Legend:

This colour means that this information will be on the exam.
No colour means the information will not be on the exam, although this is still important information.
These notes include everything you will learn in grade 10 academic science.

Handwritten notes by Carter Nickerson.

Enjoy

Chemistry

Chemical Reactions and Word Equations

Chemical Reactions and Word Equations

- When two or more substances react and undergo a chemical change, we can say that a chemical reaction has occurred.
- Substances used in the start of a chemical reaction are called reactants, and the new substances formed after a reaction has taken place are called the products.
- Products have different physical and chemical properties from the reactants.

Word equations

- Used to describe what happens during chemical reactions. The name of the reactants are written on the left side of an arrow and the products are written on the right side

- Ex. Solid lithium metal reacts with liquid water to yield hydrogen gas and aqueous lithium hydroxide.

- **Word Equation**:
- Lithium + Water → Hydrogen Gas + Lithium Hydroxide

Formula equation

- A shortened description of a chemical reaction; using symbols and formulas to indicate the substances involved in the change.
- **Formula Equation:**
- $Li_{(s)} + H_2O_{(l)} \rightarrow H_{2\,(g)} + LiOH_{(aq)}$

The "**state symbols**" are:

- (s) – solid
- (l) – liquid
- (g) – gas

- (aq) – aqueous (dissolved in water)
- may use solution in word equation

Types of reactions

Synthesis Reaction

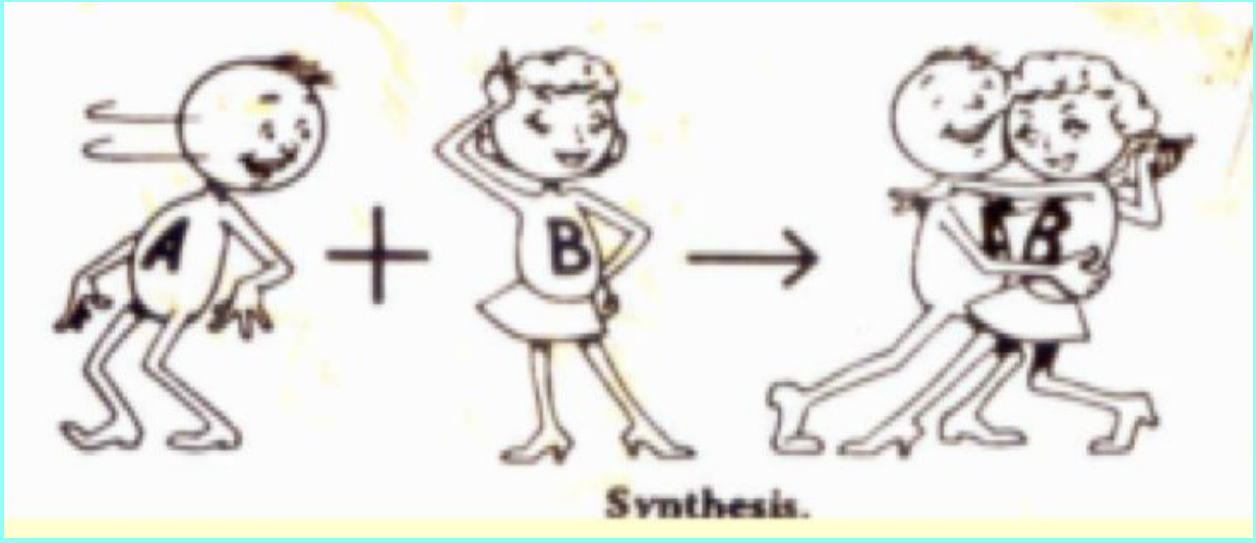
- The combination of atoms or small molecules to make a larger molecule. AKA combination reactions.
- Two reactants and one product
-
- The general equation is:

$$A + B \rightarrow AB$$

Examples:

$2Na_{(s)} + Cl_{2(g)} \quad 2\,NaCl_{(s)}$

$Mg_{(s)} + 2F_{2(g)} \quad MgF_{2(s)}$



Synthesis.

Decomposition Reactions

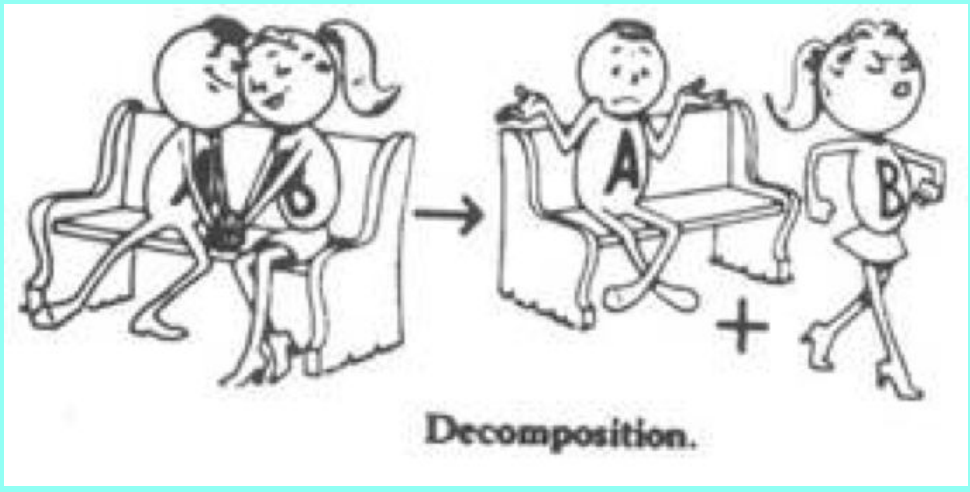
- Involves larger molecules splitting into elements or smaller molecules.
- One reactant and two or more products
- The general equation is:

$$AB \rightarrow A + B$$

Examples:

$2H_2O_{(l)} \quad 2H_{2(g)} + O_{2(g)}$

$2NI_{3(s)} \quad N_{2(g)} + 3I_{2(s)}$



Decomposition.

Single Displacement Reaction

- Involves one element or atom taking the place of another in a compound.

1st Type

- A metallic atom trades places with a metallic ion (or hydrogen ion) in a compound.
- The general chemical equation is:

$$AB + C \rightarrow CB + A$$

- Ex. Iron (III) oxide reacting with aluminum

$$Fe_2O_{3\,(s)} + 2\ Al_{(s)} \rightarrow Al_2O_{3(s)} + 2\ Fe_{(s)}$$

Single Displacement Reactions

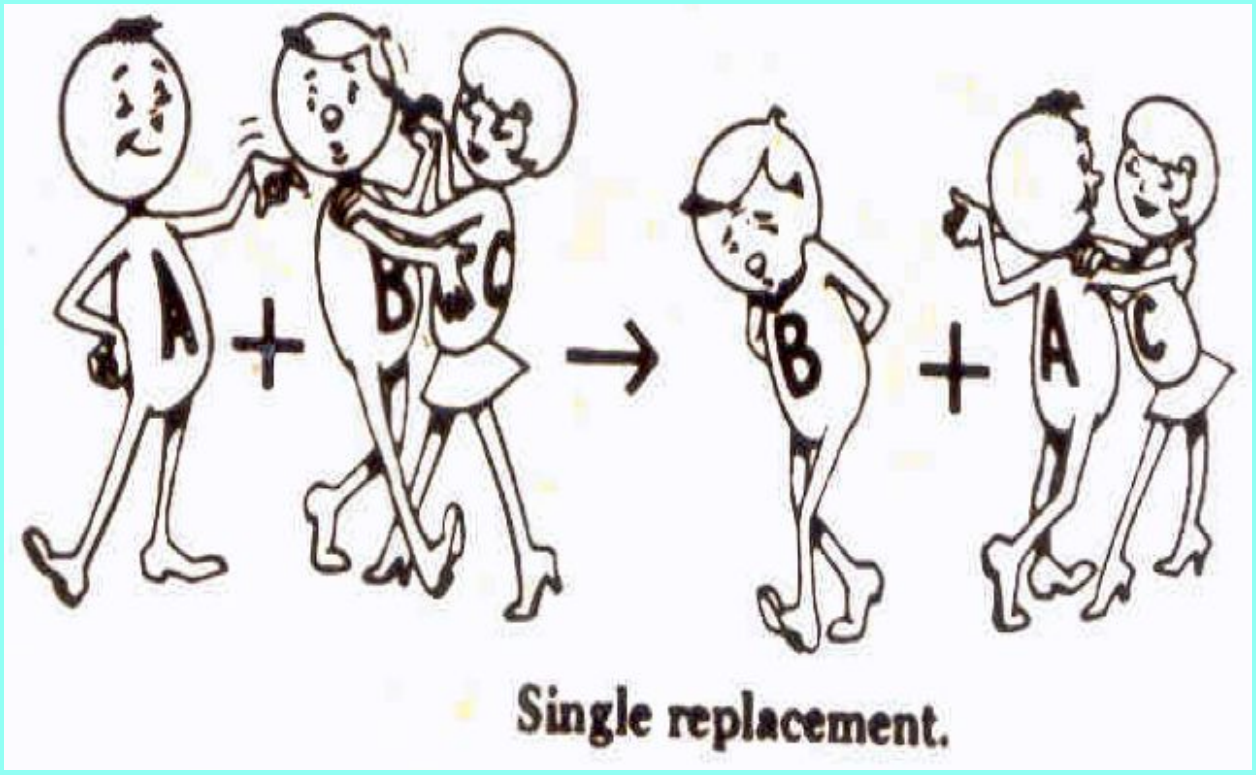
2nd Type

- A non-metal in a compound is displaced by another non-metal (except H)
- The general chemical equation is:

$$AB + C \rightarrow AC + B$$

- Ex. Magnesium fluoride reacting with chlorine gas

$$MgF_{2\,(s)} + Cl_{2\,(g)} \rightarrow MgCl_{2\,(s)} + F_{2\,(g)}$$



Single replacement.

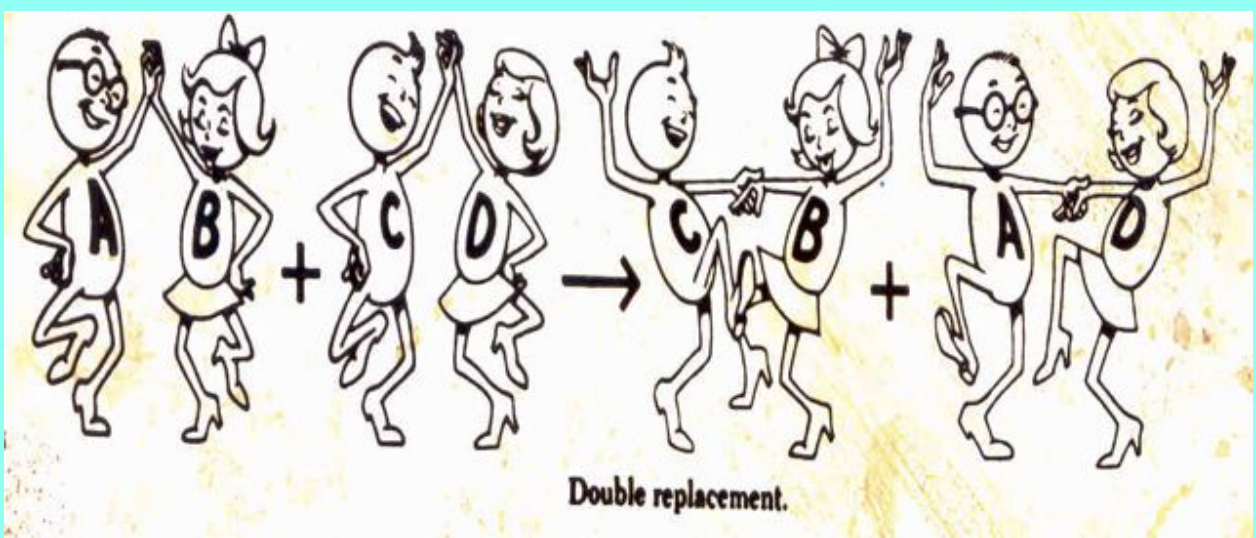
Double Displacement Reactions

- Involves both compounds exchanging ions to create two new compounds
-
- The general formula is:

AB + CD → AD + CB

- Ex. Barium chloride reacting with sodium sulphate

$BaCl_{2(s)}$ + $Na_2SO_{4(s)}$ → $BaSO_{4(s)}$ + 2 $NaCl_{(s)}$



Combustion

- A rapid reaction of a hydrocarbon with oxygen to produce carbon dioxide, water and energy
- **Hydrocarbons:** A compound composed of carbon and hydrogen atoms

Some examples of hydrocarbons include:

- Gasoline in our cars
- Natural Gas for our home furnaces
- Candles on a birthday cake

- **Example:** Combustion of Butane - C_4H_{10}

$$2\ C_4H_{10\,(g)} + 13\ O_{2\,(g)} \rightarrow 8\ CO_{2\,(g)} + 10\ H_2O_{(g)}$$

Acids and bases share some common characteristics, these include

- Dissolve in water (aqueous). Ions disassociate from one another
- Conduct electricity in an aqueous solution
- Can irritate or burn skin

Acids and bases can be distinguished from one and another by the following characteristics

acids	**bases**

Taste Sour	Taste Bitter
Do not feel slippery	Do feel slippery
pH < 7	pH > 7
Release hydrogen ions (H+) in aqueous solution	Release hydroxide ions (OH-) in aqueous solution

Corrode metal	Do not corrode metal
Reacts with metals to produce a compound and hydrogen gas	Do not react with metals

- The pH scale is used to determine how acidic or basic a substance is. Measured from 0-14
- Acids have a pH less than 7
- The greater the acidity the lower the number
- Bases have a pH greater than 7
- The more basic the higher the number

One unit of change on the pH scale represents a 10 times change in how acidic or basic a solution is.

- Ex. stomach acid (pH of 1) is 10 times more acidic than lemon juice(pH of 2) and 100 times more acidic than orange juice (pH of 3)
- Ex. ammonia (pH of 12) is 10,000 times more basic than seawater (pH of 8)

<u>Neutralization reactions</u>

- A neutralization reaction occurs when an acid and a base react
- When an acid reacts with a base, the products are water and a salt:
- Acid + base → a salt + water
- $HCl_{(aq)} + NaOH \rightarrow NaCl + H_2O$
- $H_2SO_{4(aq)} + KOH \rightarrow K_2SO_4 + H_2O$

<u>Uses of neutralization acids</u>

- Adjusting pH levels in soil for different crops.
- Antacids
- Cream for bee stings
- Food preservation

<u>Acid rain</u>

- Acid rain is produced by sulphur dioxide and nitrogen oxides released into our atmosphere

- Ex. sulphur dioxide reacts with oxygen gas in the air to produce sulphur trioxide
- $SO_{2(g)} + O_{2(g)} \rightarrow SO_3$
- Sulphur trioxide then reacts with water droplets in our atmosphere to produce sulphuric acid (acid rain), $SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$

Case study questions:

- The sources of sulphur dioxide and nitrogen oxides are electricity production in coal-fired power plants, iron and steel production and smelting of metals, fertilizer production, pulp and paper production, and automobile engines.

- The effect acid rain has on buildings in our ecosystems are, it corrodes the stone in the buildings, in the roads and bridges and statues. Disfiguring them and making them weaker.

- The lakes in Alberta are protected by limestone surrounding the lake. This type of rock neutralizes the acid, which restores the pH of the lake. However, the lakes on Ontario do not have this; the lakes in Ontario are at greater risk of acidification.

- When lime mixes with water, the base calcium hydroxide can neutralize both the sulphuric acid and the nitric acid that is found in acid precipitation. The neutralization reaction involving nitric acid is: $2HNO_{3(aq)} + Ca(OH)_{2(S)} \rightarrow Ca(NO_3)_{2(aq)} + 2H_2O_{(l)}$

- The efforts to prevent acid rain has lead to smokestack scrubbers and automobile emissions controls. Scrubbers are devices that are found in tall, industrial smokestacks of industries that release sulphur dioxide gas and nitrogen oxide gases, such as coal-fuelled power plants and ore smelting facilities. Scrubbers remove these gases using a specially formulated chemical mixture. The gases in a smokestack contact the chemical mixture in the scrubber and enter into chemical reactions. The products of the chemical reactions are a wet slurry or a solid. Scrubbers also have a filter that collects and traps small particles that would otherwise be released into the atmosphere. The substances collected can then be separated for recycling. Internal combustion engines found in automobiles emit a number of harmful gases, including nitrogen oxides. One approach to reducing harmful emissions is to use technologies that convert the harmful gases to other, harmless substances. The most common of these technologies is the catalytic converter, which is located in the exhaust system of a vehicle. A catalytic converter uses nitrogen oxides in a chemical reaction that decomposes them into nitrogen gas and oxygen gas, for example when dinitrogen trioxide is the reactant, the following chemical reaction occurs: $2N_2O_{3(g)} \rightarrow 2N_{2(g)} + 3O_{2(g)}$

Optics

Producing visible light

- Light comes from what we reflect, not just the sun, a light bulb or fire.
- All objects are sources of light.
    (a) Luminous: produce their own light e.g. the Sun, burning candle
    (b) Non-luminous sources: cannot produce their own light; we can see the object because light reflects from or passes through them e.g. car, tree, another person

Luminous sources of light can be natural or artificial

- A substance that produces light when heated to a very high temperature.
- E.g. filament inside a light bulb, melting metals

(a) Fluorescent

- A substance that produces visible light when it is exposed to electromagnetic radiation
- Ex. a fluorescent light bulb is filled with mercury vapour and is coated with phosphor
- An electric current energizes the atoms of the mercury vapour (gas) which emits UV radiation (a type of electromagnetic radiation)
- The UV radiation strikes the phosphor which glows and emits light

(a) Phosphorescent

- A substance that glows after being exposed to a source of light
- These materials can store the energy from a light source and emit it slowly over a period of time
- Ex. glow in the dark toys

(a/n) Chemiluminescent

- A substance that produces light from a chemical reaction without a rise in temperature
- Ex. glow sticks
- Ex. the use of luminol to detect blood at a crime scene

(n) Bioluminescence

- Any living thing that has the ability to produce light
- A type of chemiluminescence
- E.g. Firefly, jellyfish

(a/n) Triboluminescent

- A substance that produces light from friction
- Ex. quartz can produce light by rubbing two pieces together

(a/n) Electric discharge

- A method of producing light in which an electric current passes through the air or another gas and different colours are created

When light strikes an object, it can be:

1. Absorbed; light is taken in and converted to heat energy. E.g light gets absorbed by a brick wall and it warms up
2. Reflected; light bounces off (changes direction.) E.g light is reflected off a mirror
3. Transmitted; light passes through. E.g light is transmitted through a window (does not get absorbed and turned into heat energy).

There are two types of reflection:

Regular reflection:

- The light rays strike a smooth surface and reflect in the same direction, staying parallel to one another; all the rays are reflected at the same angle

Diffused reflection:

- The light rays reflect off a rough or uneven surface and do not remain parallel but are scattered in different directions; the rays are reflected at different angles

- Any substance that transmits light is called a medium
- All substance that may be classified according to how they transmit, reflect or absorb light:

a. Transparent: materials that transmit light freely e.g window
b. Translucent: materials that transmit some light, but not enough to see right through E.g frosted window pane
c. Opaque: materials that do not transmit light at all e.g blackboard, door.

Plasma displays:

- Brighter than led displays
- Requires more power than led displays
- In plasma, each colour is a tiny fluorescent light, in which an electrical signal causes a gas, such as neon to emit ultraviolet radiation, which is absorbed by a phosphor and produces red, green or blue light
- Different phosphors produce different colours of light, creating any colour on the visible spectrum

Properties of light and EMS

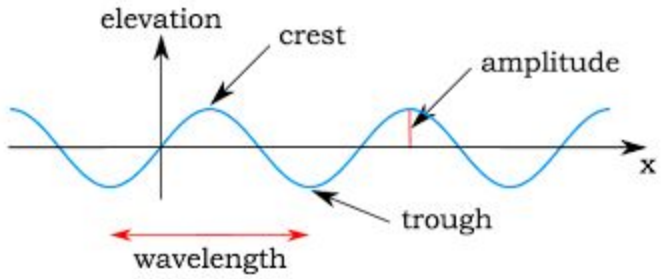
Electromagnetic radiation:

- A wave pattern made of electric and magnetic fields that do not require a medium (solid, liquid, gas) for transmission.
- Can travel through empty space
- Light is classified as a form of electromagnetic radiation
- All forms of electromagnetic radiation travel at $3.00 \times 10_{8}$ m/s

Radio waves: MRI scans, cell phone calls, car radio
Microwaves: heating up food, radar technology, satellite
Infrared waves: measure heat, keep food warm in restaurants
Ultraviolet rays: disinfect drinking water, also to show things that might not be visible in visible light
X-rays: make an image of dense objects

Light is a form of energy that is visible to the human eye

- Light travels in a straight line
- It sometimes displays properties of a wave and sometimes properties of particles



Crest - the highest point in the wave
Trough - the lowest point in the wave
Wavelength the distance from crest to crest or trough to trough symbol is
Amplitude - the height of the wave from the rest position

- The larger the amplitude, the more energy is carried
- The smaller the amplitude, the less energy i carried

Frequency (f) - the rate of repetition in a wave

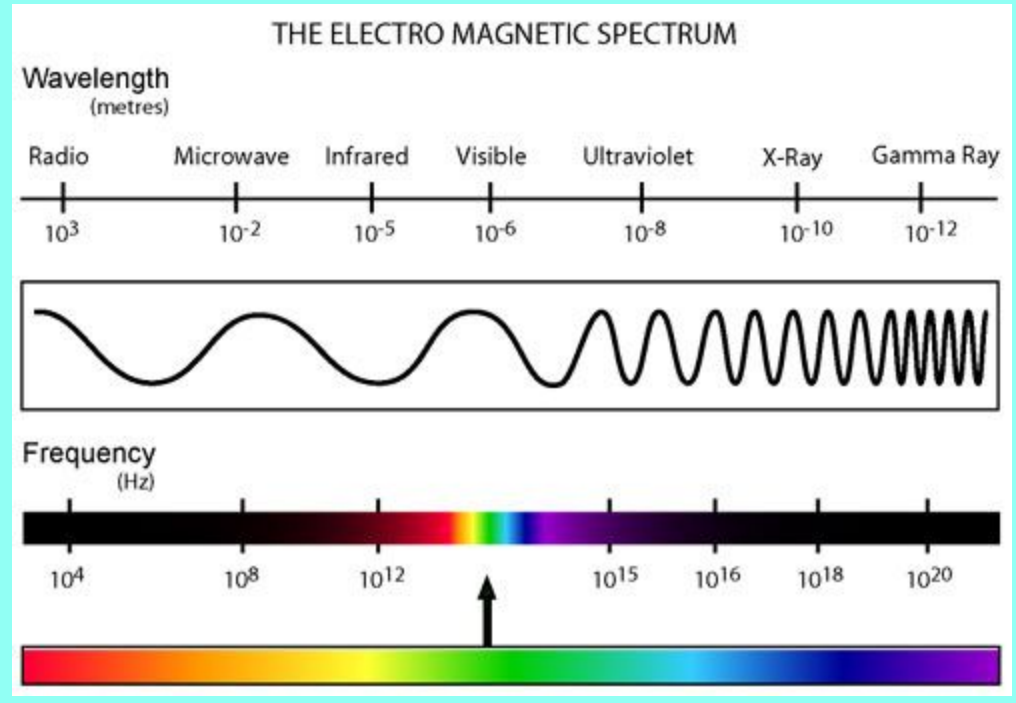
- Measured in hertz (Hz) which is the number of cycles/ s
- The higher the frequency, the more energy the wave passes along

The relationship between frequency and wavelength

- There is an inverse relationship between frequency and wavelength
- As the frequency ↑ the wavelength ↓
- As the frequency ↓ the wavelength ↑

Colour theory of light

- ROY G BIV



Colour	**Wavelength**
red	650
orange	600
yellow	580
green	550
blue	450
violet	400

Primary colours

- The colours required to produce white light (red, green, blue)

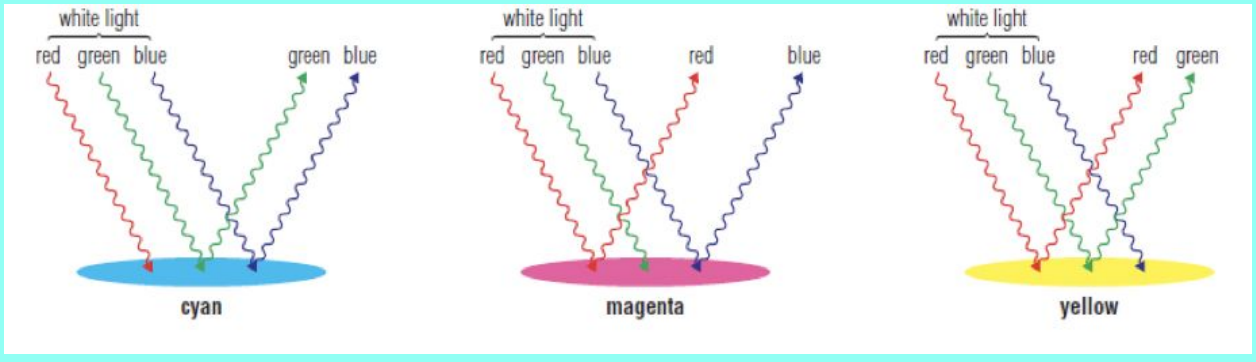
Secondary colours

- The colours produced when two of the primary colours are projected at the same time:
- Red + green → yellow
- Green + blue → cyan
- Blue + red → magenta

Subtractive colour theory of light

- Coloured matter selectively absorbs different wavelengths of light
- Magenta + yellow → red
- Yellow + cyan → green

- Magenta + cyan → blue
- Magenta + yellow + cyan → black



- When magenta and yellow filters are placed on top of each other, the only wavelength of light that is allowed to pass through both is red
- Therefore we see red

Law of reflection

- The colours that are absorbed by an object are "subtracted" from the reflected light that is seen by the eye
- E.g. a green sheet of paper will absorb all the colours of light, but will reflect green light (it does not absorb green light)
- What colour will the paper appear in red light?
- Answer: black

- E.g. A crayon appears cyan when seen in white light. What colour will appear in
- Red light?
- Green light?

