Senior Biology Revision Bites

Are You Smart?

S – Set Specific goals
M- Measure your progress
A- Are your goals Achievable?
R- Are your goals Realistic?
T- Set Time limits for each subject

1.3 NUTRITION

The Function of Food: Growth, Repair, Energy

ELEMENTS IN FOOD:

Bimolecular units: The elements in food combine in different ratios to form different food components

Common Elements: Carbon (C) , Hydrogen (H) ,Oxygen (O), Nitrogen (N), Phosphorus (P), Sulphur (S)

Salts of: Sodium (Na), Magnesium (Mg), Chlorine (Cl), Potassium (K), Calcium (Ca)

Trace elements : Iron (Fe), Copper (Cu), Zinc (Zn)

CARBOHYDRATES

Contain elements: C, O, H.

General formula: $C_x(H_2O)_y$

Structural role: cellulose forms part of the cell wall

Metabolic role Source of energy for metabolism

Types of Carbohydrate

Monosaccharides e.g. glucose

Disaccharides e.g. sucrose

Polysaccharides e.g. cellulose

MINERALS

Plants need **Magnesium** to make chlorophyll and **calcium** for the cell walls

Animals need **iron** to make haemoglobin and **calcium** for healthy bones.

WATER

Properties of water:

- Gives cells their shape
- Transports materials
- A universal solvent
- A medium for metabolism

FATS

Contain elements: C, O, H.

Different ratio to carbohydrates – have more oxygen

Fats are solid at room temperature

Oils are liquid at room temperature

Structural role: protect the body organs

Metabolic role Source of energy for metabolism

Triglycerides: made up of three Fatty acids and one Glycerol

Phospholipids formed when one fatty acid of a lipid molecule is replaced by a phosphate group

ENERGY TRANSFER REACTION

Anabolic reactions: Small molecules are built up into large ones, using energy e.g. photosynthesis

Catabolic reactions: large molecules are broken down into smaller ones, energy is released e.g. respiration

PROTEINS

Contain elements: C, O, H, N

They sometimes contain P, S

They are made up of amino acids

Structural role: they join with phospholipids to form the cell membrane

Metabolic role: all enzymes are proteins and they control the cells chemical reactions

VITAMINS

Vitamin	Type	Source	Function	Deficiency
C	Water soluble	Lemons	Connective tissue formation	Scurvy
D	Fat soluble	Cod-liver oil	Absorb calcium	Rickets

1.3.1 – 1.3.4 Food & Biomolecules

Functions of food:

1. To provide organisms with energy, and
2. To provide the materials for growth and repair of cells and tissues.

Elements in Food:

carbon (C)	hydrogen (H)	oxygen (O),
nitrogen (N)	sulphur (S)	phosphorous (P)

Trace elements : Fe, Cu, Zn

Salts of Na, Mg, Cl, K, Ca

Biomolecules:

Carbohydrates	Lipids (fats)	Proteins
Vitamins	Minerals	Water

Carbohydrates

Composed of elements carbon, hydrogen and oxygen. Called saccharides .

General formula of carbohydrate

$$C_x(H_2O)_y$$

Three Types of Carbohydrates

Monosaccharides: single sugar units, e.g. **glucose** – $C_6H_{12}O_6$

Disaccharides: two sugar units, e.g. **Sucrose, maltose** – $C_{12}H_{22}O_{11}$

Polysaccharides: many sugar units, e.g.
- **starch** (plant storage carbohydrate),
- **cellulose** (plant structural carbohydrate),
- **glycogen** (animal storage carbohydrate),
- **chitin** (animal structural carbohydrate).

Sources in diet: bread, rice, pasta.

Lipids (Fats & Oils)

Composed of the elements carbon, hydrogen and oxygen, but not in the same proportion as sugars.

Triglyceride: smallest lipid – three fatty acid and one glycerol molecule).

Phospholipid: a lipid with one of its fatty acids replaced with a phosphate group.
Fats are solids at room temperature and lipids are liquids.
Sources in diet: Fat, butter, red meat, oil.

Proteins

Composed of the elements carbon, hydrogen, oxygen, nitrogen and sometimes sulphur. Basic unit is the amino acid. There are approximately twenty different amino acids.
Sources in diet: lean meat, fish, eggs

Structural Role of Biomolecules

Carbohydrates – cellulose (plant cell walls), chitin (fungi cell walls).
Proteins – myosin in muscle, collagen in hair
Lipids – phospholipids found in the cell membrane

Metabolic role of Biomolecules

Carbohydrates – primary sources of energy (glucose)
Proteins – enzymes control chemical reactions in cells
Lipids – release of energy & long term energy storage
Vitamins – essential organic catalysts of metabolism, e.g.

Vitamin	Solubility	Function	Source	Deficiency
C	Water	Skin, bone, blood	Citrus fruits, green veg	Scurvy
D	Fat	Absorb calcium	Dairy products, sunlight	Rickets, osteomalacia

Minerals needed by PLants

Mineral	Function
Calcium (Ca)	to make cell walls
Magnesium (Mg)	to make chlorophyll
Nitrates (N)	to make proteins
Phosphates (P)	to make ATP, DNA

Minerals needed by Animals

Mineral	Function
Calcium (Ca)	to make bones and teeth
Iron (Fe)	to make haemoglobin
Sodium (Na)	to regulate water content of cells and blood

Water

A major component of cells and body fluids
- Slow to heat up and cool down – maintains a constant temperature
- Good absorber of energy – sweating and transpiration are cooling processes
- Moves dissolved material in and out of cells, e.g. Glucose, O_2, CO_2, etc.
- Controls cell shape - osmosis
- Universal solvent – for transporting substances in blood or xylem
- Medium for metabolism
- Reactant in photosynthesis
- Product in respiration
- Has strong adhesive and cohesive properties – transpiration

1.4.1 – 1.4.12 Ecology Terms

abiotic environment	commensalism	endotherm	interspecific competition	pollutant
abiotic factors	community	energy flow	intraspecific competition	pollution
acid rain	competition	energy transfer	key	population
ammonification	conservation	environment	leaching	population curve
aquaculture	consumer	environmental conditions	legume	population dynamics
aquatic	contest competition	equilibrium	leguminous plant	predation
aquatic factors	control measures	eutrophication	migrate	predator
aspect	decompose	external environment	migration	prey
atmosphere	decomposer	extinct	monoculture	primary consumer
behaviour	deforestation	fauna	mutualism	primary producer
biodegradation	denitrification	field layer	niche	producer
biodiversity	denitrifying bacteria	flora	nitrate	pyramid of biomass
biogeography	dependence	food chain	nitrification	pyramid of numbers
biological key	detritus	food niche	nitrifying bacteria	recycling
biological magnification	detritus food chain	food pyramid	nitrite	sanitation
biomass	detrivore	food web	nitrogen cycle	scramble competition
biome	direct count	frequency	nitrogen fixation	secondary consumer
biosphere	direct search	geographical factor	nitrogen-fixing bacteria	selection
biotic	dissolved oxygen	global warming	nitrogenous fertiliser	soil
biotic environment	diurnal	grazing food chain	nocturnal	soil fertility
biotic factors	dynamic equilibrium	greenhouse effect	nutrient recycling	symbiosis
capture-recapture technique	ecological	greenhouse gases	omnivore	symbiotic
carbon cycle	ecological niche	ground layer	parasite	symbiotic association
carbonic acid	ecological pyramids	habitat	parasitic bacteria	symbiotic union
carnivore	ecology	hedgerow	parasitic nutrition	terrestrial
CFCs	ecosystem	herbivore	parasitism	tertiary consumer
chemical weathering	ectoparasite	herbivorous	pest	top carnivores
chlorofluorocarbons	ectotherm	humidity	pesticide	trophic level (T)
climatic factors	edaphic factors	immigration	physical factor	vegetation
climax community	emigration	incinerator	physical weathering	warm blooded animal
colonisation	endangered species	insecticide	phytoplankton	weathering
colony	endoparasite	interdependence	plankton	weed

1.4.6 + 1.4.10.H Pyramid of Numbers

Use of Pyramid of Numbers

Ecological pyramids are used to compare different communities of the ecosystem by comparing trophic levels.

They attempt to discover and show the energy structure of an ecosystem as a chart by counting the number of individuals at each trophic level.

In general:

The number of organisms declines as you go up the pyramid

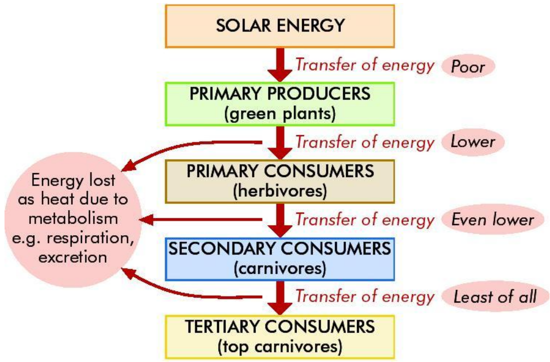
This is due to the large energy loss (about 90%) between each trophic level

As a result there is less energy available to organisms higher up the pyramid

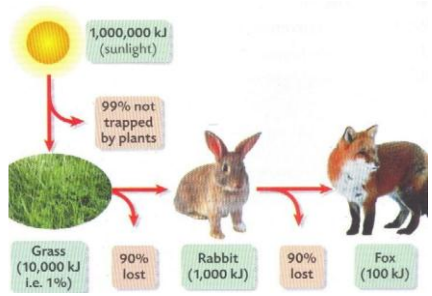
Loss of energy and body size increase as you go up the pyramid

Energy Transfer

This is the flow of energy ***into the ecosystem*** from the sun; and ***within the ecosystem*** through the different trophic levels along food chains, and finally ***out of the ecosystem*** into the atmosphere as heat loss due to respiration.



Energy loss in a Food Chain or Ecosystem

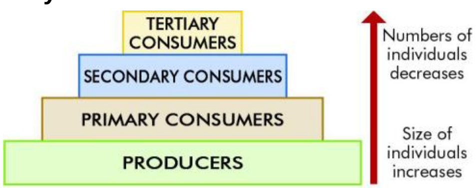


From the diagram above we can see that only about 10% of the energy in an organism is transferred when one member of a food chain is eaten by the next

The large energy loss from one trophic level to the next explains why food chains contain no more than four or five levels

Each trophic level contains less energy than the previous one

Normal Pyramid of Numbers



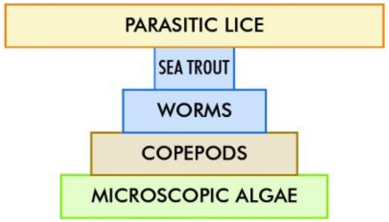
Limitations of use

The size of organisms is not considered in a pyramid of numbers.

e.g. one rose bush can support thousands of greenfly.

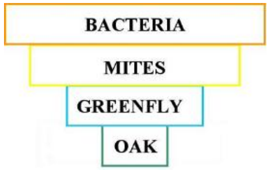
A distorted Pyramid of Numbers

A similar problem arises with parasites – numerous parasites on one host – resulting in a distorted pyramid

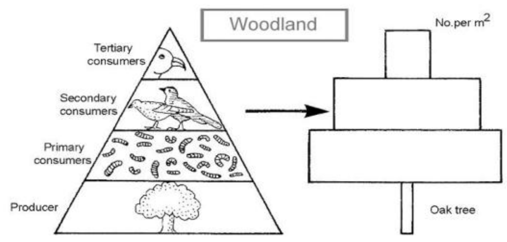


An inverted Pyramid of Numbers

When organism size is not considered very unusual pyramid shapes are likely to occur.



Another example



Food pyramid–Unusual shape

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1.4.11.H Ecological Relationships

Factors that control Population

1. Competition
2. Predation
3. Parasitism
4. Symbiosis

These factors help maintain *population* numbers and bring about a 'balance of nature'

Competition
When organisms of the same or different species 'fight' for necessary resources that are in short supply.

Intra-specific competition:
Between members of the **same species** i.e. within a species
Inter-specific competition:
Between members of **different species**

Plants
compete for light, water, minerals and space
Animals
compete for food, water, shelter, territory and mates

Two types of competition

1. Contest Competition
involves an active physical confrontation between two organisms – one wins

Example
Two dogs fighting over a bone. One may have stronger muscles and sharper teeth and so win the bone

2. Scramble Competition
This is where each organism tries to acquire as much of the resource as possible.

Example
An ivy plant and a hawthorn tree may compete for light. The ivy uses adventitious roots to grip the hawthorn and climb higher.

Competition & Population Size

- Restricts population size
- Only successful competitors will survive and reproduce
- Is a driving force behind evolution i.e. **adaptive techniques** (sharp teeth of carnivores or climbing abilities in ivy) develop in response to the need to survive competition

How do animals survive competition?
- They adapt to their environment by:
- Changing their feeding habits
- Camouflage
- Producing protective coats
- Moving away from over-populated areas
- Reproductive strategies e.g. Kangaroo can carry up to three offspring
  - Joey
  - New born baby (2.5 cm long)
  - Fertilized Egg sitting in tubes to go to womb

How do plants survive competition?

e.g. weeds (i.e. plants growing in a place where they are not wanted)
These compete with other plants for water, minerals and light and will survive because:
- They produce large numbers of seeds
- Seeds germinate quickly, even in poor soil
- Plants thrive even in poorer soil conditions

Predation

Predation: the act, of some animals (predators), of capturing and killing other animals for food.

Predator: animal that hunts, captures and kills other animals (prey) for food.
Predators have evolved adaptive techniques to survive, e.g. wolf has keen hearing and eyesight, strong muscles, sharp teeth, camouflage and hunts in packs.

Positive Effects of Predation

1. Predation stabilises the community
2. Predators control the number of herbivores and so prevent overgrazing
3. Predators eliminate the less well adapted (weaker) prey

Adaptations of Predators

Keen senses and sharp teeth
Catch easiest prey – old and sick (less energy used)
Change diet to suit prey available e.g. foxes
Live and hunt in packs
Migrate to where prey is plentiful
Camouflage

Three examples of Adaptations of Predators
1. Hawks have excellent eye sight
2. Ladybirds have strong mouth parts
3. Cheetahs can run at 60 km/h

Adaptations of Prey

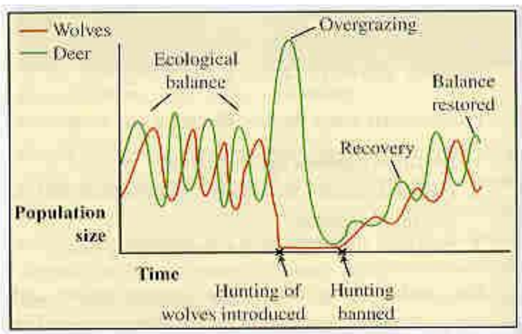
Plants may have thorns, spines or stings
Nasty taste when eaten e.g. giant hogweed
Are faster than their predator
Staying in herds or flocks – safety in numbers
Camouflage – greenfly, stick insects

Three examples of Adaptations of Prey
1. Frogs are well camouflaged
2. Zebras have strips, when in a group lions can't distinguish where one ends & another begins.
3. Ladybirds contain large amounts of Formic acid so they are unpalatable to taste

1.4.11.H Predator / Prey Relationship

Predator / Prey relationship

The populations of wolves and deer are interconnected. Both have evolved adaptive techniques to survive e.g.
wolves – keen hearing and eyesight, strong muscles, sharp teeth, camouflage and hunt in packs.
deer – keen hearing and eyesight, quick to turn and run and camouflage to evade the wolves.
Wolf / Deer in Alaska



- When the deer population increased, the wolf population had more food and increased too.
- As the wolf population increased, the number of deer being killed increased – graph resulting in a decline in the deer population
- When the deer population declined, there was less food for the wolves and they declined in numbers too.
- This led to an increase in the deer population.
- This cycle continued over years and had obviously found a natural balance to do with availability of food for both populations.
- When the wolf population was drastically reduced due to hunting, the resulting explosion of the deer population led to overgrazing of the vegetation.
- This produced huge mortality and emigration in the deer population with a collapse of the relationship.
- After the banning of hunting, a balance was slowly re-established in the two populations.

The populations are controlled by negative feedback, where a drop in numbers is generally self-correcting.

Over a long period of time, the deer evolve structures and behaviours to survive predation better, e.g. quicker reactions, etc.

The wolves also evolve better predation techniques to cope with the evolving prey.

Parasitism

One organism, the *parasite*, benefits from another, the *host*, and does harm to it

e.g. fleas **on** a dog (*ectoparasites*),

liverfluke **in** cattle/sheep (*endoparasites*).

Parasites do harm to their hosts but usually do not kill them too quickly.

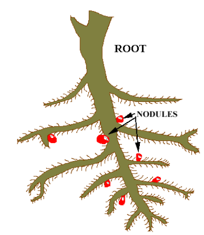
Symbiosis

Symbiosis (‘living together’) – where two organisms of different species have a close, specific relationship with each other where at least one of them benefits.

Parasitism is a form of symbiosis

Examples
A lichen is composed of an alga and a fungus intertwined.
The alga obtains support and a mineral supply from the fungus; the fungus obtains food from the alga.

Nitrogen-fixing bacteria in the nodules of leguminous plants (below left):
The bacteria make nitrogen compounds needed by the plant and the plant makes carbohydrates and other food material needed by the bacteria



Bacteria living in the colon (above right) produce vitamin B_2 and vitamin K. The body absorbs these vitamins.

1.4.12.H Population Dynamics

Factors that contribute to Predator-Prey relationships

1. **The availability and abundance of food**
   Large number of deer will increase the number of wolves.
   This will decrease the number of deer and then wolves.
   When wolves decrease deer will increase again.

2. **Concealment**
   When there is less prey they can hide better, this allows population of prey to survive and increase.

3. **Movement of Prey & Predators**
   If there is not enough food the prey will move to a more abundant location;
   predator moves to area with more prey.

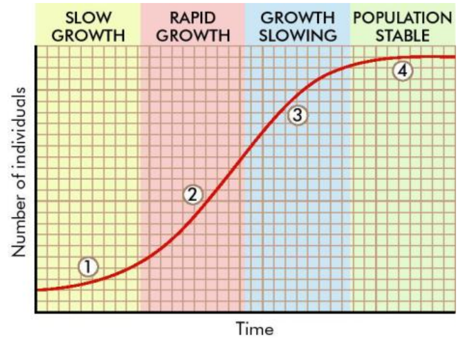
Population Dynamics

A ***population*** is a group of organisms of the one species.
Population density is a measurement of the numbers of a species over a stated area.
Population increases are due to increases in the birth rate and immigration.
Population decreases are due to increases in the mortality rate and emigration.

Most population numbers tend to fluctuate in the short term, but find an overall balance in the long term where births and immigrations are equal to deaths and emigrations.

Mortality rates are high in nature – many organisms die before they can reproduce.
Deaths are usually due to predation, parasites and lack of food rather than old age.
A high mortality rate is important to populations because it protects the stock of food and eliminates the less well-adapted organisms.

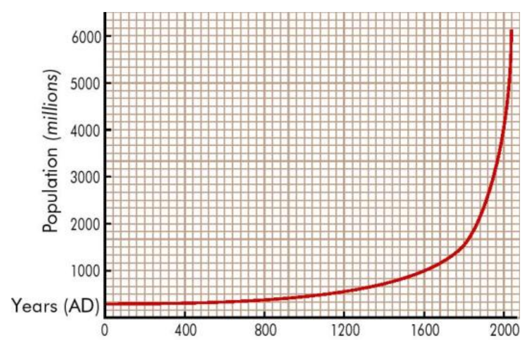
Normal Population Curve



1. Organisms arrive and then adapt to their new environment
2. Growth takes place rapidly due to newly-available food
3. Growth constraints are felt – predation, overcrowding, available food, etc.
4. Growth settles at a level that the environment can support.

Human Population Curve

Has not been susceptible to the normal constraints of nature and looks very different



The increase in the human population is not due to an increase in birth rates, but is caused by reduced death rates.

Factors affecting Human Population Numbers

Famine

A lack of food leads to malnutrition and death due to disease or starvation e.g.
Great Irish Famine of 1845 – 47, about one million people died.
Some countries still suffer from famine, but it is often a problem of food distribution rather than food shortages.
Advances in agricultural techniques have so far allowed food supplies to match population growth.

Disease

Vaccines – reduce the incidence of diphtheria, whooping cough, tetanus, polio, meningitis, TB, etc.
Sanitation + insecticides – have controlled malaria, yellow fever and sleeping sickness.
Anaesthetics have improved surgical methods & new drugs have saved many lives.
Antibiotics have prevented deaths that would have been caused by bacteria.

War

Reduces the human population.
Effects can be temporary.
Increased birth rates (baby booms) often follow wars.

Contraception

Increased availability has reduced birth rates since the 1960s. Evident in *developed* countries e.g. in Western Europe and USA the average family size = 2.1.
This is close to the level needed to ensure the pop remains constant.

The fertility rate in *developing* countries has fallen from 6.1 in 1970 to 3.5 today, due to contraception.

1.4.5 Environmental Factors

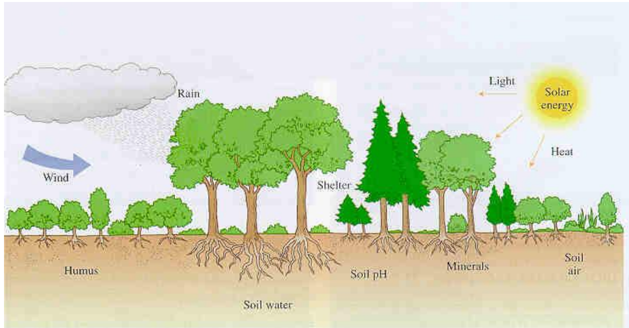
Abiotic factors

Are the non-living features of an ecosystem (i.e. the physical and chemical conditions) that affect the community.

Examples:

Temperature Light intensity
Air speed Water current
Humidity pH
Salinity Dissolved oxygen
Nitrate, phosphate and other plant nutrients

Edaphic, Aquatic and Climatic factors are abiotic factors.



Biotic factors

Are the living features of an ecosystem that affect the other members of the community.

