IB Biology HL Essay Questions

Notes:

Unit 1: Cell Biology

1.1: Introduction to cells

1. **Discuss possible exceptions to cell theory.** *4 marks*

- skeletal muscle fibers are larger/have many nuclei/are not typical cells
- fungal hyphae are (sometimes) not divided up into individual cells
- unicellular organisms can be considered acellular
- because they are larger than a typical cell/carry out all functions of life
- some tissues/organs contain large amounts of extracellular material
- *e.g.* vitreous humor of eye/ mineral deposits in bone/ xylem in trees/other example
- statement of cell theory/all living things/most tissues are composed entirely of true cells

2. **Eukaryotic cells have intracellular and extracellular components. State the functions of one named extracellular component.** *4 marks*

name of component: 1 max

- e.g. plant cell wall/cellulose/interstitial
- matrix/basement membrane/glycoprotein/bone matrix;

functions: 3 max

EITHER

- e.g. (plant cell wall) strengthens/supports the cell/plant (against gravity);
- prevents the entry of pathogens;
- maintains the shape of plant cells;
- allows turgor pressure/high pressure to develop inside the cell;
- prevents excessive entry of water to the cell;

OR

- helps cells to stick together/adhere;
- needed to hold cells/tissues together / example of cells/tissues holding together;
- forms interstitial matrix / forms basement membrane to support single layers of cells;
- e.g. around a blood capillary;
- forms (part of the) filtration membrane in the glomerulus;

3. **Explain how the surface are to volume ratio influences cell sizes.** *3 marks*

- small cells have larger ratio (than larger cells)/ratio decreases as size increases
- surface area/membrane must be large enough to absorb nutrients/oxygen/substances needed
- surface area/membrane must be large enough to excrete/pass out waste products
- need for materials is determined by (cell) volume
- cell size is limited (by SA/Volume ratio)/cells divide when they reach a certain size
- reference to diffusion across/through membrane/surface area

4. **Outline differentiation of cells in a multicellular organism.** *4 marks*

- differentiation is development in different/specific ways
- cells carry out specialized functions/become specialized

- example of a differentiated cell in a multicellular organism
- cells have all genes/could develop in any way
- some genes are switched on/expressed but not others
- position/hormones/cell-to-cell signals/chemicals determine how a cell develops
- a group of differentiated cells is a tissue

5. **Describe the importance of stem cells in differentiation.** *3 marks*

- stem cells are undifferentiated cells;
- embryo cells are stem cells;
- stem cells can differentiate in many/all ways / are pluripotent/totipotent;
- differentiation involves expressing some genes but not others;
- stem cells can be used to repair/replace tissues/heal wounds;

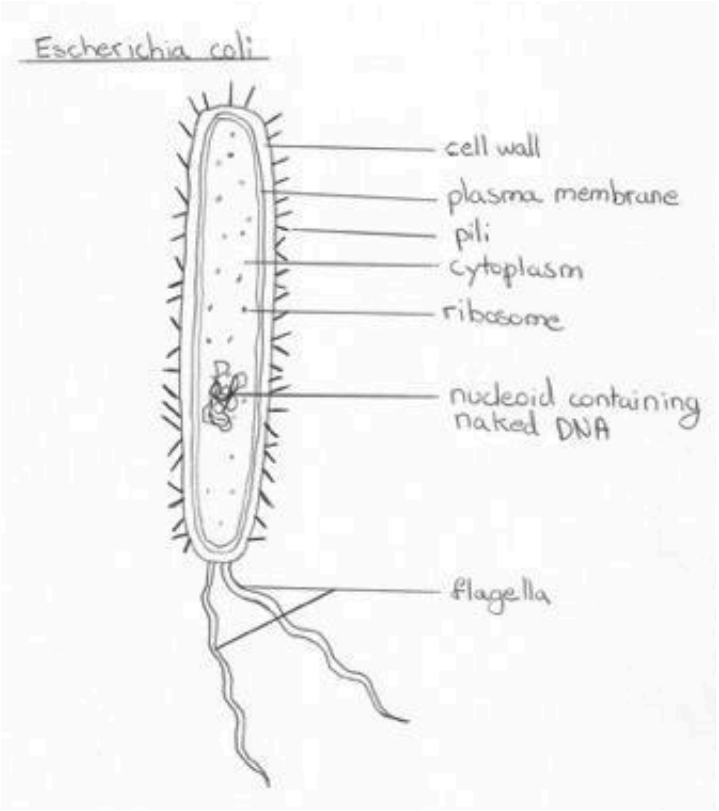
1.2: Ultrastructure of Cells

6. **Draw a labeled diagram to show the ultrastructure of Escherichia coli.** *6 marks*

Award 1 for each structure clearly drawn and correctly labeled.

- cell wall – with some thickness;
- plasma membrane – shown as single line or very thin;
- cytoplasm;
- pilus/pili – shown as single lines;
- flagellum/flagella – shown as thicker and longer structures than pili and embedded in cell wall;
- 70S ribosomes;
- nucleoid / naked DNA;
- approximate width 0.5 μm / approximate length 2.0 μm;

Award 4 max if the bacterium drawn does not have the shape of a bacillum (rounded-corner rectangle with length approximately twice its width). Award 4 max if any eukaryotic structures included.