Additive - different wavelengths of light are **added** together (i.e. shined on-top of each other on a surface)

Subtractive - a surface absorbs certain wavelengths of light only.

a. Allow certain wavelengths of light to pass through (translucent material)
b. Allow certain wavelengths of light to reflect (opaque material)

Ray Model Of Light

Pinhole camera and plane mirrors

Ray model of light

- Light is represented as straight lines called rays, which show the direction that light travels
- Since light is an electromagnetic wave, you could think of a light ray as the path of a point on the crest of a wave

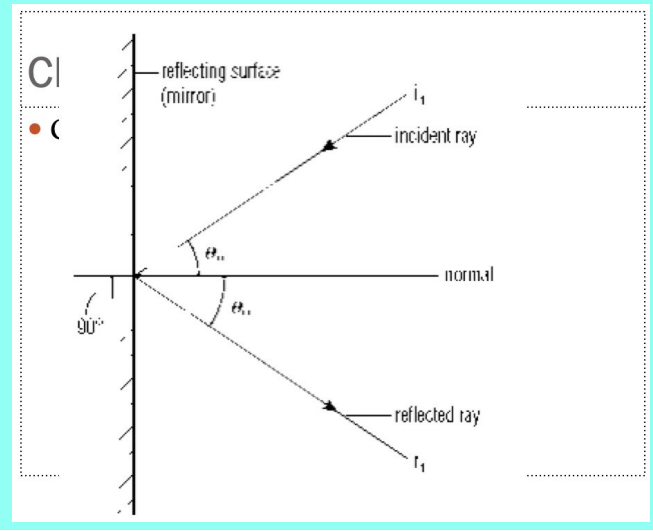
- Ray diagrams are drawings that show the path that light takes after it leaves a source and strikes a surface
- Each ray ends with an arrow to indicate the direction of travel

The pinhole camera

- Usually consists of two parts, one which slides into the other
- At one end is a small pinhole
- At the other end is a translucent screen (wax paper)
- The light rays passing through the pinhole spread out and hit the screen
- The image created is inverted

Laws of reflection lab terminology:

Incident ray - the incoming ray that strikes a reflecting surface
Normal - an imaginary dashed line drawn perpendicular to a reflecting surface at the point of reflection
Angle of incidence - the angle between the incident ray and the normal
Reflected ray - the ray that represents the light reflected by the surface
Angle of reflection - the angle between the reflected ray and the normal



What is the law of reflection?

- The angle of incidence equals the angle of reflection

Mirrors n' stuff:

An image can be described by four characteristics: size, location, attitude and type.
Size:

- Is the image larger than, smaller than, or the same size as the object?

Attitude:

- Is the image upright, or inverted compared to the object?

Location:

- Is the image in front of or behind the mirror?
- Is the image closer to, further from, or the same distance from the mirror as the object?

Type:

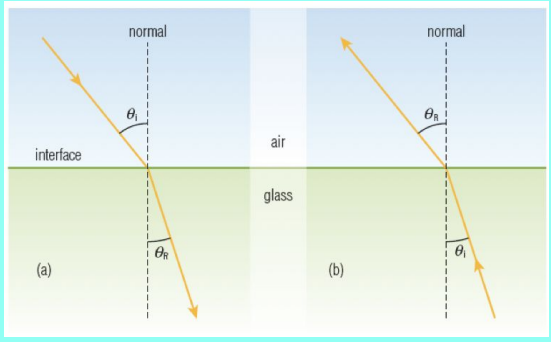
- Is the image virtual or real?
- A real image is an image formed when two reflected rays intersect in front of the mirror
- A virtual image is an image formed when the two reflected rays do not intersect but must be extended behind the mirror (virtual rays)
- A real image can be seen on a screen, a virtual image cannot be seen on a screen

Curved mirrors terminology:

Concave mirror (converging) - a reflecting surface that curves inward like a bowl
Convex mirror (diverging) - a reflecting surface that curves outward
Principal axis - an imaginary line passing through the center (vertex) of a mirror
Vertex - the middle point of a curved mirror
Centre of curvature (c) - the centre of a sphere of which the mirror is apart of
Focus (f) - the point where light rays meet or appear to meet. Located halfway between the mirror and (c)
Focal length - the distance from the vertex to the focus of a curved mirror

<u>Refraction</u>

- When light changes direction as it passes from one medium to another



Bent Spoon

- When light from the spoon passes from the water to air, the light rays bend and the handle appears broken at the top

What causes light to refract?

- Due to changes in the speed of light
- The speed of light changes in different media
- Ex. as the light moves from air to water its speed decreases
- The more light slows down, the more it refracts

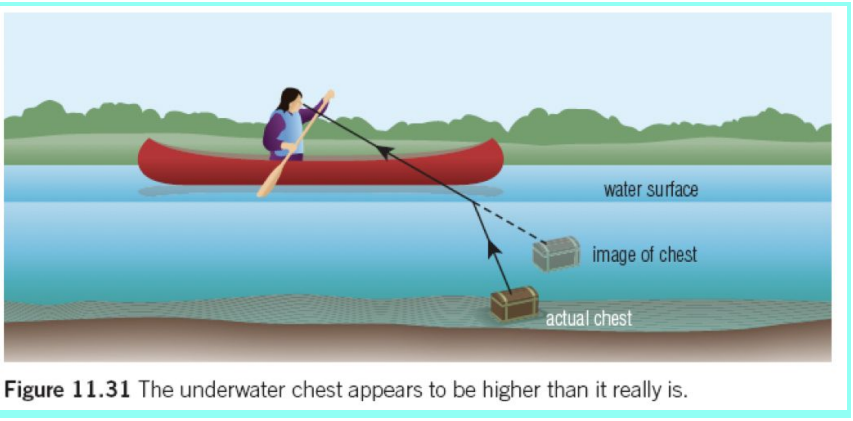


Figure 11.31 The underwater chest appears to be higher than it really is.

- This picture shows light rays moving from water into the air and refracting as they leave the water
- When we view the refracted rays, we assume they have travelled in a straight line

What is the speed of light?

- In a vacuum, the speed of light is 3.0×10^8 m/s
- Remember, a ray of light is electromagnetic radiation that is transmitted in waves
- Particles that make up a particular medium slow down the passage of these waves

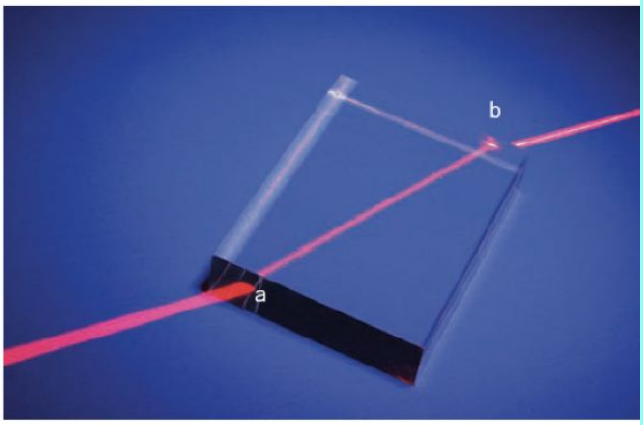


Figure 11.32 Light refracts as it enters and then leaves this block of Plexiglas.

- The light ray strikes the plexiglass at an angle
- As the light enters the plexiglass, it slows down and refracts
- When the light leaves the plexiglass and enters the air, it speeds up and refracts again
- Light refracts only at the boundary when it is entering or leaving a medium

How do you know how much light slows down in a medium?

- A number called the **index of refraction** tells you the amount of which a medium decreases the speed of light
- The larger the number, the more the medium decreases the speed of light, and more refraction will occur
- The refractive index of the speed of light in a vacuum is assigned a value of 1.00

index of refraction =

$$\frac{\text{Speed of light in a vacuum}}{\text{Speed of light in given medium}}$$

$$N = \frac{C}{V}$$

Medium	Index of Refraction
Air	1.000293
Carbon Dioxide	1.00045
Water	1.33
Ice	1.31
Glass (crown)	1.52
Diamond	2.42

θi and θr

- The angle of incidence (θi) and the angle of refraction (θr) are measured from the normal
- The normal is drawn perpendicular to the boundary of the two media

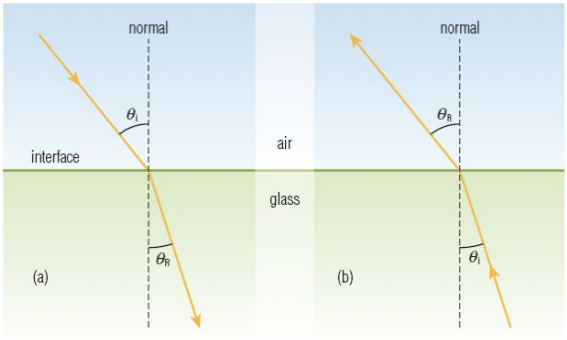
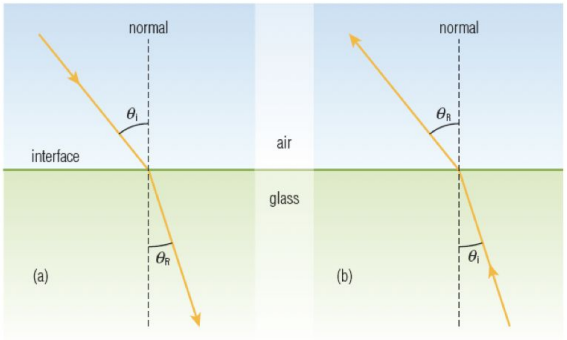
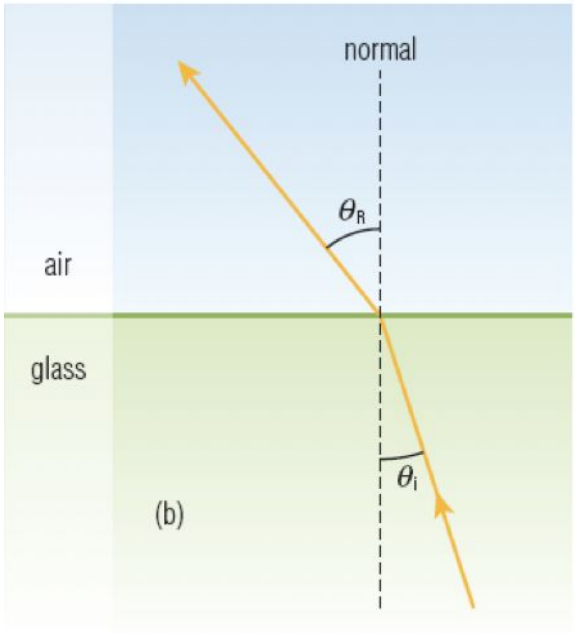


Figure 11.35 Light moves (a) from air to glass and (b) from glass to air.

- When light travels from a medium with a low refractive index into a medium with a higher refractive index (more optically dense), it bends <u>toward</u> the normal.



- When light travels from a medium with a higher refractive index into a medium with a lower refractive index, it bends away from the normal



How do you calculate the angle of refraction in a medium?

- Snell's law is used to calculate the relationship between the angle of incidence and the angle of refraction

Snell's law

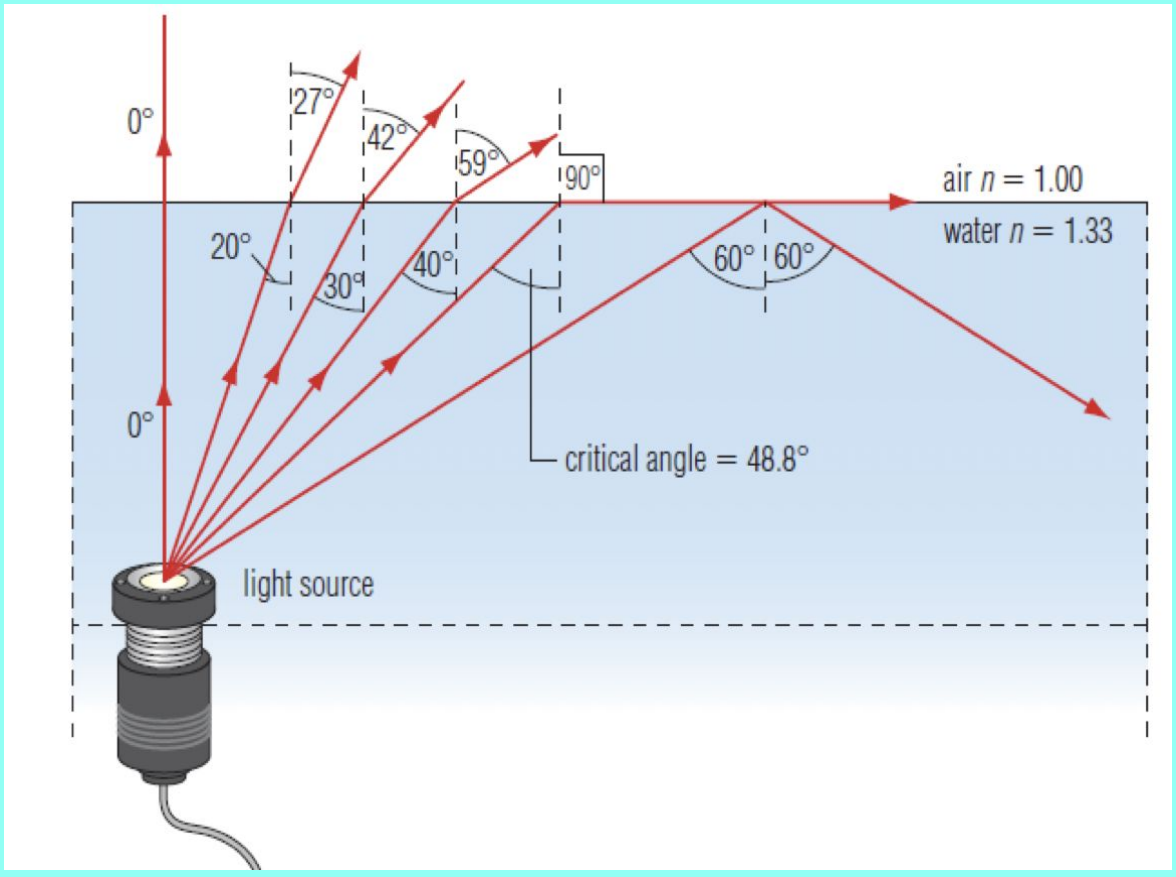
- Snell's law uses the value for the index of refraction to calculate the new angle that a ray will take as a beam of light strikes the boundary between the two media
- The formula for Snell's law is $n_1 \sin\theta_1 = n_2 \sin\theta_2$
- The angle of incidence is θ_1 and the angle of refraction is θ_2
- $n_1 \sin\theta_1 = n_2 \sin\theta_2$

θ_1 = angle of incidence
θ_2 = angle of reflection

Total internal reflection

- When the angle of incidence in water reaches a certain critical value, the refracted ray lies along the boundary, having an angle of refraction of 90 degrees
- This angle of incidence is known as the critical angle
- The critical angle is the largest angle of incidence for which refraction can still occur
- For any angle of incidence greater than the critical angle, light will undergo total internal reflection

*with critical angle, theta 2 is always 90 degrees



Lenses

What is a lens?

- An optical device which transmits and refracts light, either converging or diverging the light that passes through. Most lenses are made of transparent glass or hard plastic.

Lens Terminology

- **Optical Centre:** The middle point of a lens where the principal axis and axis of symmetry meet
- Define the following terms using pages 450-451 and the glossary.
- Axis of symmetry (Optical Axis); Principal Axis; Principal Focus (F); Secondary Principal Focus (F'); and Focal Length

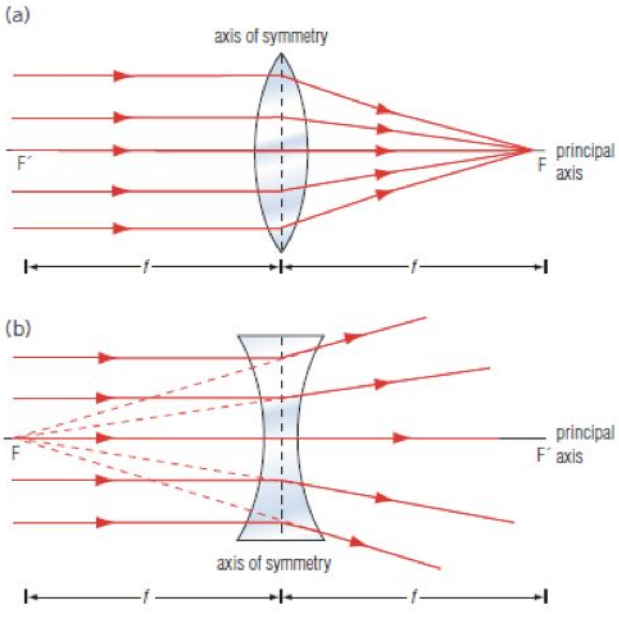
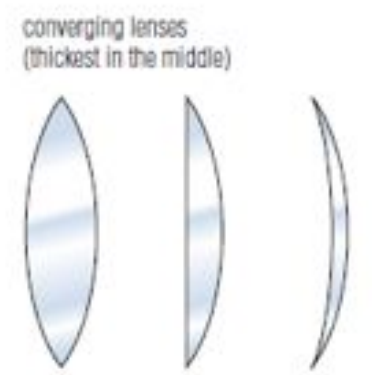


Figure 11.50 (a) Converging lens and (b) diverging lens

Converging Lenses (Biconvex)

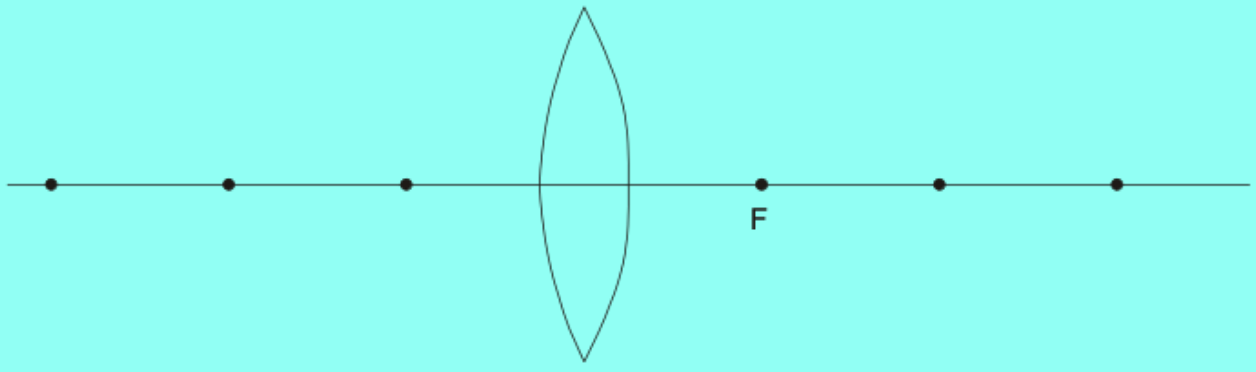
- Also called a bi**convex lens** because it is thicker at the centre than at the edges.
- The principal focus is behind the lens, and the second principal focus is in front of the lens



Drawing a Converging Lens Ray Diagram

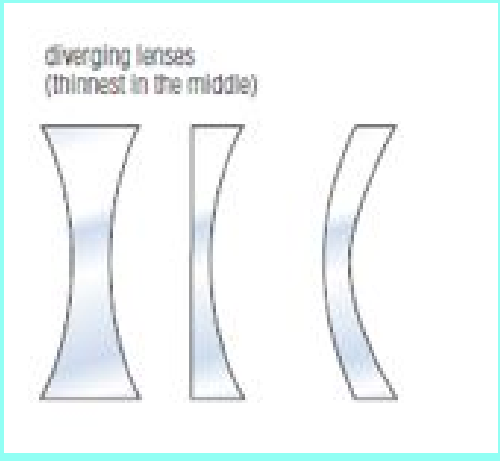
- The principal focus (F) is located on the opposite side of the lens (of the light source or object)
- Ray # 1 travels from the tip of the object parallel to the principal axis, hits the lens (specifically the axis of symmetry) and refracts through the principal focus (F)
- Ray #2 travels from the tip of the object through the secondary focus (F'), hits the lens (specifically the axis of symmetry) and refracts parallel to the principal axis.
- Ray #3 travels from the tip of the object straight through the optical centre without refraction.

- The image is where the three rays intersect.



