(SEM) for 3D imaging, used to see organelles (e.g. internal structure of mitochondria or chloroplasts), magnification of up to x2,000,000 & resolution down to 0.2nm.

☆ HOW TO PREPARE A SLIDE:
1. Add a drop of water to a clean slide for securing the specimen.
2. Cut an onion, separate into layers & use tweezers to remove epidermal tissue from the bottom.
3. Using tweezers, place epidermal tissue on water on slide.
4. Add a drop of iodine solution as a stain (e.g. methylene blue for DNA or eosin for cytoplasm).
5. Place a cover slip over the upright next to the water, then carefully lower using a mounted needle (avoid air bubbles).

☆ Magnification is the degree to which the size of an image is increased; whereas, resolution is the degree to which an image is made clearer.

☆ OBSERVING A SPECIMEN:
1. Clip slide onto stage.
2. Select lowest-powered objective lens.
3. Use coarse adjustment knob to move stage just below objective lens.
4. Looking down eyepiece, use coarse adjustment knob to move stage downwards until in focus.
5. Adjust focus further using fine adjustment knob.
6. If you need greater magnification, swap to higher-powered objective lens.

☆ CALCULATING MAGNIFICATION:
total magnification = eyepiece lens magnification x objective lens magnification
magnification = image size / real size

➢ BIOLOGICAL MOLECULES & TRANSPORT IN CELLS:

☆ Living things produce enzymes to act as a biological catalyst for the reactions inside a human body; they reduce the need for high temperatures & only speed up useful reactions. Enzymes are large proteins, so they are made up of chains of amino acids.

☆ Catalysts are substances that increases the rate of reaction, without being changed or used up.

☆ Each enzyme has an active site with a unique shape – thus, they are specific to one reaction because the substrate must fit properly for the reaction to be catalysed.

☆ Enzymes are said to have high specificity for their substrate, as shown by the 'lock & key model'.

☆ If the enzyme's amino acid bonds break, it denatures – this changes the shape of the active site.

☆ Enzymes need the right (optimum) conditions to work best, including: temperature (if it gets too hot, the enzyme's bonds break, it denatures & the active site changes shape; however, if it's too low, not enough heat energy is convert to kinetic energy for the enzyme & substrate to collide), substrate concentration (rate of reaction increases to point until it flattens because the active sites are full & it become saturated), pH (if too high or low, the bonds between the amino acids is broken down & the enzyme is denatured) & inhibitor molecules (block the active site & change its shape).

☆ Most enzyme have an optimum temperature of 37°C (& denatures at 45°C) & pH of neutral 7.

☆ HOW TO INVESTIGATE THE EFFECT OF pH ON AMYLASE: this enzyme catalyses the breakdown of starch in maltose. Starch is detected by iodine solution (brown orange to blue-black).
1. Put a drop of iodine solution in every well of a spotting tile.
2. Using a Bunsen burner or electric water bath, heat water to amylase's optimum temperature.
3. Using a syringe, add 3cm^3 of amylase solution & 1cm^3 of buffer solution with pH 5 (measured using pH meter) into a boiling tube & place in water using test tube holder. Wait 5 minutes.
4. Using a different syringe, add 3cm^3 of starch solution.