Examples:

Plants for food and shelter
Predators
Prey
Parasites
Pathogens
Decomposers
Competitors
Pollinators

Edaphic Factors

Are the physical, chemical and biological characteristics of the soil that influence the community.

Examples:

Soil type,
Soil pH,
Available (soil) water,
Air and Mineral content,
Humus,
Soil texture and Structure.

Aquatic Environmental Factors

Examples:

Light penetration
Currents
Wave action

Some of the Abiotic, Biotic and Climatic factors are also found in an aquatic environment.

Climatic Factors

Are elements of the climate (weather) that influence the life and distribution of the organisms that live in a particular environment.

Examples:

Temperature
Rainfall
Humidity
Wind
Light intensity (including seasonal variations)
Day length

1.4.6 Energy Flow

Energy Flow

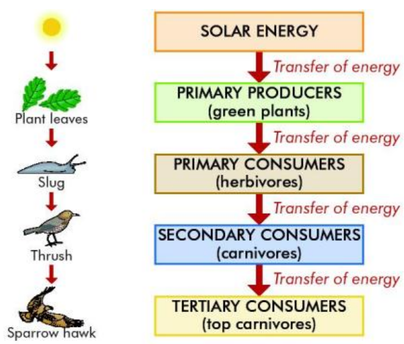
An ecosystem is a community of living organisms interacting with one another and their non-living environment within a particular area, e.g. woodland,.

Energy flow is the pathway of energy transfer from one organism to the next in an ecosystem due to feeding, e.g. along a food chain

Ecosystems require energy which comes from the sun – the primary source of energy

Food Chain

Is a flow diagram that begins with a plant and shows how food/energy is passed through a series of organisms in a community.
Each organism feeds on the one before it.



A food chain ends when there is not enough energy to support another organism.

Woodland food chain

Honeysuckle ➜	aphids ➜	ladybirds ➜	thrushes
Producer ➜	Primary consumer ➜	Secondary consumer ➜	Tertiary consumer

Two types of food chain

1. A Grazing food chain

is one where the initial plant is living e.g.

Grass → grasshoppers → frogs → hawks

Honeysuckle → aphids → ladybirds → thrushes

Seaweed → winkles → crabs → herring gulls

Phytoplankton → zooplankton → copepod → herring.

2. A Detritus food chain

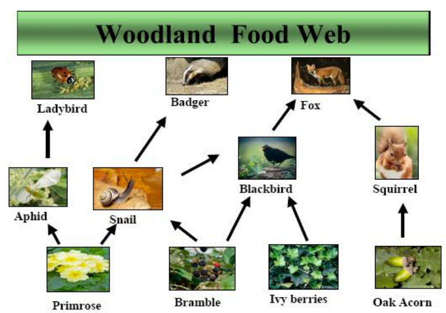
is one where the chain begins with dead organic matter and animal waste (detritus) e.g.

Detritus → edible crab → seagull

Fallen leaves → earthworms → blackbirds → hawks

Food Web

This is a chart showing all the interconnecting food chains in the habitat./ecosystem.



Trophic Levels

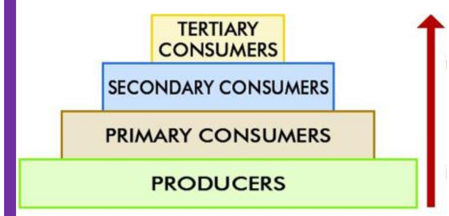
Refers to the position of an organism in a food chain.

Plants are at the 1st trophic level (T1) and

Herbivores occupy the 2nd trophic level (T2).

Carnivores that eat herbivores are at the 3rd trophic level (T3).

The 4th trophic level (T4) is often occupied by the top carnivore.



As you go up the pyramid the numbers of organisms decrease and their size gets bigger

Pyramid of Numbers

A diagram that represents the numbers of organisms at each trophic level in a food chain.

Bottom layer is the largest and represents a very large number of primary producers

The next layer smaller and represents a smaller number of primary consumers

The next layer – the no. of secondary consumers

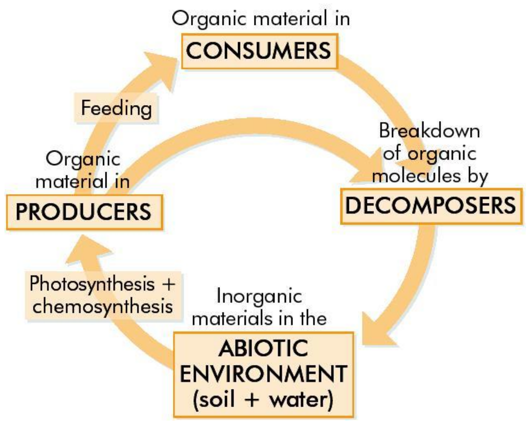
The uppermost layer where there may be only one tertiary consumer

1.4.7 – 1.4.8 Niche & Nutrient Recycling

Niche

A **niche** is the functional role of an organism in an ecosystem.

Nutrient Recycling



ensures that there is no real longterm drain on the Earth's nutrients, despite millions of years of plant and animal activity.

Nitrogen Cycle

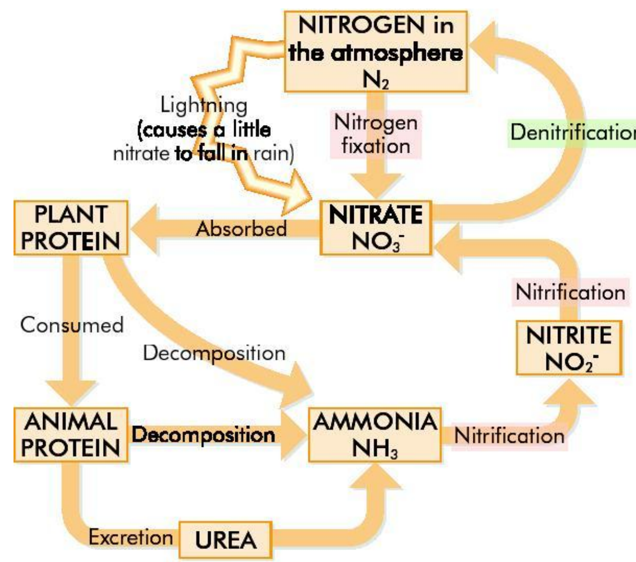
All organisms need nitrogen for protein, DNA & RNA manufacture

78% of the Earth's atmosphere is nitrogen gas, but it cannot be used in this form by plants and animals. Nitrogen gas must first be 'fixed', i.e. changed to a suitable form (ammonia or nitrate) before it can be used.

- ***Nitrogen-fixing bacteria*** in the soil convert N_2 gas in the air into ammonia (NH_3). This accounts for the majority of all N_2 fixation.
- ***Lightening storms*** and *fuel burning in car engines* produce nitrates, which are washed by rain into the soil water.
- Nitrates are absorbed by plant roots and converted to plant protein.
- Plant proteins are passed along food chains to become animal protein.
- When organisms die, their proteins are converted to ammonia by bacterial decomposition.
- ***Nitrifying bacteria*** in the soil then convert ammonia (NH_3) into nitrites (NO_2^{2-}) then into nitrates (NO_3^-).
- Nitrates can be absorbed by other plants to continue the cycle.
- ***Denitrifying bacteria*** convert soil nitrates into N_2 gas.

  This is a loss of N_2 from the cycle.

  Only happens in anaerobic conditions (when O_2 levels are low) – due to flooding or accumulation of sewage.
- Nitrate also enters the cycle through the addition of nitrogen rich fertilisers to the soil – made industrially from nitrogen gas.



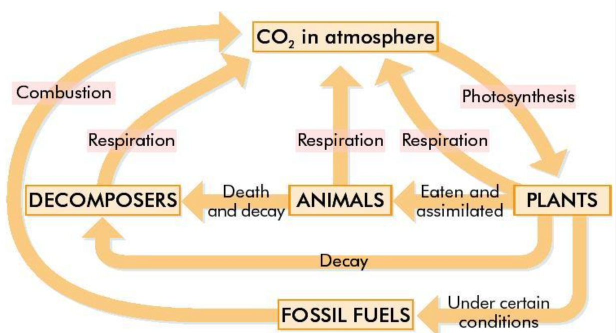
Carbon Cycle

Carbon forms part of all organic nutrients – carbohydrates, fats and proteins.

Carbon dioxide is **removed** from the environment by photosynthesis in plants, and under certain conditions, over long periods of time, some of these plants may form fossil fuels such as coal, oil, peat and natural gas.

Carbon dioxide is **returned** to the environment by:

1. Respiration in plants, animals & micro-organisms.
2. Decay caused by micro-organisms.
3. Combustion i.e. burning fossil fuels



1.4.9 Human Impact on an Ecosystem

Pollution

Pollution is any human addition (contamination) to a habitat or the environment that leaves it less able to sustain life.

Chemicals of human origin that harm the environment are called ***pollutants***.
CO_2 from respiration is not a pollutant – excess CO_2 from burning fossil fuels is.
SO_2 from marshes & volcanoes is not – SO_2 from factory chimney is.

Some pollutants are normally present in an environment, e.g. CO_2, but levels are increased by human activity. Other pollutants never exist in an environment e.g. oil slick, CFCs.

Need to know the effects of one pollutant from any of the following areas: domestic, agricultural, industrial." and give an example of one way in which pollution may be controlled in the selected area.

Area	Pollutant	Source	Effects
Agricultural	Slurry & Fertiliser	Washed or leached from land	Formation of *algal blooms* and *eutrophication*
Industrial	Sulphur dioxide	Burning fossil fuels	Forms 'acid rain' More detail later
Domestic	Plastic bags	Shopping	Non-biodegradable Suffocate small animals, Litter

Area	Pollutant	Control Measures
Agricultural	Slurry & Fertiliser	Avoid spreading these: • on wet, waterlogged, frozen or steeply sloping land • within 1.5m of any watercourse.
Industrial	Sulphur dioxide	Fit catalytic scrubbers in factory chimneys
Domestic	Plastic bags	Bag tax/levy. Reuse/Recycle bags

Ecological impact of one human activity
Burning Fossil Fuels

Acidic oxides and acid rain

All rain is acidic – but not the same pH
CO_2 in the air dissolves in rainwater to form carbonic acid – pH = 5.5 in unpolluted air
Acid rain refers to very acidic rain with a pH of 4.5 or less
(Note: pH 4.5 is 10 times more acidic than pH 5.5)

Acid Rain

Burning of fossil fuels releases acidic oxides into the air, especially SO_2 and nitrogen oxides (NO_x).
SO_2 dissolves in rainwater to form sulphurous acid (H_2SO_3) or reacts with particles in the air to form sulphuric acid (H_2SO_4).
The resulting rain is very acidic and can be carried far by the wind.

Effects of acid rain

- Reduces soil pH
- Phosphorus (*P*) binds to soil particles and is unavailable to plant roots
- *Al* becomes soluble and poisonous and with *K*, *Ca* and *Mg* is washed (leached) from the soil into lakes and water supplies
- Soil is impoverished and fish die in highly mineralised water. Why?
- Erodes limestone buildings
- Causes breathing difficulties – irritates the delicate lining of the lungs
- Inhibits chlorophyll formation and burns the leaves of plants

Acid rain is a 'trans-boundary problem'.
Norway 'imported' its acid pollutions from the English Midlands and the Ruhr valley in Germany.

Dealing with acid rain

Reducing the quantity of fossil fuels burned
Using catalysts to treat chimney gases ('scrubbers' are fitted to the insides of chimneys)
Catalytic converters fitted to modern cars
Developing alternative 'clean' energy sources.

Conservation

Conservation is the protection and wise management of natural resources and the environment.
Benefits of Conservation

1. Existing environments are maintained
2. Endangered species are preserved for reproduction
3. The balance of nature is maintained
4. Pollution and its effects are reduced

Need to know One Conservation practice from one of the following areas

Area	Conservation Practice
Agriculture	Mixed farming, Crop rotation Biological controls, Gene banks
Fisheries	Fishing Net size, Quotas, Re-stocking
Forestry	Re-planting, Broadleaf/conifer mix

Waste Management

is the collection, transport, processing, recycling or disposal of waste materials, produced by human activity, in an effort to reduce their effect on human health or local aesthetics or amenity.
It also tries to reduce waste materials' effect on the natural world and the environment and to recover resources from them.

Urban rubbish is mostly dust, dirt, hair, paper, food scraps, metal, glass and plastic.
Traditional disposal has been to bury rubbish in landfill sites or incinerate.

Landfill operation

The area being filled has a rubberized landfill liner is in place.
This prevents leaching materials migrating downward through the underlying rock.

One of the following is necessary

Waste management in:
Agriculture **OR** Fisheries **OR** Forestry

1.4.9 Waste Disposal & Micro-organisms

Problems with Waste Disposal

- Lack of availability of suitable landfill sites
- The toxic or polluting content of fumes from incineration (CO_2, other acidic oxides and dioxins – produced from burning plastic)
- Decaying waste produces methane gas which contributes to the "greenhouse gases"
- Harmful substances may leak into groundwater supplies (wells, lakes, reservoirs)
- Plants and animals in rivers and lakes may be killed through direct poisoning or eutrophication

Possible solutions

- Alter attitudes to littering, waste minimisation and disposal through education programmes.
- Use micro-organisms to degrade the rubbish and produce fuel pellets.
- Reduce the use of paper and recycle more paper.
- Replace non-biodegradable materials with biodegradable ones, e.g. bags made of paper instead of plastic.
- Increase incineration temperatures to avoid dioxin production and fit catalytic scrubbers inside chimneys.

At Present

- Tax has been placed on plastic bags.
- Rubbish sorting at source makes disposal more efficient e.g. Householders separate metals, paper, plastic, glass for recycling and 'vegetable' waste for composting.

Micro-organisms in Waste Management – Composting

Bacteria & Fungi

Bacteria and fungi are both used in the decomposition of organic matter in the process of composting.

Compost recycles all the nutrients required for plant growth.

Fungi break down the 'tougher' materials in the waste such as lignin and cellulose.

Their filamentous structure penetrates the composting material and helps to improve aeration and drainage in the compost heap.

The Compost Heap

Since it is aerobic the organic waste mixture to be composted must be turned and loosened to allow air into it.

Temperatures within a compost heap can reach 70˚C as the bacteria and fungi work to breakdown the material.

Pathogens e.g. human viruses and infectious bacteria, are unable to survive at such high temperatures.

The temperature at the outside of the heap is cooler than in the centre, so it is important to mix the pile to ensure maximum pathogen and weed seed kill.

Keep the pile ventilated or it will become too hot for micro-organisms to survive.

Suggestions for Waste Minimisation

Reduce – use less, minimise waste.

Re-use – use again, without changing but maybe for a different purpose.

Recycle – change, recover some material and use again.

Vermicomposting

A method of producing compost by using worms to turn biodegradable waste into very high quality compost.

The compost consists mostly of worm casts and decayed organic matter.

Role of micro-organisms in Pollution Control

Bacteria and fungi break down organic matter into compost that recycles all the nutrients required for plant growth.

This reduces environmental pollution caused by disposal of organic wastes in landfills and streams or by incineration.

1.4.9 Waste Management

Agriculture

The main problems here are the waste products from farms i.e.

- slurry
- silage effluent
- overuse / incorrect use of chemical fertilisers and animal manures – excess of these may enter watercourses and cause *algal blooms* and *eutrophication*.

Agriculture solution

Spreading the slurry on the land as a fertiliser. This must be managed accurately in order to maximise the value of the nutrients for crop production and minimise their impact on the environment.

Soil Nutrient Programmes aim to ensure optimum crop yields and protect the quality of water resources by avoiding pollution from agriculture.

Soil Nutrient Programme

The amounts of fertiliser applied can be determined to ensure optimum yields without causing environmental damage.

When devising a fertiliser programme the soil fertility status must be known on foot of regular soil testing.

There must be full recognition of all sources of nutrients, both organic and inorganic.

Regular soil testing is very important to help maintain a balance of nutrients in the soil.

Plastics on the farm

Plastic bags from fertiliser and plastic silage wrap strewn all around a farm is becoming a thing of the past.

Legislation on *Producer Responsibility Obligations* ensures that the plastic must be collected by the producers and dealt with appropriately.

Fisheries

Fish waste from fish landing and cleaning is a major pollutant of marinas and harbours.

Accumulated fish waste leads to:

- Unpleasant odours
- Infestations of rats
- Maggots
- Low O_2 levels in the harbour water due to decomposition of waste by bacteria

Solid organic by-products of the fishing industry were going to landfill.

This has been greatly reduced by recent legislation and dumping at sea is not an option (EU regulation).

New projects are testing various methods of management of fish wastes e.g. composting, anaerobic digestion, recycling of protein/oil etc.

Animal feeds and Oils

Fish offal is converted to fish meal and this is sold on as **animal feed** for e.g. chickens, pigs.

Some **oil is extracted** from the waste during the process and this is exported for further refining and then used in health food supplements.

Ensiling (converting to silage)

The fish waste is chopped and liquefied, then formic acid is added to it.

The resulting liquid silage can be used for fertiliser.

Fish waste Composting

Composting of fish waste is becoming more popular now and it results in a soil enhancer/fertiliser that is odour free, stable and easily stored.

This will probably become the favoured option for the industry in the near future.

Forestry

- Leaves from coniferous trees should not be allowed fall into rivers – make the water acidic
- Chemicals and fertilisers should not be allowed run off into waterways - algal blooms and eutrophication
- When trees are harvested only bare poles are removed so a lot of tree debris (called brash) and the stumps are left behind

Forestry solutions

- Waste Management in the forestry sector is all based on recycling.
- When the trees are harvested brash and the stumps are left behind.
- The stumps are sprayed with a urea-type compound which speeds up the decomposition process
- The brash is either left to decompose on the forest floor or collected and sold as a fuel source.
- In some of the larger sites the sawdust and debris is sold on for conversion to fibreboard e.g. MDF

1.5.2 Study of an Ecosystem 1

Selecting an Ecosystem

An area within the school may be suitable

What to observe in an Ecosystem

Name the type of habitat

Observe if it is exposed, sheltered, flat, on a slope, what direction does it face, influence of wind – direction, intensity, drainage, etc.

1. Form a general overview.
2. The **diversity of flora and fauna** in the ecosystem.
3. Look for inter-relationships between the various living organisms in the ecosystem.
4. What is the influence of the non-living (abiotic) components on the flora and fauna of the ecosystem?

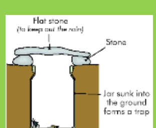
What to examine broadly

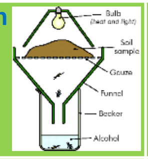
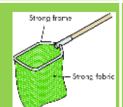
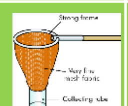
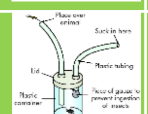
A minimum of five flora and five fauna
Name each organism – examine the range of variation of any single species e.g. height, mass, colour, etc.

Does the same species of plant grow in bright and dark areas of the habitat e.g. ivy – note the difference in leaf size and colour in each area.

Specimen identification

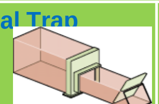
Collection methods (Named in syllabus)

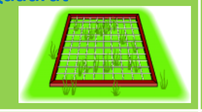
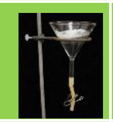
Apparatus	Notes
Pitfall Trap 	Jam jar buried in ground and covered with raised flat stone. Used to collect nocturnal and diurnal ground surface animals and insects, e.g. spiders, woodlice, beetles, etc.

Apparatus	Notes
Tullgren Funnel 	Used to extract animals from soil by heating the soil on one side.
Insect Net 	Used for catching flying insects.
Fish Net 	Used to collect small fish from pools and streams
Plankton Net 	Used to collect microscopic plants and animals from pools and streams
Sweep Net 	Used to collect insects from tall grass
Pooter 	Used for picking up very small animals.

Cryptozoic trap

A piece of wood or stone which is left on the ground. After a suitable interval, animals such as slugs, woodlice, centipedes and millipedes will be found underneath.

Apparatus	Notes
Mammal Trap 	Used to collect small mammals e.g. mice, voles, etc.

Apparatus	Notes
A Quadrat 	A frame that forms a known area usually 0.5m X 0.5m = 0.25m² Can be used to measure: Frequency and % Cover
Baermann funnel 	Used to extract nematodes from a soil sample.
Sieve 	Organisms living in leaf litter can be extracted using a sieve Use the sieve over a beating tray or a large sheet of paper.
Beating tray 	A white tray, cotton sheet or large sheet of white paper. It is placed under a bush or tree branch. The tree branch is shaken suddenly and vigorously. Insects and other invertebrates fall onto the tray.

Settlement tray

This is used in freshwater.
It consists of a shallow wooden frame which has a metal gauze or perforated zinc sheet bottom.
The tray is placed on the bottom of a pond or stream and is covered with gravel or mud and is left in place for a month or more.
It is then carefully removed and examined and the organisms which have settled on it are recorded.

Apparatus	Notes
Environmental Comparator 	An electronic device often with a digital display. Used for accurate measurement of different environmental abiotic factors, e.g. temperature, pH, light intensity, etc.

1.5.2 Study of an Ecosystem 2

Organism Distribution

Qualitative survey
a study determining the presence/absence of a substance or organism in a sample or habitat

Quantitative survey
a study determining the amount of a substance or number of an organism present in a sample or habitat

Quantitative studies

(a)To calculate the frequency of an organism (suitable for plants and for sedentary and slow moving animals)
(b)To calculate the percentage cover of an organism (suitable for most plants)
(c)To calculate the population density of an organism (suitable for plants and for sedentary and slow moving animals)

Materials/Equipment Needed

Frame quadrat
Grid quadrat
Needle/pencil

Procedure

- Familiarise yourself with all procedures before starting.
- Select the sample area in the ecosystem and mark it off.
- Decide on the organisms to be studied and recorded.
- Throw a small object over your shoulder to select a random sample point. Place the quadrat at the random sample point.
- **Record the presence or absence of the named organisms within the quadrat, on a chart**
- **Lower the needle at each sampling point and note the organism(s) hit.**
- Count and record the number of hits for each organism within the quadrat, on a chart similar to the one below
- Repeat for a number of throws.
- Use the formula below to calculate frequency / % cover
- **Calculate the average number of organisms per quadrat. If you are using a 0.5 m × 0.5 m quadrat you will have the number of organisms per 0.25 m².**
- **Calculate the number of organisms per m² (density).**
- Transfer results to graph or bar chart.