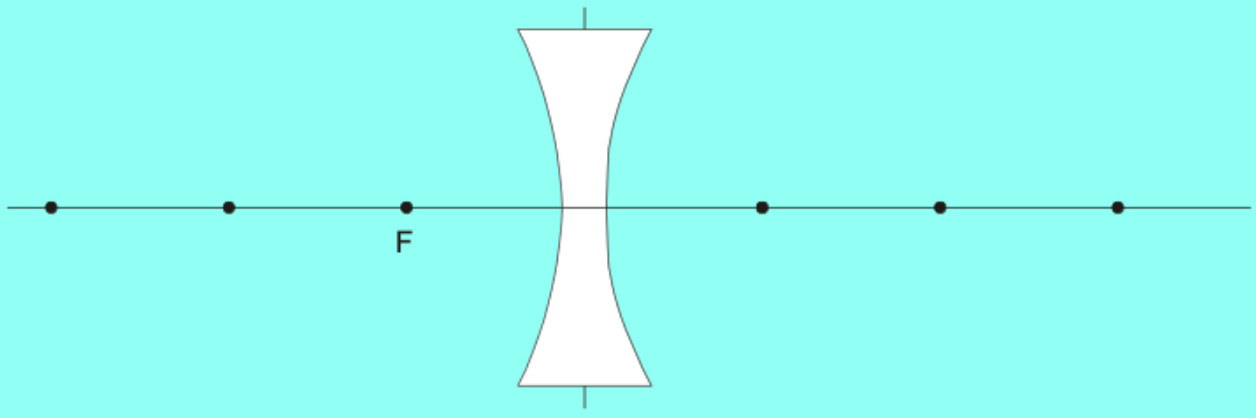
Diverging Lenses (Biconcave)

- Also called a **biconcave lens** because it is thinner at the centre than at the edges.
- The principal focus is in front of the lens and the second principal focus is behind the lens
- When the light passes through the concave lens, the rays diverge away from the principal axis therefore, the light rays will never meet on the other side of the lens.



Drawing a Diverging Lens Ray Diagram

- The principal focus (F) is located on the same side of the light source or object
- Ray # 1 travels from the tip of the object parallel to the principal axis, hits the lens (specifically the axis of symmetry) and refracts as if it appears to come from the principal focus (F)
- Ray #2 travels from the tip of the object straight through the optical centre without refraction.
- The image is where the two rays appear to intersect



Thin Lens Equations

Calculating Magnification:

Magnification

- is the measure of how much larger or smaller an image is compared to the object.

Magnification of Height

- Expressed as a ratio of the height of the image to the height of the object

Magnification of Distance

- Expressed as a ratio of the distance from the image to the mirror and the distance from the object to the lens

Thin Lens Equation

Sign Convention (assuming d_o and h_o is positive)

- Focal length (f) is positive (+) for converging (biconvex) lens and negative (-) for diverging (biconcave) lens
- Positive (+) d_i represent distances measured on the other side of the lens, opposite of the object {real image produced}
- Negative (-) d_i represent distances measured on the same side as the object {virtual image produced}
- Positive (+) h_i or M represents an upright image
- Negative (-) h_i or M represents an inverted image

The Human Eye

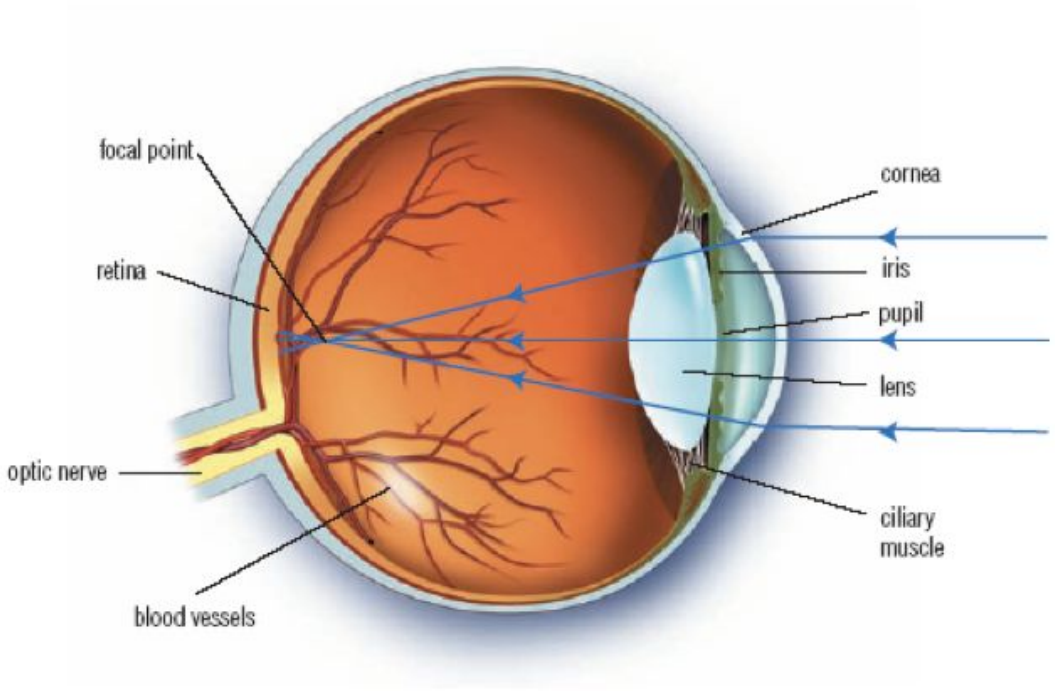


Figure 12.6 A cross-section of the human eye

Parts of the Human Eye

The outer surface of your eye where light enters is made of a transparent layer of tissue called the **cornea**.

- Your cornea is tough enough to protect your eye and hold it together while remaining extremely sensitive to touch.
- The light rays that arrive at your eye are refracted by the cornea.

- helps direct light correctly into your eye.

Pupil

- After passing through the cornea, the light rays reach the pupil.
- The pupil is a hole that allows light to pass into the eye. The pupil is black because light rays enter but do not leave.

Iris

- The pupil is created by a circular band of muscle and connective tissue called the **iris**.
- Controls the size of the pupil - controls the amount of light that enters the eye.

(a)

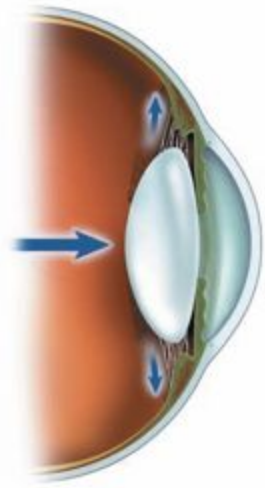
(b)

Figure 12.7 (a) Dilated pupil and (b) contracted pupil

Lens

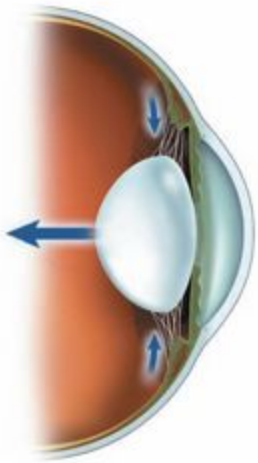
- Your eye includes a biconvex lens.
- Your lens allows you to change your focus so that you can see an object clearly regardless of where it is.
- The lens is able to adjust its focal length because it is attached to ciliary muscles that can change the shape of your lens.

- When the ciliary muscles are relaxed, they pull your lens flatter and thinner.
- This is good for seeing distant objects.



Lens

- When the ciliary muscles contract, this allows the lens to expand into a more spherical or thicker shape.
- Your lens can now strongly refract light, which helps you focus on nearby objects.



Aqueous and Vitreous Humour

- The aqueous humour is the clear, watery fluid that fills the space between the cornea and the lens
- The vitreous humour is the clear solution that fills the space between the lens and the retina

Retina

- The inner lining at the back of the eye - acts as a projection screen for the light rays entering your eye.
- The image formed on the retina is inverted but your brain interprets the image as being upright

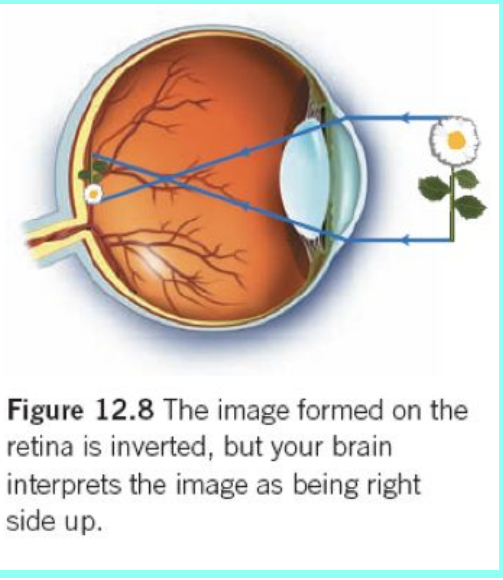


Figure 12.8 The image formed on the retina is inverted, but your brain interprets the image as being right side up.

Detecting the image

- Once the image is focused on the retina, light rays are absorbed by **photoreceptors** (cells in the retina that are sensitive to light).
- Photoreceptors include rod cells and cone cells
- **Rod cells** help us detect shapes and movement in low light situations.
- **Cone cells** are photoreceptor cells used to detect colour.

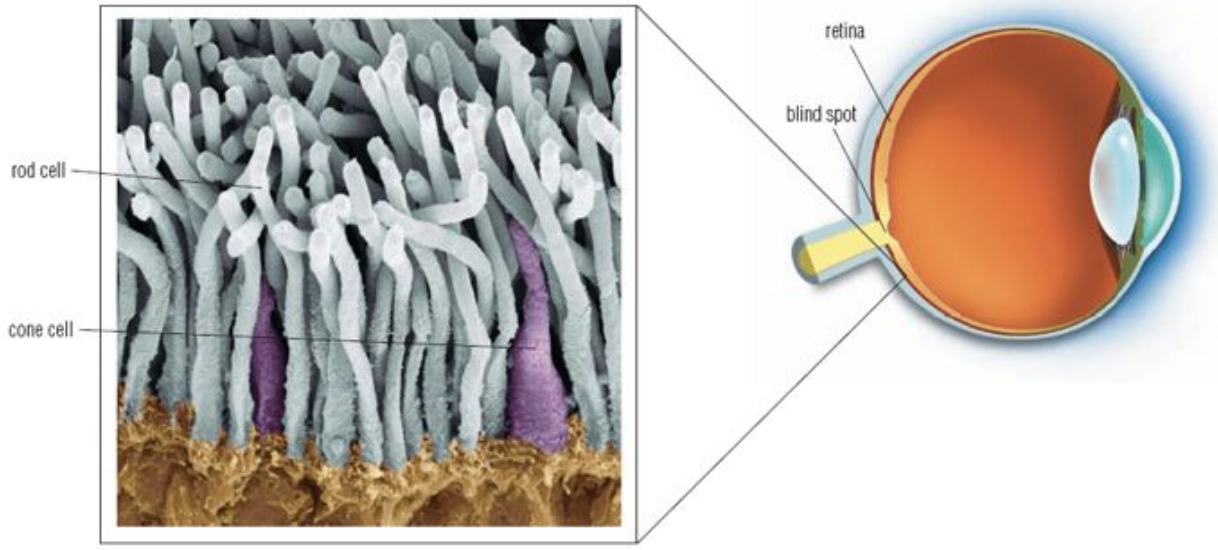


Figure 12.10 This is a false-colour electron micrograph image showing rod and cone photoreceptor cells in the retina at a magnification of 1800× at 10 cm. Cones are found in the central region of the retina. The more numerous rods are located outside the central region of the retina.

- There is one place on the retina called the blind spot, which has no photoreceptors and which cannot detect light.
- The **blind spot** is the place where the optic nerve attaches to the retina.
- The **optic nerve** connects your eye to your brain

Vision Problems

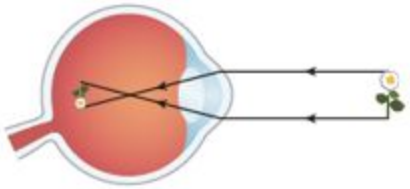
Almost any focusing problem can be improved by placing a lens in front of your eyes.

Correcting Far-Sightedness

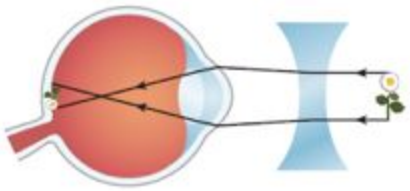
(a) far-sightedness

(b) far-sightedness corrected by convex lens

Correcting Near-Sightedness



(a) near-sightedness



(b) near-sightedness corrected by concave lens

Figure 12.13 (a) Near-sightedness and (b) near-sightedness corrected by a diverging lens

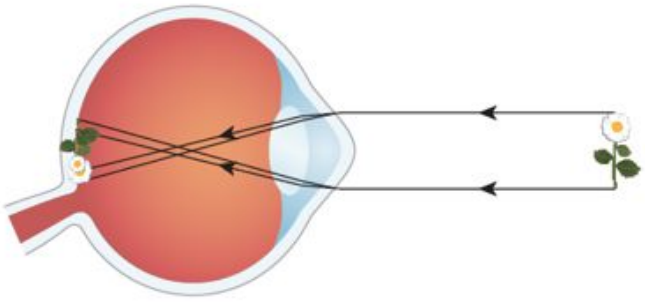


Figure 12.14 Astigmatism is a vision problem that results from a cornea that has an irregular shape.

Figure 12.15 Contact lenses sit directly on the cornea and can be used to correct far- and near-sightedness as well as astigmatism.

Laser Eye Surgery

- Corrects nearsightedness, far-sightedness, and astigmatisms
- Reshapes the cornea.
- Nearsightedness - cornea is flattened to reduce converging power of the eye. - removes more tissue from the centre of the cornea than around.

- Farsightedness - central cornea is steepened to enhance the converging power of the eye. Remove more tissue from the periphery than the centre.
- To treat astigmatism, the cornea must be made more spherical (uniformly curved).

Biology

Biology Introduction

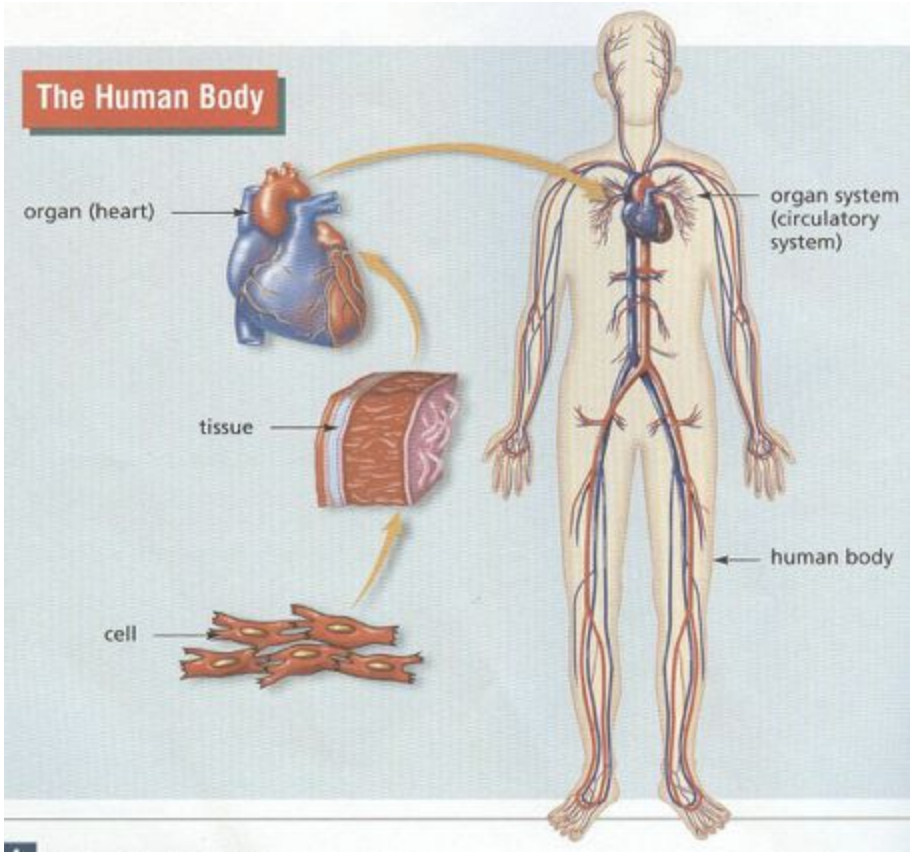
The Cell Theory

The cell theory is an explanation of the relationship between cells and living things.

The cell theory states:

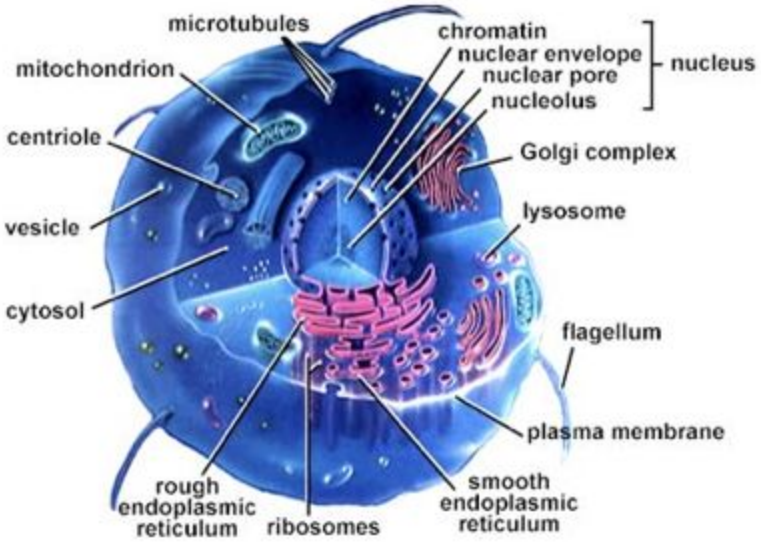
- All living things are made of one or more cells.
- Cells arise from pre-existing cells
- Cells are the basic unit of structure and function in all living things

Biological organization

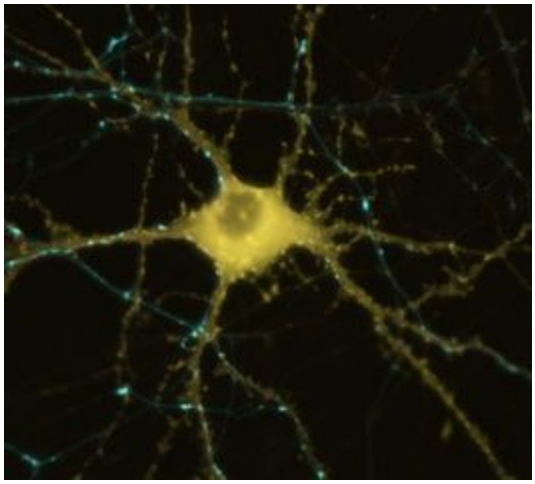


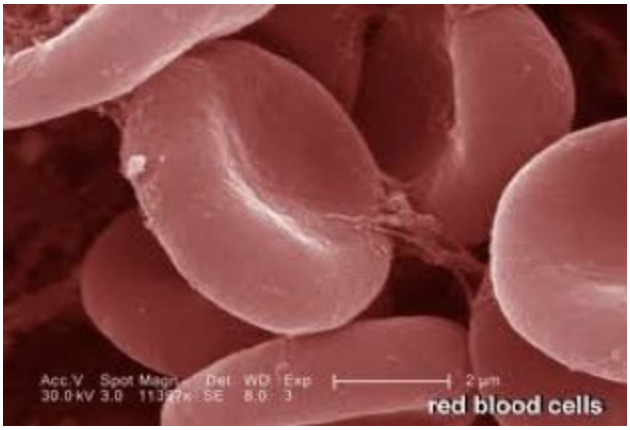
Different Types of Cells

Animal Cells do not always look like this….

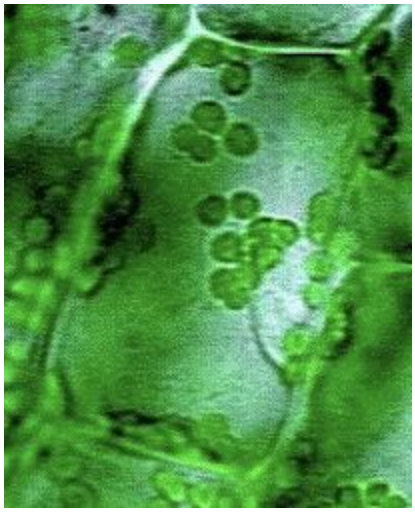


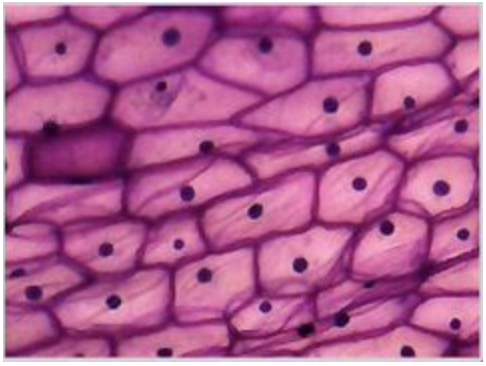
They come in all shapes and sizes





Even plant cells





Cells and Organelles

- Cells are the basic unit of life.
- Cells contain many different organelles that help with the life functions of the cell such as:
- Reproduction
- Gas exchange
- Intake of nutrients and removal of wastes
- Locomotion (movement)
- Growth

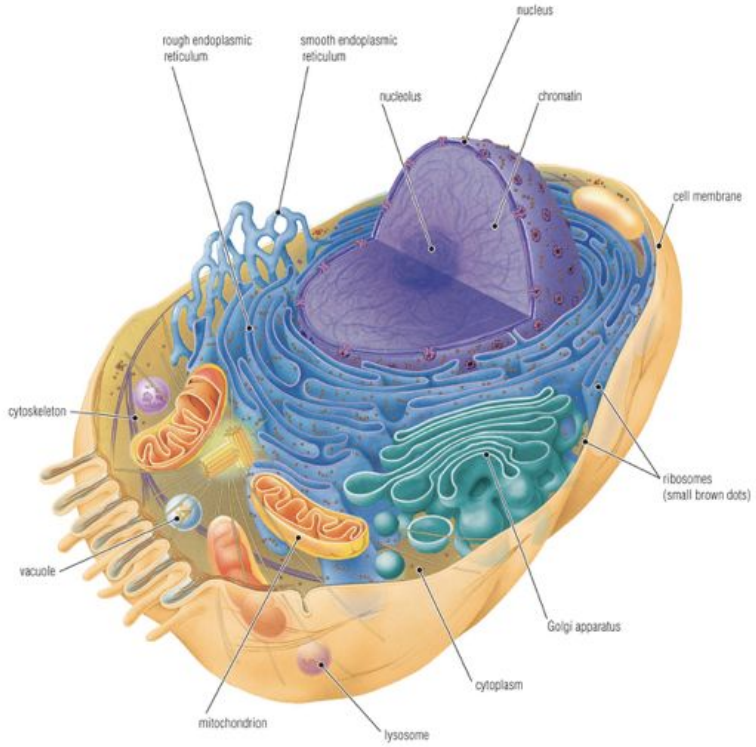
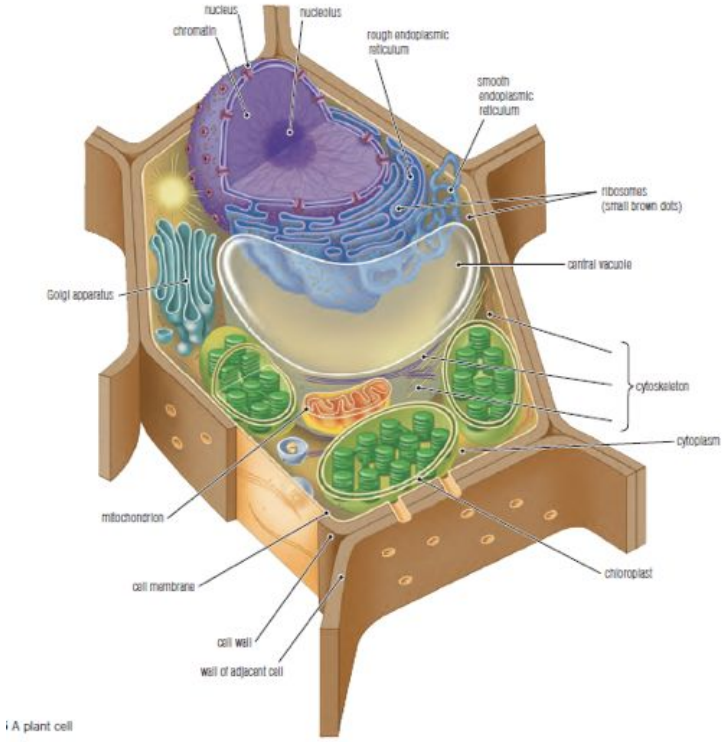


Figure 1.6 An animal cell



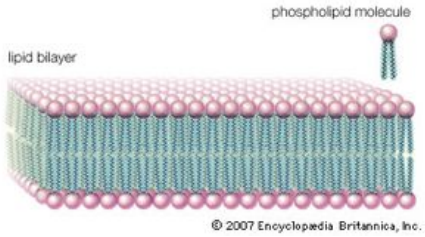
i A plant cell

Chloroplasts

- A chloroplast is an organelle that is only found in plant cells.
- Chloroplasts contain little sacs called thylakoids, which contain a chemical called chlorophyll.
- Chlorophyll is green in colour and uses energy from the Sun to convert carbon dioxide and water to sugar and oxygen, this process is called photosynthesis.