- ☆ Neurones are specialised cells so they have adapt to function efficiently, including: cell body with nucleus, dendrites/ dendrons (carry electrical impulse towards cell body), axons (carry electrical impulse away from cell body), some are covered in myelin sheath (electrical insulator to speed up impulse) & they are very long (to prevent slowing down impulse).
- ☆ Synapses are the gaps between neurones. The nerve signal is transferred across the gap by chemicals called neurotransmitters – which set off another electrical signal in the next neurone.
- ☆ These synapses slow down transmission because the neurotransmitters must diffuse across the gap.
- ☆ Reflexes are fast automatic (without thinking) responses to prevent damage from stimuli. They are quick because they bypass your brain (only use spinal cord or unconscious part of brain).
- ☆ The passage of information from receptor to effector is known as the reflex arc.
- ☆ HOW RELFEX ARCS WORK:
  1. When receptor detects stimuli, impulse is sent from sensory neurone to relay neurone (CNS).
  2. Impulse is transmitted by neurotransmitters across synapse between sensory & relay neurone.
  3. After impulses transmits across relay, neurotransmitters diffuse to motor neurone.
  4. Impulse then travels along motor neurone to effector.
  5. Effector responds by contracting or secreting hormones.
- ☆ Brain is part of the CNS – it is made up to billions of interconnected neurones. It controls & coordinates everything you do.
- ☆ The brain is made of different regions, including: cerebrum (largest part, separated into two cerebral hemisphere – where right side controls left muscles & vice versa), cerebellum (found at the back of the brain) & the medulla oblongata (found at base of brain/ top of spinal cord).
- ☆ Each region has a different function, including: cerebrum (movement, intelligence, memory, language, & vision), cerebellum (muscle coordination & balance), & medulla oblongata (unconscious activities, e.g. breathing & heart rate).
- ☆ Investigating the function of the brain involves surgery or scanners.
- ☆ CT scanners use x-rays to show images of brain's main structure (not function). However, if the scan shows the damaged brain structure, the loss of function can be explained.
- ☆ PET scanners can show the structure & function in real time. Before the scan, the patient is injected with a tracer (radioactive chemical) – which moves around the body & collect in certain areas. More active cells absorb more tracer so unusually active or inactive areas are highlighted.
- ☆ Treating problems in the CNS is difficult & comes with its own set of problems, including: neurones do not repair themselves; some areas are not easily accessible, & treatment could lead to permanent damage (e.g. paralysis).
- ☆ If the spine become damaged in the lower part, you risk paralysis of the legs. If the neck of the spinal cord is damaged, you risk becoming a quadriplegic (arms & legs paralysed).
- ☆ The eye is sense organ.
- ☆ HOW TO LABEL THE EYE:
  1. Cornea: transparent outer layer that refract light into eye & gets oxygen by diffusion from air.
  2. Lens: refracts lights & focuses it on retina.
  3. Pupil: hole where light enters.
  4. Iris: contains muscles that control diameter to pupil, thus controlling amount of light that enters eyes.
  5. Retina: layer at back of eyes with light receptor cells.
  6. Ciliary muscle & suspensory ligament: control shape of lens.
  7. Optic nerve: sensory neurone for light receptor cells.
- ☆ Retina contains two types of photoreceptors (cones & rods). Cones are sensitive to colour (blue, green, & red), work best in bright light & is found at retina's centre. Rods are sensitive to light intensity (black & white), work best in dim light & is found at edge of retina.

3. Once made, the mRNA molecule moves out of the nucleus & joins the ribosome in the cytoplasm.

☆ After the mRNA is bound the ribosome, the protein can be assembled by translation.

☆ HOW TRANSLATION WORKS:

1. Amino acids are brought to ribosome by transfer RNA (tRNA).
2. The order the amino acids are brought to the ribosome matches the order of the base triplets on the mRNA – known as a codon.
3. The codon is complementary to the anticodon on the tRNA's structure; the pairing ensures the amino acids are brought in the right order.
4. Amino acids are joined in the ribosome to make polypeptides (proteins). Once the amino acid is deposited, the empty tRNA molecule moves away again.

☆ When there are mutations/ variants in the non-coding region, the phenotype can still be affected (even though it does not code for protein). This is because, before transcription, the RNA polymerase binds to a non-coding region. A mutation could make it easier or harder to bind to.

☆ This could affect how much mRNA is transcribed, & therefore how much protein is produced. Depending on the protein's function, the phenotype may be affected by how much is made.

➢ GENETIC DIAGRAMS & INHERITANCE:

☆ Your genes control the characteristics you develop; most characteristics are controlled by multiple genes interacting (different genes control different characteristics).

☆ All genes exist in different versions known as alleles (gametes have one allele, but somatic cells have two because there is one allele on each chromosome in a pair).

☆ You receive one allele from each parent.

☆ For characteristics controlled by one gene, if the alleles for the gene are the same, the organism is homozygous for that trait (BB or bb); if the alleles for the gene are different, the organism is heterozygous for that trait (Bb).

☆ If the allele is heterozygous, only one determines the characteristic. The characteristic shown is called the dominant allele (shown by a capital letter), & the other is called the recessive allele (shown by a lowercase letter). Hence, the dominant allele is expressed when the allele is heterozygous or homozygous, but the recessive is only shown when homozygous.

☆ Your genotype is the combination of allele (e.g. BB) that work at a molecular level to determine your characteristics – known as your phenotype (e.g. brown eyes).