Plant / Animal Name	Quadrat Throw										Total Total Total Number	Frequency Total Points Avg. per quadrat	% Frequency % Cover Density (No. per m²)
	1	2	3	4	5	6	7	8	9	10			

(d) To conduct a quantitative study of organisms along a belt transect

(suitable for areas where there is an obvious environmental gradient or an unequal distribution of organisms)

Materials/Equipment Needed

Tape measure (30 m)
2 tent pegs
Frame quadrat/grid quadrat and needle

Procedure

1. Familiarise yourself with all procedures before starting.
2. Select the sample area in the ecosystem and stretch the tape across it.
3. Fix the tape at either end with tent pegs so that it remains taut.
4. Decide on and record the organisms to be studied.
5. Place the quadrat at the 0 mark of the tape. Note and record either the % cover or the number of the named organisms in each quadrat, on the chart on the next page.
6. Repeat at suitable intervals along the tape.
7. Transfer results to bar charts or belt transect diagram.

(e) To calculate the population of an animal using the capture-recapture technique (suitable for mobile animals)

Materials/Equipment - Suitable markers

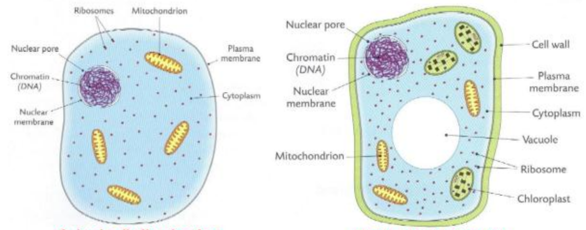
Procedure
1. Familiarise yourself with all procedures before starting.
2. Select the sample area in the ecosystem and mark it off.
3. Decide on the animal to be studied.
4. Search the area for the selected animal. Mark each animal found in a suitable way.
5. Count and record the number of animals captured and marked. Replace each animal where it was found.
6. Return to the area the following day. Search for animals in the same way. Count and record the total number of animals recaptured.
7. Count and record the number of marked animals in the recapture sample. Replace each animal where it was found.
8. Use the formula below to calculate the total number of animals in the sample area.

Total Population =

$$\frac{\text{No. captured and marked on 1}^{\text{st}}\text{ visit} \times \text{No. captured on 2}^{\text{nd}}\text{ visit}}{\text{Number of marked animals in the recapture sample}}$$

2.1.2 – 2.1.4 + 2.4 Cells & Tissues

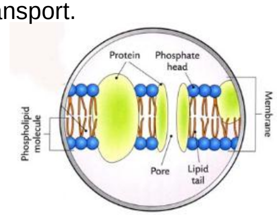
Cell: the smallest unit of matter that can carry on all the processes of life. They are the basic units of structure and function in an organism.



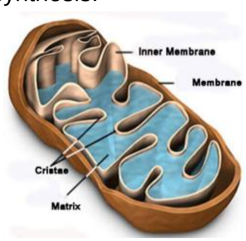
Animal cell ultrastructure *Plant cell ultrastructure*

Organelle: a structure in a cell specialised to perform particular specific function, e.g. Cell membrane, Nucleus, Mitochondria, Chloroplast, Ribosomes, DNA, Cell Wall, Vacuole.

Cell membrane: made of phospholipids and proteins. Is semi-permeable. Retains cell contents. Allows substances enter or leave the cell by diffusion, osmosis and active transport.



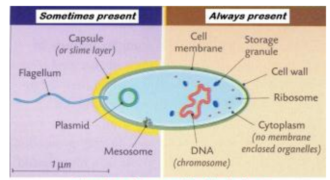
Nucleus: contains the cell's genetic information that is passed on to future generations. It controls the activities of the cell. May contain nucleoli, which function in protein synthesis.



Mitochondrion: supply energy to the cell by the process of respiration. Cells with lots of mitochondria produce a lot of energy.

eukaryote: cell that has a membrane-bound (true) nucleus. It may also have mitochondria and/or chloroplasts, e.g. plant and animal cells.

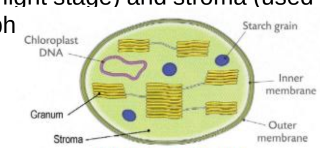
prokaryote: cells that do not have a membrane-bound (true) nucleus or membrane-bound organelles, e.g. bacteria.



Structure of a generalised bacterium

Ribosome: rich in RNA and functions in protein synthesis.

Chloroplast: contain chlorophyll and function during photosynthesis. They are composed of grana (used during the light stage) and stroma (used during the dark stage) of ph



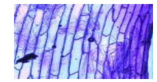
Ultrastructure of chloroplast

Cell wall: (only in plant cells) non-living, rigid and fully permeable. Found outside the cell membrane, made of cellulose by the cytoplasm. Gives shape, strength and support. See Plant cell ultrastructure diagram above.

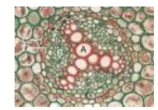
Vacuole: (usually only in plant cells) fluid-filled cavity in the cytoplasm containing aqueous solutions/salts. Provide structural support, maintains turgidity of cell by osmosis, helps in osmoregulation. Also involved in storage, waste disposal, protection and growth.

Tissue: a group of similar cells that are adapted to carry out the same function

Plant tissues

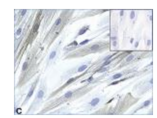


Dermal tissue - a single layer of cells that surrounds the different parts of a plant. Epidermis protects the plant



Vascular Tissue - Transports materials around the plant Xylem transports water and minerals up from the roots. Phloem transports food from the leaves to the other parts of the plant.

Animal tissues



Muscle tissue can contract and cause movement.

Nervous tissue composed of nerve cells called neurons.

Organ: a structure containing a group of tissues with a common function(s), e.g. plant organs: leaf, root, stem, flower; animal organs: stomach, ear, testis, ovary, etc.

(Organ) System: group of organs concerned with one function, e.g. digestive system.

Organism: living thing or group of systems functioning together for living, e.g. human, plant, mouse, etc.

ENZYMES

What are Enzymes?

Enzymes are organic biological catalysts made of protein they speed up a reaction without being used up themselves in the reaction.

Enzyme Action

The substance that an enzyme acts on is its **substrate**

The substance(s) that the enzyme forms is called the **product(s)**

The part of the enzyme that joins with the substrate is known as the **active site**

Denatured enzymes

Enzymes whose active site has been changed permanently

Inhibitors
Attach to enzymes and destroy their shape
Harmful inhibitors: Nerve Gas, cyanide
Beneficial inhibitors: Insecticides and some drugs.

The induced fit model of enzyme action

What happens when an enzyme meets a substrate?

- The enzyme joins with the substrate
- The active site of the substrate changes shape slightly
- The enzyme and substrate form an **enzyme-substrate complex**

Enzyme Facts

- Human enzymes work best at body temperature (37 °C)
- Plant enzymes work best at 20-25 °C
- Above certain temperatures enzymes start to lose their shape and the rate of reaction falls
- When the shape is fully lost the enzyme is said to be **denatured** this is usually a permanent condition

Factors that affect rate of enzyme action

1. Temperature
2. pH
3. Substrate concentration
4. Enzyme concentration

Bio - processing

Bio-processing is the use of enzyme controlled reactions to produce a useful product

Bio-processing can be used to produce a vast range of products such as cheeses, beer, antibiotics, vaccines, vitamins and perfumes.

Immobilised or fixed enzymes

This means they are attached to each other or an inert substance.

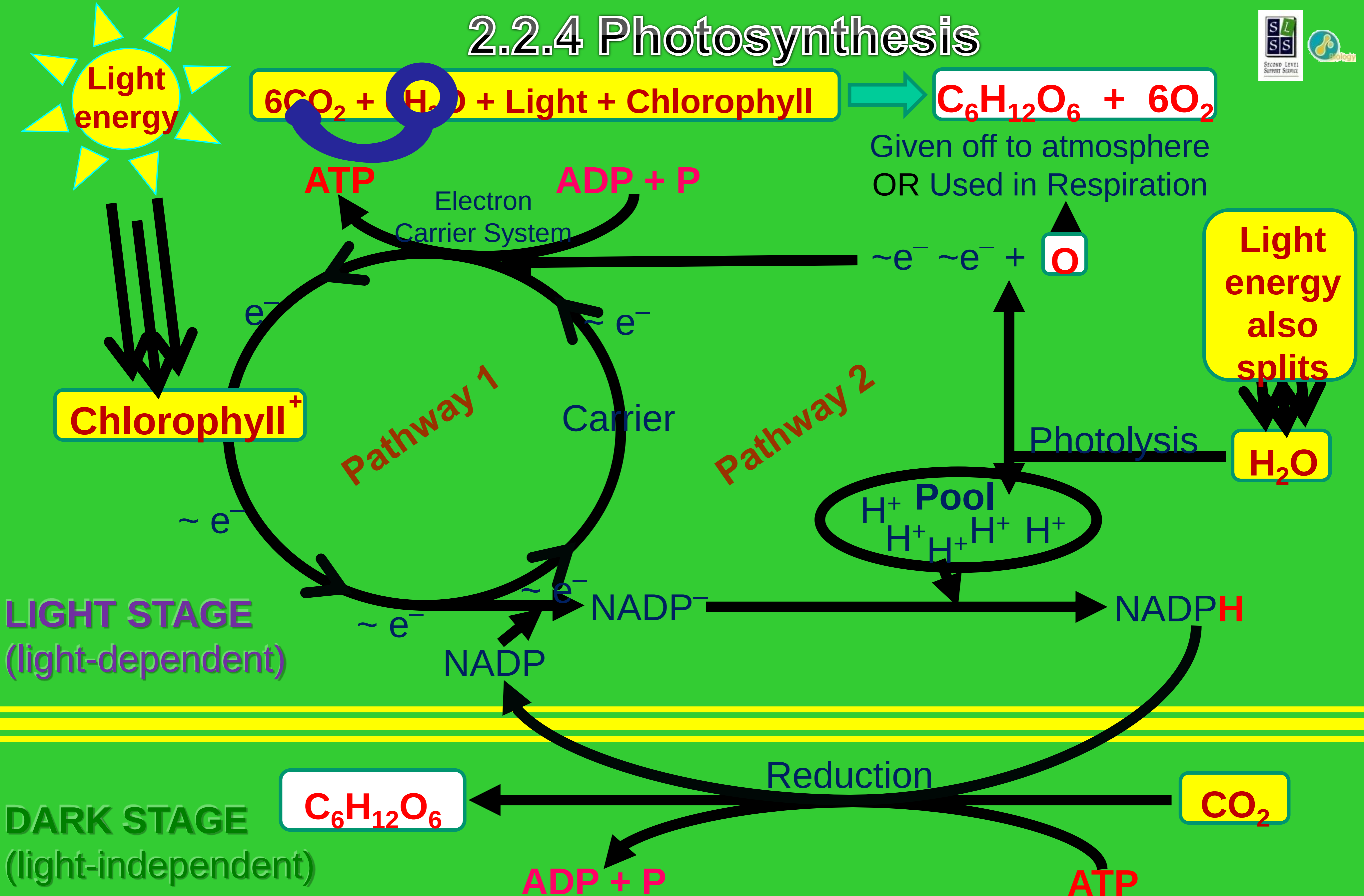
Advantages

- Can be reused - this cuts costs
- Efficiency of enzyme is not affected
- Immobilised enzymes can be easily recovered from the product so you can get a pure sample of product easily
- Enzymes frequently become more stable when immobilised

Uses of immobilised enzymes

- Food sweeteners
- Make antibiotics

2.2.4 Photosynthesis



Role of NADP: It traps and transfers energised electrons and hydrogen ions

~e⁻ = high energy / energised electron

2.2.6 Movement through Cell Membranes

Permeability

Membranes can be

Permeable – let everything in and out

Semi Permeable - let some things in and out

Impermeable – let nothing in and out

Diffusion

The movement of [gas or liquid] molecules from a region of high concentration to a region of low concentration.

Examples of diffusion

- gaseous exchange in alveoli and leaves
- absorption of digested food in the small intestine
- Absorption of minerals by root hairs
- transpiration through stomata

Osmosis

The movement of <u>water</u> molecules from a region of high (water) concentration to a region of low (water) concentration across a S.P.M.

Osmosis is a special case of diffusion – does not require energy (is passive).

Examples of osmosis

- Water entering root hair cell
- Water moving from cell to cell in transpiration
- Water moving between our body cells and blood
- Water re-absorption in the nephron

Osmosis & Food Preservation

SALTING - causes water to be drawn from bacterial cells and denatures bacterial enzymes - kills all bacteria.
Fish and Meat (bacon) may be stored in a salty solution.

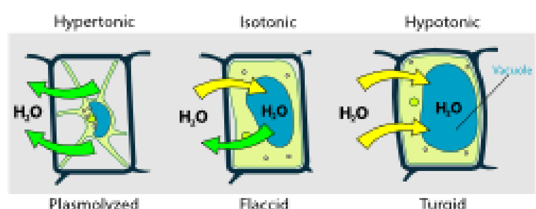
SUGAR - in high concentrations causes water to be drawn from bacterial cells - kills all bacteria.
Jams and tinned fruits are stored in a sugary solution.

Osmosis and Plant Cells

Cell walls are fully permeable and will allow all substances in and out of the cell.
If a plant cell is surrounded by a less concentrated solution then water from outside will move into the cytoplasm and vacuole of plant cells.
This is how roots absorb water by **osmosis.**

Turgor

When the outside water enters the plant cell the vacuole becomes bigger and the cytoplasm swells.
This causes the membrane to be pushed out towards the cell wall.
When cells are fully "swelled" like this with the membranes pushing against the cell wall they are described as **Turgid.**

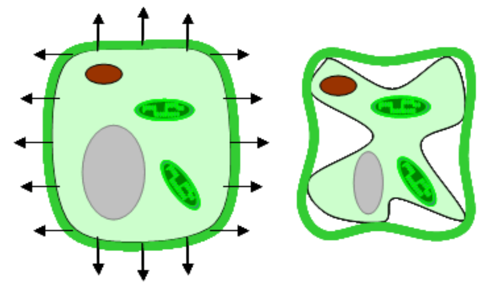


Turgor pressure

This turgor pressure gives plants their strength.
If plants did not have this they would be wilted.
Plants that don't have wood such as lettuce and house plants rely on turgor pressure for strength.

Plant cells in a more concentrated solution

- If plant cells are surrounded by a more concentrated solution (for example if plant cells were surrounded by salt water) the water inside the cell would move out to the more concentrated solution outside.



- When this happens the cell wall stays intact but the membrane shrivels up away from it.
- This is called **Plasmolysis**.
- Cells in this condition are called **plasmolysed** cells.

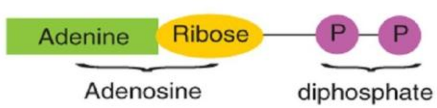
2.2.8.H Role of ATP and NAD

Energy Carriers

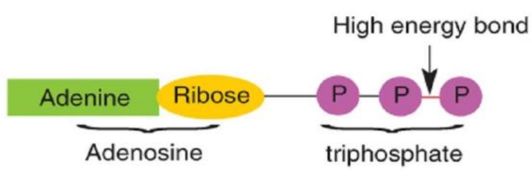
ADP, ATP, NADP$^+$ and NAD$^+$ play a vital role in trapping and transferring energy in cellular activities

ADP and ATP

- ADP is an abbreviation for Adenosine Diphosphate this is a molecule found in the cells of all organisms
- It is made of the base adenine, a 5 carbon sugar called ribose and two phosphate groups

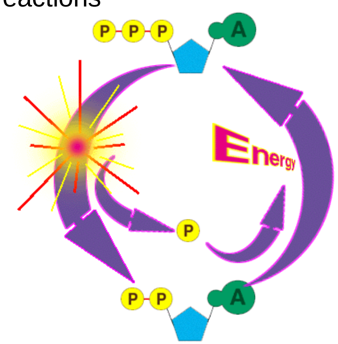


- ADP is a low energy molecule
- If another phosphate is added to ADP it forms ATP (Adenosine Triphosphate)



- Extra energy is also added as there is an extra bond between the last two phosphate groups
- Addition of a phosphate like this is called **Phosphorylation**

- ATP is rich in energy and stores this energy carrying it around in the cell
- ATP cannot store energy for very long it breaks down releasing energy and converting back to ADP
- Most cells release energy from ATP 10 million times every second! This energy is used for cellular reactions

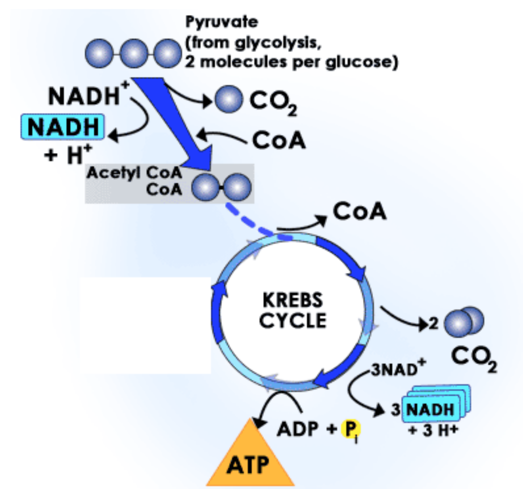


NADP$^+$ and NADPH

- NADP$^+$ is a low energy molecule involved in photosynthesis
- NADP$^+$ can combine with two high energy electrons and a proton to form NADPH
- NADPH is a very high energy molecule
- It's energy is used to form glucose in photosynthesis

NADP$^+$ and NAD

- NAD$^+$ is used in respiration
- It can combine with two high energy electrons and a proton to form NADH which is very high in energy
- NADP$^+$ is used in photosynthesis (Remember P for photosynthesis)
- Both NADH and NADPH release energy and protons when they break down into NAD$^+$ and NADP$^+$
- These electrons, protons and energy are used by cells

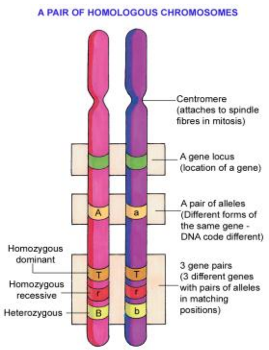


2.3 Cell Continuity & Cell Division

Cell Continuity

All cells develop from pre-existing cells

Chromosomes



- Structures in Nucleus, made of DNA & Protein
- Not dividing = Chromatin (long thin threads)
- When dividing = Chromatin forms a numbers of clearly distinguishable chromosomes
- Each species has a definite no. of chromosomes, Humans= 46 chromosomes
- Each chromosomes has 1000's of genes

Haploid

A Haploid cell has one set of chromosomes (n), e.g. Egg cell and sperm are haploid, n = 23

Diploid

A Diploid has two sets of chromosomes (2n), e.g. somatic cells, 2n = 46

Chromosomes are in pairs (homologous pairs) in diploid cells. One chromosome of each pair comes from the mother and the other comes from the father.

Cell Cycle

Describes the life of a cell. It includes the period between divisions when the cell is not dividing, called Interphase.

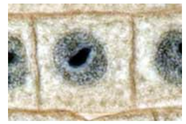
Nucleus divides = Mitosis

Cytoplasm divides = Cell division

Mitosis

- Mitosis is a form of nuclear division in which one nucleus divides to form two nuclei, each containing identical sets of chromosomes
- Two new IDENTICAL daughter cells are produced

Interphase



- Longest phase in cell cycle
- Chromosomes elongated = chromatin
- Cell very active in Interphase, produces new mitochondria, chloroplasts, etc. and chemicals needed for growth

Prophase

- Chromosomes contract and become visible
- Each chromosome appears as a duplicated strand
- Fibres appear in cytoplasm
- Nuclear membrane starts to break down

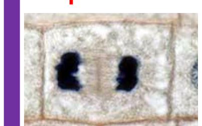
Metaphase

- Chromosomes line up across the equator of cell
- Fibres attach to chromosomes at centromere

Anaphase

- Fibres contract, chromosomes pulled apart
- Chromosomes pulled to opposite ends of cell.
- Hence, identical set of genes pulled to each end of the cell

Telophase



- Nuclear membrane forms around each of the two sets of chromosomes
- Chromosomes elongate within each nucleus

Mitosis is complete

Once complete, original cell divides* to form two cells

* By constriction in an animal cell or cell plate develops in a plant cell

Function/Role of Mitosis

In Unicellular Organisms it is a method of reproduction

In Multicellular Organisms it is responsible for growth, renewal and repair of cells

Cancer

Rate of cell division (mitosis) is carefully controlled.
Sometimes a cell or group of **cells lose the ability to control the rate of cell division.**
They form a mass of cells called a tumour which can be benign (harmless) or malignant (cancerous).

Causes of Cancer

Caused when normal genes are altered to form cancer-causing genes called oncogenes.
Brought about by cancer causing agents called carcinogens, e.g. cigarette smoke, asbestos fibres, x-rays & ultraviolet radiation and some viruses.
Most cancers can be cured with Radiation (burn out cancer), Chemotherapy (Chemicals slow down mitosis) and surgery.

Meiosis – Reduction division

Is a form of nuclear division in which the number of chromosomes is halved.
Diploid cell (2n) ÷ meiosis → 4 haploid cells (n) all genetically different

Meiosis occurs in the ovaries and testes to produce **gametes** called eggs and sperm so there are 23 chromosomes in each egg and sperm

Function/Role of Meiosis

In Multicellular Organisms
Allows sexual reproduction by producing haploid gametes
Allows new combinations of genes – variations

Where does Meiosis occur?

In the human – in the testes and ovaries
In the flowering plant – in the anthers and ovules

2.4 Tissue Culture

Tissue culture: a method for growing individual cells in a container of sterile nutrient medium to which hormones and growth substances may have been added.

The tissue sample is removed from a plant or animal and grown in glassware (in vitro) or in a bioreactor.

Growth is by mitosis and produces a cluster of identical offspring - a clone.