The Cell Membrane

- Found in all cells, forms a protective barrier around the cell.
- Seen only with an electron microscope – it is only 8nm thick.
- The membrane is made up of a double layer of lipids
- This bi-layer separates the external and internal environment of the cell.



- Cell membranes are designed to allow water, and some substances to pass in and out of the cell, and to keep other substances out.
- Because cell membranes only allow certain substances to pass through, the cell membrane is described as **semi-permeable**

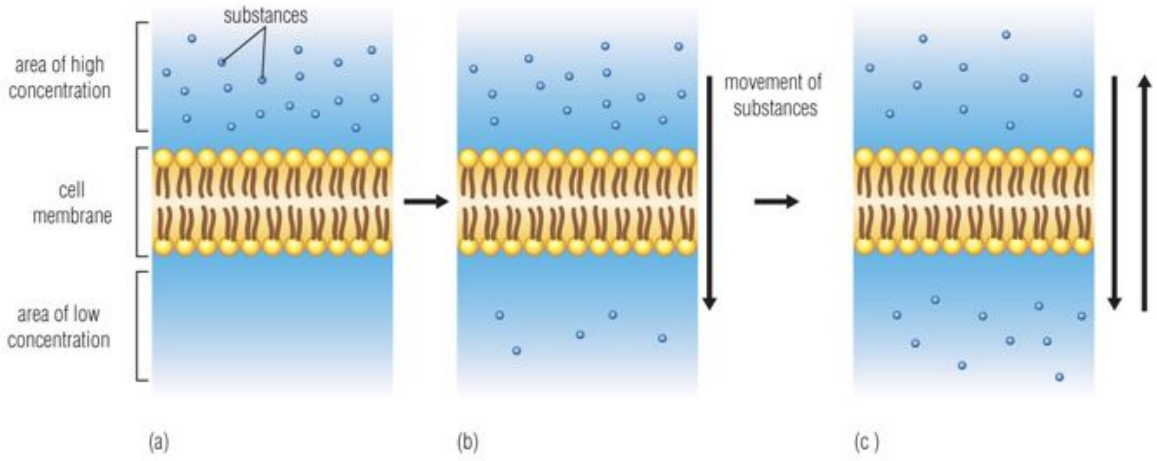
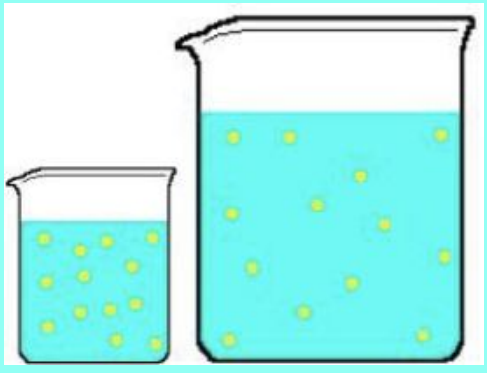


Figure 1.8 (a) There is a higher concentration of substances on one side of the cell membrane. (b) The substances move to the side that has a lower concentration until a balanced state, called equilibrium, is attained. (c) When equilibrium is reached, the substances diffuse across the cell membrane in both directions.

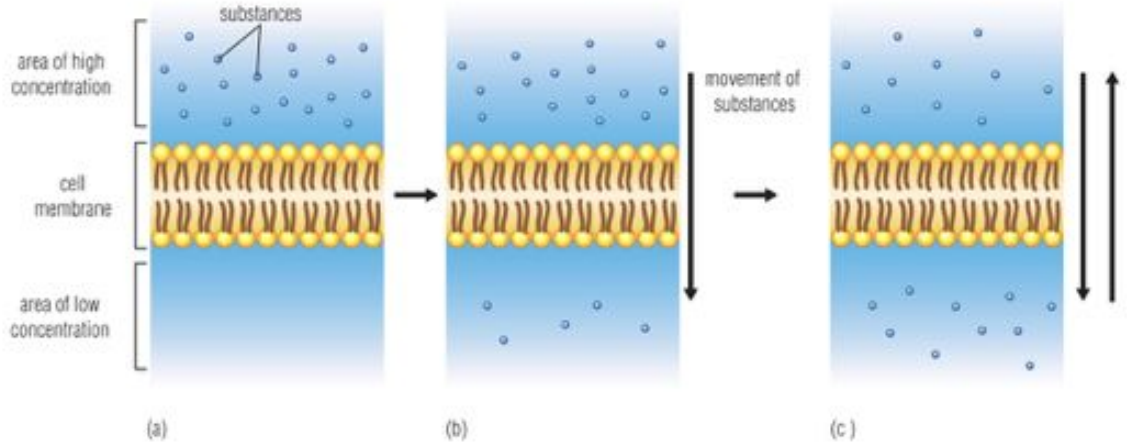
Diffusion

- Solution - It is formed when one or more substances are dissolved in one or more other substances. Ex. Salt in water
- Solvent - The component of a solution that is present in the greatest amount. It is the substance in which the solute is dissolved.
- Solute - The solute is the substance which is dissolved by the solvent



Diffusion

- **Diffusion** – The net movement of a substance from a region of higher concentration to a region of lower concentration.



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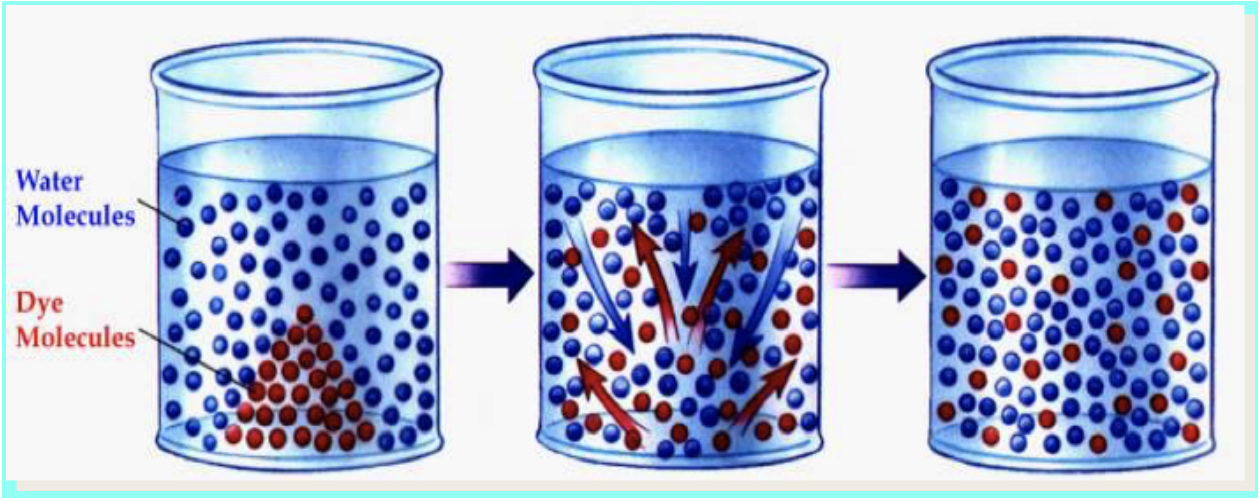
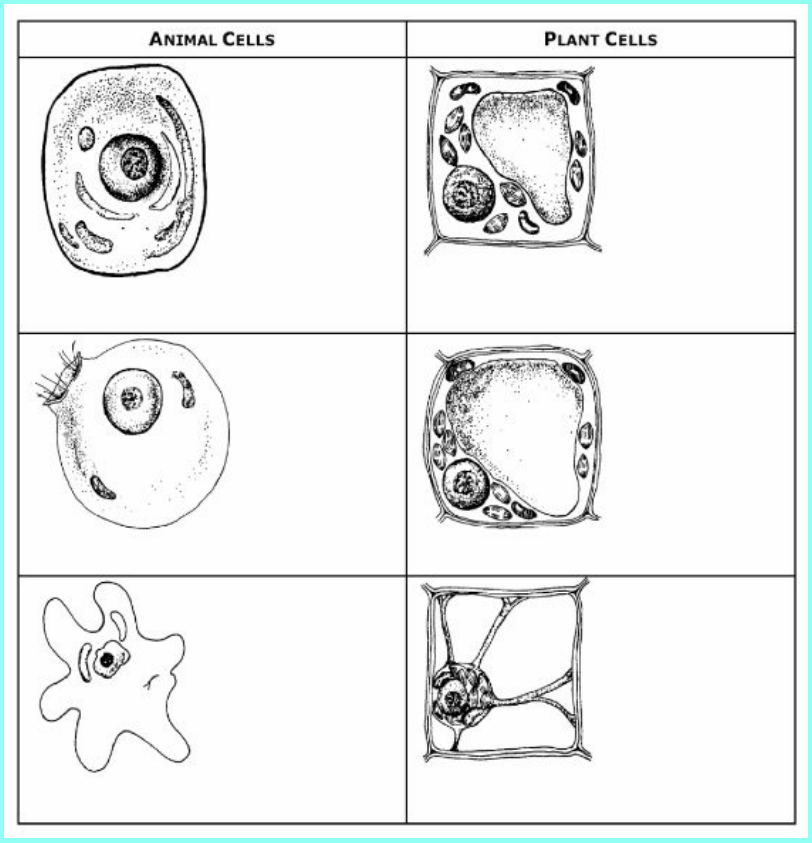


Osmosis

- Osmosis- the diffusion of water through a semi-permeable membrane.
- *Water moves towards the area of high solute concentration

Osmosis Demonstration

http://www.stolaf.edu/people/giannini/flashanimat/transport/osmosis.swf



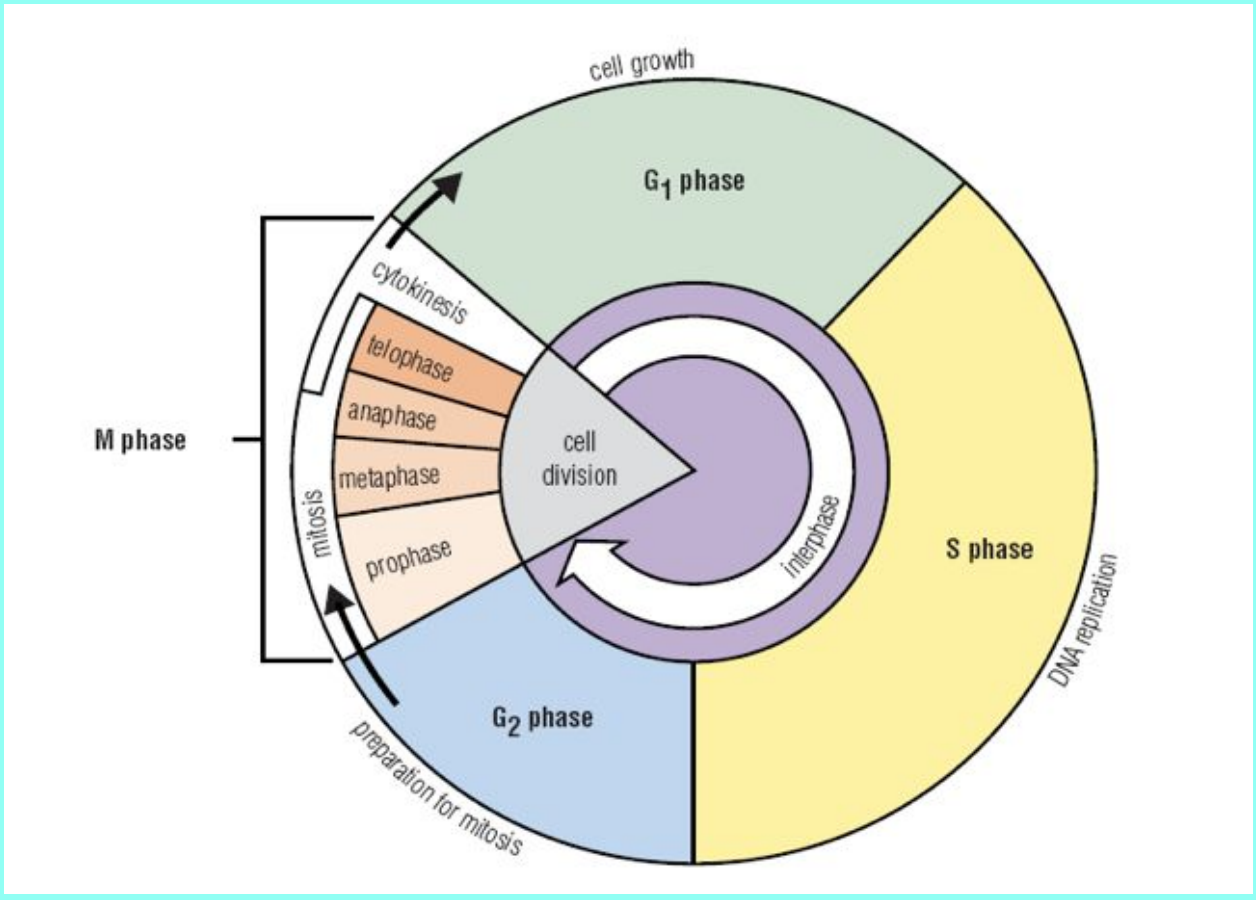
The digestion of food in humans involves several processes…

- 1. Ingestion
- 2a. Digestion (Mechanical) - foods are broken down using physical means ie. chewing
- 2b. Digestion (Chemical) - foods are broken down using enzymes released by organs
- 3. Absorption of Nutrients - Nutrients are absorbed into the circulatory system to be transported to the body
- 4. Elimination

The Cell Cycle

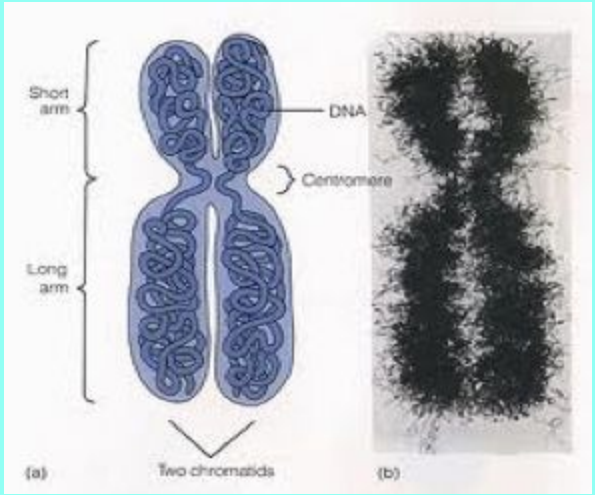
What is the Cell Cycle?

- The repeating cycle of events in the life of a cell in which it grows and prepares for division
- The cell cycle includes
- Interphase
- Mitosis
- Cytokinesis
- Each of these processes can be further divided into more phases

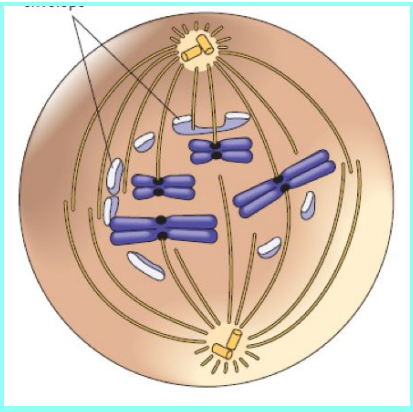


Structures Involved in Cell Division

- Chromosomes – A long piece of coiled DNA (genetic information) and proteins; only visible during mitosis.
- Sister Chromatid – Two identical copies of a chromosome that are connected by a centromere.

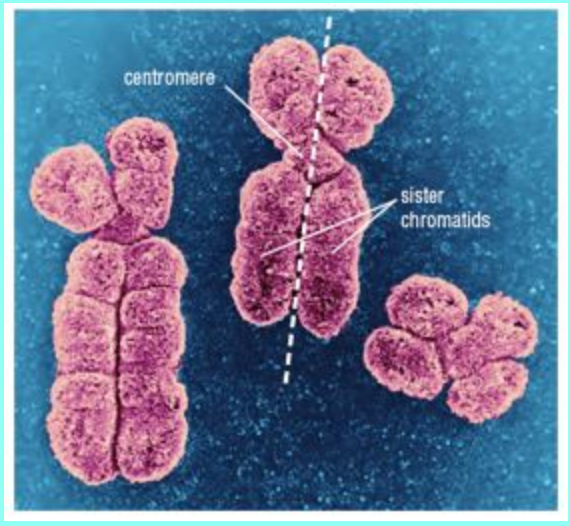


Centromere – The region that joins two sister chromatid
Spindle Fibres – Microtubules that attach themselves to the centromere of the chromosomes during mitosis



Chromosome Structure

- Each chromosome duplicates itself during interphase.
- The original chromosome and its duplicate are attached to each other by a structure called the centromere.
- While attached to one another, the original strand and its duplicate are referred to as sister chromatid.

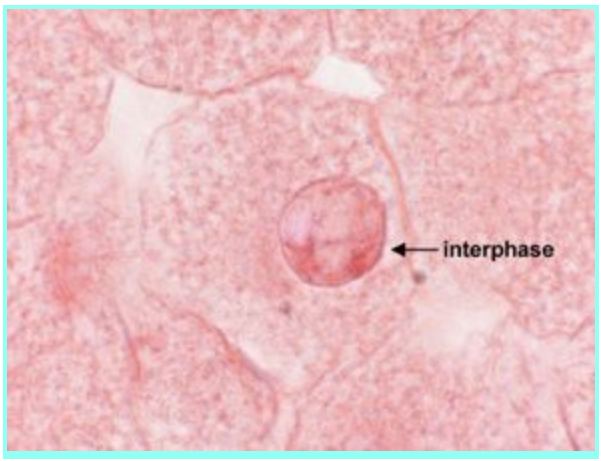


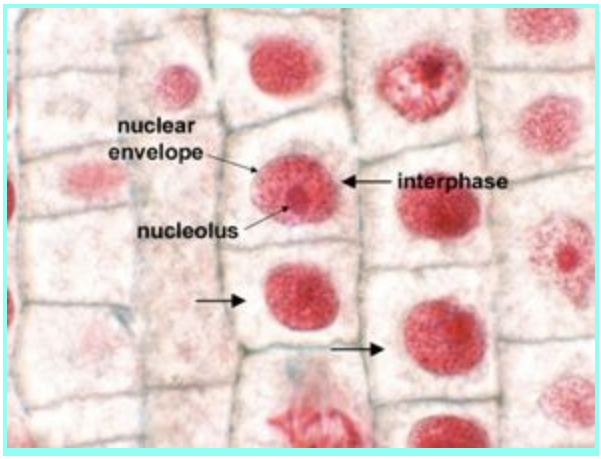
Interphase

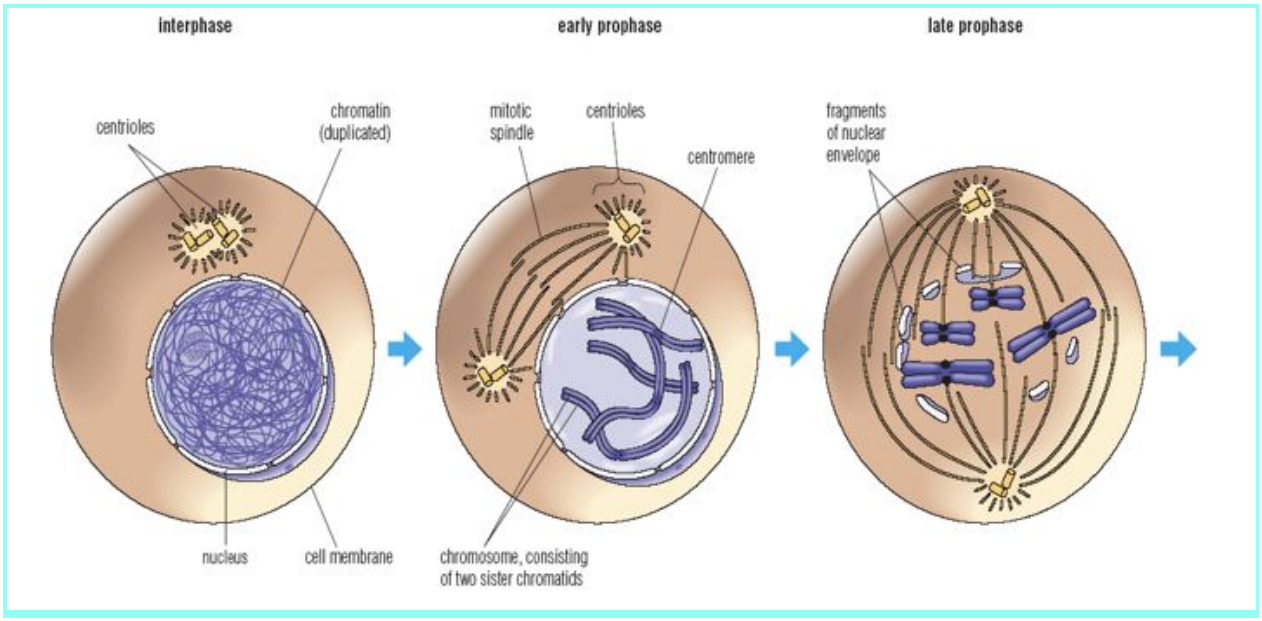
- **NOT** a part of mitosis.
- Longest phase in the cell cycle of a typical cell.
- Used to be referred to as the "Resting Phase".

Three Phases:

- **G1 Phase** – Growing and preparing for replication
- **S Phase** – DNA is duplicated. There are 46 chromosomes (23 pairs) in human somatic cells. DNA is uncondensed (called chromatin)
- **G2 Phase** – Cell begins it's final preparation for cell division. Structures directly involved with mitosis are formed.


interphase


nuclear envelope
interphase
nucleolus


interphase
early prophase
late prophase
centrioles
chromatin (duplicated)
nucleus
cell membrane
mitotic spindle
centrioles
centromere
chromosome, consisting of two sister chromatids
fragments of nuclear envelope

Mitosis

- Mitosis is the process of cell division.
- Mitosis occurs to replace old damaged cells, for growth, and for reproduction.