7. **Draw a labelled diagram to show the organelles which are found in the cytoplasm of plant cells.** *6 marks*

- rough endoplasmic reticulum
- free ribosomes
- Golgi apparatus
- mitochondrion
- chloroplast
- vacuole
- nucleus
- lysosome
- smooth endoplasmic reticulum

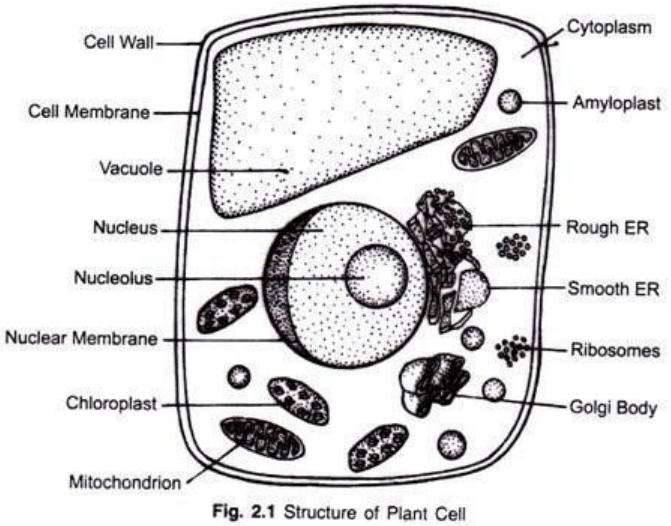


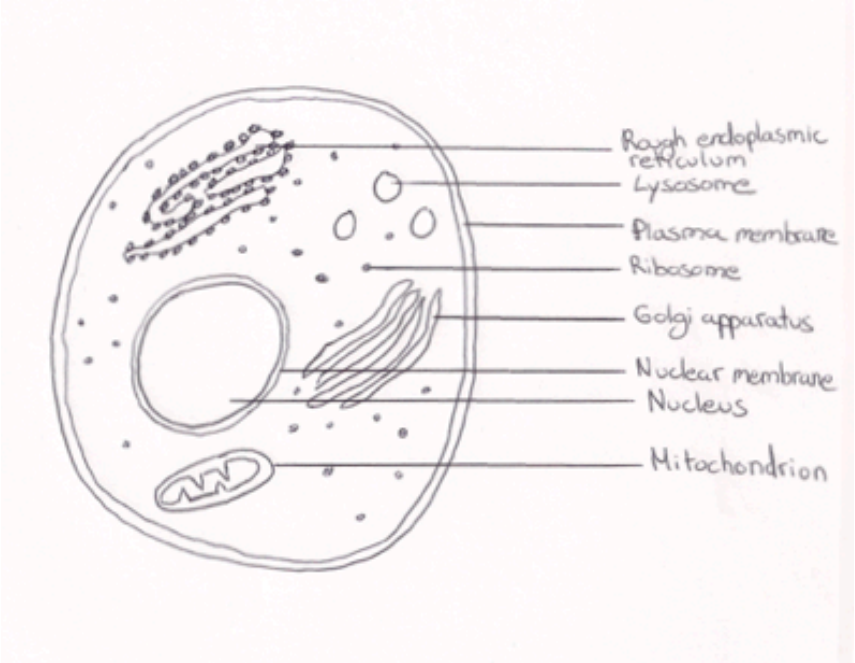
Fig. 2.1 Structure of Plant Cell

8. **Draw a labelled diagram showing the ultra-structure of a liver cell.** *4 marks*

Award 1 for each structure clearly drawn and correctly labelled. Whole cells not necessary.

- (plasma) membrane – single line surrounding cytoplasm;
- nucleus – with a double membrane and pore(s) shown;
- mitochondria(ion) – with a double membrane, the inner one folded into internal
- projections, shown no larger than half the nucleus;
- rough endoplasmic reticulum – multi-folded membrane with dots/small circles on surface;
- Golgi apparatus – shown as a series of enclosed sacs with evidence of vesicle formation;
- ribosomes – dots/small circles in cytoplasm/ribosomes on rER;
- lysosome;

Award 0 if plant cell is drawn. Award 2 max if any plant cell structure (e.g. cell wall) is present.



9. **State one function of each of the following organelles: lysosome, Golgi apparatus, rough endoplasmic reticulum, nucleus, mitochondrion.** *5 marks*

- *lysosome*: hydrolysis/digestion/break down of materials (macromolecules)
- *Golgi apparatus*: synthesis/sorting/transporting/secretion of cell products
- *rough endoplasmic reticulum*: site of synthesis of proteins (to be secreted)/ intracellular transport of polypeptides to Golgi apparatus
- *nucleus*: controls cells activities/mitosis/replication of DNA/transcription of DNA (to RNA)/directs protein synthesis
- *mitochondrion*: (aerobic) respiration/generates ATP