Conditions necessary for Tissue growth

- Oxygen
- Nutrients
- Growth factors and hormones
- Correct pH
- Optimum temperature
- Sterile conditions
- Freedom from competition

Tissue Culture – Animals

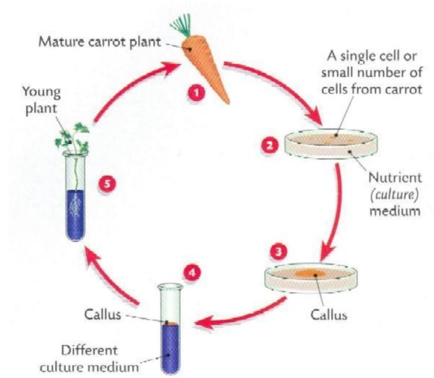
Human cells tend to grow in single layered sheets rather than clumps.
Progress has been made in growing skin cells to replace burnt skin.
Bone tissue and cartilage are grown for use in reconstructive surgery.

Some success in growing large quantities of cells that produce a specific chemical e.g. insulin producing cells.

- Find gene responsible for making a particular protein.
- Insert this gene into a bacterium.
- Very easy to grow large quantities of this transformed bacteria that will produce the protein.
- This process easier than trying to grow the original cells.

Tissue Culture – Plants

e.g. pieces of carrot will produce a lump of cells called a callus, which will produce new carrot plants that can be planted in soil.
These plants are genetically identical (clones).



Micropropagation in carrot plants

This technique useful in genetic engineering for the production of transgenic organisms
(i.e. organisms that have been altered using genetic engineering techniques)

Transgenic plants & products

- Potatoes
- Tomatoes
- Onions
- Carrots
- Apples
- Turnips
- Leeks
- Cauliflowers
- Radishes
- Bread

Applications of tissue cultures

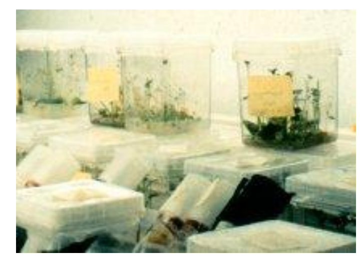
Virus reproduction

- HeLa cells (**He**nrietta **La**cks) used to grow and investigate viruses.

Note: The HeLa cell line was derived for use in cancer research. These cells proliferate rapidly. All HeLa cells are descended from a biopsy taken from the same tumour cells of a visible lesion on the cervix of Mrs. Lacks as part of the diagnosis of her cancer.

Micro propagation of plants

- Produces exact copies
- Quickly produces mature plants
- Doesn't need pollinators or seeds
- Producing plants that are disease resistant and virus free



Growing human tissue for organ transplants

- Skin cells
- Liver cell
- Pancreas cells

Producing biotechnology products

- Insulin
- Interferon
- Pregnancy testing kits
- Drug testing kits
- Cancer testing kits

2.5.2 – 2.5.4 Genetics + Profiling

Genetics: study of the mechanism of inheritance and variation of traits or characteristics as transmitted from one generation of plants or animals to another .

Species: is a group of animals or plants that can interbreed and produce viable, fertile offspring. Members of a species share the same characteristics and differ only in minor details.

Heredity: is the study of the natural law or property of organisms whereby their offspring have various physical and mental traits of their parents or ancestors i.e. certain traits are transmitted from one generation to the next.

Genetic information is carried on the DNA molecule as a gene.

Gene: is the unit of heredity found on a chromosome, and is an instruction (code) to the cell to make a particular substance, which helps regulate a trait of an organism, e.g. the gene for tongue-rolling in humans. There are two possible genes you can have. One gives you the ability to roll your tongue. The other does not give you this ability. These are different forms of the same gene (alleles).

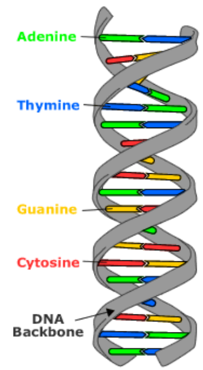
Alleles: Are alternative forms of a gene or a pair of genes found at the same locus / position on homologous chromosomes controlling the same trait.

Gene expression: is the process of changing the information in a gene into a protein and the effect that protein has on the organism.

homozygous: possessing a pair of similar genes for a trait e.g. TT or tt.

heterozygous: possessing a pair of dissimilar genes for a trait e.g. Tt i.e. the dominant and recessive genes.

DNA Structure: DNA is a long, coiled molecule called a double helix.
Composed of two strands of sugars and phosphates – the uprights of the ladder.
Strands are linked by bases – form the rungs.
Four different bases – Adenine (A), Guanine (G), Cytosine (C) and Thymine (T).
Base pairing rule - A ***always*** with T, and
C ***always*** with G.



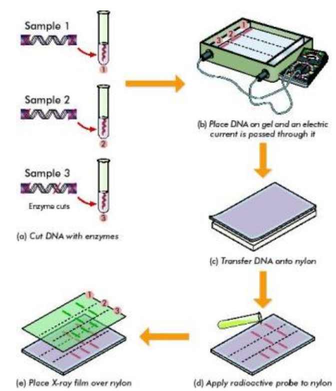
Bases can be found in any order along DNA strand – but the order of bases is unique for each DNA molecule.
The order codes for the proteins made by the cell.
Each message for a particular protein is called a gene.
The parts of the DNA that code for proteins are called *exons*.

Interons: Not all of the DNA carries messages.
The majority of it does not code for proteins and just separates the genes. These non-coding pieces are called junk genes or *interons* and are highly variable.
Found within or between two genes.
These variable parts of DNA are used when taking a DNA profile (fingerprint).

Triplet base code: DNA has a code that determines the order of amino acids in a protein.
The code is made up of groups of three bases.
Each group codes for a specific amino acid.

DNA profile – procedure

- Take a sample of material containing cells e.g. blood or semen.
- Extract the DNA from the cell by breaking up the cell and nuclear membranes.
- Treat the DNA with special enzymes which recognise specific sequences of bases, usually in the junk genes, and cut the DNA at those sites.
- This produces fragments of DNA of varing lengths.
- The fragments are placed at one end of a gel.
- An electric charge is passed through the gel and the fragments move down the gel.
- The smallest pieces move fastest.
- The DNA is then transferred onto a nylon membrane
- Radioactive DNA probes are put onto the membrane
- These attach to the fragments.
- The membrane is then put in contact with X-ray film and the distance travelled by the fragments can be seen.
- The result is a series of bands similar to bar codes.



Use of DNA profile

Identify criminals – from blood, semen or other tissue left at the scene of a crime.
Identify fathers in paternity cases – the old method of using blood types only proved that a man was not the father.

2.5.5 + 2.5.15.H Protein Synthesis

Protein synthesis essentials

1. A supply of amino acids – cytoplasm
2. Instructions as how to join the amino acids together – genetic code
3. An assembly line – ribosomes
4. A messenger to carry information from DNA to ribosomes

DNA has a code that determines the order of amino acids in a protein.

The code is made up of groups of three bases.

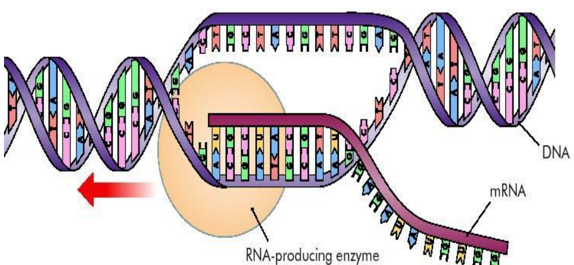
Each group codes for a specific amino acid which will be placed in that specific position.

There are more codes than amino acids => some amino acids have more than one code e.g. GCA and GGG code for the same amino acid.

Protein synthesis – how it works

1. Transcription

The piece of DNA which codes for a protein is rewritten – ***transcribed*** into a new molecule called messenger RNA (mRNA). This takes places in the nucleus of the cell.
DNA uncoils and unzips.
The exposed DNA bases are matched up with RNA bases in the nucleus to form mRNA.



The RNA leaves the nucleus and travels into the cytoplasm and attaches to a ribosome.

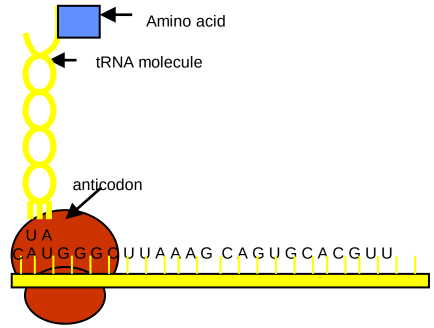
2. Translation

At the ribosome the message is ***translated.*** The strand of mRNA is pulled across the ribosome three bases at a time, in triplets.

Each of these triplets on the mRNA strand is called a codon.

A transfer RNA molecule (tRNA) brings an amino acid to the first three bases (codon) on the mRNA.

The three unpaired bases (anticodon) on the tRNA link up with the codon.

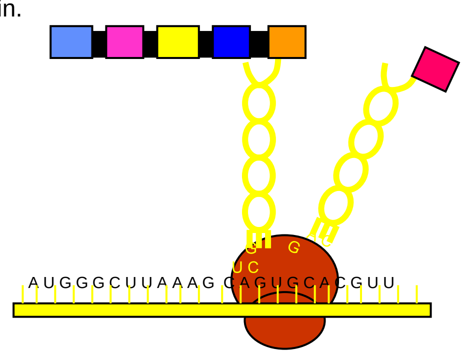


Another tRNA molecule comes into place, bringing a second amino acid.

Its anticodon links up with the second codon on the mRNA.

A peptide bond joins the two amino acids to start the formation of a polypeptide chain.

The process continues and amino acids are assembled in the correct sequence in a long chain to make the protein.



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The process requires enzymes and ATP.

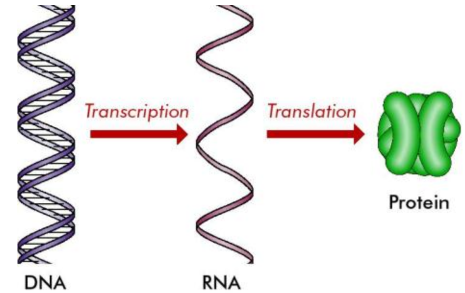
The polypeptide chain gets longer.

This process stops when a termination (stop) codon is reached.

The polypeptide is then complete.

The protein now has to undergo folding and the addition of bonds.

Folding allows the Protein to reach its 3D (Tertiary Shape) which influences its function



Three Types of RNA

messenger RNA (mRNA)

Contains the information for a specific **protein**.

Made up of **codons** (sequence of three bases)

Each **codon** is specific for one **amino acid**.

transfer RNA (tRNA)

Picks up the appropriate **amino acid** floating in the cytoplasm

Transports **amino acids** to the **mRNA**.

Has **anticodons** that are complementary to **mRNA codons**.

Recognizes the appropriate **codons** on the **mRNA** and bonds to them with H-bonds.

ribosomal RNA (rRNA)

Important structural component of a **ribosome.**

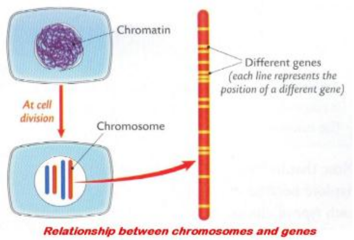
Associates with **proteins** to form **ribosomes.**

All RNA produced in the nucleus

2.5.6 Genetics & Inheritance 1

allele(s): alternative forms of a gene or a pair of genes found at the same locus/position on homologous chromosomes controlling the same trait.

chromosome: rod/thread-like structure composed of DNA and protein, contains the genetic information (genes) which is passed from one generation of cells or organisms to the next. Occur in pairs in most plant and animal cell nu[illegible]



Relationship between chromosomes and genes

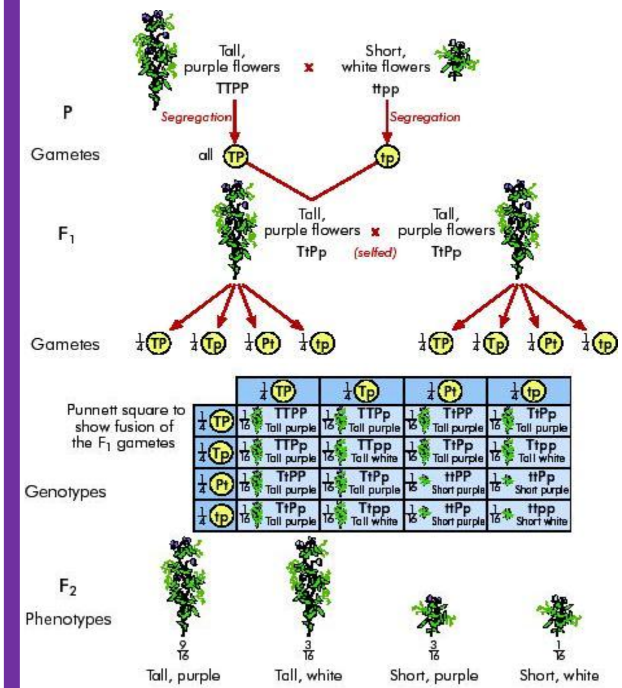
colour-blindness: inherited condition (sex-linked recessive trait) where certain colours cannot be distinguished.

contrasting traits: traits that are in opposition to one another or show a striking difference to one another, e.g. tall and dwarf, yellow and green, etc.

DNA: substance found in cell nuclei in the chromosomes. Regulates protein synthesis and is the main molecule of genes.

DNA profile: a picture (auto radiograph) of the pieces of DNA produced when an organism's DNA is broken up using specific enzymes and then sorted by size on a gel.
The stages involved are:
1. Cells are broken down to release DNA.
2. DNA strands are cut into fragments using restriction enzymes.
3. Fragments are separated on the basis of size using gel electrophoresis.
4. The pattern of fragment distribution is analysed

dihybrid cross: a genetic cross which examines the transmission of two traits together, e.g. shape and colour of seed (green and wrinkled).



dominant: characteristic, trait or gene which expresses itself in offspring, even when the corresponding opposite one (recessive) is also inherited, e.g. Tt = tall, T is dominant or, simply, dominant gene = gene that is expressed in the heterozygous condition.

F_1 generation: the first filial (daughter) generation. Offspring from crossing the parental generation (homozygous parents differing in one or more characteristics or traits).

F_2 generation: the second filial (daughter) generation. Offspring from crossing members of the F_1 generation with each other.

gamete: any cell which must fuse with another cell in order to produce a new individual. Haploid reproductive cell, i.e. contains half the required genetic information for the formation of a new individual or half the somatic number of chromosomes (in humans = 23), e.g. sperm cells, egg.

gene: unit of heredity found on a chromosome, and is an instruction to the cell to make a particular substance, a protein, which helps regulate a trait (characteristic) of an organism.

gene expression: the process of changing the information in a gene into a protein and the effect that protein has on the organism.

gene linkage: genes on a chromosome transmitted together.

genetic engineering: modern techniques or processes used to artificially alter the genetic information in the chromosome of an organism. The process involves the following:
- isolation of gene
- cutting (restriction)
- transformation (ligation), introduction of base sequence changes
- expression.

genetic screening: tests to identify the presence or absence of changed or harmful genes possessed by an individual.

genotype: genetic makeup of an individual or the genes that they inherit, e.g. Tt.

heredity: the natural law or property of organisms whereby their offspring have various physical and mental traits of their parents or ancestors, i.e. certain traits, controlled by a genetic code within the chromosomes, are transmitted from one generation to the next.

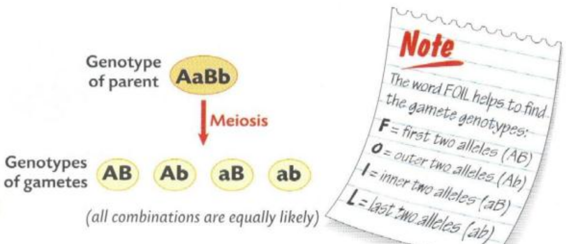
2.5.6 Genetics & Inheritance 2

heterozygous: possessing a pair of dissimilar genes for a trait, e.g. Tt, i.e. the dominant and recessive genes.

homozygous: an organism that breeds true (true-breeding) for a particular trait, because it possesses a pair of similar genes for the trait, e.g. TT or tt.

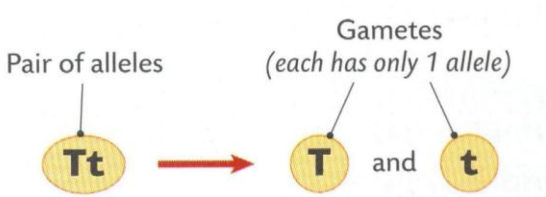
incomplete dominance: in the heterozygous condition both alleles show complete dominance and an intermediate phenotype results, e.g. in shorthorn cattle red x white, F_1 = Roan. Also called co-dominance.

law of independent assortment: states that during gamete formation each member of a pair of genes may combine randomly with either of another pair.



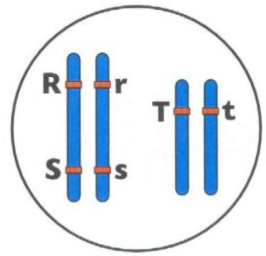
Mendel's law of independent assortment

law of segregation: states that characters (traits) are controlled by pairs of genes (e.g. Tt) that separate (segregate) at gamete formation. Each gamete carries only one gene for the trait. At fertilisation the new organism will have two genes for each trait – one received from each parent.



Mendel's law of segregation - behaviour of alleles

linkage: genes on the same chromosome that are not separated at gamete formation and are inherited together. Complete linkage, i.e. genes never separating, seldom occurs. The closer the genes are on a chromosome the greater the degree of linkage; the further apart, the lesser the degree of linkage. In the diagram **R** and **S** are linked; as are **r** and **s**.



Chromosome diagram showing linkage

mutagen: a substance or agent capable of causing or bringing about a mutation, e.g. UV light/radiation, x-rays and certain chemicals.

mutation: a spontaneous change in the sequence of nitrogenous bases in a gene or a chromosome. There are two types of mutation – chromosome mutation (e.g. Down's syndrome) and gene mutation (e.g. Sickle cell anaemia).

phenotype: physical appearance of an individual as a result of the interaction of the genotype with the environment.

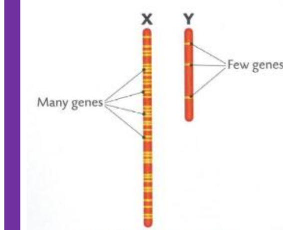
recessive (allele): gene which can only be expressed when both alleles are the same, i.e. homozygous condition, e.g. tt = dwarf; t is recessive.

segregate: to separate a pair of allelic genes during the process of meiosis and resulting in each gamete having only one of the pair of genes.

sex chromosome: one of a pair of chromosomes which contains the genes that helps determine the sex of an individual, e.g. in humans

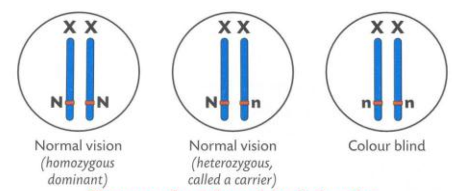
XX = female,

XY = male.

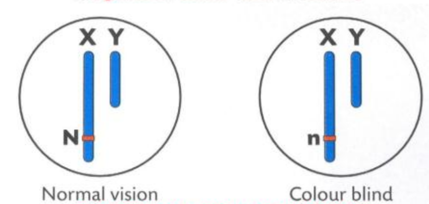


The sex chromosomes

sex-linkage: genes carried on the sex chromosomes (i.e. X and Y chromosomes) are sex-linked. They are transmitted together so the phenotype is related to the sex of the individual. Those that are carried on the part of the X chromosome and have no corresponding part on the Y chromosome (i.e. non-homologous part of X chromosome) are X-linked. Examples of such genes are those controlling haemophilia and red/green colour-blindness in humans.



The genes for colour vision in females



The genes for colour vision in males

species: group of animals or plants that can interbreed and produce viable, fertile offspring. Members of a species share the same characteristics and differ only in minor details. Each member of a species is unique

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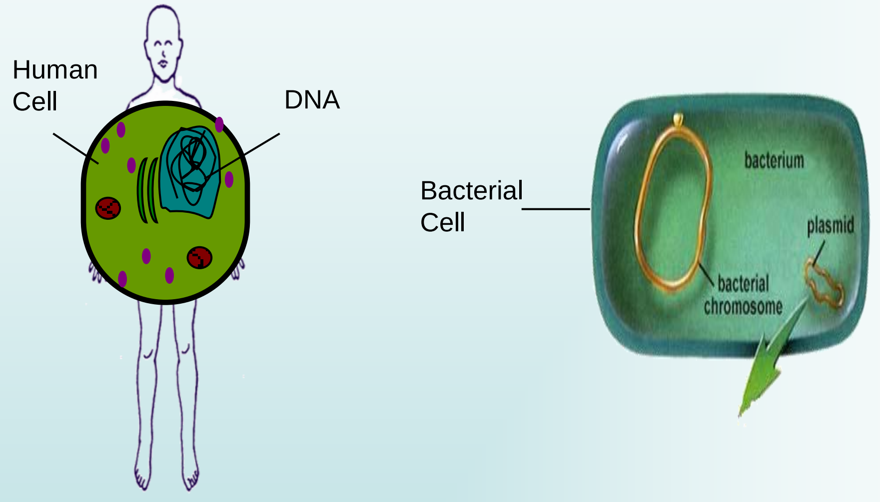
GENETIC ENGINEERING

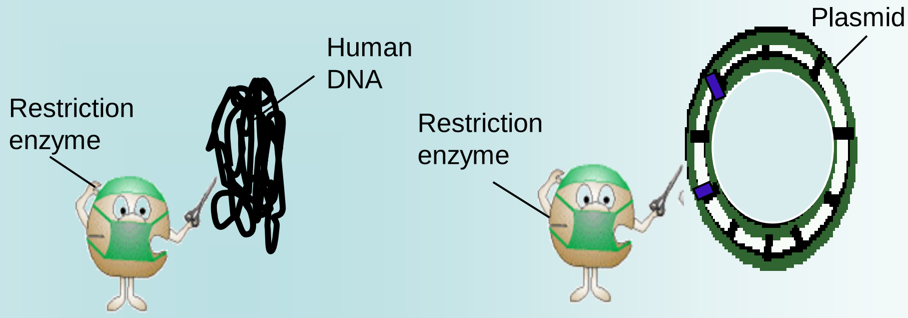
1 Isolation

Cells are broken open using chemicals and enzymes releasing the DNA from the human cell and the plasmid from the bacterial cell.