Consists of 4 phases:

- Prophase
- Metaphase
- Anaphase
- Telophase

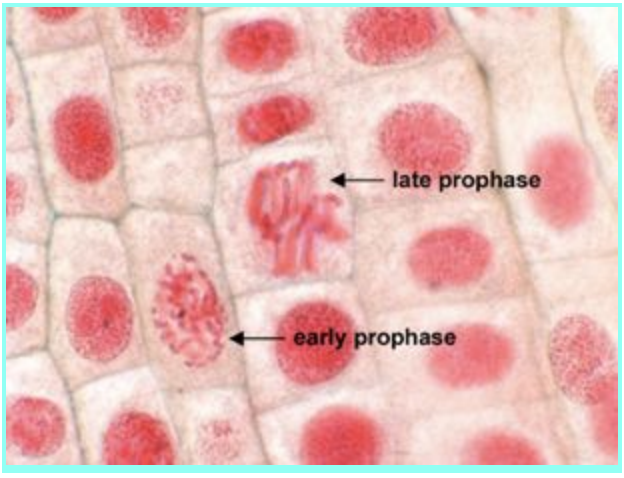
Prophase

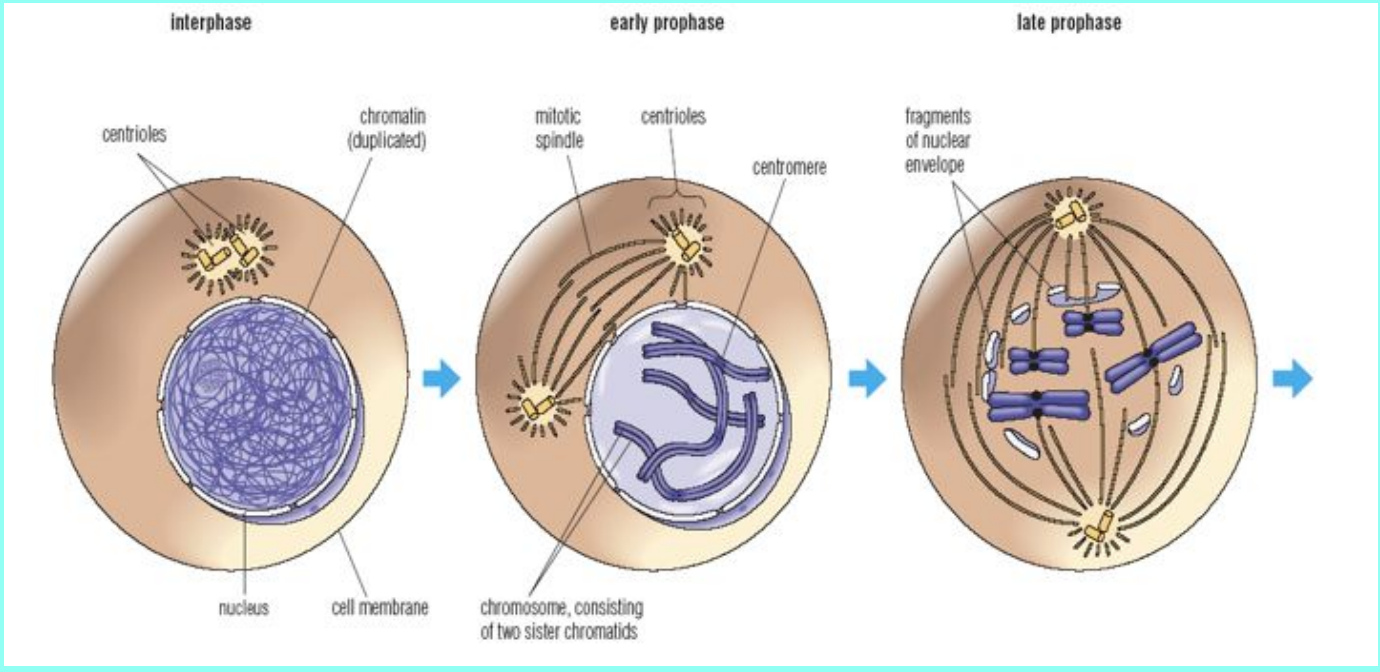
Early Prophase

- Chromatin condenses to form chromosomes
- Centrioles start to move to opposite poles
- Centrioles begin to develop microtubules (spindle fibres) as they move. Called the spindle apparatus

Late Prophase (aka Prometaphase)

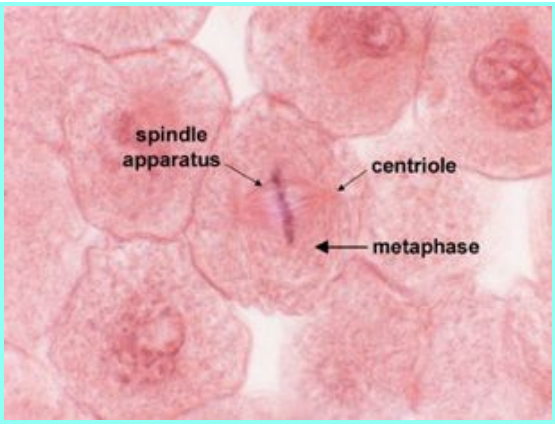
- Nuclear membrane breaks down and the nucleolus disappears
- Each chromosome is connected to a spindle fibre at its centromere

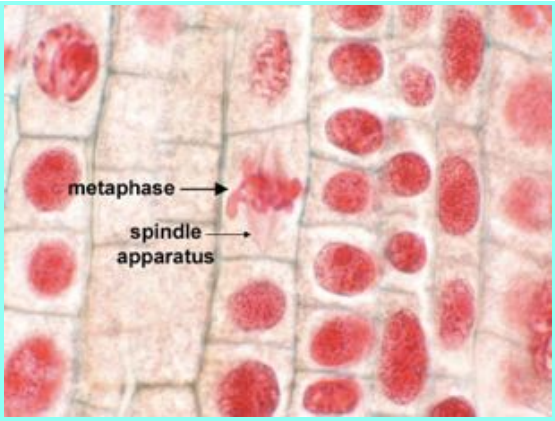


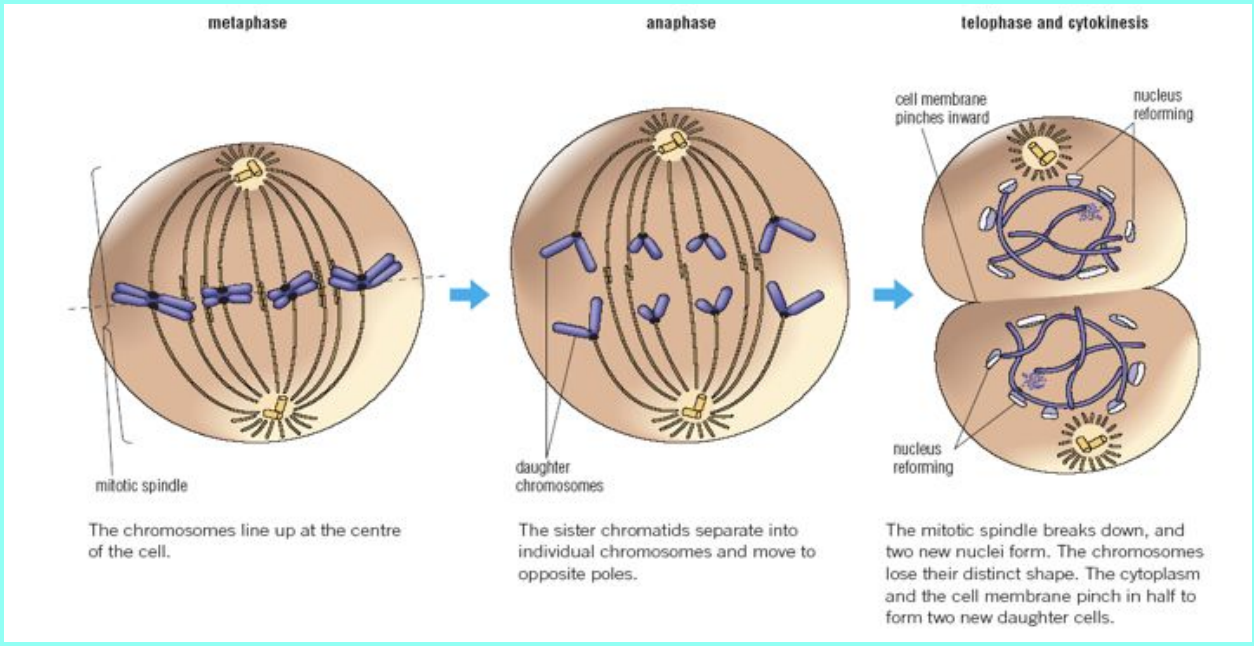


Metaphase

- The chromosomes line up at the metaphase plate. The spindle fibres are responsible for this.
- Each chromatid now faces the pole opposite that of its sister chromatid

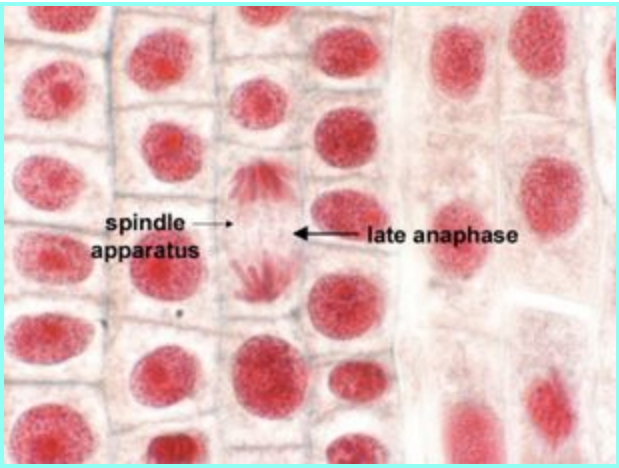


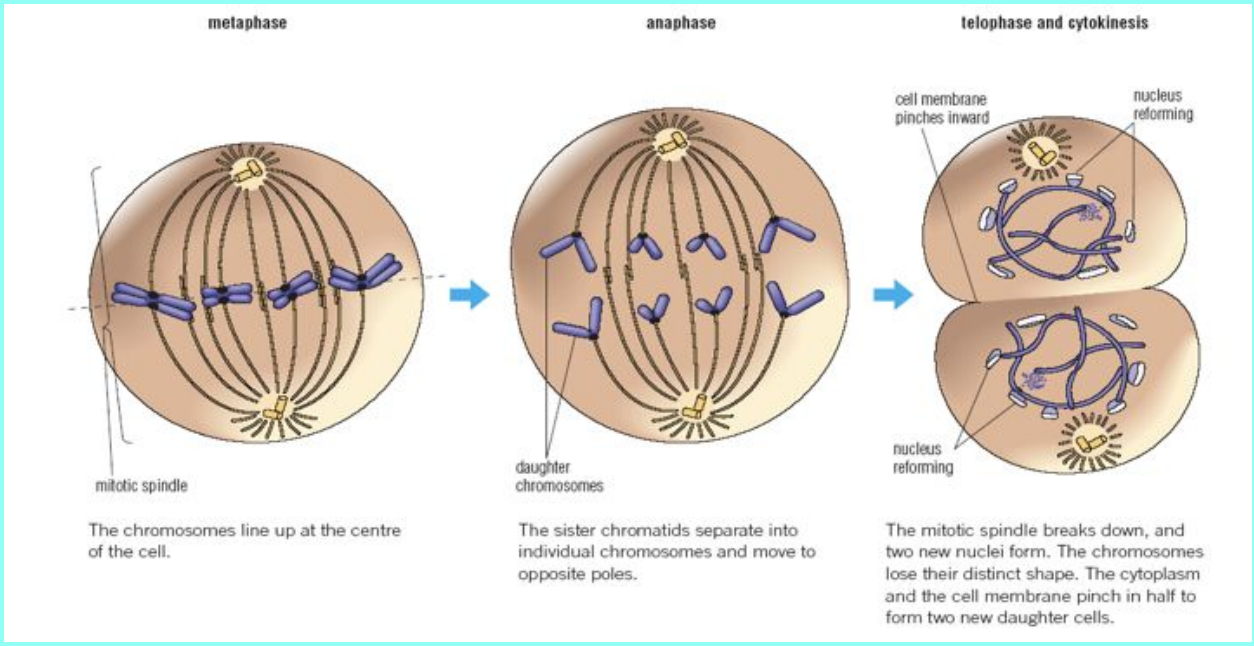




Anaphase

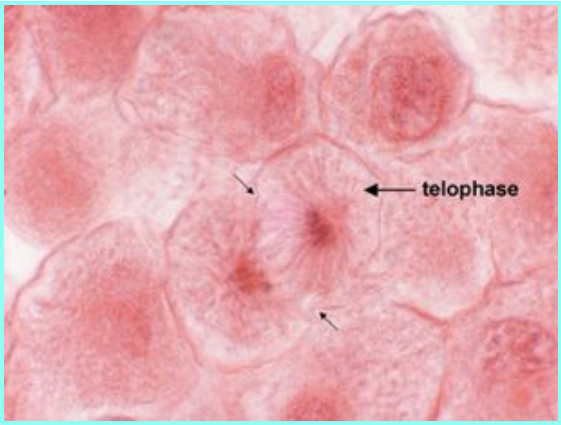
- As the spindle fibres shorten, the sister chromatid separate into individual chromosomes and move to the opposite pole.

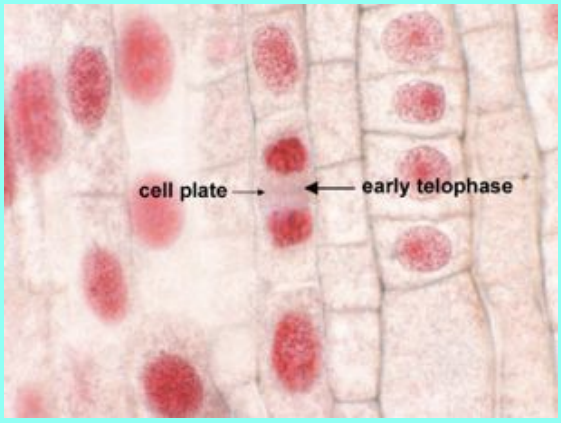


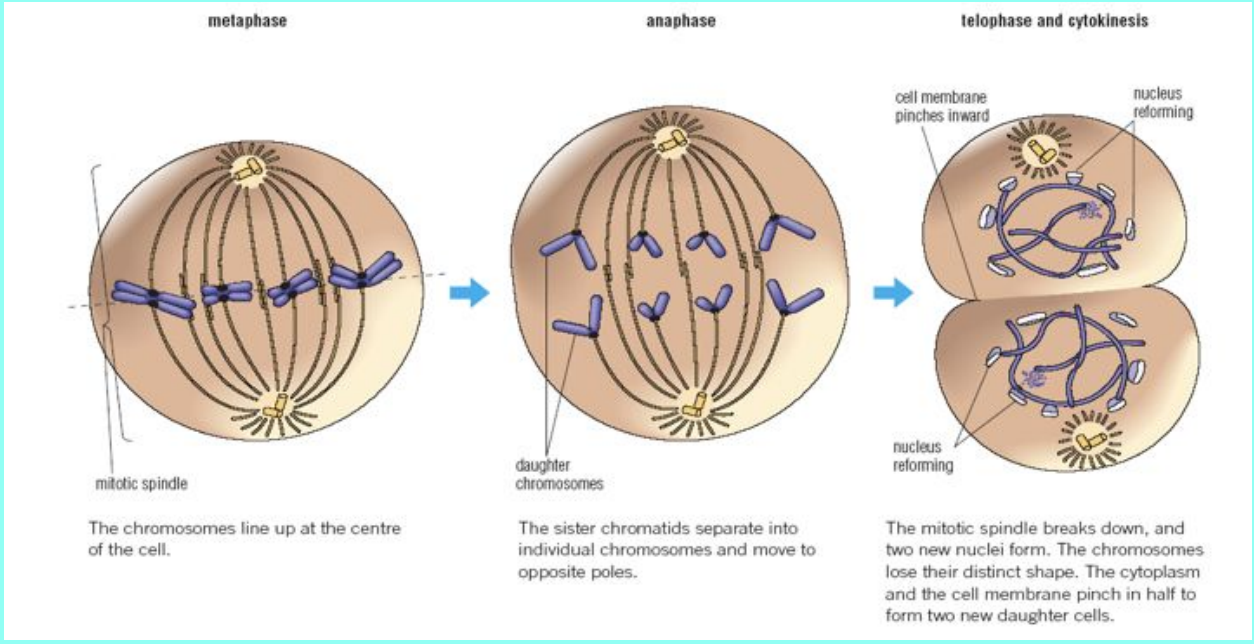


Telophase

- Characterized by the return to interphase conditions
- The spindle apparatus breaks down
- The nuclear membrane reforms and the nucleolus reappears.
- The chromosomes elongate by uncoiling to become chromatin again



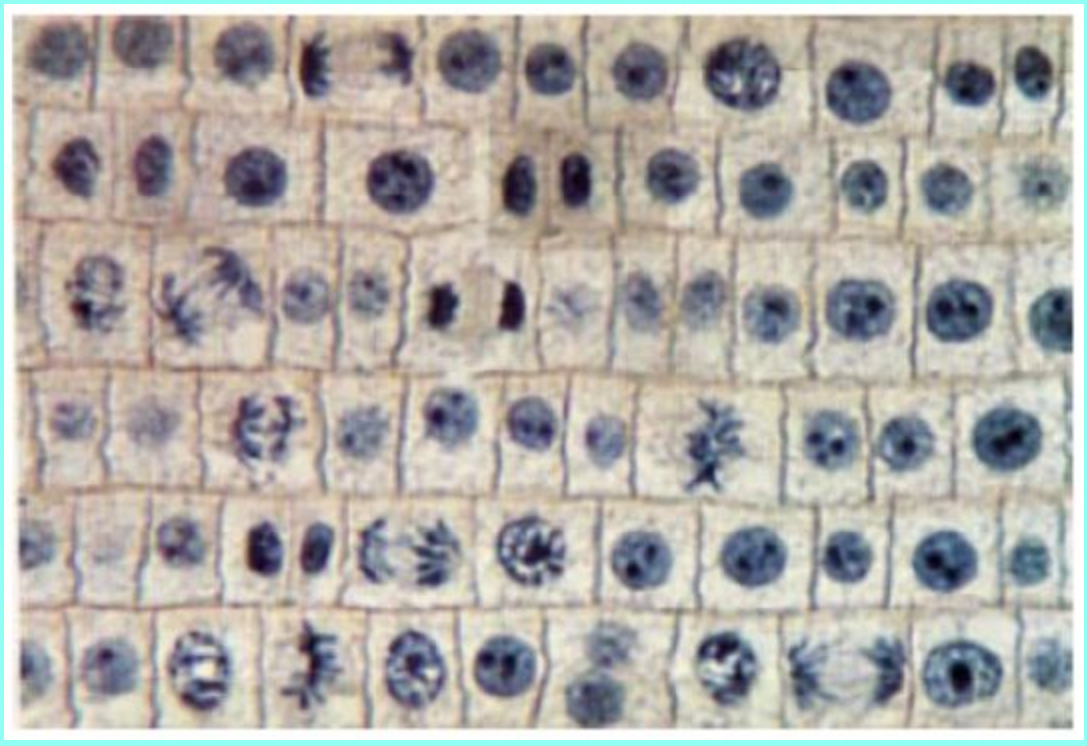




Cytokinesis

- The division of cytoplasm occurs and the cell membrane pinches in half to form two new, genetically identical daughter cells

- The stages of mitosis are clear in these cells from the African globe lily (*Scadoxus katherinae*)



Mitosis: Differences Between Animal and Plant Cells

- Plants use a similar process with a few differences:
- A plant cell creates a mitotic spindle and has a centrosome but, it lacks centrioles.
- Spindle fibres originate from a place called the centrosome.
- In animal cells, the cell membrane pinches in creating a cleavage furrow.
- in plants, the cell wall that will separate the two daughter cells starts growing in the middle of the cell between the two nuclei, this is known as the cell plate.□□

What is cancer?

- Our bodies are made up of billions of tiny parts that fit together like building blocks. These parts are called cells.
- Healthy cells grow, divide and eventually get worn out and die. This cycle usually continues without any problems.
- Cancer happens when something goes wrong with the cell and it grows and divides in an uncontrolled way. Cancer cells divide too much and don't die in the way normal cells do. These cells can form a lump called a tumour.

A tumour can form inside:

- an organ (part of the body that does a specific job, such as the liver or kidney)
- a bone
- the lymphatic system (a network that helps defend your body from disease) – when a tumour forms here, it is called lymphoma.

If cancer affects your blood, the cancer cells do not form a tumour but affect the bone marrow (the spongy centre of your bones where your blood cells are made). This type of cancer is called leukemia.

Cancer cells from a tumour can spread to other parts of the body. That is why having treatment as soon as possible is important.

There are more than 200 different types of cancer. Each type has its own name and treatments. People with cancer need to have tests to find out exactly what type of cancer they have and to find out whether it has spread. This helps the doctors plan the right treatment for each person.

The Digestive system consists of:

Oral cavity (Mouth)

↓

Esophagus

↓

Stomach

↓

Small Intestine

↓

Large Intestine

↓

Rectum

The Oral Cavity

Mouth

- Your mouth is lined with epithelial tissue
- Saliva, mucus, and enzymes are released from glands in your mouth to moisten food and to start the chemical digestion of carbohydrates.

Swallowing:

- The tongue pushes food to the back of the mouth where it is swallowed.

The epiglottis covers the trachea to make sure food doesn't go into the lungs

Esophagus

- Transports food from the mouth to the stomach.
- Made up of muscle tissue and is lined with a protective layer of epithelial tissue.

Food passes through by the alternate waves of relaxation and contraction along the esophagus called peristalsis

The Stomach

- Made of epithelial, connective, nervous, and muscle tissues
- Glands in the lining of the stomach secrete acid and enzymes that help breakdown proteins.
- A thick *mucus layer* that lines the stomach walls prevents the stomach from digesting itself.

The Small Intestine

•Made of epithelial, connective, nervous, and muscle tissues

•The glands of the small intestine secrete enzymes that finish the breakdown carbohydrates, proteins and fats.

•Absorption of nutrients occurs here

Functions of other glands and organs

Liver

•Produces bile which helps with the digestion of fats.

Gallbladder

•The bile that is produced in the liver is stored in the gallbladder.

Pancreas

•Secretes enzymes that help with the process of digestion into the small intestine

The Large Intestine (The "Colon")

•Indigestible food passes into the large intestine from the small intestine

•The large intestine absorbs water

•Undigested waste (feces) is passed and stored in the rectum and periodically eliminated through the anus.