☆ Monohybrid inheritance is single gene inheritance (only one gene determines your characteristic). It can be studied by monohybrid crosses (two parents bred together to look at one characteristic).

☆ Genetic diagrams are used to predict as ratios & explain outcomes of monohybrid crosses; it can be used to work out the probability of have offspring with certain characteristics.

☆ OUTCOME OF MONOHYBRID CROSSES:

homozygous + homozygous = all the same
heterozygous + heterozygous = 3:1 (dominant: recessive)
dominant homozygous + heterozygous = all the same
recessive homozygous + heterozygous = 1:1 (dominant: recessive)

☆ There are 3 main types of genetic diagrams (Punnett square, genetic diagrams & family pedigree).

☆ HOW TO CONSTRUCT A PUNNETT SQUARE:

1. Draw a grid with four squares.
2. Put possible alleles from each parent along the side & top & label gametes' alleles.
3. In each square, add genotypes.

2. Random distribution indicates it is an airborne disease.
3. Symptoms indicate an environmental cause (e.g. nutrient deficiency).

➢ FIGHTING DISEASE:

☆ The body's first line of defence is non-specific & are known as 'barriers'; they are either chemical or physical – like plant defences.

☆ HOW HUMANS DEFEND THEMSELVES CHEMICALLY:
1. Hydrochloric acid in the stomach kills pathogens.
2. Enzymes called lysozymes kill pathogens (found in tears, saliva, & lungs).

☆ HOW HUMANS DEFEND THEMSELVES PHYSICALLY:
1. Skin: acts as a barrier & uses blood clots to quickly seal cuts & keep out pathogens.
2. Mucus: (from goblet cells) is sticky & traps pathogens.
3. Hairs: (in nose & ears) also trap pathogens.
4. Cilia: (microscopic hair-like structures) moves mucus containing pathogens.

☆ The immune system kills pathogens that manage to get past the barriers. The most important part is the white blood cells – which travel through the blood stream patrolling for pathogens. They can respond in different ways.

☆ Some white blood cells engulf foreign cells & digest them – this is known as phagocytosis (non-specific response). This white blood cells are known as phagocytes. Whereas B-lymphocytes are involved in specific immune response – where they produce proteins called antibodies rapidly that bind to the antigens on pathogens. This allows any pathogen of this type to be found & attacked.

☆ When a pathogen first enters the body, the immune response is slow, since there are not many B-lymphocytes that can make the antibodies needed to bind to the new antigen. Eventually, the body produces enough antibodies to overcome the infection (at this time, the infected person shows symptoms). While producing antibodies, they also produce memory lymphocytes that 'remember' specific antigens & stay in the body for a long time.

☆ Memory lymphocytes make the person immune because their immune system is now able to respond quickly to a second infection; this is because if the same pathogen enters, more cells will recognise it, & be able to produce antibodies against it. The secondary immune response is faster & stronger, so the body gets rid of the pathogen before you show symptoms; this is shown on a graph (concentration of right antibodies in blood by time) by a steeper line.

☆ Immunisation (or artificial immunity) involves injecting weakened/dead microorganisms – this is known as a vaccine. The pathogens are antigenic, so it stimulates your white blood cells to produce antibodies specific to the vaccine. This also triggers the production of memory lymphocytes so they can rapidly mass-produce antibodies if you are exposed to the live pathogen later.

☆ If the pathogen is too potent, they would inject the antibodies instead.

☆ Immunisation has many advantages, including: controlling infectious disease, personal immunity, & herd immunity at 95% vaccinated (protects people who cannot be immunised & prevents epidemics since there are fewer people to spread it). However, it also has disadvantages, including: not working, having a bad reaction, & fear of needles.

☆ HOW TO PRODUCE MONOCLONAL ANTIBODIES:
1. Mouse is vaccinated with desired antigens on pathogens.
2. Spleen cell/ B-lymphocytes produces antibodies.
3. Antibodies are fused with myeloma/tumour cells to form hybridoma cells.
4. These are grown in labs.

gravitropism. Growth in the roots & shoots (knowns as the meristems) is controlled by the plant hormone called auxin (moves through plant in solution).