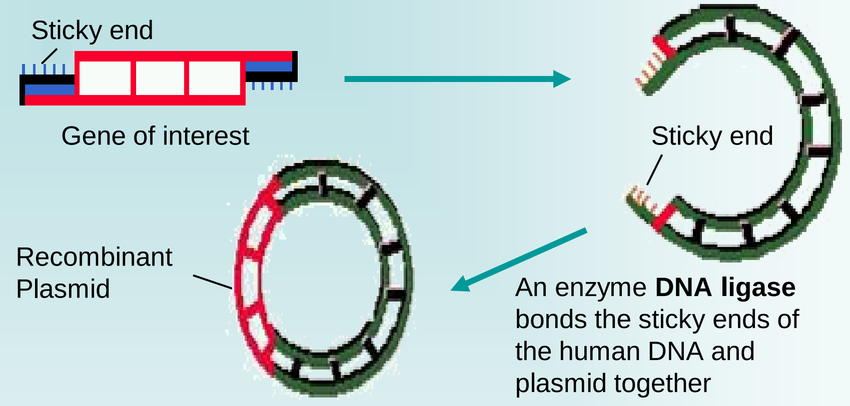
2 Cutting

Restriction enzymes recognise specific sites and cut the human DNA isolating the gene of interest. The same restriction enzyme is used to cut the plasmid.



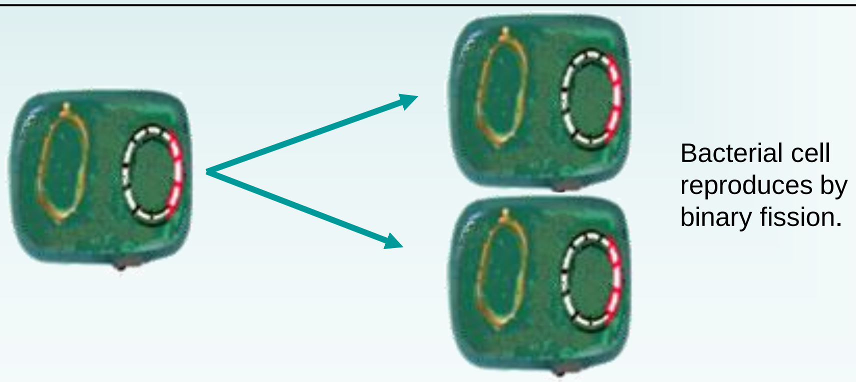
3 Transformation

The gene of interest is inserted into the plasmid. The sticky ends of the human DNA complementary pair with the sticky ends of the plasmid.



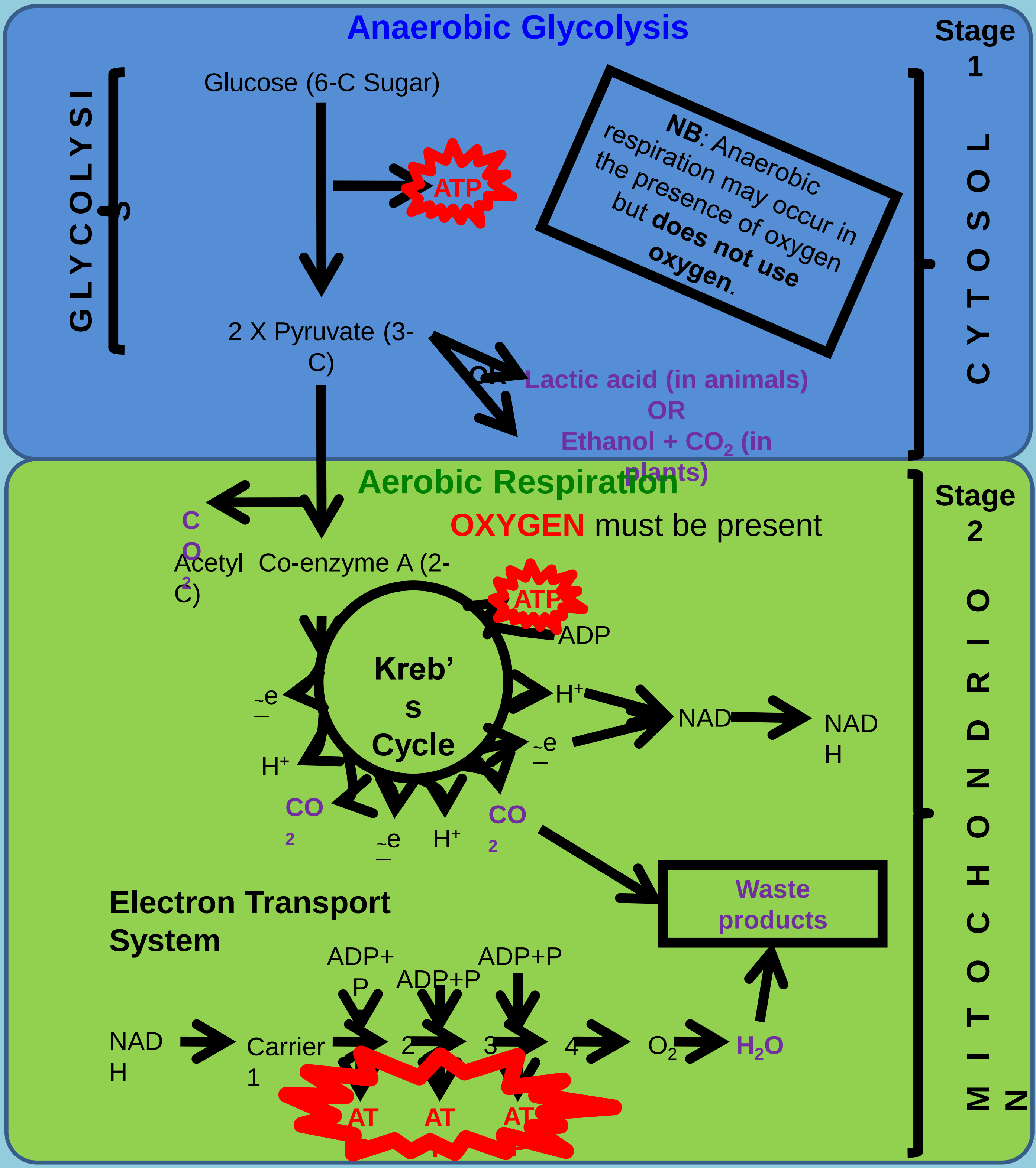
4. Expression

The recombinant plasmid is inserted back into a bacterial cell. The bacterial cell reproduces producing the polypeptide coded for by the donor DNA.



2.2.5 BIOCHEMISTRY OF RESPIRATION

$C_6H_{12}O_6 + 6O_2 \rightarrow$ ENERGY $+ 6CO_2 + 6H_2O$



Role of NAD: It traps and transfers electrons and hydrogen ions.

	Fate of Waste Products	
	CO_2	H_2O
Plants	Excreted OR Used in Photosynthesis	Transpired OR Used in Photosynthesis
Animals	Excreted via Lungs	Excreted via Kidneys

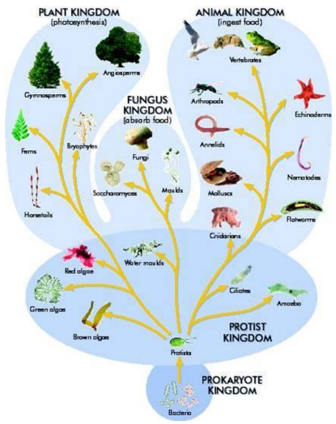
3.1.1, 7, 8 Diversity of Organisms

Classification

Taxonomy is the study of classification.

Five kingdom system of classification

- **Monera**
- **Protista**
- **Fungi**
- **Plantae**
- **Animalia**



Five kingdom system of classification
Each kingdom subdivided into smaller categories.
Each successive category contains organisms that are more and more similar.
The final category into which organisms can be placed is the **species**.
Members of the same species are capable of interbreeding to produce fertile offspring.

Monera (Prokaryotae)

This kingdom contains about 10,000 identified species of bacteria.

It is estimated that there are many more.
Bacteria were the first organisms on earth.
They are by far the most numerous organism on the planet.

Monera – main features

- microscopic and single celled organisms
- do not have a membrane enclosed nucleus
- have membrane enclosed organelles such as mitochondria and chloroplasts
- normally reproduce asexually

Protista (Protoctista)

Contains a wide variety of organisms from large plant-like algae seaweeds to single-celled organisms such as Amoeba.
Protists are found almost anywhere water is present.

Protista – main features

- single celled (Amoeba) and simple multicellular organisms (Algae)
- have a membrane-enclosed nucleus
- some feed by absorbing organic substances through the cell wall
- others photosynthesise

Fungi

Examples of fungi include mushrooms, mildews, moulds and yeasts.
Fungi play a vital role in that they break down dead organisms and allow minerals to be recycled.

Fungi - main features

- are mainly multicellular
- are composed of threads called hyphae
- a Hypha consists of one or more cells surrounded by a tubular cell wall
- cell walls are made of a carbohydrate called chitin
- are unable to make their own food
- their reproduction involves spores

Plants

This kingdom includes the mosses, ferns and seed-producing plants.
Seed producing plants can be further sub-divided into flowering and non-flowering.

Plants – main features

- are multicellular
- cells have cell walls made of cellulose
- cells have large vacuoles
- are eukaryotic, i.e. they have a true nucleus and membrane enclosed organelles
- cells have chloroplasts containing chlorophyll which enables photosynthesis. Plants are autotrophs
- reproduce asexually and sexually

Animals

This kingdom includes jellyfish, flatworms, snails, roundworms, segmented worms, frogs, lizards, birds and humans.
The first animals evolved in the sea about 700 million years ago.

Animals – main features

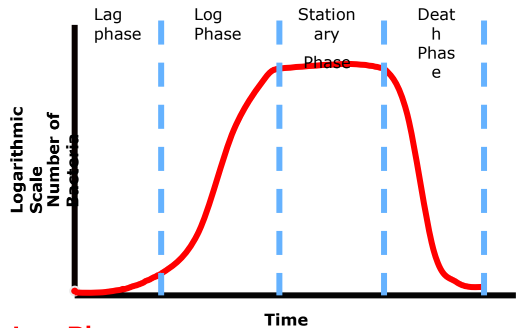
- are multicellular
- are eukaryotic, i.e. have a nucleus and membrane enclosed organelles
- cells have no cell walls
- are heterotrophic – they cannot produce their own food
- reproduce sexually

3.1.10.H Growth Curves

Rate of Growth

- Bacteria divide by **Binary Fission**.
- This is a form of **asexual reproduction**.
- Under ideal conditions it can take place every 20 minutes!
- In this way huge numbers of bacteria can be produced very rapidly.
- Because of this we use a special scale called the logarithmic scale to represent their numbers, i.e.
  10^0, 10^1, 10^2, 10^3, 10^4, 10^5... OR
  1, 10, 100, 1,000, 10,000, 100,000 ...

Growth curve for Bacteria



The Lag Phase

- After inoculation there is normally a brief period of adaptation by the cells to the new conditions.
- Bacteria are producing the enzymes necessary to digest the nutrients.
- The rate of growth begins to increase towards the end of this phase.

The Log (Logarithmic OR Exponential) Phase

- There is a rapid period of growth during this phase due to the fact that:
- Bacteria have developed the necessary enzymes and there are plenty of nutrients.
- There are few waste products being produced.
- The rate of cell division is currently at its maximum with the number of bacteria doubling as often as every 20 minutes.

The Stationary Phase

- The rate of growth levels off during this period.
- This is because:
  - The nutrients are becoming used up.
  - The amount of waste produced by the bacteria themselves is increasing.
  - The rate at which new cells are produced is equal to the rate at which other cells are dying.

The Death (Decline) Phase

During this phase more bacteria are dying than are being produced. This is because:

- Very few nutrients are left.
- Many bacteria are poisoned by the waste produced by such large numbers
- Thus the rate of growth is falling.

Endospore Formation

In unfavourable conditions many bacteria can form endospores

These are highly resistant to drought high temperature and other environmental hazards.

How Endospores are formed:

- The bacterial chromosome replicates.
- One of the new strands becomes enclosed by a tough-walled endospore formed inside the parent cell.
- The parent cell then breaks down
- Endospores can remain dormant for a long period of time.
- When conditions are favourable a new bacterium can be formed again and continue to reproduce.

Batch and Continuous Flow Food Processing

A bioreactor is a vessel in which biological reactions take place

Bio-processing

Involves the use of living organisms to produce a wide range of products, e.g. yoghurts, cheeses, vitamins, alcohol products such as wines and beers, etc.

There are two main methods of food processing:

- Batch food processing
- Continuous flow food processing

Batch food processing

A fixed amount of sterile nutrient is added to the micro-organisms in the bioreactor.

The micro-organisms go through the stages of a typical growth curve, i.e. The Lag, Log, Stationary and Death phases

Although the reaction may be stopped before the death phase as very little product will be formed at this stage.

In Batch Processing most of the product is formed during the Log and Stationary phases

At the end of production:

- The product is separated and purified.
- The bioreactor is cleaned and re-sterilised.
- The process can then be repeated.

Continuous Flow food processing

- Nutrients are continuously fed into the bioreactor.
- At the same time the culture medium (containing some micro-organisms) is continually withdrawn.
- Micro-organisms are maintained in the Log phase of growth and the process can continue uninterrupted for weeks, even months.
- Factors such as temperature, pH, rate of stirring, concentration of nutrients, oxygen and waste products are constantly monitored in order to maintain growth and produce the maximum yield.

In Continuous Flow Processing most of the product is formed during the Log phase

3.1.3 Monera – Bacteria

Bacteria

- Bacteria belong to the kingdom Monera. They are unicellular organisms
- Also known as prokaryotes as they have no membrane bound nucleus or membrane bound cell organelles
- They are classified according to three shapes
  - **Spherical (cocci)**
  - **Rod (bacillus)**
  - **Spiral (spirillum)**

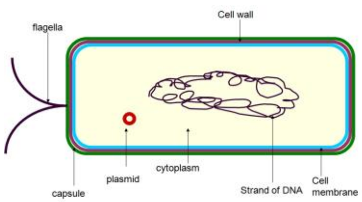
Bacterial Shapes

Spherical (cocci)
E.g. Staphlococcus aureus
causes pneumonia

Rod (bacillus)
E.g. Bacillus anthracis causes anthrax
Escherichia coli (E.coli) live in human gut

Spirillum (spiral)
E.g.Treponema pallidum causes syphilis

Bacterial Structure



Cell Parts & Function

Cell wall - shape & structure
Cytoplasm - contains ribosomes and storage granules but **no** mitochondria or chloroplasts
Nuclear material - single chromosome of DNA
Capsule* - protection
Flagella* - movement
Plasmid* - circular piece of DNA containing few genes for drug resistance

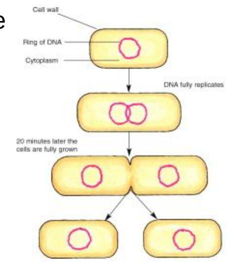
* Sometimes present.

Bacterial reproduction

- Bacteria reproduce asexually
- The method used is called **Binary Fission**

Binary Fission

- The chromosome attaches to the plasma membrane and the DNA is replicated
- The cell elongates and the two chromosomes separate
- The cell wall grows to divide the cell in two
- Two identical daughter cells are formed



Bacterial Reproduction

- Bacteria reproduce asexually - their offspring are genetically identical
- As there is little recombination of genetic material in this method of reproduction one would expect that bacteria would be slow to evolve
- Bacteria has a very short lifecycle (some can reproduce every 20 minutes).
- New mutations can spread very quickly
- This is how bacteria evolve resistance to new antibiotics

Endospore formation

- Some bacteria can withstand unfavourable conditions by producing endospores
- Formed when the bacterial chromosome replicates
- One of the new strands becomes enclosed in a tough-walled capsule called an endospore
- Parent cell breaks down - endospore remains dormant
- When conditions are favourable the spores absorb water, break their walls and reproduce by binary fission

Bacterial Nutrition

Autotrophic and Heterotrophic

Autotrophic – organisms which make their own food
Heterotrophic – organisms which take in food made by other organisms

Autotrophic Bacteria

Autotrophic
(make food)

- **Photosynthetic**
  e.g.
  Purple sulphur bacteria
- **Chemosynthetic**
  e.g.
  Nitrifying bacteria

Heterotrophic Bacteria

Heterotrophic
(Take in food)

- **Saprophytic**
  e.g.
  Bacteria of decay
- **Parasitic**
  e.g.
  Streptococci

3.1.3 Monera – Bacteria

Factors affecting the growth of bacteria

- For the maximum growth rate bacteria must have access to a food source and the conditions of their environment must be monitored closely
- Too much or too little of any of the following factors will slow down the growth of bacteria:
  1. Temperature
  2. pH
  3. Oxygen concentration
  4. External solute concentration
  5. Pressure

1. Temperature

- Most bacteria grow well between 20°C and 30°C.
- Some can tolerate much higher temperatures without their enzymes becoming denatured.
- Low temperatures slow down the rate of reaction of enzymes resulting in slower growth

2. pH

- If a bacterium is placed in an unsuitable pH its enzymes will become denatured

3. Oxygen concentration

- Aerobic bacteria require oxygen for respiration e.g. Streptococcus
- This is why oxygen is sometimes bubbled through bioreactors
- Anaerobic bacteria do not require oxygen to respire
  - **Facultative anaerobes** can respire with or without oxygen e.g. *E. Coli* (found in intestines)
  - **Obligate anaerobes** can only respire in the absence of oxygen e.g. *Clostridium tetani* (causes tetanus)

4. External Solute concentration

- Bacteria can gain or lose water by osmosis
- If the external solute concentration is
  - higher than the bacterial cytoplasm water will move out of the bacteria (Dehydration)
  - Food preservation techniques are based on this
- Bacteria can gain or lose water by osmosis
- If the external solute concentration is
  - lower than the bacterial cytoplasm solute concentration water will enter the bacteria
  - Cell wall will prevent bursting in most cases

5. Pressure

- The growth of most bacteria is inhibited by high pressures.
- Some bacteria can withstand high pressures. Pressure tolerant bacteria for use in bioreactors can be formed by genetic engineering techniques.

Economic importance of bacteria

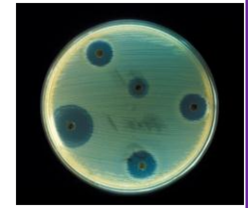
Beneficial bacteria

- Bacteria such as Lactobacillus are used to convert milk to products such as cheese and yoghurt
- Genetically modified bacteria e.g. E. Coli are used to make products such as insulin, enzymes, drugs, food flavourings and vitamins
- Antibiotics can be formed by some microorganisms
- Bacteria in the colon help produce vitamins
- Bacteria are active in the Carbon and Nitrogen Cycles

Harmful bacteria

- Pathogenic micro-organisms cause disease in plants and animals, e.g. tuberculosis, pneumonia, etc.
- If they enter the body through a wound they can multiply and effect the nerves and activity of muscles
- Bacteria can cause food spoilage and tooth decay.

Antibiotics



- Antibiotics are substances produced by micro-organisms that stop the growth of, or kill, other micro-organisms without damaging human tissue.
- Antibiotics can be used to control bacterial and fungal infections but do not effect viruses
- The first antibiotic, Penicillin, was isolated from a fungus was by Sir Alexander Fleming
- Now antibiotics are mostly produced by genetically engineered bacteria
- When an antibiotic is used to treat an infection most of the bacteria are killed
- **Mutations** in bacterial genes can allow bacteria to develop **antibiotic resistance**.
- Antibiotics will then kill 'sensitive' bacteria and favour resistant bacteria.
- Bacterial strains have emerged which are resistant to almost all known antibiotics (**multi-resistant**). As a result present day antibiotics become ineffective. **MRSA** is one example.

Misuse of Antibiotics

Overuse of antibiotics

- This results in the increased growth of antibiotic resistant bacteria
- Failure of some patients to complete a course of antibiotics prescribed to them by a doctor allows the bacteria to survive and re-grow

Bacteria

Good Guy? Bad Guy?

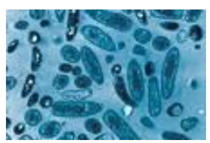
Good Guy?

Some micro-organisms produce ***antibiotics*** e.g. *Streptomyces*

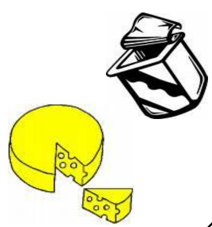
Bacteria in the colon feed on the waste and produce some B group vitamins and vitamin K e.g. *E. coli*

Genetically modified bacteria (G.M.O.'s) are used to make insulin and vitamins e.g. *E. coli*

Bacteria are active in the Carbon Cycle and the Nitrogen Cycle



Bacteria can convert milk to yoghurt and cheese e.g. *Lactobacillus*



V

Bad Guy?

Bacteria can cause potentially serious diseases in humans, animals and plants.

- **TB caused by *M. tuberculosis***
- **Food poisoning by *S.aureus***
- **Meningitis by meningococcus.**
- **Common Scab of potato by *Streptomyces***

Bacteria can cause food spoilage e.g. milk souring by *Lactobacillus*

Bacteria can dissolve tooth enamel leading to tooth decay

3.1.4 Fungi 1 - *Rhizopus*

Features of Fungi

- They do not make their own food.
- They are mostly multi-cellular.
- They are made up of threads called hyphae.
- Hyphae combine in masses to form a mycelium.
- Their walls are made of a carbohydrate called **chitin.**

Nutrition

All fungi are **heterotrophs,** i.e. they take in food made by other organisms.
Fungi are either: **Saprophytic or Parasitic**

Saprophytic fungi

- Most fungi are saprophytic. They obtain nutrients from dead material.
- As they digest it minerals are released and recycled.
- Play a vital role in the environment as they are responsible for decay, e.g. mushrooms and moulds

Parasitic Fungi

- Absorb their food from live hosts.
- They get their food mostly from plants although some fungal parasites live on animals, e.g. athlete's foot.