Parts of the Circulatory System

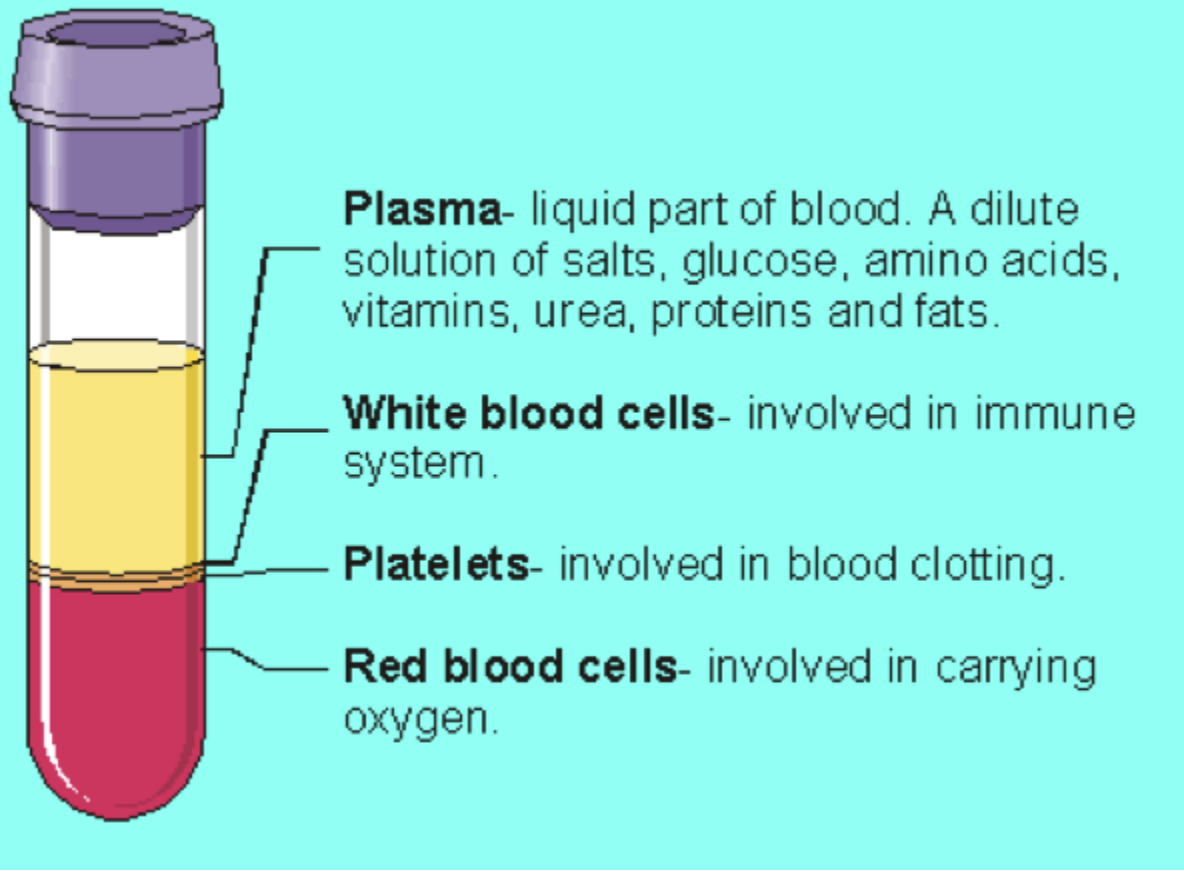
The circulatory system is the blood's transportation system. The circulatory system includes:

1) Blood
2) Heart
3) Blood vessels

The heart acts as a pump to transport blood through blood vessels.

Blood

- Composed of a Liquid Medium (Plasma) and Blood Solids (red blood cells, white blood cells, and platelets)



The Heart

- Supplies blood and oxygen to all parts of the body.
- Consists of four chambers: two atria and two ventricles

The Heart

- The right side (right atrium and right ventricle) pumps blood to the lungs so that the blood can pick up oxygen and drop off carbon dioxide.
- The left side (left atrium and left ventricle) pumps the oxygenated blood through the aorta to the rest of the body.

Blood vessels

Blood vessels carry blood to every part of your body

There are three types of blood vessels:

- Arteries
- Veins
- Capillaries

Arteries and veins have the same basic structure:

- an inner epithelial layer
- middle muscular layer
- outer connective tissue layer

Arteries

- Carry blood away from the heart.
- Most arteries carry oxygenated blood.
- Arteries have thick walls which allow them to withstand higher blood pressure

Veins

- Carry blood toward the heart.
- Most veins carry deoxygenated blood.

Capillaries

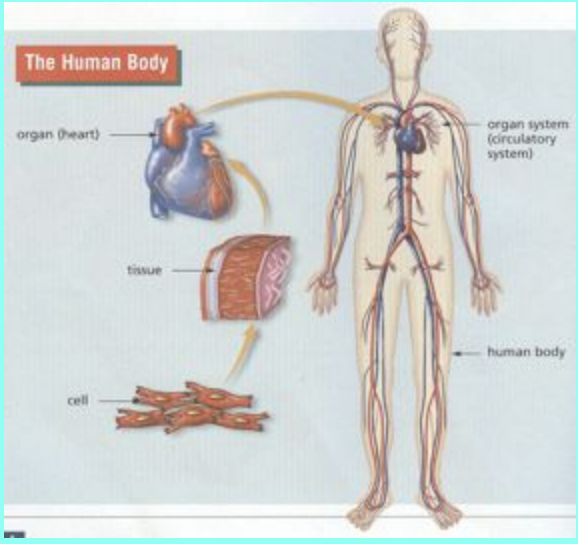
- Small, thin-walled blood vessels that connect arteries to veins
- Allow oxygen to diffuse from the blood into the cells and carbon dioxide to diffuse from the cells into the blood.

Gas Exchange

- If the red blood cells have more oxygen than the tissues, oxygen will diffuse across the capillary walls and enter the tissues
- If the tissues have more carbon dioxide than the red blood cells, the carbon dioxide will diffuse across the capillary walls and enter the red blood cells
- The carbon dioxide is then carried to the lungs by the red blood cells where it is released as you exhale.

Organs and Organ Systems

- An **organ** is a group of tissues that perform a specific function
- Organs that function together are called an **organ system.**



Plant Organ systems

Plants have two organ systems:

- Root system
- Shoot systems
- Root System – everything underground
- Shoot System – everything above ground

Plant Organs

- Plant organs include roots, leaves, stems, and the flower or fruit.
- Each plant organ consists of different types of plant tissue

Root

- Collect water from the soil
- Store food
- Anchor the plant in the soil

Stem

- Transports water and nutrients
- Supports leaves and flowers

Flower

- Reproductive structure. Produces seeds through sexual reproduction

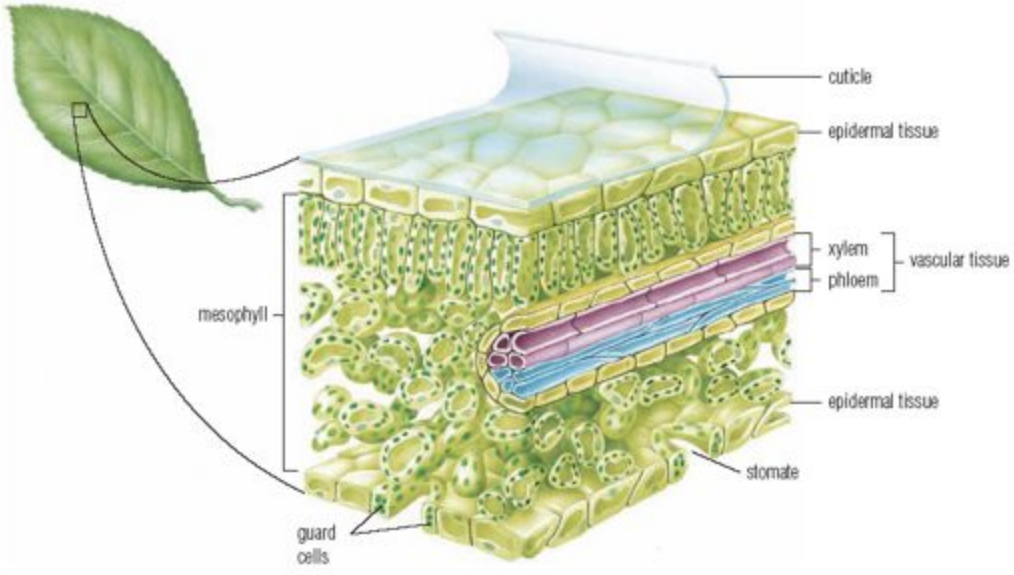
The Leaf

- Where photosynthesis occurs
- **Photosynthesis:** A reaction where carbon dioxide and water are converted into sugar and oxygen.
- $6\ CO_2 + 6\ H_20 \rightarrow C_6H_{12}O_6 + 6\ O_2$

Vascular tissue carries water needed for photosynthesis from root to leaf and sugar to the rest of the plant.

Epidermal tissue lining the leaf have openings called stomata that allow carbon dioxide to enter and oxygen to leave. These opening are controlled by guard cells.

Ground Tissue makes up most of the leaf. Photosynthesis takes place in a specialized ground tissue called mesophyll which contains many chloroplasts per cell.



Tissues and their functions

What is a tissue?

Tissue: Group of cells that function together to perform specialized tasks

Animal tissues:

There are four types of tissues:

- Epithelial tissue
- Connective tissue
- Muscle tissue
- Nervous tissue

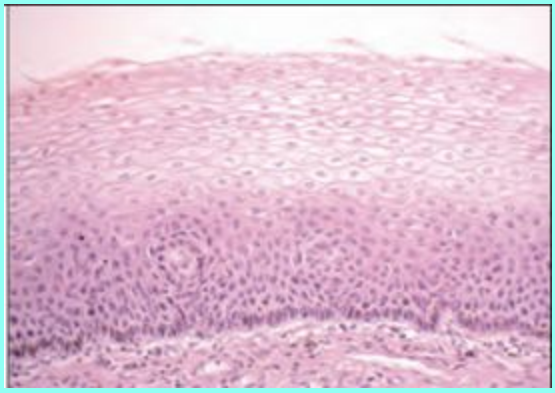
Epithelial tissue

Major Function

- lines body cavities and outer surface of the body
- tightly packed together to protect structures
- May be one cell thick or consist of several layers of cell
- forms glands that produce hormones, enzymes, and sweat

Examples

- Epithelial cells in the skin
- Epithelial cells lining the small
- intestine



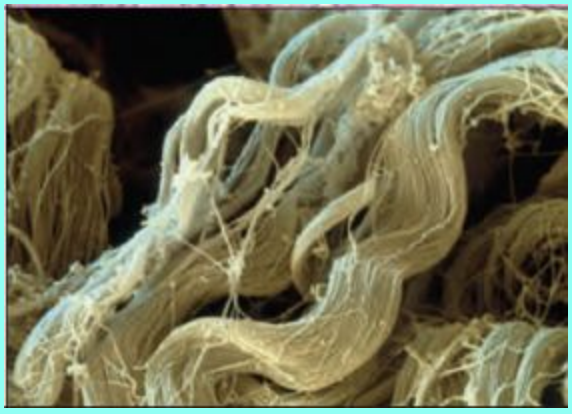
Connective Tissue

Major Functions

- joins tissues together
- supports and protects structures
- forms blood
- stores fat
- fills empty space

Examples

- Tendons (connect muscle to bone); Ligament (connect bone to bone); Bone; Cartilage; and Blood



Muscle Tissue

Major Function

- Allows for movement

Examples

- Smooth (muscle cells in blood vessels and stomach)
- Skeletal (muscle cells for movement in arms and legs)
- Cardiac (muscle cells in the heart)

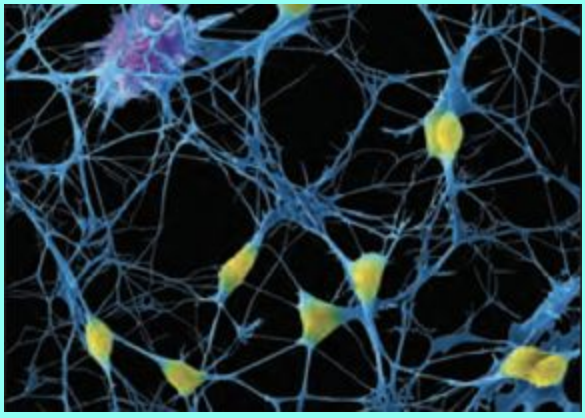
Nervous Tissue

Major Functions

- responds to stimuli
- transmits and stores information

Examples

- Nerve cells in the brain
- Nerve cells in the spinal cord



Plant Tissues

There are four types of tissues:

- Epidermal tissue
- Vascular tissue
- Ground tissue
- Meristematic tissue

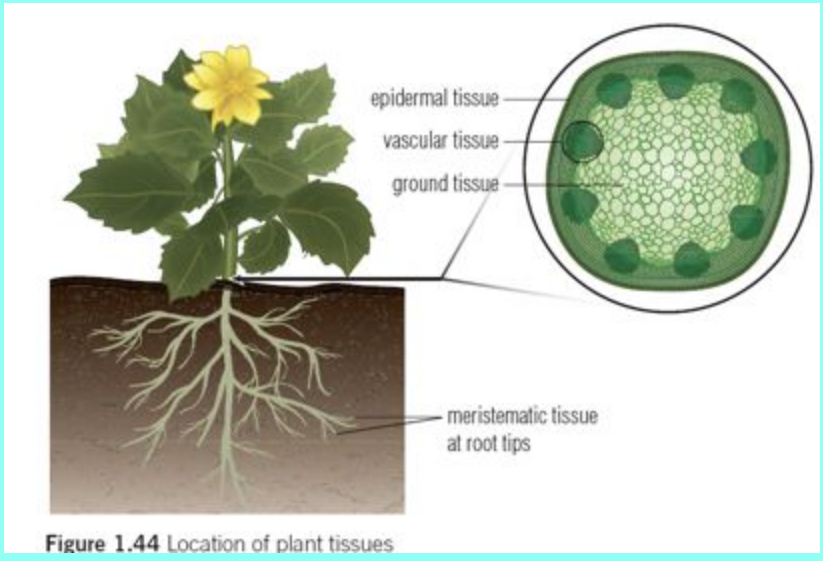


Figure 1.44 Location of plant tissues

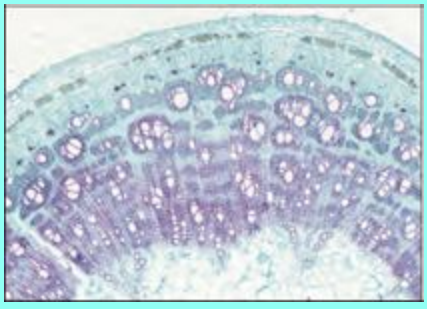
Epidermal Tissue

Major Functions

- forms the protective outer covering
- allows the exchange of materials and gases into and out of the plant through specialized guard cells that form a tiny opening called a stoma

Examples

- Epidermal cells located on the top and underside of a leaf
- Also form the outside layer of a stem



Vascular Tissue

Major Functions

- provides strength and support in the stem
- transports water and nutrients throughout the plant

Examples

- xylem (transport water and minerals from the roots up the stems to the leaves)
- phloem (transports sugar produced during photosynthesis from the leaves to other parts of the plant)

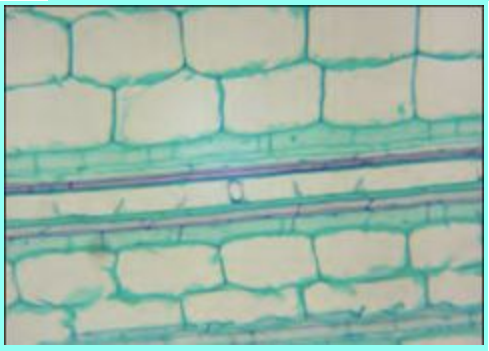
Ground Tissue

Major Functions

- In the stem: provides strength and support
- In the roots: stores food and water
- In the leaves: where photosynthesis occurs

Examples

- Mesophyll – the part of the leaf where photosynthesis occurs



Meristematic Tissue

Major Functions

- unspecialized tissue capable of dividing by mitosis
- responsible for growing new parts of the plant

Examples

- Found in several locations in the plant but mostly at the tips of roots and shoots

What is a stem cell?

- A stem cell is a type of cell that is capable of becoming any cell (nerve, blood, lung) under the proper environmental conditions.
- Every cell in your body originally was a stem cell.
- What does cell
- Does specialization mean?
- Stem cells are considered unspecialized
- Stem cells can become specialized cells that perform particular functions in a process called cell specialization.

Types of Stem Cells

There are different types of stem cells: embryonic, umbilical and adult stem cells.

- Embryonic stem cells
- Come from embryos and are pluripotent
- Pluripotent – a stem cell that can become almost any cell in the body
- Adult stem cells and umbilical stem cells
- Adult stem cells are found in skin, blood and neural tissue.
- Umbilical stem cells are found in the umbilical cord.
- Both types of cells are multipotent.
- Multipotent – a stem cell that can become only a limited range of cells

Meristematic Cells

- Stem cells are also found in plants
- Plant stem cells are called **meristematic cells**, they are found in the growing tips of roots and stems

ETHICS

- Should the government provide funding for embryonic stem cell research? Why or why not?
- Should there be laws to regulate stem cell research? If so, what would they look like? For example, how would you regulate research using different types of stem cells? What about embryonic stem cells created using cloning technologies?
- Do embryonic stem cells represent a human life? This is an ongoing debate that brings up the question of when life begins.
- Should frozen embryos created through in vitro fertilization be used to create stem cells? Why or why not?

The Digestive System of a Frog

- Similar pathway to humans: mouth → esophagus → stomach → small intestine → large intestine
- Digestion - stomach and small intestine.

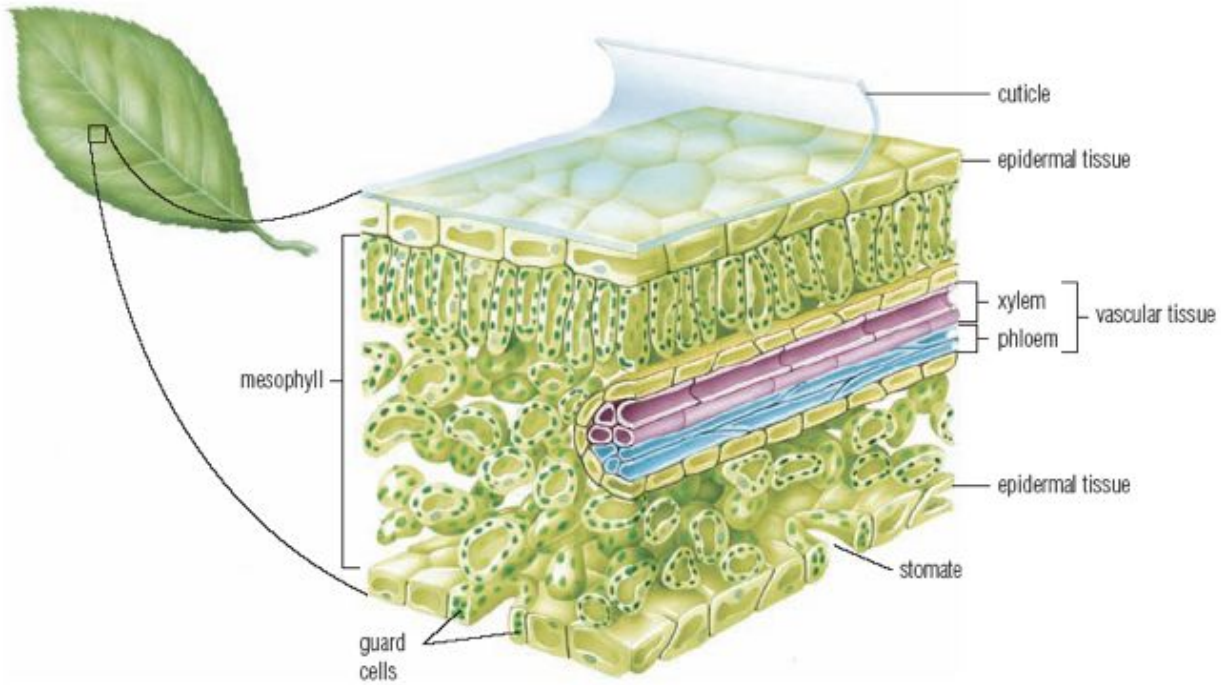
- Nutrient absorption - small intestine
- Waste materials exit through the cloaca.
- Digestion in Worms

The digestive system of a worm

- Pathway: mouth → pharynx → esophagus → crop → gizzard → intestine.
- The esophagus has glands that release calcium carbonate to rid the earthworm's body of excess calcium.
- Food is stored in the crop
- The gizzard uses stones to grind the food completely.
- Digestion and absorption - the intestine
- Waste exits through the anus

Circulatory System of a Frog

- 3-chambered heart: two atria and one ventricle
- Blood leaving the ventricle passes into a forked aorta, where the blood can travel to the lungs or the body.
- Blood returning to the heart from the lungs passes into the left atrium
- Blood returning from the body passes into the right atrium.
- Both atria empty into the single ventricle. Disadvantage?



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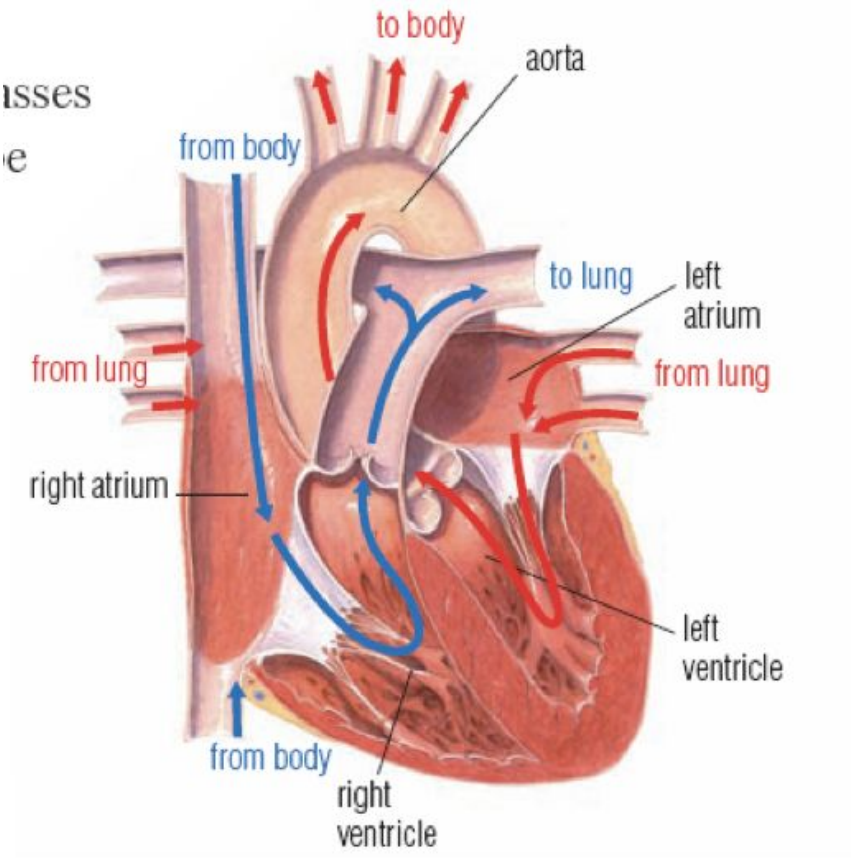

to body
aorta
from body
to lung
left
atrium
from lung
from lung
right atrium
left
ventricle
from body
right
ventricle

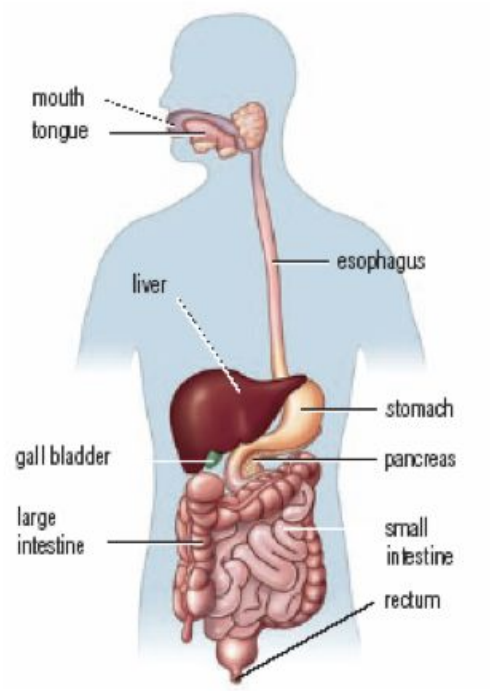
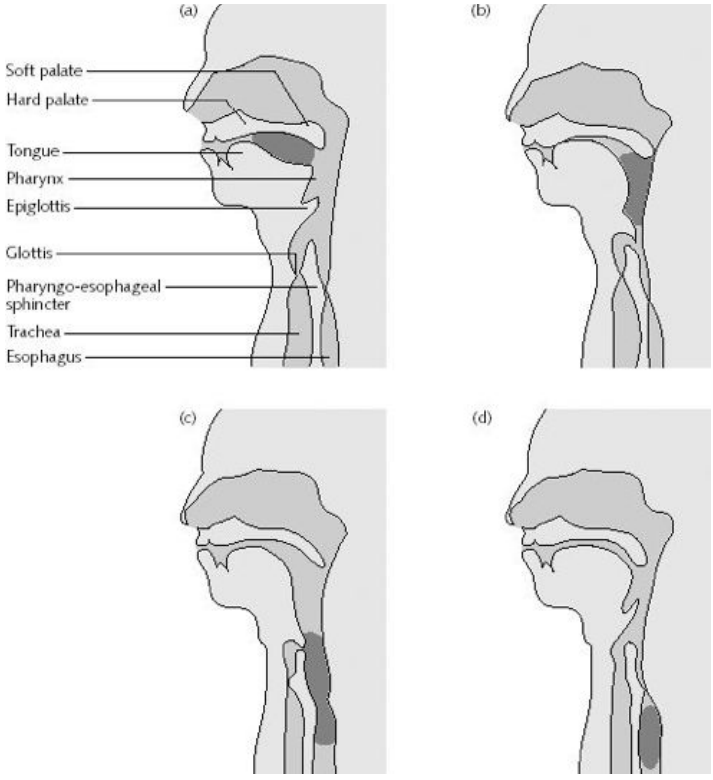