- ☆ Auxin produced in the shoot tips moves backwards to stimulate the cell elongation process in the cells just behind the tip; auxin produced in the root tips moves backwards to inhibit cell elongation in the cells behind the roots.
- ☆ HOW PLANTS RESPOND TO PHOTOTROPISM (when exposed to light):
  1. Positively phototropic response in shoots as more auxin accumulates on the shaded side. This causes the shaded cells to elongate & bend towards the light.
  2. Negatively phototropic response in the roots as more auxin accumulates on the shaded side. This inhibits cell elongation of the shaded cells so the root bends away from the light.
- ☆ Shoots that grow in the dark are tall & spindly as auxin in the tips make all sides elongate quickly – taller plants have a better chance of finding light.
- ☆ HOW PLANTS RESPOND TO GRAVITROPISM (when growing sideways):
  1. Negatively gravitropic response in the shoots as more auxin accumulates on the lower side due to gravity. This causes the lower side's cells to elongate faster & bend upwards.
  2. Positively gravitropic response in the roots as more auxin accumulates on the lower side due to gravity. This causes the lower side's cells elongation to be inhibited & bend downwards.
- ☆ In shoots, more auxin on one side means the cells grow faster & bend away from that side; in roots, more auxin on one side means the cells grow slower & bend towards from that side.
- ☆ You can investigate the effect of gravitropism of plant growth using a clinostat – which rotates to avoid the effect of gravity (unable to know which way is which). To investigate the effect of light on plant growth, you can put a petri dish of seed in a cardboard box with hole in the side for light (unilateral light source).
- ☆ Plant hormones can be extracted & used commercially in agriculture (farming) or horticulture (gardening); artificial/ synthetic versions can also be made. Auxin is used for controlling plant growth; gibberellins are used to stimulate seed germination, stem growth & flowering; & ethene is used to speed up ripening & influences growth by controlling cell division.
- ☆ While auxin & gibberellin are plant growth hormones, ethene is a ripening hormone produced by aging parts of a plant.
- ☆ HOW PLANT HORMONES ARE USED COMMERCIALLY:
  1. AUXINS as selective weed killers: weeds in crop fields are broad-leaved (unlike grass & cereal) so selective weed killer can be developed using auxin; this is done by disrupting normal growth pattern & killing them.
  2. AUXINS as rooting powder: cutting (part of another plant) normally don't grow when put in soil but adding rooting powder allows it to produce roots rapidly & grow as a new plant; this allows clones to be produced quickly.
  3. GIBBERELLINS to control flower/ fruit formation: use to make plants flower earlier or under conditions they normally wouldn't or to reduce flower formation (can improve fruit quality).
  4. GIBBERELLINS to control seed germination: makes seed germinate at any time of the year (normally need to go through certain conditions first) or all at the same time.
  5. GIBBERELLINS to produce seedless fruit: fruits with seeds in the middle normally only grow on flowering plants that have been pollinated by insects (otherwise fruits & seeds don't grow); adding gibberellins can allow unpollinated flower to grow fruit, but the seeds don't.
  6. ETHENE to speed up fruit ripening (either on plant or on transport to shops): ethene gas can be added later to unripen fruit (firmer & less easily damaged) or ripening can be delayed in storage by blocking ethene's effect or reduce amount of ethene produced with chemicals.

classified as a tissue (similar cells working together to perform a specific function of transported substances around the body).

