants

B) Woody Stems (Perennial)
- Generally very **hard** and **dark** in colour
- May live for over **100** years
- Examples include **oak** and **maple trees**

Woody stems contain:
a) Bark: A **protective** tissue (epidermal)
b) Vascular bundles: transport of water, minerals and sugars
c) Vascular cambium: cells accumulates on the inside of the cambium as **continuous, circular layers** of wood that increase the **girth** of the stem (forms **annual rings**)



The Leaves



Stomates
Regulate the movement of water & gases into and out of the leaf through the epidermis

Mesophyll
(Photosynthetic tissue)
Stomates open into these spaces.

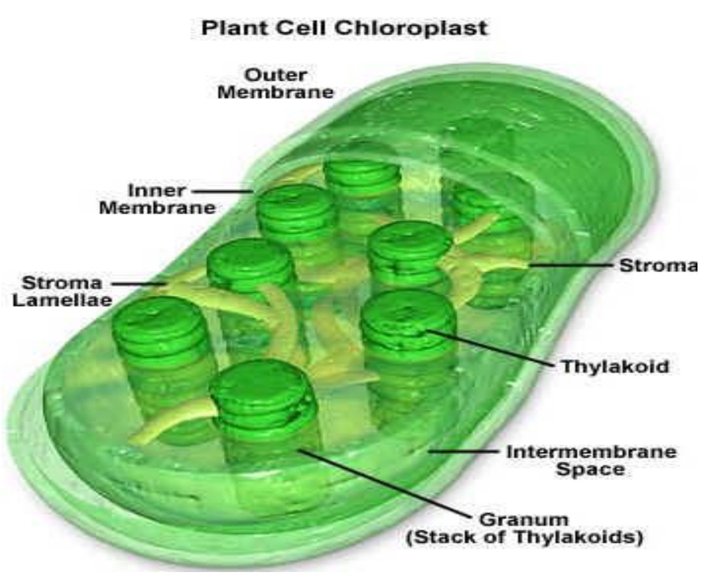
Two types:
i) **Palisade** mesophyll (upper portion)
Tall, tightly packed cells filled with chloroplasts

ii) Spongy mesophyll (lower portion)
Irregular shaped cells separated by large air spaces for storage of gases

Vascular Tissue
Consists of a complex network of vascular bundles or veins. Each vein consists of a strand of xylem above and a strand of phloem below.

Most leaves have a **thin shape** that also allows for easy gas exchange and are **broad** so that sunlight can reach the photosynthetic parenchyma cells. Inside these cells are high concentrations of **chloroplasts**. Chloroplasts are responsible for conducting photosynthesis; the process that takes carbon dioxide from the air and water from the soil and light energy to produce glucose and oxygen.

Chloroplasts contain sacs called **thylakoids**, which when stacked upon one another are called **granum**. Inside each thylakoid are molecules called **chlorophyll** that contain light trapping molecules. Chloroplasts are able to change their shape and or location in order to increase the amount of light they need to capture.



Genetic Engineering

Genetic engineering is the direct manipulation of **DNA** by humans in a way that DOES NOT occur under **natural conditions**.

While there have been great advances in the field of genetic engineering over the past few **decades**, the use and manipulation of organisms to produce useful products has been a common practice for **centuries**.

Farmers were able to select the **best suited** and **highest-yield** crops to produce enough food to support a growing population. Specific organisms and organism by-products have been used to **fertilize**, restore **nitrogen**, and control **pests**. Consequently, over the years farmers have inadvertently altered the **genetics** of their crops through introducing them to new **environments** and breeding them with other plants to get desired characteristics (**selective breeding**). This process of selective breeding has also been done with animals for generations to enhance or eliminate certain traits.

Transgenic Organisms

For years scientists have now been **combining the DNA** of different species of organisms. The species whose genes are altered are often called **genetically modified organisms** (GMO) or **transgenic** organisms.

Examples of GMO's include bacteria injected with human proteins used for medical treatments (ex. **insulin**), crops injected with bacteria DNA to resist specific pests and animals injected with growth hormones that promote growth.

Many people see the manipulation of genes as a way to solve various problems, others worry about the long-term consequences of such actions.