Figure 2.7 Organs of digestion



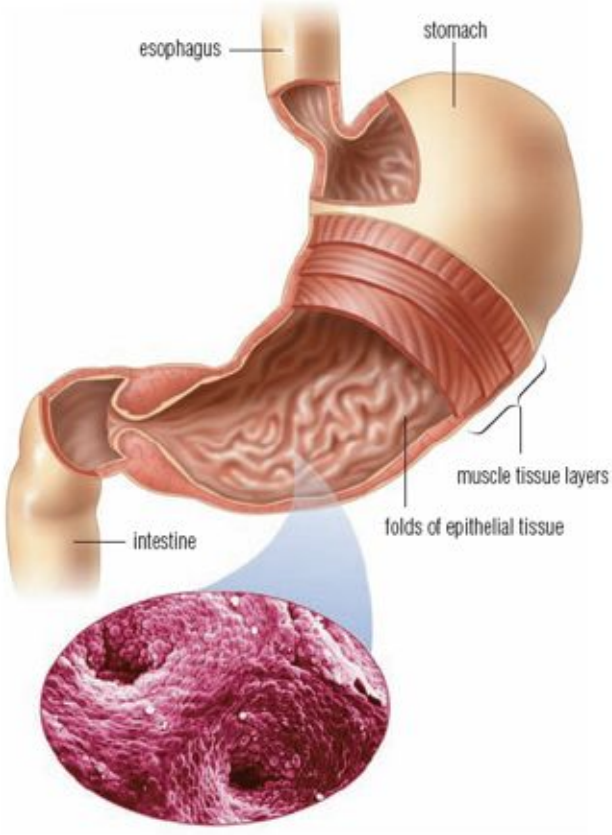
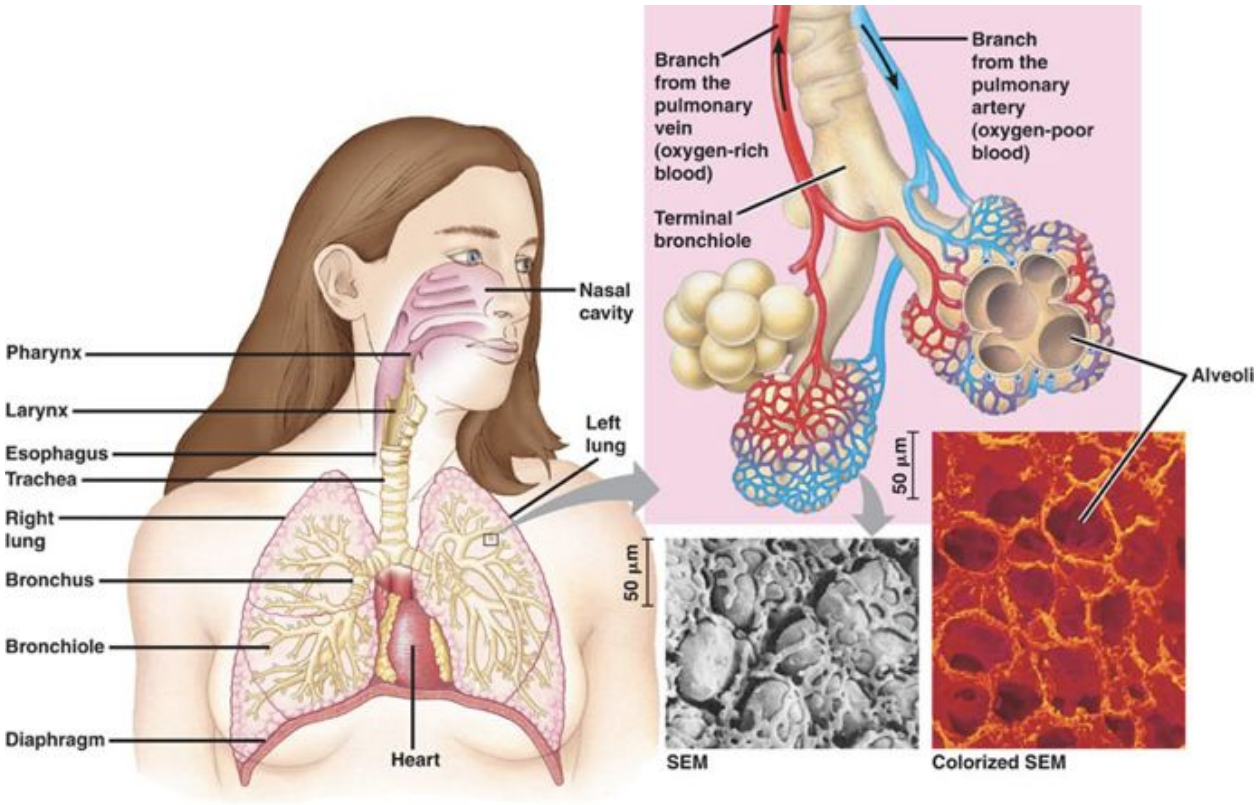


Figure 2.8 The stomach is made of smooth muscle and epithelial tissue as well as connective tissue and nervous tissue (not shown).



Circulatory system in worms

- Blood is circulated through vessels.
- 3 main blood vessels: aortic arches, dorsal blood vessels, and ventral blood vessels.
- Five pairs of aortic arches act like a heart and pump blood into the dorsal and ventral blood vessels.
- The dorsal blood vessels carry blood to the front (anterior) of the body.
- The ventral blood vessels carry blood to the back (posterior) of the body.

Respiration in frogs

- Gas exchange occurs in three locations in the frog:
- 1) the lungs
- 2) the lining of the mouth
- 3) the skin (cutaneous respiration)
- Frogs have a trachea and a pair of lungs
- The skin of a frog is permeable to O_2 and CO_2
- There are a number of blood vessels near the surface of the skin.
- When a frog is underwater, O_2 is absorbed through the skin directly into the bloodstream by diffusion.
- On land, adult frogs use their lungs to breathe.

Respiration in Worms

- They exchange gases through their skin.
- O_2 and CO_2 pass through the skin by diffusion.
- The skin must be kept moist for diffusion to occur.
- Body fluid and mucus are released to keep the skin moist.

Respiration

Function

- To supply the blood with oxygen in order for the blood to deliver oxygen to all parts of the body.
- In Humans, this is done through breathing.

Medical Imaging

X-Rays

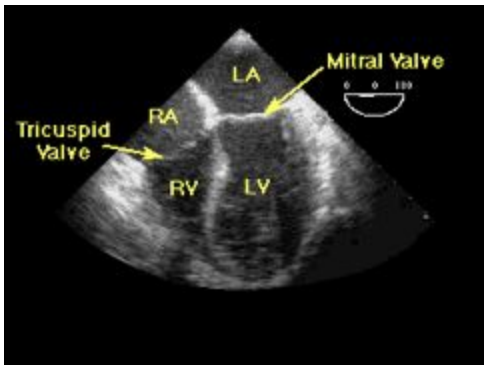
- High energy radiation that passes through the skin but not bone and dense structures

Fluoroscopy

- After ingesting a contrast liquid (barium or iodine), X rays are used to show the movement of liquid through organs.

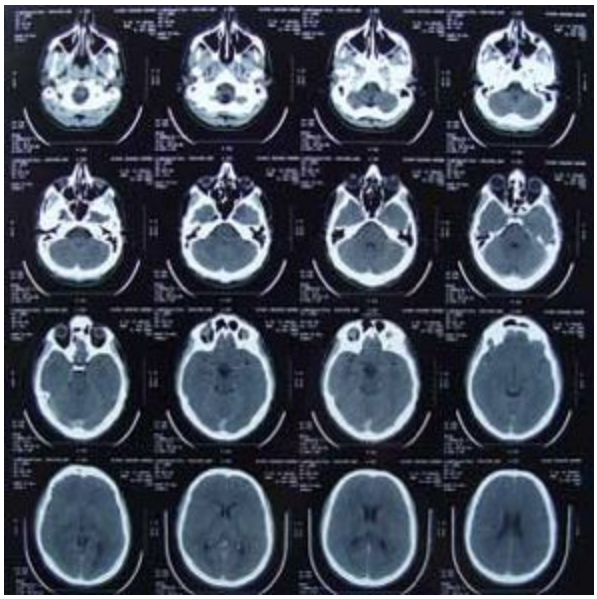
Ultrasound

- Images of body tissues and organs are created using high-frequency sound waves
- As the sound waves enter the body they are reflected back like an echo when in contact with tissues and organs



CT Scan

- X rays are used to form a 3D image from a series of images taken at different angles
- Allows for a cross-sectional view



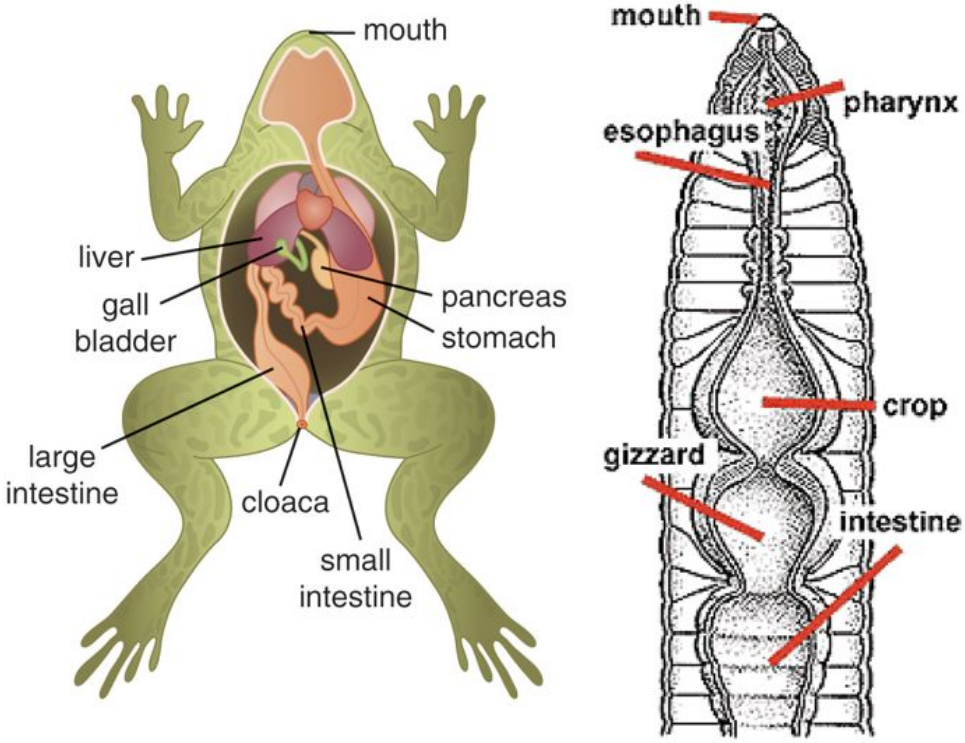
MRI

- Produces detailed images of the body using magnets and radio waves.

Endoscopy

- An endoscope is a flexible thin tube with a light and video camera on the end to visualize internal structures.
- Endoscopic surgery allows for non-invasive alternatives to traditional surgery

Important diagrams:



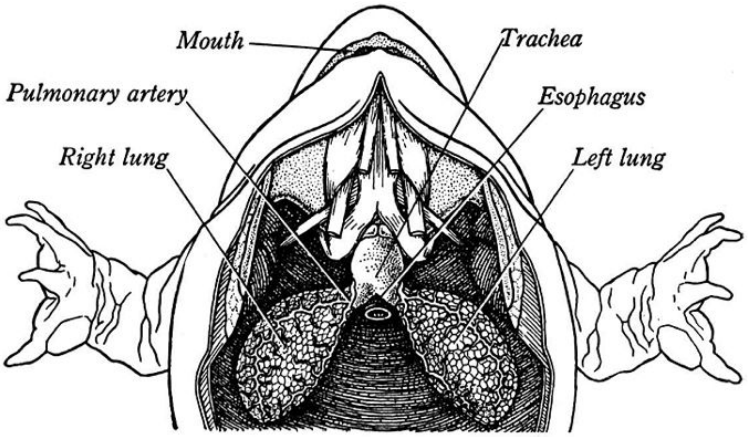


FIG. 388. *Lungs of Frog*

Climate

Climate is the average weather conditions that occur in a region over a long period of time, usually a minimum of 30 years.

Weather refers specifically to the environmental conditions that occur at a particular place at a particular time

Scientists who study weather are called **meteorologists**
Scientists who study climate are called **climatologists**

The four main factors that determine the climate of an area are:
Latitude - the invisible lines that run across the earth
Elevation - the height above or below sea level that is measured
The air masses that flow over the area - the wind current
Nearness to water - how near an area is to a large body of water such as a lake or ocean

The sun is the source of all energy on Earth because the Earth isn't actively producing its own energy, it relies on solar radiation to get its energy. The Earth then transfers that solar radiation into thermal radiation to use.

Sphere	Explanation
Biosphere	bio = living, sphere = ball; the living layer around the planet; includes the atmosphere, lithosphere, and hydrosphere
Atmosphere	atmos = gas; the gas layer around the planet
Lithosphere	lithos = rock; the rock layer around the planet
Hydrosphere	hydro = water; the water layer around the planet

Earth's Biosphere

The climate of a region is affected not only by the amount of solar radiation it receives but also by interactions among components of Earth's biosphere. The **biosphere** is the relatively thin layer of Earth that has conditions suitable for supporting life. It is composed of all the living things on Earth and the physical environment that supports them. Other planets in our solar system do not appear capable of supporting life as we know it.

The Atmosphere

Air is the mixture of different gases found in Earth's atmosphere. The **atmosphere** is the layer of gases that extends outward about 300 km from the surface of Earth. The major gases found in this mixture are nitrogen and oxygen. Other gases found in trace amounts are argon, carbon dioxide, neon, helium, methane, and krypton.

The Lithosphere

The **lithosphere** is the solid portion of Earth that floats on the semifluid portion of the mantle. The lithosphere is home to many micro-organisms, plants, and animals, including humans. It is the outer surface of Earth (its crust) plus the solid part of the upper mantle. It extends downward from Earth's surface and varies in thickness from as little as 5 km thick beneath parts of the oceans to as deep as 100 km beneath the continents. A few metres at the surface of the lithosphere are warmed by the incoming energy from the Sun. The rest is warmed mainly by the decay of radioactive elements in the lithosphere and mantle.

The Hydrosphere The **hydrosphere** includes all of the water on Earth. About 97 percent of this water is salt water in Earth's oceans. The other 3 percent is freshwater and includes liquid water, such as in groundwater, lakes, and streams, and frozen water, such as the ice in snow and glaciers. Many different organisms, from whales to algae, live in the large water bodies of the hydrosphere. However, the vast majority of living organisms found in the lithosphere or atmosphere need water to survive and so also depend on the hydrosphere, even though they do not make their homes in it. The hydrosphere is warmed by incoming solar radiation.

The eyes of Nye overview

The Greenland ice cores range from today to 250,000 years old.

Climate change will affect our great lakes by reducing the quality of our lakes, and if the sea level gets too high, contaminating the lakes with salt water

Our agriculture will have less consistent crop growth and more irrigation

Layer	**Average Altitude from Earth's Surface (km)**	**Temperature Range (°C)**	**Characteristics**
Troposphere	0-10	20 to -60	• 80 percent of atmospheric gas by mass • can support life • contains most of the carbon dioxide and water vapour in the atmosphere • contains almost all of the atmospheric dust in the atmosphere • where weather takes place

Stratosphere	10-50	0 to –60	• contains most of the ozone gas in the atmosphere, which protects living organisms from damaging high-energy radiation • clumps of cells found but no other life • Air temperature increases with height as ozone gas absorbs ultraviolet solar radiation.
Mesosphere	50-80	0 to –100	• very little gas • Air is thin, and atmospheric pressure is low. • fewer oxygen molecules (O2)
Thermosphere	80+	–100 to 1000	• very little gas • Gas particles are hot during the day and cold at night.

Thermal Energy Transfer

- It is the movement of thermal energy from an area of high temperature to an area of low temperature.
- Thermal energy can be transferred by:
- conduction
- convection
- radiation

Convection

- The transfer of thermal energy through the movement of particles from one location to another.
- Occurs in gases and liquids.

Convection (Cont'd)

- The particles in liquids and gases can move from place to place.
- Convection happens when particles with a lot of thermal energy in a liquid or gas move and take the place of particles with less thermal energy.
- As a gas or liquid is heated, it warms, and the particles start moving further apart.
- As the particles move away from one another the liquid or gas expands and rises because it is now less dense than the particles around it.
- As the gas or liquid cools, the particles start moving slower, starts to condense and falls because it has now become denser.
- This creates a convection current.

Conduction

- The transfer of thermal energy through DIRECT contact between the particles of a substance, without moving the particles to a new location.
- Occurs in solids
- When a substance is heated, its particles gain energy and vibrate more vigorously.
- The particles bump into nearby particles and make them vibrate more.
- This passes the thermal energy through the substance by conduction, from the hot end to the cold end.
- This is how the handle of a metal spoon soon gets hot when the spoon is put into a hot drink.

Conductors and Insulators

- Substances that allow thermal energy to move easily through them are called conductors.
- Give an example of a good conductor

- Substances that do not allow thermal energy to move through them easily are called insulators.

Radiation

- The emission of energy in waves
- No particles are involved in radiation
- This means that thermal energy transfer by radiation can even work in space
- Radiation is how we can feel the heat of the Sun, even though it is millions of kilometres away in space.
- All objects transfer thermal energy by infrared radiation. The hotter an object is, the more infrared radiation it gives off.
- Conduction and convection need moving particles to transfer the thermal energy, but radiation does not.

What is Albedo?

- The albedo of a surface is the percent of the incoming solar radiation that it reflects.
- Questions
- Which surface has a higher albedo, a snow-covered ground or dark pavement?
- Which surface will heat up quicker, a light yellow surface or a dark brown? Why?
- The winter in Ontario has a higher albedo than in the summer because of snowfall, frost, or dried grass.

Thermal Energy Transfer in the Atmosphere

- The temperature of the atmosphere increases in areas close to the equator. As air heats, it rises.
- In areas close to or at the poles, the temperature of the atmosphere decreases. As air cools, it falls.
- If Earth were not spinning, there would b a continuous convection current between the polar and the equatorial regions

The Coriolis Effect

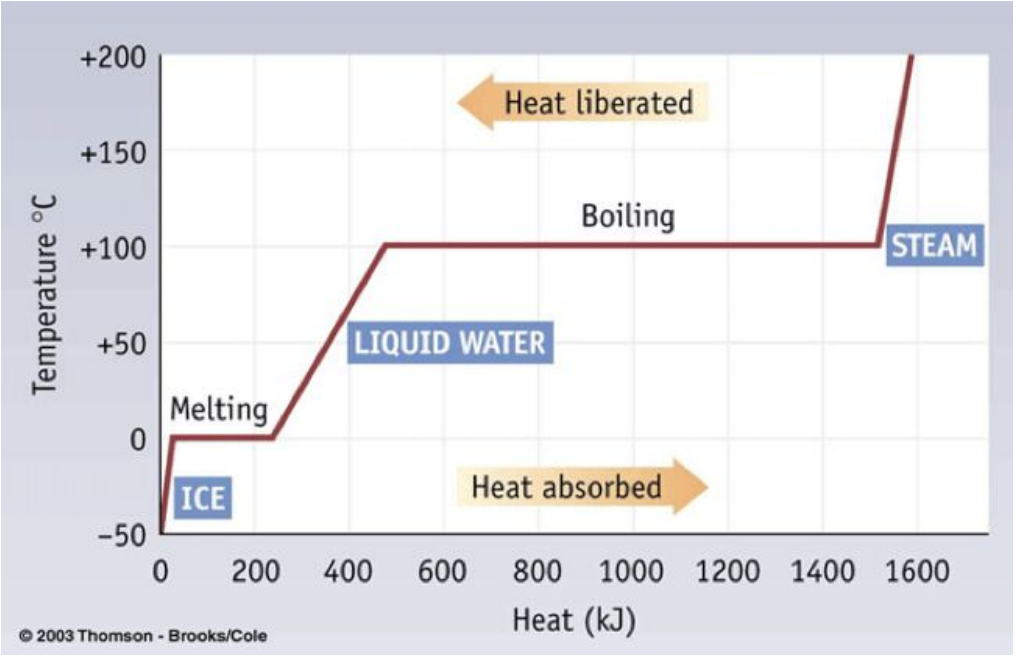
- Since Earth is rotating on its axis, the winds are deflected either toward the right or toward the left.
- Coriolis effect - the deflection of an object from a straight-line path by the rotation of Earth.
- Causes moving air or wind to turn right in the northern hemisphere and left in the southern hemisphere.

Global Wind Patterns

- The convection currents in the atmosphere and the Coriolis effect result in the global wind patterns.
- Global winds transfer thermal energy from the equator to the poles.
- If this did not occur, areas at or near the equator would grow very hot while the rest of Earth would become much colder.

Jet Streams

- A jet stream is a band of fast-moving air in the stratosphere. Because of their high altitude, these winds are much faster than winds closer to Earth's surface.
- Cooler months - the jet streams are closer to the equator and move more quickly.
- Changes in the jet streams affect the formation of severe weather events such as squalls, storms and cyclones.



The Greenhouse Effect

- How does a greenhouse work?