Types of Parasitic Fungi

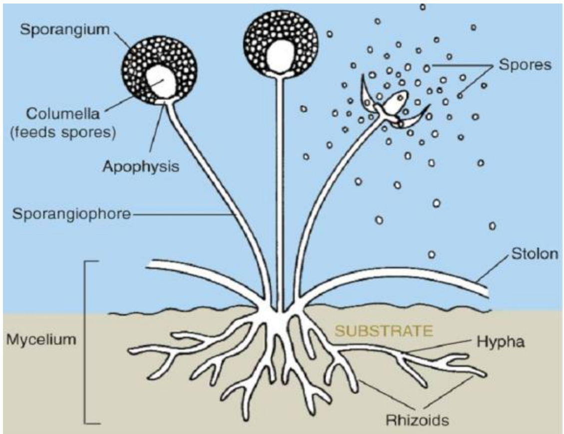
- **Obligate parasites** – live on live hosts but do not normally kill them.
- **Facultative parasites** – kill the host and feed on the remains.
- Some fungi form symbiotic relationships with other organisms.
- A lichen is an organism which is a combination of a fungus and an alga

Edible and poisonous fungi

- Some fungi are edible, but many are poisonous if eaten
- It is often difficult to distinguish between the edible and poisonous varieties growing in the wild

Structure of Rhizopus

- Consists of threadlike structures called Hyphae
- They are tubular with no cross walls and are **multinucleate**. Each nucleus is haploid.
- Large numbers of hyphae are called a **mycelium**
- The hyphae digest the substrate on which they grow.
- **Rhizoids** provide extra surface area for absorption of the digested material .
- Stolons are hyphae which allow Rhizopus to spread sideways.



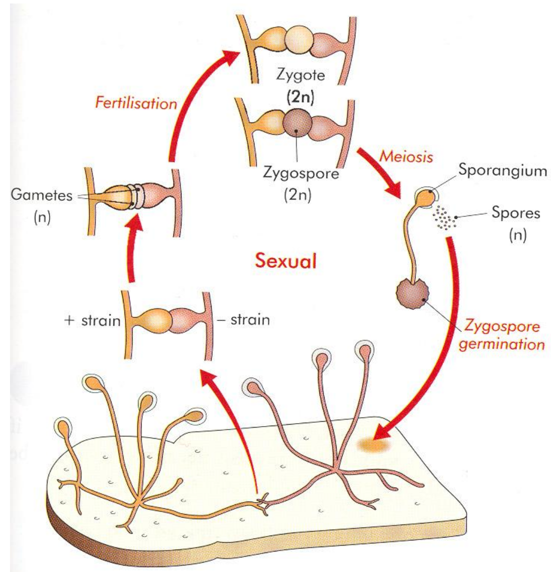
Life cycle of Rhizopus

Asexual reproduction

- **Sporangiophores** grow up from the substrate
- Cells within the sporangium divide by mitosis to produce **spores** (haploid)
- The sporangium dries out in the right conditions and opens releasing many spores.
- Each spore will grow into a new hypha and mycelium if it lands on a suitable substrate

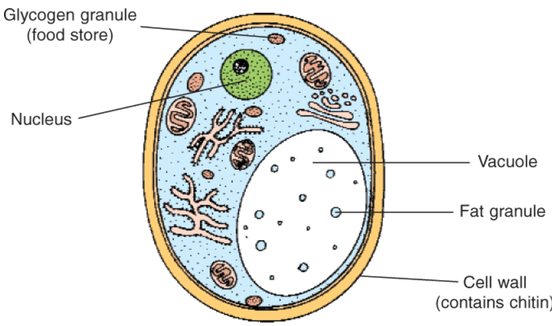
Sexual reproduction

- Sexual reproduction in Rhizopus can only occur between a plus and a minus strain
- When hyphae from opposite strains grow close together swellings grow on both strains and touch each other
- Nuclei from both hyphae move into these swellings which are now called progametangia
- Cross-walls form to produce gametangia
- The walls of the gametangia dissolve and a number of fertilisations take place producing diploid zygote nuclei
- A zygospore forms around these nuclei
- When conditions are suitable the zygospore germinates by meiosis
- A hypha grows out of the zygospore and produces a sporangium at the tip
- The sporangium opens releasing many haploid spores which grow into new individuals

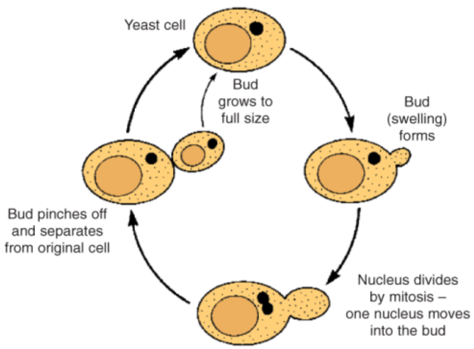


3.1.4 Fungi 2 – Yeast and *Rhizopus*

Structure of yeast

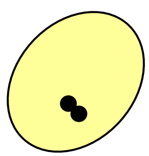


Reproduction in Yeast

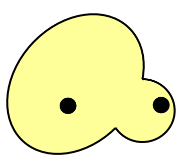


Asexual reproduction – budding

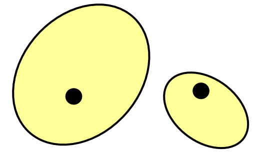
The nucleus of the parent cell divides by mitosis.



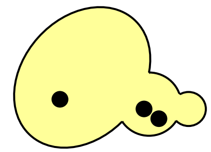
One of the daughter nuclei enters a small developing bud on the outside of the yeast cell.



This bud can separate from the parent to become a new individual.



In some cases the bud does not separate, but can itself bud. In this way long colonies of yeast cells can develop.



Economic importance of fungi

Beneficial fungi

- Fungi can be used as a source of food, e.g. Mushroom
- Yeasts can be used to make bread and alcohols such as wine and beer – anaerobic respiration

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

Ethanol ↓ Brewer

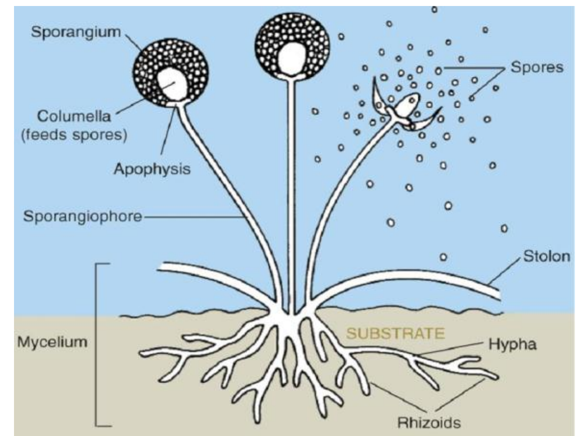
CO_2 ↓ Baker

Note: the CO_2 produced by yeast causes the dough to rise - the heat evaporates the ethanol

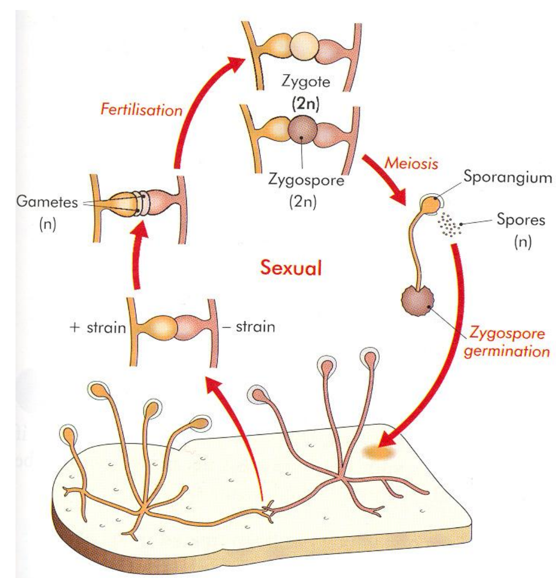
Harmful fungi

- Fungi (parasitic) can attack crops, e.g. corn and wheat and cause major financial losses as a result
- Fungi (parasitic) such as athlete's foot and ringworm can infect animals
- Fungi (saprophytic) can spoil food, e.g. *Rhizopus* grows on bread

Structure of Rhizopus



Sexual reproduction in Rhizopus



3.1.2 + 3.1.5 Lab Procedures when Handling Micro-organisms

Micro-organisms

- Can only be seen with the help of a microscope.
- Include bacteria, some fungi (yeast) and some protists (plankton).
- Occupy a wide range of habitats, e.g. salt water, fresh water, soil, dust, air, hot springs, etc.
- Fungi are mostly terrestrial.
- Bacteria can be found in extreme environments from the inside of volcanoes to inside the human gut.

Procedures when handling micro-organisms

Asepsis means that measures are taken to exclude unwanted organisms.
Sterile means that all micro-organisms are destroyed, i.e. there is nothing living.
Inoculation is the addition of cells to the nutrient medium.
Incubation is the growing of the microbes in a warm environment.

Growth of micro-organisms

- Under suitable conditions one micro-organism can be grown into a colony of micro-organisms which is visible to the naked eye.
- Micro-organisms are grown on a special medium containing a food supply – usually nutrient agar.
- The procedures involved require caution as the micro-organism to be grown (or any contaminating micro-organism, if present) may be a disease causing microbe.
- As a result certain precautions are taken when handling micro-organisms to reduce the possibility of contamination and to prevent the growth of undesirable micro-organisms.

Precautions when handling micro-organisms

- Wash hands before and after the experiment.
- Wash the bench with disinfectant before and after the experiment.
- Sterilise all equipment before and after use. This can be done by placing all equipment:
  - In an autoclave (or pressure cooker) at 120 °C for 15 minutes or
  - in Dettol for 24 hours
- After an experiment material can be placed in a dustbin only after sterilisation. Sterilised equipment can be reused
- Flame all needles, loops and necks of test-tubes by heating them in the flame of a Bunsen burner.
- Turn off the Bunsen burner when not in use or make sure that the flame is visible.
- Open all containers for the shortest possible time. Open lids the shortest possible distance.
- Seal all plates once inoculated.
- Label all plates once prepared.

How to grow a culture.

- Take a sterile agar plate.
- Flame an inoculating loop to sterilise it.
- Dip the loop into sterile water or alcohol to cool it.

- Flame the neck of the container from which the sample is to be taken.

- Inoculate the loop by placing it briefly into the sample to be grown.
- Re-flame the neck of the container.

- While only slightly opening the agar plate streak the inoculating loop across the surface of the agar.

- Sterilise the loop again by flaming it.
- Label and seal the petri-dish and incubate it upside down for 2 – 3 days.

- Examine the plate and record the results.

Growth conditions

- Once agar plates are sealed and labelled turn them upside down and place them in an incubator to allow any bacteria and fungi to grow.
- Placing them upside down reduces problems due to condensation.

- Yeasts and moulds grow best at 25 – 30 °C.
- Bacteria generally require 35 °C.

Results

- Bacterial colonies are usually seen as white, cream or yellow shiny dots.

- Fungal colonies appear as a powder or as a fuzzy growth, similar to cotton wool in appearance

Disposal

- All micro-organisms should be destroyed after use by sterilising all petri-dishes and equipment:
  - by placing them in an autoclave (or pressure cooker) at 120°C for 15 minutes or
  - by placing them in Dettol for 24 hours.

3.1.6 Protista, e.g. Amoeba

Protista characteristics

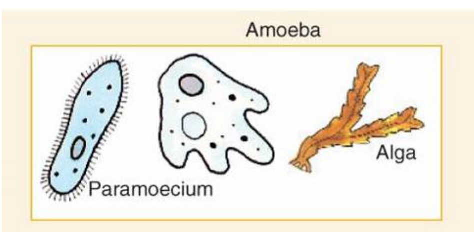
- Contains single-celled and simple multi-cellular organisms
- They are eukaryotic – they have a membrane-enclosed nucleus and membrane enclosed organelles
- Some feed by taking in organic substances, others can photosynthesise.

Examples include:

- **Amoeba** – moves by means of pseudopods and is well known as a representative unicellular organism.

- **Algae** – a large and diverse group of plant like organisms ranging from unicellular to multicellular forms.

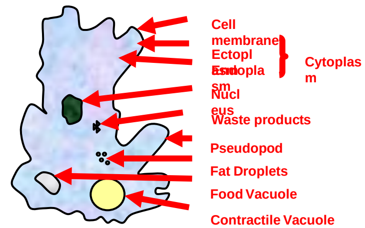
- **Paramecium** – consist of a single cell yet are visible to the naked eye.



Amoeba

- Consists of a single cell
- It is a consumer. It feeds on small plants, animals and bacteria
- It lives in freshwater ponds (most likely to be found on the mud at the bottom)

Structure of Amoeba



- Cell membrane – semi-permeable
- Cytoplasm divided up into
  - Endoplasm
  - Ectoplasm

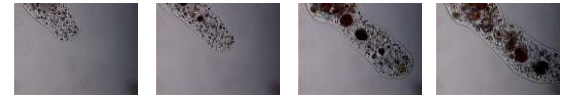
Endoplasm and ectoplasm

- The endoplasm is fluid-like. It has a grainy appearance due to the presence of food vacuoles and waste materials
- Ectoplasm can become soft in places to allow the development of pseudopodia

Development of Pseudopod

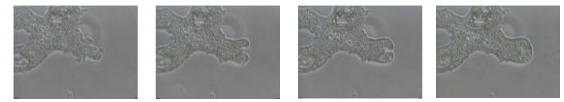
- Pseudopods are referred to as 'false feet' as they are produced at any point on the body and have no fixed position
- Pseudopodia extend in the direction Amoeba wishes to move
- Pseudopods develop when the ectoplasm softens and moves forward and the endoplasm moves in to replace it
- Amoeba uses pseudopodia to engulf its prey

Endoplasm and ectoplasm



Food vacuoles

- Amoeba feeds by surrounding its prey with pseudopodia and secreting digestive enzymes into the vacuole created
- Food can then be stored within the vacuole.



Contractile vacuole – how it works

- Amoeba's cytoplasm has a higher solute concentration than the surrounding fresh water
- As a result water constantly rushes in by osmosis
- In order to deal with this uptake of water Amoeba forms a contractile vacuole
- The contractile vacuole swells with water and moves to the edge of the cell…
- Where it bursts and expels the water…
- The cycle is then repeated

Contractile vacuole

- The contractile vacuole is said to be responsible for osmoregulation
- Without it the Amoeba would expand and burst

Contractile vacuole bursting

3.1.3 Monera – Bacteria

Factors affecting the growth of bacteria

- For the maximum growth rate bacteria must have access to a food source and the conditions of their environment must be monitored closely
- Too much or too little of any of the following factors will slow down the growth of bacteria:
  1. Temperature
  2. pH
  3. Oxygen concentration
  4. External solute concentration
  5. Pressure

1. Temperature

- Most bacteria grow well between 20°C and 30°C.
- Some can tolerate much higher temperatures without their enzymes becoming denatured.
- Low temperatures slow down the rate of reaction of enzymes resulting in slower growth

2. pH

- If a bacterium is placed in an unsuitable pH its enzymes will become denatured

3. Oxygen concentration

- Aerobic bacteria require oxygen for respiration e.g. Streptococcus
- This is why oxygen is sometimes bubbled through bioreactors
- Anaerobic bacteria do not require oxygen to respire
  - **Facultative anaerobes** can respire with or without oxygen e.g. *E. Coli* (found in intestines)
  - **Obligate anaerobes** can only respire in the absence of oxygen e.g. *Clostridium tetani* (causes tetanus)

4. External Solute concentration

- Bacteria can gain or lose water by osmosis
- If the external solute concentration is
  - higher than the bacterial cytoplasm water will move out of the bacteria (Dehydration)
  - Food preservation techniques are based on this
- Bacteria can gain or lose water by osmosis
- If the external solute concentration is
  - lower than the bacterial cytoplasm solute concentration water will enter the bacteria
  - Cell wall will prevent bursting in most cases

5. Pressure

- The growth of most bacteria is inhibited by high pressures.
- Some bacteria can withstand high pressures. Pressure tolerant bacteria for use in bioreactors can be formed by genetic engineering techniques.

Economic importance of bacteria

Beneficial bacteria
- Bacteria such as Lactobacillus are used to convert milk to products such as cheese and yoghurt
- Genetically modified bacteria e.g. E. Coli are used to make products such as insulin, enzymes, drugs, food flavourings and vitamins
- Antibiotics can be formed by some microorganisms
- Bacteria in the colon help produce vitamins
- Bacteria are active in the Carbon and Nitrogen Cycles

Harmful bacteria
- Pathogenic micro-organisms cause disease in plants and animals, e.g. tuberculosis, pneumonia, etc.
- If they enter the body through a wound they can multiply and effect the nerves and activity of muscles
- Bacteria can cause food spoilage and tooth decay.

Antibiotics

- Antibiotics are substances produced by micro-organisms that stop the growth of, or kill, other micro-organisms without damaging human tissue.
- Antibiotics can be used to control bacterial and fungal infections but do not effect viruses
- The first antibiotic, Penicillin, was isolated from a fungus was by Sir Alexander Fleming
- Now antibiotics are mostly produced by genetically engineered bacteria
- When an antibiotic is used to treat an infection most of the bacteria are killed
- **Mutations** in bacterial genes can allow bacteria to develop **antibiotic resistance**.
- Antibiotics will then kill 'sensitive' bacteria and favour resistant bacteria.
- Bacterial strains have emerged which are resistant to almost all known antibiotics (**multi-resistant**). As a result present day antibiotics become ineffective. **MRSA** is one example.

Misuse of Antibiotics

Overuse of antibiotics

- This results in the increased growth of antibiotic resistant bacteria
- Failure of some patients to complete a course of antibiotics prescribed to them by a doctor allows the bacteria to survive and re-grow

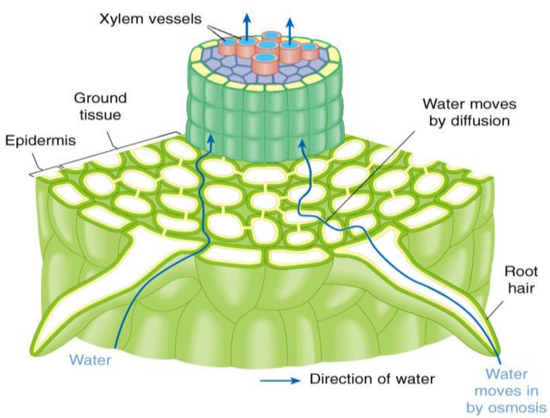
3.3.1 Mineral Nutrition in Plants

Transport of water in flowering plants

Water enters the root hair by osmosis then diffuses across the ground tissue into the xylem.

Reasons for water entering root hairs

1. Root hairs have a large surface area.
2. They have thin walls.
3. Their cytoplasm is more concentrated then the soil water.



Mineral uptake by plants

Minerals are dissolved in the water and enter the plant by diffusion.
They follow the same pathway as water.

Mechanisms that contribute to the upward movement of water through the stem

1. Root Pressure

As water molecules move into the root by osmosis they push the ones in front of them up the xylem.

2. **Transpiration**

As water evaporates from the leaf by transpiration, more water is pulled upwards through the xylem into the leaf.

Details of transpiration

Every time a water molecule is lost from the leaf by transpiration an osmotic gradient (difference in concentration) occurs between the leaf (spongy mesophyll) and the xylem vessels.

The leaf therefore becomes less turgid.

A water molecule from the xylem vessel enters the leaf to replace the one lost by transpiration.

What controls the water lost by leaves?

A waxy cuticle and closed guard cells both stop excess water being lost by the leaf.

The cohesion-tension model of water transport

By Henry Dixon and John Jolly, two Irish scientists.
It explains how water is transported against the force of gravity in plants.

- Water molecules stick to each outer (cohesion) and to the xylem vessels (adhesion).
- This causes the water molecules to form a thin continuous column.
- As each molecule is lost by transpiration, it pulls the next water molecule up the xylem to replace it.
- This continues all the way down to the roots causing a tension.
- The tension is hard to break and can pull a column of water molecules to great heights in plants.

Function of transport system

To transport materials needed for metabolic processes including respiration and photosynthesis.

3.2.2 The Circulatory System

Heart

Heart: A muscular pump that moves the blood throughout the body.

Four chambers:

atrium- 2 upper chambers

ventricle- 2 lower chamber

Valves: Prevent the backflow of blood from the ventricles into the atria

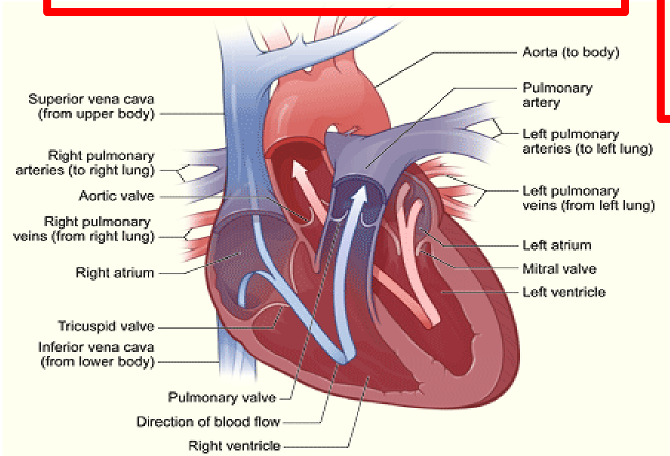
Bicuspid valve: tricuspid Valve

Each ventricle also has a **SEMILUNAR VALVE T**he blood flows through the semilunar vales on its way out of the heart.

Septum: Separates the right side of the heart from the left

Flow of blood:

The right atrium takes blood in from the body, through the vena cava's. It then goes though the tricuspid valve into the right ventricle. It goes out through the pulmonary artery to the lungs. It returns from the lungs through the pulmonary vein. It enters the left atrium and then goes through the bicuspid valve into the left ventricle. The left ventricle pumps the blood through the aorta to the body for the process to happen again.