- ☆ HOW BLOOD IS MADE UP:
  1. Red blood cells/ erythrocytes (transport oxygen around the body): in the lungs, the oxygen diffuses into the blood & combines with the haemoglobin to form oxyhaemoglobin (at the body tissues, the reverse happens, & oxygen is released).
  2. White blood cells (defend against pathogens): phagocytes change shape to engulf pathogens in phagocytosis; B lymphocytes produce antibodies against pathogens; & other lymphocytes produce antitoxins to neutralise toxins.
  3. Platelets: small fragments of cells with no nucleus that help blood clot at wound – these seals it, prevents blood loss & pathogens entering (lack of them causes excessive bleeding/ bruising).
  4. Plasma (pale straw-coloured liquid which everything is suspended in): carries red & white blood cells, platelets, nutrients, carbon dioxide, urea, hormones, proteins, & antibodies & antitoxins.
- ☆ Erythrocytes have a biconcave disc shape for increase surface area for absorbing oxygen (for respiration) & have no nucleus to increase space; they also contain the red pigment haemoglobin – which contains irons.
- ☆ When you have an infection, the white blood cells multiply to fight it off (shown by high white blood cell count on a blood test).
- ☆ Arteries are blood vessels that carry oxygenated blood away from the heart, towards organs. The walls are strong & elastic since the heart pumps the blood out at high pressure; they contain thick layers of muscle & elastic fibres for stretch & spring. The walls are thick compared to the lumen.
- ☆ Arteries branch into capillaries; capillaries are involved in the exchange of materials at the tissue by carrying the blood really close to every cell (supply food & oxygen & remove carbon dioxide). They are microscopic as they have one cell thick walls to decrease diffusion distance; these walls are permeable to allow diffusion. Their narrowness allows them to squeeze through the gaps of cells; the large surface area: volume increase rate of diffusion as well. The speed & pressure of the blood is low to allow for material exchange.
- ☆ Capillaries joins to form veins – which carry deoxygenated blood to the heart. The blood is at a much lower pressure, so the walls do not need to be thick (like arterial walls); they have a large lumen to help blood flow, despite the low pressure – & the contraction of muscles. Veins also have valves to prevent the backflow of blood.
- ☆ HOW DIFFERENT TYPES OF CIRCULATORY SYSTEM:
  1. Single (only one type of blood goes through heart, e.g. fish): deoxygenated blood from body travels to heart – which pumps it again in a single circuit; the blood goes via the gills where it picks up oxygen.
  2. Double (both types of blood go through heart, e.g. mammals): first, heart pumps deoxygenated blood to lungs to take oxygen, then the oxygenated blood returns to the heart. Second, the heart pumps the oxygenated blood around the body, then deoxygenated blood returns to heart.
- ☆ In single circulatory system, the blood pressure is low to prevent damage to gill capillaries; in double circulatory system, blood is pump at low pressure to lungs & high pressure to the rest of the body (quicker).
- ☆ Hearts in single circulatory system only have two chambers (ventricle & atrium).
- ☆ The mammalian heart has four chambers (left/ right atrium & left/ right ventricle) used to pump blood around. The major blood vessels leading to & from the chambers are the aorta, vena cava & pulmonary vein & artery. The walls are mainly made from muscle tissue – which contracts to pump blood. Like the vein, the heart has valves to prevent backflow. The heart receives its own supply of blood flow from the coronary artery that surround the heart.

$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_5H_5OH$

- ☆ This can be utilised by fermentation for alcohol production (e.g. beer).
- ☆ By measuring the amount of oxygen consumed by organisms in a given time, you can calculate their rate of respiration. You need woodlice or germinating peas, a water bath, & a respirometer – which allows you to measure the effect of temperature on rate of respiration.
- ☆ Respirometers can have two test tubes (one with living organism & one control tube of glass beads) suspended in a water bath. There is a tube connecting the tubes called a manometer – which contains coloured fluid with a calibrated scale. One test tube has a syringe to set the manometer in its bung, while the other has a closed tap.
- ☆ HOW TO INVESTIGATE EFFECT OF TEMPERATURE ON RATE OF REACTION:
  1. Take two test tubes with soda lime granules & cotton wool
  2. Add glass beads to one & woodlice to the other (same mass of each).
  3. Set up respirometer & set water bath temperature.
  4. Leave apparatus for 5 minutes to allow test tubes to reach temperature of water bath.
  5. Use the syringe to set fluid in manometer.
  6. Leave apparatus for a set period of time.
  7. During this time, the volume of air in the tube decreases as the woodlice use oxygen to respire.
  8. The decrease in volume reduce pressure in the tube, causing the fluid in the manometer to move towards the woodlice test tube (higher the rate, more it moves).
  9. Calculate rate of respiration using the volume of oxygen used.
  10. Repeat experiment at different temperature to see the effect.
- ☆ CALCULATING RATE OF RESPIRATION:
  rate of respiration (cm^3/ min) = volume of oxygen taken up / time taken
- ☆ CALCULATING OXYGEN TAKEN UP:
  oxygen taken up = distance moved by manometer fluid $\times \pi r^2$
- ☆ The soda lime/potassium hydroxide (KOH) absorbs the carbon dioxide produced from respiration. The process of respiration uses enzymes, so if the temperature is too high, they will denature.
- ☆ There are ethical issues in using live organisms, including: chance of woodlice running out of oxygen & dying, temperature getting too hot, or woodlice touching corrosive soda lime (use gauze).