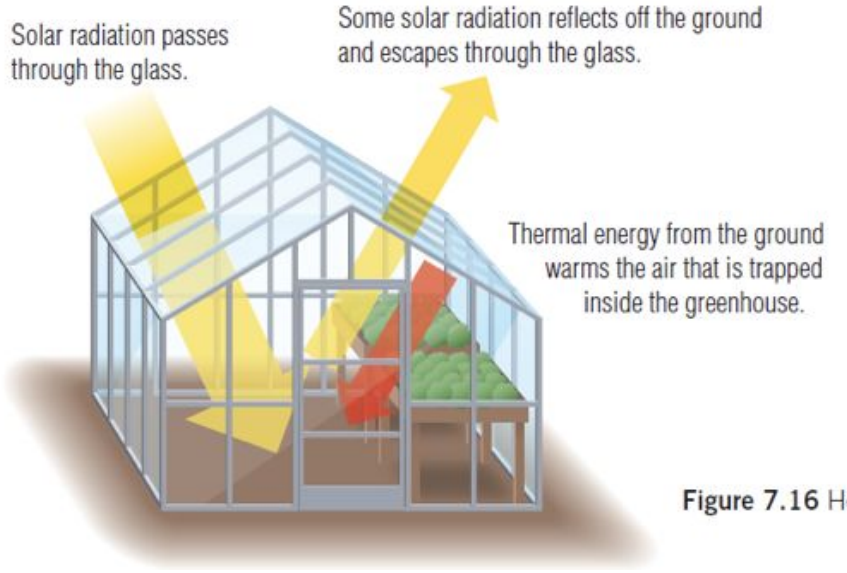
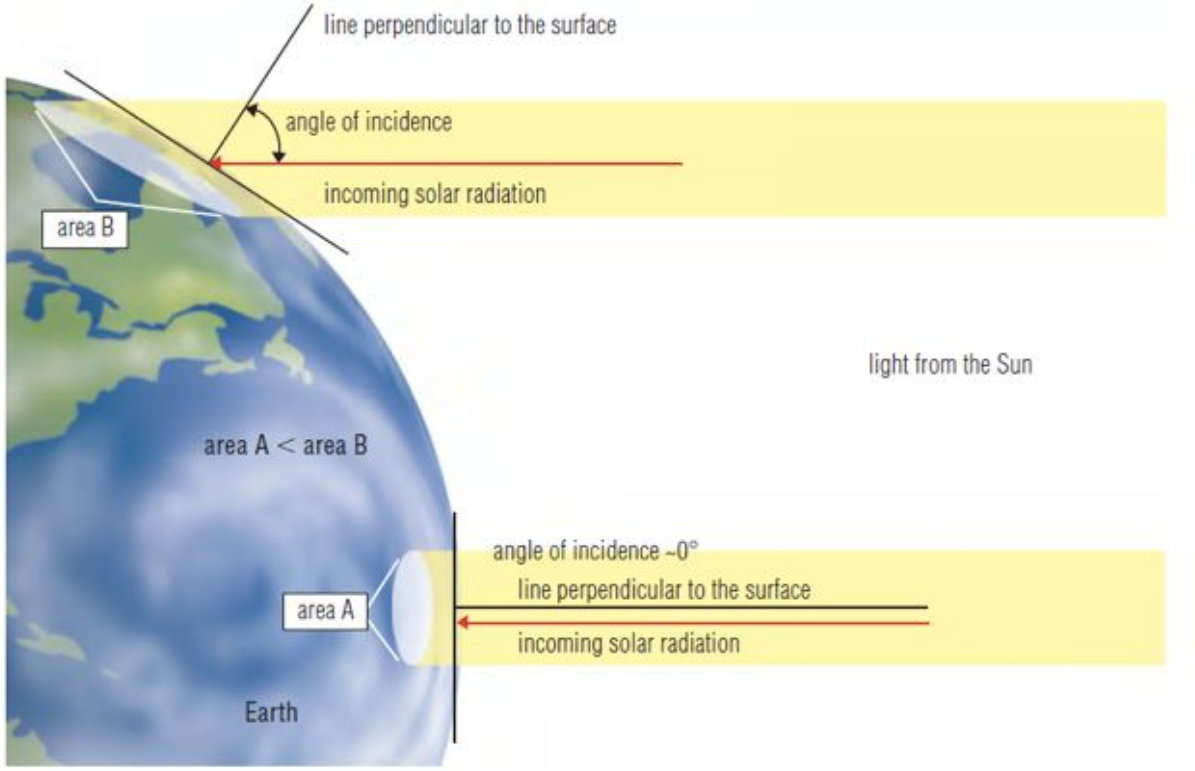


Figure 7.16 How a greenhouse works

Insolation

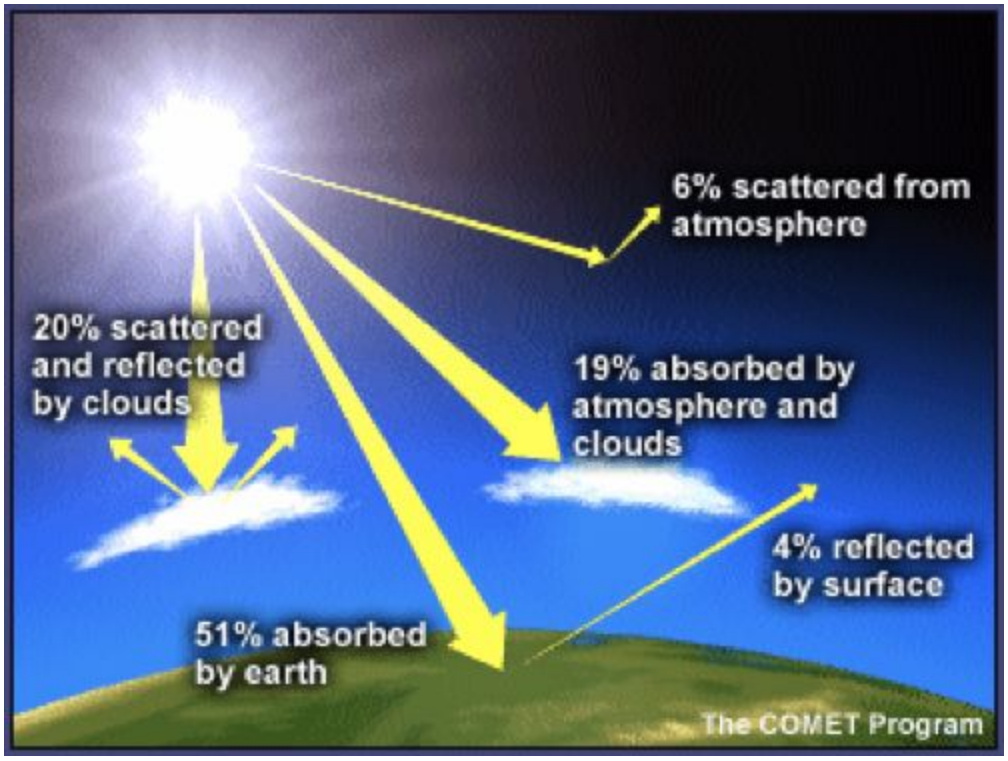
- the amount of solar radiation received by a region of Earth's surface.
- Depends on latitude – the distance from the equator
- Areas north and south of the equator receive less solar radiation due to the angle that the solar radiation comes in at (angle of incidence)
- Also depends on the characteristics of the lithosphere, atmosphere, and hydrosphere.



As solar radiation reaches Earth, some are:

- Absorbed, scattered and reflected by the clouds and the atmosphere
- Absorbed and reflected by the surface of the Earth

Distribution of Solar Radiation



Net Radiation Budget

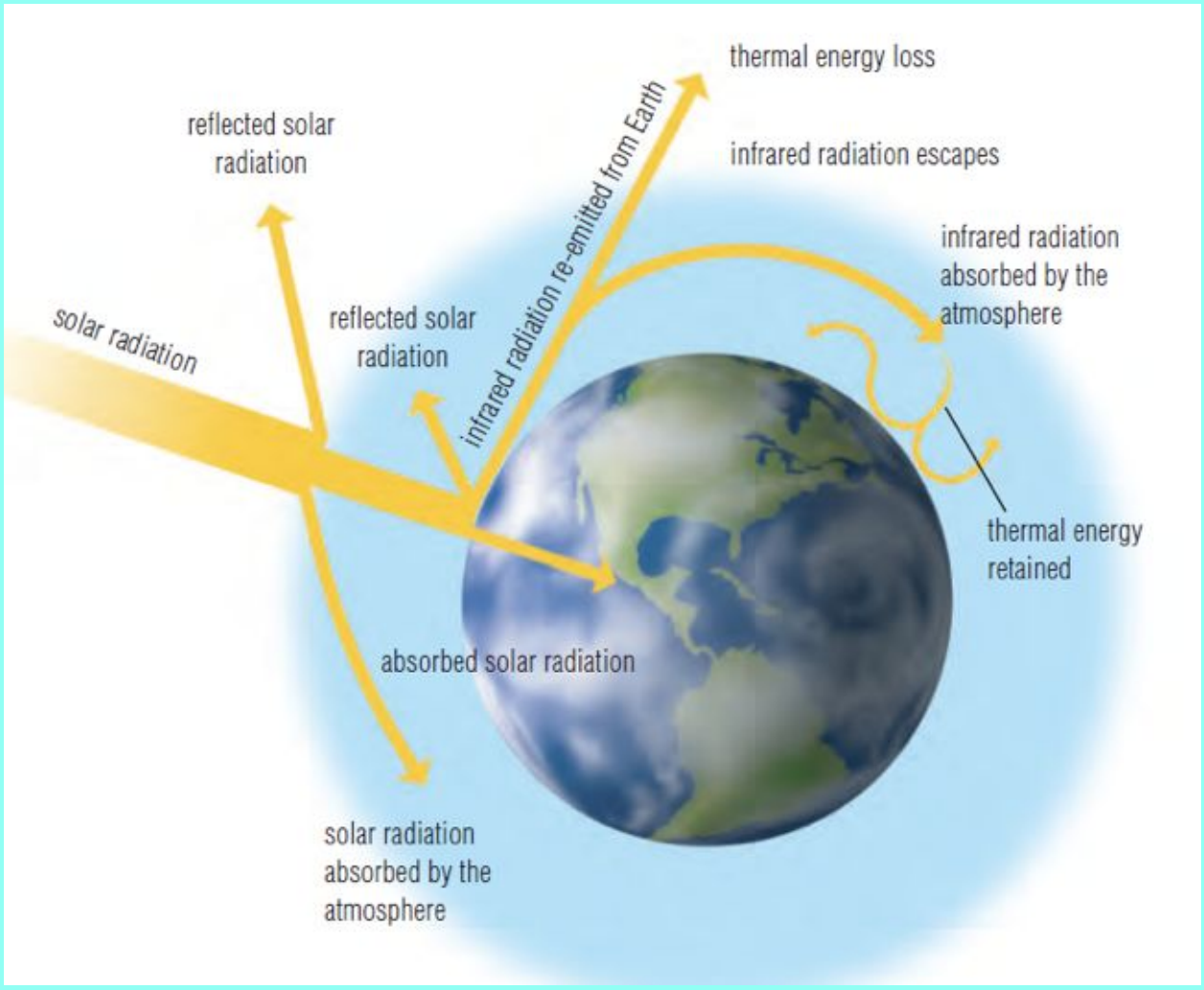
- A square metre Earth receives approx 342 W of solar radiation each year.
- ~31% is reflected back into space by clouds, atmosphere and Earth
- ~ 30% is absorbed by the atmosphere
- The rest is absorbed by Earth. (Only 1 % is used for photosynthesis)

Net Radiation Budget

- The difference between the amount of incoming radiation and the amount of outgoing radiation
- Earth as a whole has a balance of zero.
- Some regions on Earth are unbalanced – depends on latitude.
- The poles have less incoming than outgoing. I.e. deficit
- The equator has more incoming than outgoing. I.e surplus

Natural Greenhouse Effect

- Some of the solar radiation that is absorbed by Earth's surface is re-emitted into the atmosphere as infrared radiation.
- Most of this infrared radiation re-emitted by the Earth is absorbed as thermal energy in the atmosphere by clouds and gases such as:
- 1) water vapour,
- 2) carbon dioxide (CO_2)
- 3) methane (CH_4)
- 4) Nitrous oxides
- This keeps the average temperature of the Earth's surface at 14.7˚C



Greenhouse Gases

- Water vapour, carbon dioxide, nitrous oxide, and methane are called greenhouse gases because they all are able to absorb thermal energy in the atmosphere

What would happen if we didn't have an atmosphere?

- The thermal energy would not get trapped and would escape into space
- The temperature on Earth would be less than -20˚C
-
- The absorption of thermal energy by the atmosphere is known as the natural greenhouse effect.
- Water vapour is the main contributor to the natural greenhouse effect because of the large amount present in our atmosphere

Sources of Greenhouse Gases

- Greenhouse gases can be produced naturally or by anthropogenic (human created)

Gas	Natural Source	Anthropogenic Source
Water Vapour	-Transpiration of plants - Evaporation	- Industrial processes that use boiling water
Carbon dioxide	-Cellular respiration (plants and animals) - Wildfires	-Burning fossil fuels (car, industry emissions, energy production) - Deforestation -Cement making
Methane	- Cow feces	-Coal mining -Production of petroleum products
Nitrous Oxide	-Lighting	-Burning fossil fuels (car, industry emissions, energy production) - Fertilizers

Global Warming Potential

- The measure of the ability of a gas to trap thermal energy in the atmosphere over a certain amount of time.

Table 8.1 Global Warming Potential of Three Main Greenhouse Gases

Gas	Global Warming Potential over 100 years	Persistence (years)
carbon dioxide (CO_2)	1	–
methane (CH_4)	25	12
nitrous oxide (N_2O)	298	114

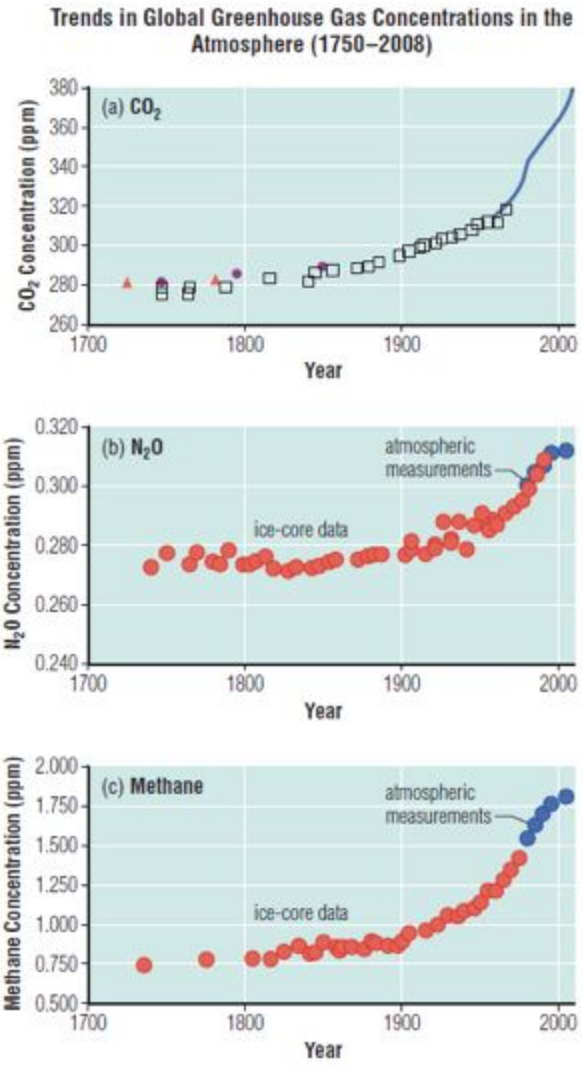
- Persistence-the length of time the gas remains in the atmosphere

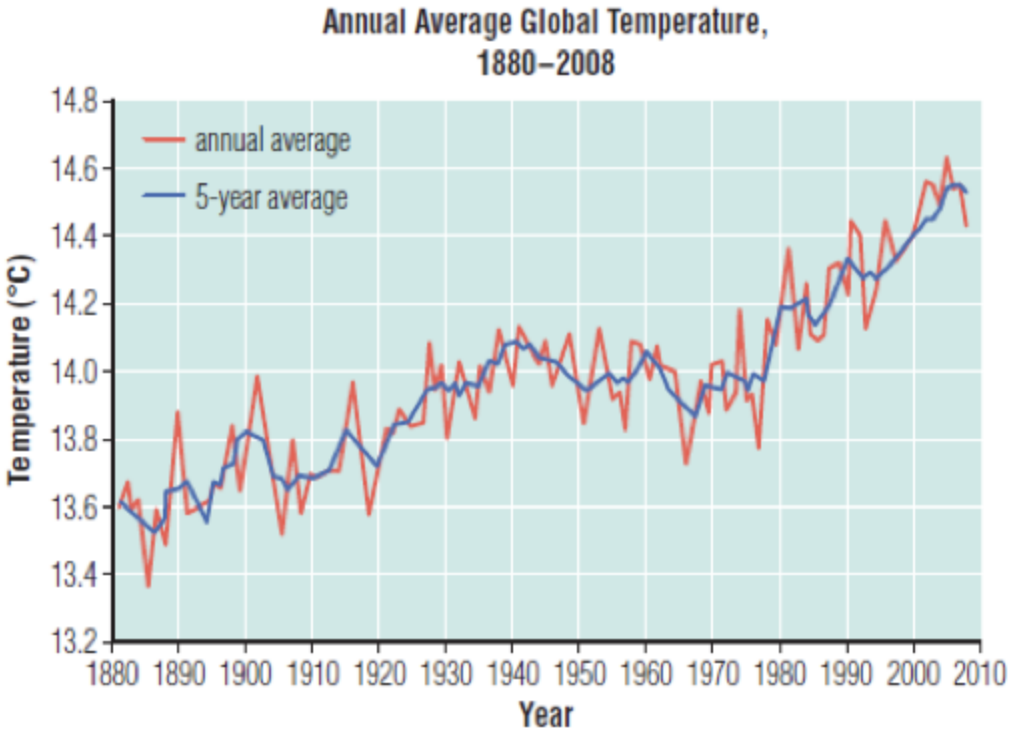
Ice core data

- Ice cores show the earth's atmosphere co_2 levels and temperature
- The deepest/oldest ice core is 250,000 y/o
- The data shows that when co_2 levels increase, the average temperature increases

Greenhouse gas concentrations in our atmosphere

- Increased greenhouse gas concentrations since the Industrial Revolution results in:
- a) less thermal energy that is released back into space
- b) more trapped in our atmosphere.
- As a result, the average temperature at Earth's surface increases.





<u>Greenhouse Gases, Global Warming, and Climate Change</u>

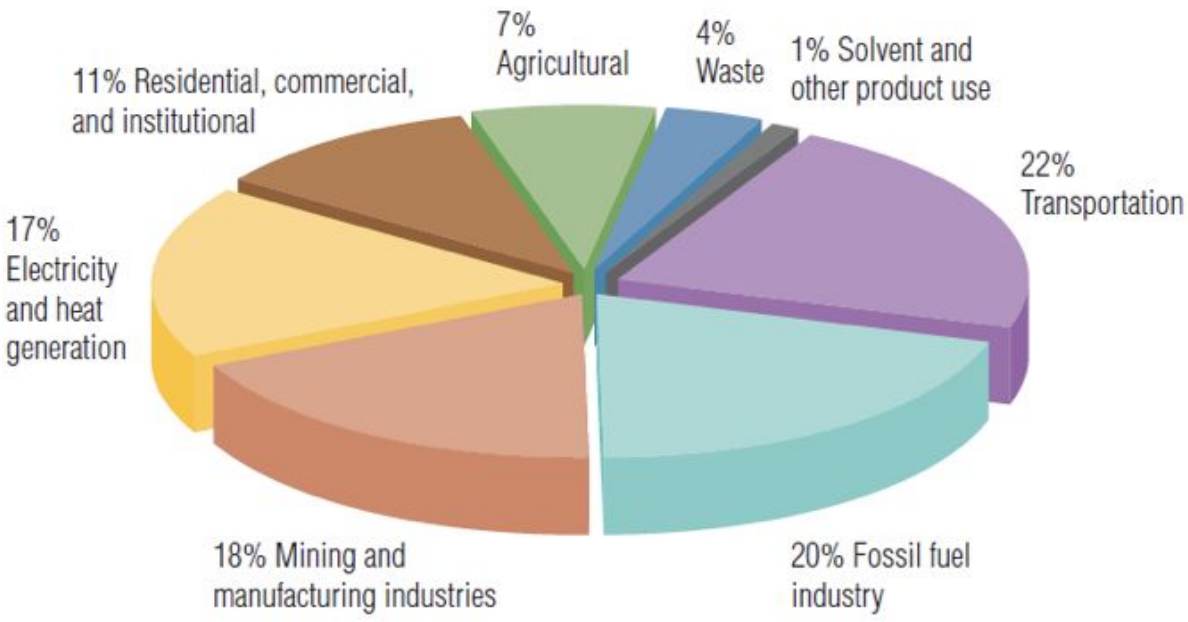
Natural versus Anthropogenic

- **Natural greenhouse effect** – the absorption of thermal energy by the atmosphere, maintaining Earth at an average temperature suitable for life
- **Anthropogenic greenhouse effect** – the enhancement of the natural greenhouse effect due to increased GHG emissions caused by human activity

- The natural and anthropogenic greenhouse effect has lead to increased global temperatures (0.74-degree increase b/t 1880 and 2008). This is called **global warming**

- **Global warming** is leading to **climate change**, the long-term change in expected climate patterns.

- **Climate change** includes increasing temperatures, change in number and severity of storms, strength in winds, and amount of precipitation.



Human activities that have contributed to climate change

Some examples:

- Forest fires – eliminate an important carbon sink and release CO_2, becoming a carbon source
- Production of electrical energy – release of CO_2
- Landfills – bacteria that breaks down garbage release methane
- Disposable products – enormous energy to produce these products that eventually end up in landfills
- Transportation – individuals and on an industrial scale – release CO_2 and NO_2

Effects of Climate Change

Effects of Climate Change in the Atmosphere

Heat Waves

- More frequent and widespread
- Can results in deaths and respiratory problems

Drought

- Defined as lack of rainfall
- Crops and animals can die – devastating to the agriculture sector

Wildfires

- The probability increases when the weather is hot and dry
- Photosynthesis is considered a carbon sink
- **carbon sink-** any process that takes carbon dioxide from the atmosphere and stores it
- Therefore wildfires increase the amount of CO_2 going into the atmosphere.

Storms

- An increase in severe weather-related disasters

- Ex. Ice storms, hurricanes, etc

Floods

- When the air temperature warms rapidly in spring - snow melts too quickly for the rivers to handle the run-off.
- Destroys homes and agriculture

Effects of Climate Change in the Hydrosphere

Melting Ice

- changes habitats of shoreline plants and animals.
- loss of property
- reduces the amount of freshwater available to communities

Ocean Warming

- As the water warms, it expands – results in higher sea levels
- Warmer water absorbs less CO_2 - it is less effective as a carbon sink.
- Warmer water – not an ideal habitat for phytoplankton growth (photosynthesizing organism).
- Less phytoplankton - less carbon dioxide absorbed - an increase in greenhouse gas emissions.
- Warmer water produces more intense hurricanes

Effects of Climate Change on Wildlife

- Range Shifts
- The ranges (home territories) of certain organisms changing
- Ex. Grey Jay nests have moved north over the past 40 years.
- Higher temperatures during mating season cause the food they have stored for their nestlings to rot causing them to starve. Further north is cooler and does not cause this problem
- Potential problems with shifting ranges?

Threatened Species

- If organisms cannot adapt or migrate, they may become extinct.
- Prediction: 40-70% of all species are at risk of becoming extinct if average temperatures increase by 3.3 degrees
- Coral reefs have decreased by 20% due to warmer water and storm damage
- Ocean acidification due to increased absorption of CO2

What can YOU/WE do about Climate Change?

Prevention

- Brainstorm what you can do to reduce greenhouse gas emissions?
- What can the government/community do to reduce greenhouse gas emissions?

Mitigation

- **Mitigation** – making something less severe or milder.

Two main ways to reduce greenhouse gas emissions:

- Reduce energy use and use alternative sources of energy that do not burn fossil fuels.

- Removal of greenhouse gases produced by industries and converting them into non-gaseous products that can be stored (usually underground)
- This is referred to as **sequestering**
- Both of these mitigation methods will reduce the **carbon** footprint
- **Carbon footprint** – the total amount of greenhouse gas emissions caused directly and indirectly by an individual, community, industry or country

Other ideas

- **Carbon offsets** – Purchased to reduce your carbon footprint. Money goes to improve carbon sinks – replanting forests, etc.
- **Emissions Trading** – When a company reduces its emissions beyond government expectations it can trade this extra amount to another company that has gone over its max.
- **Carbon Tax** – A charge by the government for creating greenhouse gas emissions. Money goes to projects that help mitigate climate change.