Cloning

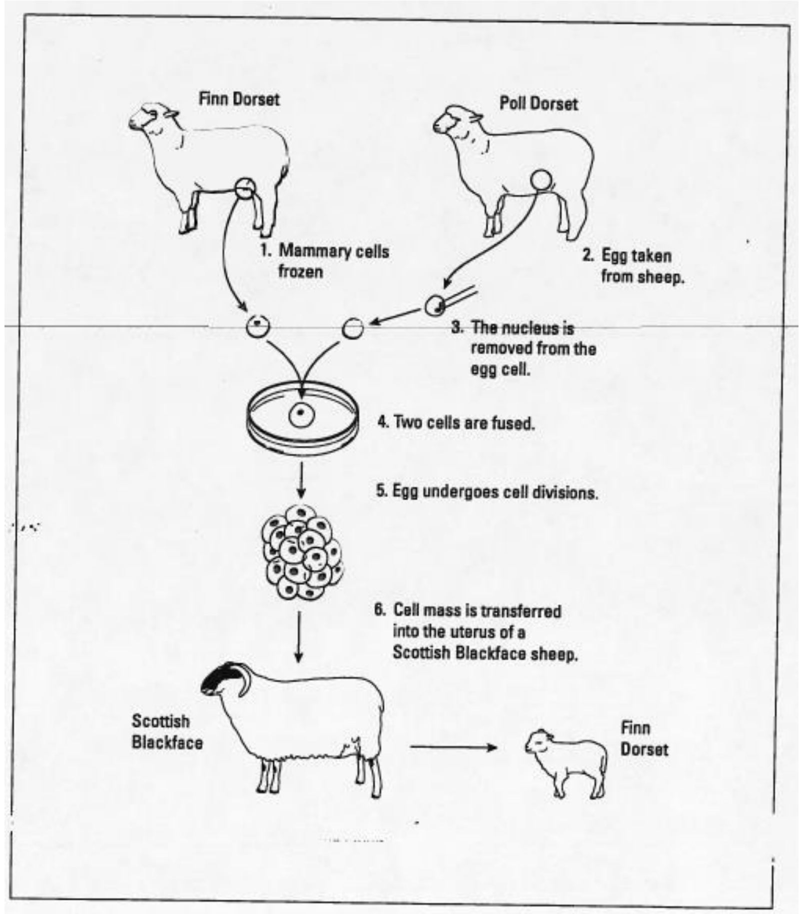
Cloning is the process of forming **identical** offspring from a single cell or tissue. It can be natural or brought about by human intervention.

As a natural process, cloning is carried out by any organism that reproduces **asexually**. It provides advantages for a species in that it requires only one **gamete** (**sex cell**), there is no wastage of gametes and **rapid reproduction** is possible. A disadvantage is that it does not allow for the genetic **variability** that allows for adaptations and **evolution**.

Different asexual reproduction strategies are employed by organisms including **binary fission** (bacteria), **runners** (plants), **budding** (yeast) and **fragmentation** (sea stars).

Cloning experiments by humans have been occurring for over **50** years. The first successful experiment with cloning in occurred in 1958 where a plant was grown from a **single carrot cell**.

A few years later a **frog** was cloned using **embryonic DNA**. This experiment was successful because a stem cell was used.



In 1996 a sheep named Dolly was cloned. Many attempts and failures occurred (over 200) before Dolly was successfully cloned. This was a significant experiment because it demonstrated that a **specialized** cell could be changed back to a **stem** cell.

Dolly showed signs of **premature aging** and eventually died at the age of six. Some people claim her life was shorter than normal because she was a cloned animal, while others argue that her death was completely natural.

Cloning is a controversial issue. Research into human cloning has been banned for over 15 years. Listed below are some thoughts in regards to cloning. Take a minute to read and think about some of the points raised.

- Clones can be used as potential organ donors (i.e. pigs)
- Scientists may attempt to create "the perfect human".
- Cloning is not an exact science and may result in many mistakes.
- Cloning is not consistent with many religious beliefs.
- Cloning could diminish the need for two sexes.
- Cloning does not allow for the genetic variation that provides for adaptations and evolution.
- Cloning could be used to restore endangered species or used to bring back endangered species.
- Who is the parent of the clone? Does someone own the clone?
- What social challenges would a clone face?