Circuits

THE PULMONARY CIRCUIT is the path of blood from the heart through the **LUNGS**.

- The **deoxygenated** blood from **all tissues** collects in the **RIGHT ATRIUM**, is pumped to the **right ventricle**, then is sent to the **pulmonary arteries**, which divide up into the **arterioles** of the lungs. These arterioles take blood to the **pulmonary capillaries**, where **CO2 and O2 are exchanged**.
- The oxygenated blood then enters **pulmonary venules**, then the **pulmonary veins**, and finally back to the **LEFT ATRIUM**.

THE SYSTEMIC CIRCUIT

- The systemic circuit includes all blood vessels except those in the Pulmonary Circuit. It takes blood from the **LEFT VENTRICLE**, through the **tissues & organs of the body**, and back to the **RIGHT ATRIUM**.
- in the systemic system, **veins carry deoxygenated blood**, and **arteries carry oxygenated blood**.
- The systemic circuit contains some blood vessels you should know:
- **AORTA**: the largest artery. Branches of the aorta lead to all major body regions and organs.
- **SUPERIOR VENAE CAVA**: large vein that collects blood from head, chest, and arms.
- **INFERIOR VENAE CAVA**: large vein that collects blood from the lower body regions and organs.
- **HEPATIC PORTAL SYSTEM**: connects the blood vessels of villi to the liver, carries nutrient rich blood to liver for processing. A **portal system** begins and ends in **capillaries** (in small intestine, and other end in liver.
- **HEPATIC VEIN** carries blood from liver to inferior venae cava.

Control of Heart Rate

PULSE: the alternate **expanding and recoiling of an arterial wall** that can be felt in any **artery** that runs near the **surface** of the body

BLOOD PRESSURE: the pressure of the blood against the wall of a vessel, created by the pumping action of the heart.

SYSTOLE = **CONTRACTION** of heart muscle.

DIASTOLE = **RELAXATION** of heart muscle.

The **CARDIAC CYCLE** (= "**heartbeat**") occurs about **70 times per minute**

Heart Rate Control

There are **TWO** nodal regions in the heart:

1. **SA (sinoatrial) NODE** (also called the **PACEMAKER**): located in the **upper back wall** of the **right atrium**.

The SA node **INITIATES THE HEARTBEAT** by sending out a signal automatically about every 0.85 seconds to make the **ATRIA CONTRACT**. The SA node is called the **"PACEMAKER"** because it keeps the beat **regular**

2. **AV (atrioventricular) NODE**: found in the **base of the right atrium** near the septum. The SA node sends its signal along fibres to the atria and also to the AV node. When the pulse sent out by the SA node reaches the AV node, the AV node itself the sends out a signal along special conducting fibres called **PURKINJE FIBRES**. These fibres take the message to the **VENTRICLES**, and cause them to **contract**.

Closed circulatory system

Vertebrates, and a few invertebrates, have a closed circulatory system. Closed circulatory systems have the blood closed at all times within vessels of different size and wall thickness. In this type of system, blood is pumped by a heart through vessels, and does not normally fill body cavities.

Open circulatory system

The open circulatory system is common to molluscs and arthropods. Open circulatory pump blood into a hemocoel with the blood diffusing back to the circulatory system between cells. Blood is pumped by a heart into the body cavities, where tissues are surrounded by the blood.

3.2.3 The Blood

Blood and Blood vessels

Blood-:plasma-liquid of blood 92% water and 8% protein

Functions of the blood

- Transport of O_2 nutrients both organic such as :glucose, vitamins, amino acids, fatty acids and glycerol; and inorganic ions such as: Na+, K+, Cl-, Ca2+ and I- to all body cells
- Transport of CO_2 and wastes . It transports metabolic wastes such as : urea, creatinine and uric acid away from cells
- Transport of chemical messengers inlcuding hormones to cells
- Maintaining pH of body fluids
- Distributing heat and maintaining body temperature
- Maintaining water content and ion concentration of body fluids
- Protection against disease-causing micro-organisms

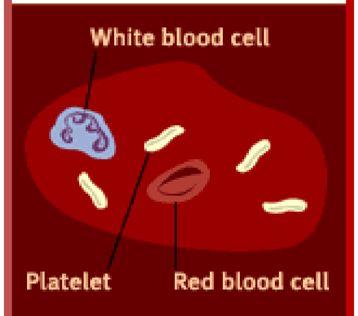
Platelets- These have no nucleus, they are fragments of cells that help the blood to clot. They are formed in red bone marrow.

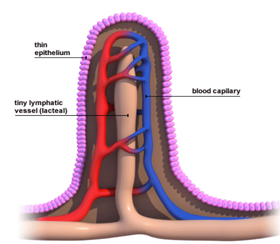
They release fibres to work with protein to create blood clots, which form plugs to help reduce blood loss.

RBC- red blood cells- most abundant type of cells. They contain Haemoglobin, and are biconcave discs. They do not contain a nucleus. They transport oxygen which they get when it diffuses into the capillaries from the alveoli. They are made in red bone marrow. They are destroyed in liver and spleen.

WBC- white blood cells. Their function is to defend against disease. They do this either by phagocytosis where the WBC engulf pathogens or by the production of antibodies. They are produced in yellow bone marrow.

Plasma – the fluid part of the blood that contains dissolved substances





The Lymphatic System

• The lymphatic system is **another vascular system** in your body.
It is **separate from your cardiovascular** system (i.e. it has its own veins and capillaries) but it is ultimately connected back with the cardiovascular system (i.e. the fluid from the lymphatic system eventually gets sent back into the bloodstream).
The function of the lymphatic system is to take up **excess tissue fluid** from the **tissues** and **returns** it to the **cardiovascular system**.

• It is a **one-way system** that starts in the tissues and empties into the cardiovascular system.

• Lymph vessels consist of **LYMPH CAPILLARIES** and **LYMPH VEINS** (which have **valves**).The fluid in the lymph vessels it is called **LYMPH**.

• Lymph contains **LYMPHOCYTES** which are a type of white blood cell. Some lymphocytes produce **antibodies**.

Other Parts of the Lymphatic system you should know:

• **Lacteal**: blind ends of lymph vessels in villi of the small intestine. **Products of fat digestion** enter here. The lacteals transport lipids to the blood.

• **LYMPH NODES**: small **oval or round structures** that occur along strategic places on lymph vessels. They **produce and store lymphocytes**, and **filter lymph** of **damaged cells and debris**.

• **SPLEEN**: located **behind the stomach**. **Contains white blood cells and stores blood**.

• **THYMUS GLAND**: located in the upper thoracic cavity, **functions in production and maturation of some lymphocytes**. Decreases in size with age (may be a factor in aging).

Summary of Main Functions of Lymphatic System

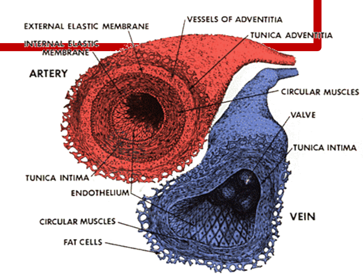
1. **transport** of excess tissue fluid back to cardiovascular system
2. **absorption** of **fat** from the intestine and transport to blood
3. **fighting infection** by production of **lymphocytes** Some lymphocytes produce **antibodies**.

Types of Blood Vessels

Arteries: large blood vessels that carry oxygenated blood. They have small lumens and thick walls to withstand high blood pressure. They carry blood from the heart to the body. They have elastic walls.

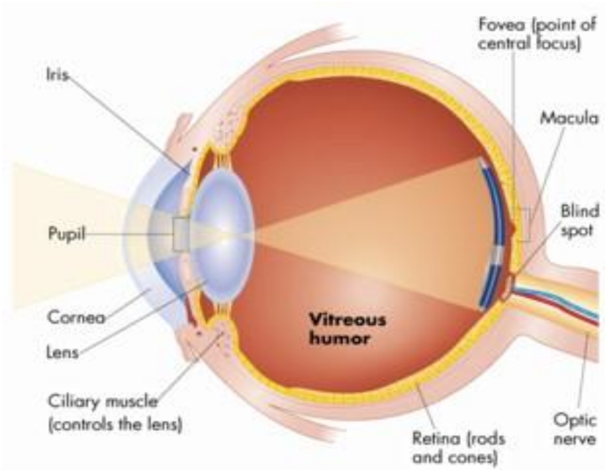
Veins: Blood vessels that carry deoxygenated blood from the body to the heart. They have thin walls and large lumens, They contain valves.

Capillaries: Tiny blood vessels that absorb food and oxygen to feed RBC and get rid of CO2 and waste. They connect arteries to Veins.



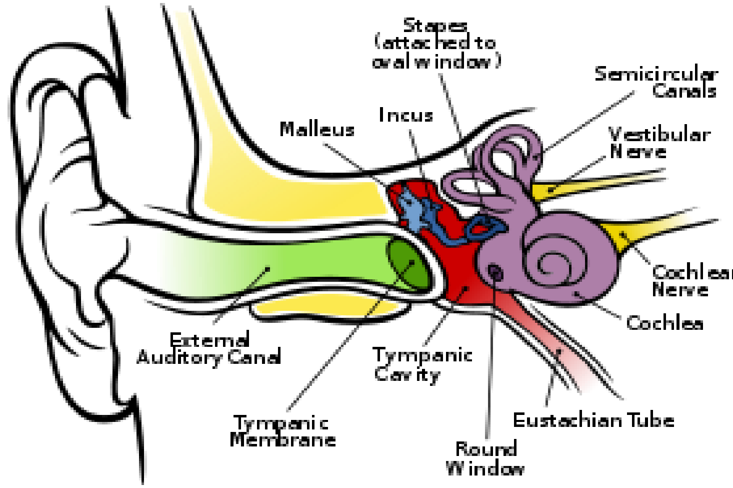
3.5.3 The Eye and the Ear

The Eye



- The **conjunctiva** is the membrane surrounding the eye. It protects the eye.
- The **sclera** is a tough, white coat that holds the eye in shape.
- The **cornea** is the front part of the sclera. It allows light into the eye and bonds it to help focus light on the retina.
- The **choroid** nourishes the eye and prevents internal reflection of light.
- **The retina** is light sensitive. It contains light receptors, rods (for black and white vision and to see in dim light) and cones (for colour vision, and to see in bright light).
- The **fovea** is the part of the retina where most images are focused.
- The **blind spot** is where the optic nerve leaves the retina. It has no rods or cones.
- The **optic nerve** carries impulses to the brain.
- The **lens** focuses light on the retina.
- The **iris** is the coloured part of the eye. It controls the amount of light entering the eye.
- The **pupil** is the black circle at the front of the eye. It lets light into the eye.
- The **Ciliary muscles** change the shape of the lens (called accommodation) to focus the image on the retina.
- The **aqueous** and **vitreous humours** is fluid that helps to keep the eye in shape.

The Ear



The ear is the organ of hearing.

- The **pinna** or ear lobe collects vibrations.
- The **auditory canal** carries vibrations from the pinna to the eardrum.
- The **eardrum** carries the vibrations to the middle ear.
- The **ossicles** (the hammer, anvil and stirrup) increase the amplitude of the vibrations and pass them on to the oval window.
- The **Eustachian tube**, connects the middle ear with the pharynx and equalises pressure between the middle and outer ear.
- The **cochlea** is responsible for hearing. It converts vibrations into electrical impulses that are sent to the brain along the auditory nerve.
- The **organ of Corti** in the cochlea contains receptor cells that us to hear
- The **semi-circular canals** are responsible for balance.

3.5.3 The Nervous System

The Nervous System

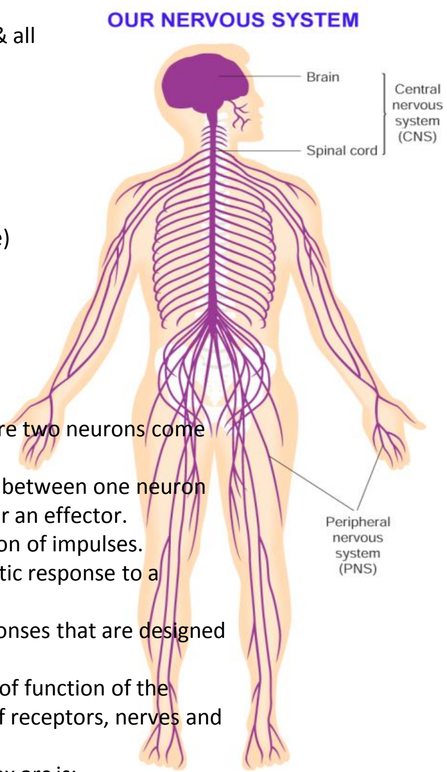
The central Nervous System is divided into

1 - Central Nervous System - including the brain & spinal cord

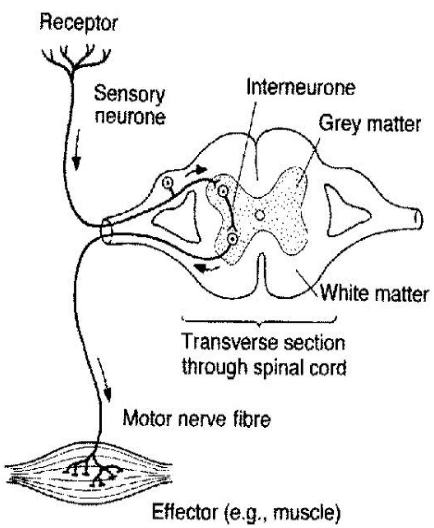
2 - Peripheral Nervous System - including cranial nerves, spinal nerves, & all branches of cranial & spinal nerves

Nervous coordination involves:

- reception (detecting a stimulus)
- transmission (movement of the impulse)
- integration (impulses are sorted, processed and decisions made)
- response (a muscle or gland carries out the effect)



Transmission of an Impulse

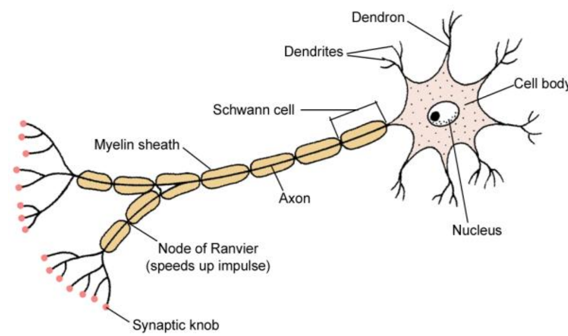


A synapse is the region where two neurons come into close contact.
A synaptic cleft is a tiny gap between one neuron and either another neuron or an effector.
Synapses control the direction of impulses.
A reflex action is an automatic response to a stimulus.
Reflex actions are fast responses that are designed to protect the body
A reflex arc is the basic unit of function of the nervous system. It consist of receptors, nerves and effectors.
The route taken along a reflex arc is:
receptor → sensory neuron → spinal cord → interneuron → motor neuron → effector.
At the interneuron stage an impulse is also sent to the brain. The brain is made aware of the action, but does not control it.

Neurons

A neuron is a nerve cell. There are three types of neurons.

- Sensory (afferent) neurons take messages to the CNS.
- Motor (efferent) neurons take messages from the CNS.
- Interneurons connect motor and sensory neurons in the CNS.



The main parts of a neuron:

- **Nerve endings** connect to receptors or sense organs.
- **Dendrites** (can be long or short, and branched) carry impulses to a cell body.
- **Axons** carry nerve impulses away from cell bodies.
- **Schwann cells** make myelin.
- **Myelin** insulates the electrical impulses
- **The cell body** forms neurotransmitters and the different parts of the neuron.
- **Neurotransmitters** are chemical s released across a synaptic cleft to carry a signal from one neuron to another. The chemical is then destroyed or removed

3.5.3 The Brain and Spinal Cord

The Brain

The brain is protected by the skull bones, meninges (three membranes) and cerebrospinal fluid.

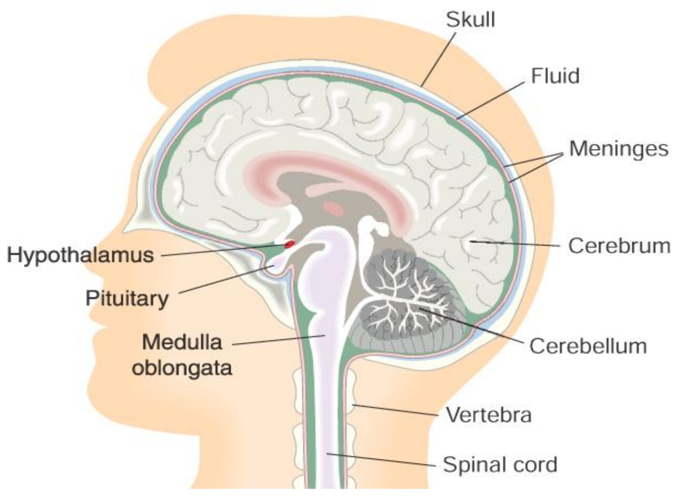
The cerebrum is our conscious brain, with different parts having different jobs to do.

The hypothalamus is the centre for the regulation of the internal organs

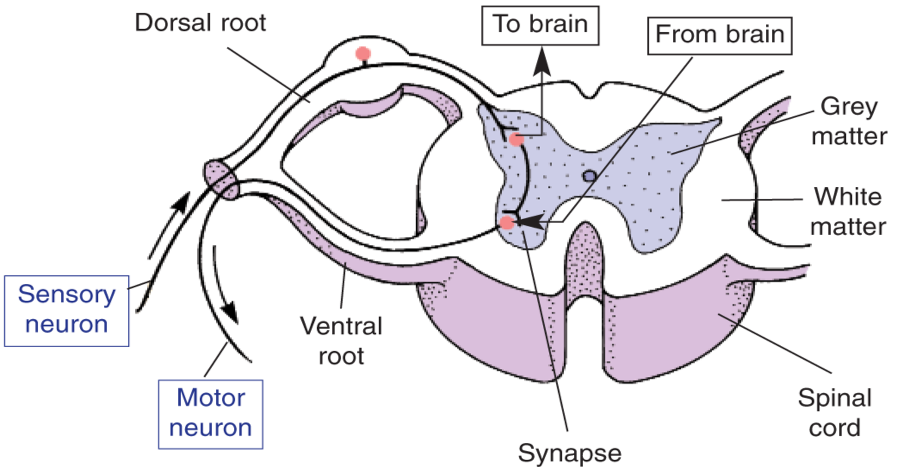
The pituitary '[master] gland secretes hormones that stimulate other glands to release their hormones.

The cerebellum co-ordinates processes that we have learned to do automatically, such as speaking.

The medulla oblongata co-ordinates involuntary, automatic processes — such as breathing, heartbeat.



The Spinal Cord



The spinal cord carries impulses to and from the brain and controls many reflex actions.

In the spinal cord:

- sensory neurons enter through dorsal roots
- the dorsal root ganglion contains the cell bodies of the sensory neurons
- white matter contains axons
- grey matter contains cell bodies and dendrites
- interneurons connect sensory and motor neurons
- motor neurons emerge through ventral roots

3.5.3 Musculoskeletal System

Structure and Function of the Skeleton

Muscles and the skeleton work together to form the musculoskeletal system.

The functions of the skeleton are:
- support
- protection
- movement
- shape
- blood cell manufacture

The Human Skeleton

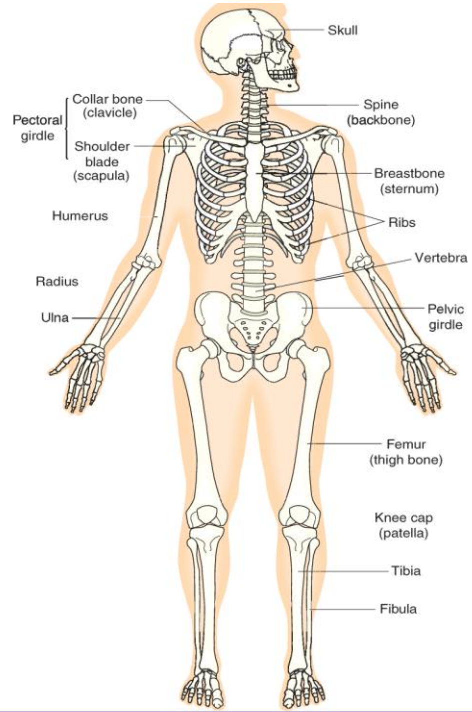
The human skeleton has 206 bones, which can be divided into two parts:
axial and appendicular.

Axial skeleton – skull, ribs (12 pairs), sternum (breastbone) & vertebrae (backbone).

Appendicular skeleton – pectoral and pelvic girdles, and their attached limbs (arms and legs)

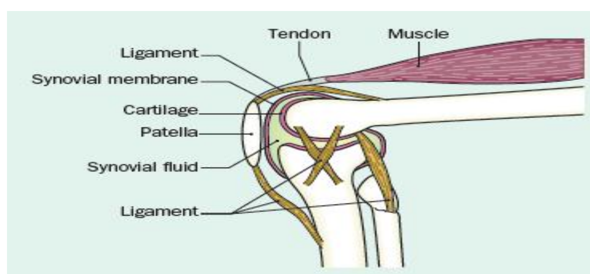
Joints

A joint is where bones meet.
The types of joints are:
- Immovable (fixed or fused) joints such as the skull
- Slightly movable joints such as those between vertebrae
- Freely movable (synovial) joints, which include:
- ball and socket (shoulder and hip)
- hinge (elbow and knee)



Cartilage:
- protects the ends of bones
- forms structures such as the ear, nose and trachea

Ligaments join bone to bone.
Tendons join muscle to bone

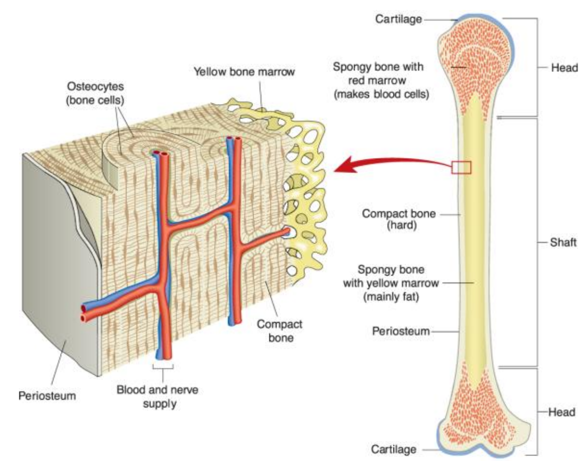


Bone Structure

There are three types of bone:
- Compact bone is hard and strong. It has bone cells (osteoblasts) in a matrix of salts (strength) and protein (flexibility).
- Spongy bone is more porous. It has hollow spaces containing bone marrow.
- Bone marrow is a soft material. Red marrow makes blood cells; yellow marrow is inactive.

The medullary cavity is a hollow tube located at the centre of the shaft of a bone.
Osteoblasts are cells that form bone.
Bones grow longer due to a growth plate between the epiphysis and diaphysis

Arthritis:
- is a disorder of the musculoskeletal system
- results from inflammation in joints
- may be prevented by reducing damage to joints in sports
- is treated by rest, exercise, drugs and surgery



3.5.3 The Endocrine System

The endocrine system is a group of specialised tissues (glands) that produce chemicals called hormones, many
of which are proteins

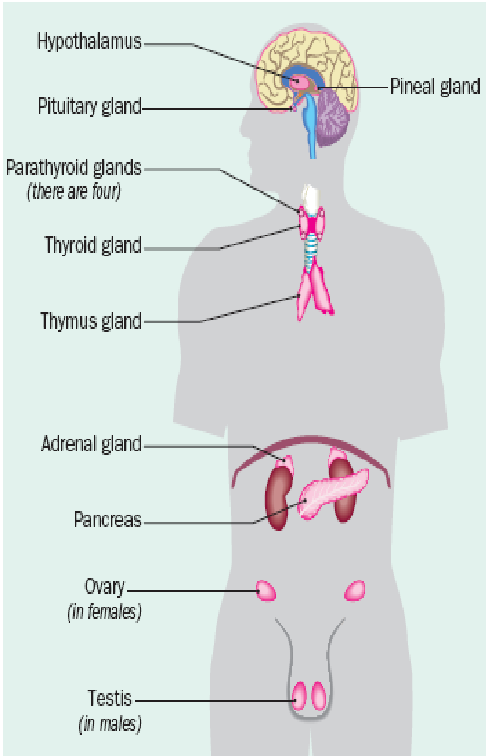
Hormones are chemical 'messengers', produced in specialised glands, and transported in the blood to a
particular area (the target organ), where they have their effect.

Gland = Organ that secretes chemical substances for the body to use.

. **Exocrine gland** -- Secretes chemical substances into a duct.

3. **Endocrine gland** -- Secretes chemical messengers (hormones) into the blood.

- **A hormone** is:
- a protein or steroid
- produced by endocrine glands
- carried in the blood to other parts where they cause their effects



Hormones

Most hormone activity is controlled directly or indirectly by **the hypothalamus** and **pituitary gland.**

The pituitary is often called the 'master gland', as many of its hormones trigger other glands to release theirs.

It produces ADH to stimulate water reabsorption in the kidneys, TSH which stimulates the thyroid gland to release thyroxine, and FSH which controls the functions of the reproductive organs.

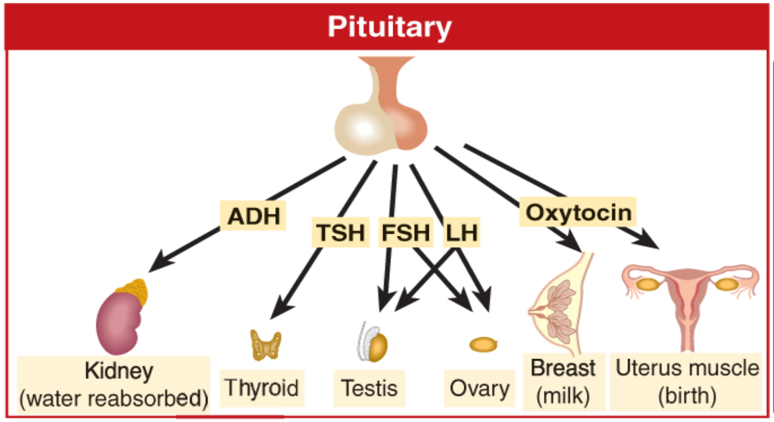
The thyroid gland, in the neck, produces thyroxine, which stimulates metabolism.

The parathyroid produces parathyroid hormone, which increases blood calcium levels

The adrenal gland produces adrenaline, which helps the body cope with emergencies —the 'flight or fight' hormone

The ovary produces oestrogen and progesterone to prepare the female for pregnancy.

The testes produce testosterone which triggers sperm production and growth in the male.



Hormonal Disorder

Deficiency of thyroxine:

- causes cretinism in young children (mental and physical retardation)
- causes goitre, myxoedema and reduced rates of metabolism in adults (slow responses, lack of energy, excess weight, fluid build-up under skin)
- is controlled by taking thyroxine or iodine

Excess thyroxine:

- causes increased rates of metabolism, weight loss, large appetite, nervousness (Graves' disease)
- is controlled by removing part of the thyroid or killing it with radioactive iodine

3.5.2 Plant Responses

Plant responses involve growth and changes in growth due to:

- external factors such as light, day length, gravity and temperature
- internal factors such as growth regulators

A tropism is the change in growth of a plant in response to an external stimulus.

A positive tropism means the growth is towards the stimulus. A negative tropism means that the growth is away from the stimulus.

- phototropism (response to light)
- geotropism (response to gravity)
- thigmotropism (touch)
- hydrotropism (water)
- chemotropism (chemicals)

Plant adapt to new situations by modifying their growth, by means of chemicals called growth regulators [hormones]. Growth is the increase in the number, size and volume of cells.

Plant growth regulators are produced in the meristems and transported through the vascular system of the plant.

Plant Growth Regulators are:

- active in very small amounts
- produced in the meristems
- transported in the xylem and phloem
- dependent on concentration for effect
- Only needed in very small amounts

Some regulators promote growth e.g. auxins, gibberellins, cytokinins.

Some regulators inhibit growth e.g. abscisic acid and ethene

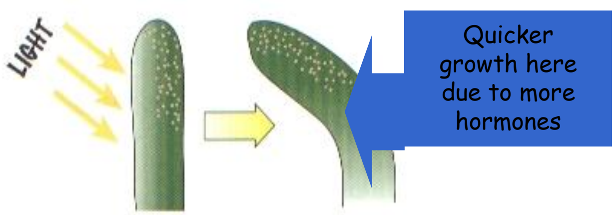
Effects of Auxins

The effects of auxins are to cause:

- **tropisms** (i.e. growth and bending responses)
- **apical dominance** (i.e. they allow the tip of the stem to grow, but inhibit side branches)
- **fruit formation** (even when fertilisation has not taken place, i.e. parthenocarpic fruit)
- **root formation** and growth

IAA affects phototropism as follows:

- IAA is made in the tip of the stem
- it diffuses down the stem
- it causes stem cells to elongate
- it diffuses down the shaded side of a stem
- the cells on the shaded side elongate, causing the stem to bend towards light



Commercial growth regulators are used to:

- stimulate root formation in cuttings
- stimulate the formation of new plants in tissue culturing
- ripen bananas

Growth Inhibitors#

Growth inhibitors include:

- ethene (or ethylene), which is a gas that ripens fruit, and causes ageing and leaf fall
- abscisic acid, which responds to stress in plants by closing stomata, forming bud scales and inhibiting seed germination

To investigate the effect of IAA on plant tissues:

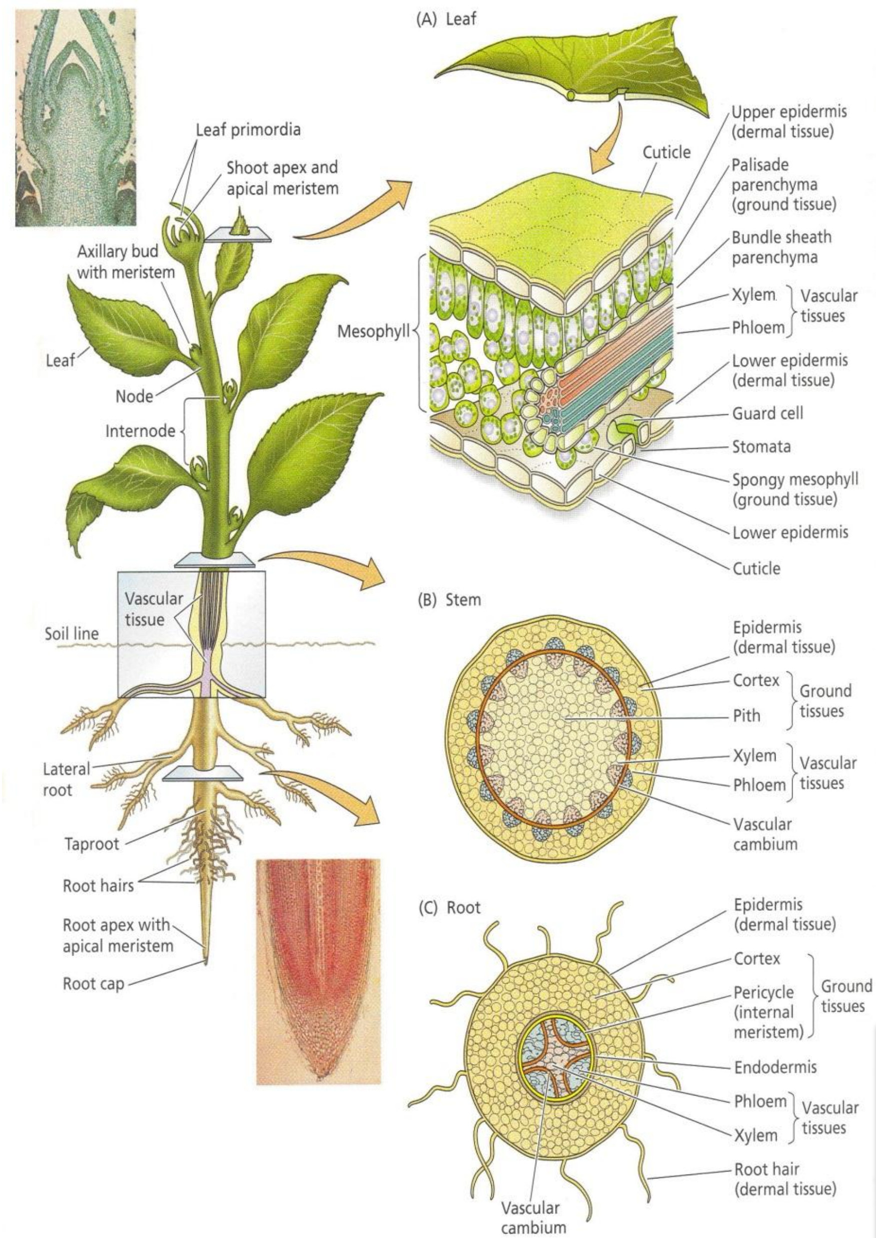
- different concentrations of IAA are prepared
- seeds are grown in the IAA concentrations
- changes in length of the seedlings are recorded

The growth and development responses can be a form of defence that allows a plant to survive difficult conditions [environmental stress] in its habitat.

Adaptations that plants use to protect themselves include:

- Spines, thorns or stinging hairs to deter animals from eating them, e.g. cacti, nettles.
- Toxins that cause illness or death, e.g. Cassava leaves and roots produce cyanide poison to protect it against insects and other herbivores
- The red pigments of autumn leaves serve as a kind of botanical sunscreen, a defence mechanism against sun damage that could interfere with the storage process and cause a leaf to drop before the tree was done with it.
- Heat-shock proteins [stress proteins] are created when cells are exposed to higher temperatures or to other kinds of environmental stress, such as UV light. Their activities are part of a cell's repair system and allow the plant to tolerate extra heat, light, etc. for a limited period, and resume normal cellular activities when the stress ends.

3.2.1 Plant Structure



Functions of the Root

- Anchor the plant
- Absorb Water and minerals
- Transport water and minerals
- Store food

Functions of the Shoot

- to support the aerial parts
- to transport materials to and from the leaves
- Sometimes store food

Functions of the Leaf

- to make food
- to exchange gases
- to allow water loss (transpiration)

The three main categories of plant tissues are:

- dermal tissue (forms a protective covering layer)
- vascular tissue (xylem for water transport, phloem for food transport)
- ground tissue (found between the other two tissues, carrying out a range of functions)

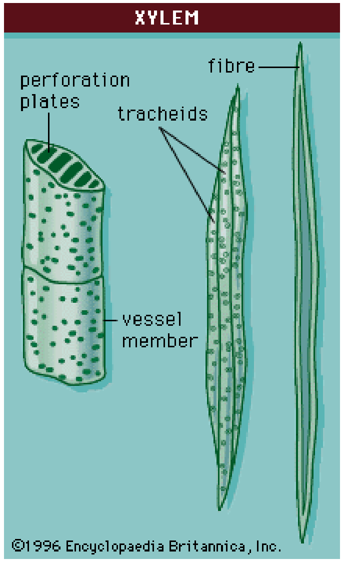
Xylem is a dead tissue that transports water.

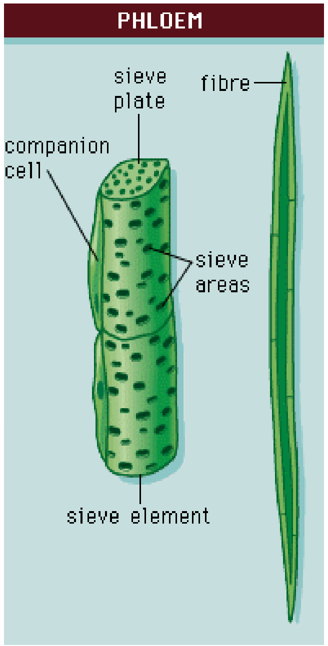
- They have lignin for strength
- No end walls
- Have pits to allow sideways movement of water

Phloem is a living tissue that transports food.

- Have companion cells
- Have sieve plates and pores

	Monocotyledons	Dicotyledons
No.of cotyledons	One	Two
Arrangement of vascular bundles	Scattered in the stem	In a ring pattern
Leaf venation	Parallel	Netted
No of flower parts	In threes	In fours and fives





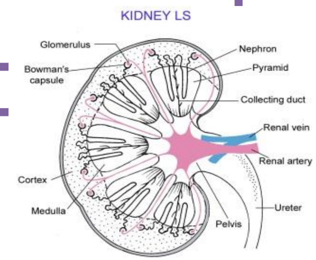
3.4.6 Excretion

Homeostasis is the maintenance of a stable internal environment in an organism.

- **Ectotherms** are animals that obtain their heat from external sources.
- **Endotherms** generate their heat with their own body reactions.

The main excretory organs are:

- lungs (water and carbon dioxide)
- skin (water and salts)
- kidneys (water, salts, and urea)



The functions of the kidneys are:

- excretion of water, salts, and urea
- osmoregulation:
- - control the water content of the blood
- - control the salt concentration of the blood
- control the pH of the blood (and body fluids)

The kidneys make urine in the following way:

- blood (containing waste) enters the kidneys through the renal arteries
- the kidneys filter waste and useful materials from the blood
- useful materials are reabsorbed from the kidneys back into the blood
- some materials are secreted from the blood into the kidneys
- urine formed in the kidneys flows to the bladder through the ureters
- blood (low in waste) leaves the kidneys in the renal veins
- **The bladder** stores urine.
- **Urine is excreted** through the urethra.

Nephrons:

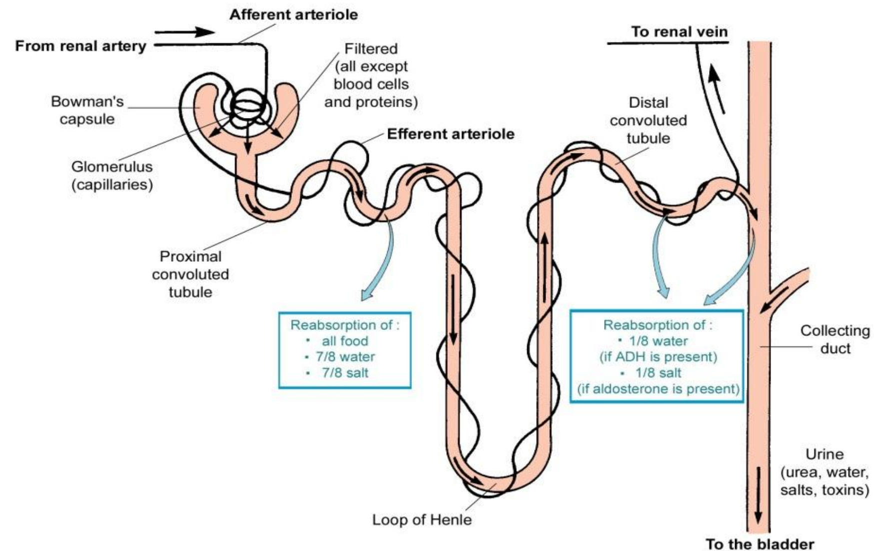
- carry out the functions of the kidneys
- are located in the cortex and medulla of the kidney.

A nephron makes urine as follows:

- **filtration**:
- blood enters the nephron in the afferent arteriole
- this forms many capillaries called the glomerulus
- high pressure in the glomerulus forces water and small molecules out of the blood
- glomerular filtrate is a dilute solution of waste and useful molecules

reabsorption takes place in the following parts of the nephron:

- **proximal tubule** = water by osmosis, useful molecules and most salts by diffusion and active transport
- **loop of Henle**
- **(i)** descending limb = water by osmosis
- **(ii)** ascending limb = salts by diffusion and then by active transport
- **distal tubule** = water by osmosis and some salts by active transport
- **collecting ducts** = water by osmosis



3.6.1 Asexual Reproduction in Plants

Asexual reproduction

- does not involve the manufacture or union of sex cells or gametes e.g. binary fission, fragmentation, spore formation and budding
- It involves only one parent and offspring are genetically identical (have the same genetic content) to the parent

Vegetative Propagation

- A form of asexual reproduction in plants
- Does not involve gametes, flowers, seeds or fruits
- Offspring are produced by a single plant (genetically identical to parent)
- Can happen **naturally** or it can be done **artificially**

Natural Vegetative Propagation

e.g. runners, tubers, plantlets, bulbs

What happens?

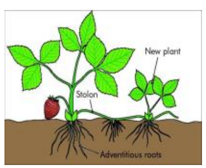
- Part of the plant becomes separated from the parent plant and divides by mitosis to grow into a new plant
- As a result the offspring are genetically identical to the parent

Parts of the parent plant may be specially modified for this purpose:

Modified Stems

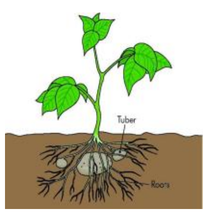
Runners

- horizontal, running over the soil surface
- terminal bud of the runner sends up new shoots
- e.g. strawberry, creeping buttercup.



Stem Tubers

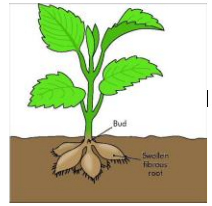
- swollen underground stem tips
- buds (eyes) produce new shoots
- e.g. potato



Modified Roots

Root Tuber

- swollen fibrous roots
- the tuber stores food, but the new plant develops from a side bud at stem
- e.g. dahlia, lesser celandine



Note:

Tap Roots e.g. carrot and turnip, are swollen roots for food storage in biennial plants… they are not reproductive organs

Modified Leaves

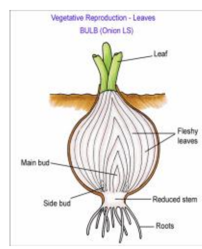
Plantlets

- Some plants produce plantlets along the edges of the leaves
- Plantlets reach a certain size, fall off and grow into new plants
- e.g. Lily, Kalanchoe Or Bryophyllum (mother of thousands)

Modified Buds

Bulbs

- A bulb contains an underground stem, reduced in size
- Leaves are swollen with stored food
- e.g. onion, daffodil, tulip
- The main bud (apical bud) will grow into a new shoot)
- The side buds (lateral buds) will also grow into new shoots



Artificial Vegetative propagation

used by gardeners to propagate plants

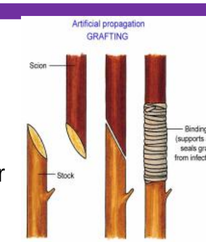
e.g. cuttings, grafting, layering, micro-propagation, etc.

Cuttings

- Parts of a plant (usually shoots) removed from plant allowed to form new roots and leaves
- rooted in water, well-watered compost, or rooting powder,
- e.g. busy lizzie, geranium

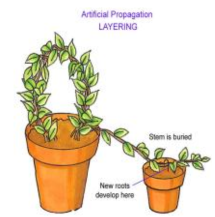
Grafting

- Part of a plant (scion) is removed and attached to a healthy, rooted part of a second plant (stock)
- Useful qualities from both plants combined into one e.g. rose flower and thorn-less stem
- e.g. apple trees



Layering

- A branch of a plant is bent over and pinned to the earth at a node
- When roots develop the branch is separated from the parent plant.
- Used to propagate woody plants
- e.g. blackberry, gooseberry.



Micropropagation (Tissue Culture)

- Cells removed from plant and grown as a tissue culture in a special medium
- Growth regulators and nutrients added so that the growing cells form a group of similar cells called a callus
- Different growth regulators are then added so that this tissue develops into a plantlet
- Plantlet can be divided up again to produce many identical plants
- Entire plant can be grown from a small piece of stem, leaf or root tissue
- Used in mass production of house plants and crops such as bananas and strawberries
- Provides a larger number of plants more quickly than cuttings.
- Can be used to check cells for a particular feature e.g. resistance to chemicals or a particular disease

Cloning

- All offspring genetically identical - produced asexually
- Clones are produced by mitosis
- All the offspring from the various methods of vegetative reproduction (both natural and artificial) mentioned are examples of clones

3.6.5 Hormonal Control of the Menstrual Cycle