10. **Distinguish between the structure of plant and animal cells.** *6 marks*

Award 1 mark per difference

plant cells

- have cell walls, animals do not
- have plastids/ chloroplasts, animals do not
- have a large central vacuole, animals do not
- store starch, animal cells store glycogen
- have plasmodesmata, animal cells do not
- fixed shape / more regular shape

animal cells

- have centrioles, plant cells do not
- have cholesterol in the cell membrane, plant cells do not
- more rounded

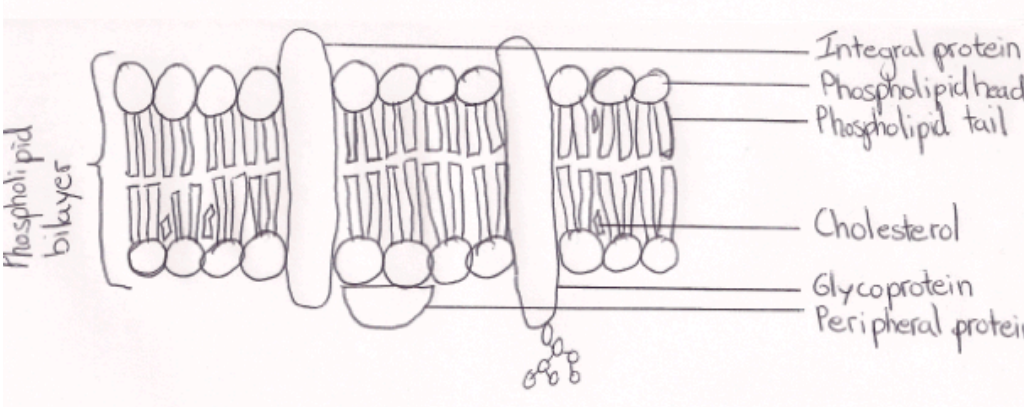
11. **Using a table, compare the structures of prokaryotic and eukaryotic cells.** *5 marks*

Prokaryotic Cells	**Eukaryotic Cells**
Naked/loop of DNA	DNA associated with protein/histones/nucleosomes/DNA in chromosomes
DNA located in cytoplasm/nucleoid/no nucleus	DNA located within a nucleus/nuclear membrane
Membrane bound organelles absent	Membrane bound organelles present
70S Ribosomes	80S Ribosomes
Same plasma membrane structure as Eukaryotic cells	Same plasma membrane structure as Prokaryotic cells
Cell wall is composed of peptidoglycan/not composed of cellulose/not composed of chitin	Cell wall is composed of cellulose/chitin/not composed of peptidoglycan
Mitochondria absent	Mitochondria present
Pili present	Pili absent
Plasmids (sometimes) present	Plasmids absent
Flagella solid	Flagella flexible/membrane-bound

1.3: Membrane Structure

12. **Draw a diagram to show the structure of a cell membrane** *5 marks*

- phospholipids labelled with hydrophillic (heads) and hydrophobic (tails)
- phospholipid bilayer clearly shown and labelled
- proteins shown in the bilayer and labelled
- transmembrane and peripheral/extrinsic proteins shown and labelled
- glycoproteins shown and labelled
- cholesterol shown and labelled
- glycolipids shown and labelled
- thickness shown as 10 nm/ + or - 2 nm



13. **Explain how the structure and properties of phospholipids help to maintain the structure of cell membranes.** *9 marks*

phospholipid structure

- hydrophobic tail/hydrophilic head
- head made from glycerol and phosphate
- tail made from two fatty acids
- saturated/ unsaturated fatty acid (in tail)

arrangement in membrane

- phospholipids form a bilayer
- heads face outside the membrane/ tails face inside the membrane/ hydrophic interior/ hydrophilic exterior of membrane
- phospholipids held together by hydrophobic interactions
- phospholipid layers are stabilized by interaction of hydrophilic heads and surrounding water
- phospholipids allow for membrane fluidity/ flexibility
- fluidity/ flexibility helps membranes to be (functionally) stable
- phospholipids with short fatty acids/ unsaturated fatty acids are more fluid
- fluidity is important in breaking and remaking membranes (e.g. endocytosis/ exocytosis)
- phospholipids can move about/ move horizontally/ "flip flop" to increase fluidity

1.4: Membrane Transport

14. **Explain the role of vesicles in transportation of materials within cells.** *8 marks*

- vesicles are membrane bound packages/droplets
- formed by pinching off/budding off a piece from a membrane
- can carry proteins
- rough ER synthesizes proteins
- proteins enter/accumulate inside the ER
- transported to Golgi apparatus for processing
- targeted to/transported to specific cellular organelles
- fuse with membrane of organelle so contents of vesicle join the organelle
- transported to the plasma membrane
- fuses with plasma membrane releases/secretes contents
- exocytosis

15. **Distinguish between active and passive movements of materials across plasma membranes, using named examples.** *4 marks*

- passive: oxygen across alveoli / other example, *whereas*, active transport: glucose absorption in ileum / other example;
- passive: diffusion / osmosis / facilitated diffusion, *whereas*, active transport: ion pumps / exocytosis / pinocytosis / phagocytosis
- a second passive method (from above), *whereas*, active transport: a second active method; (from above)
- passive: does not require energy, *whereas*, active transport: requires energy/ATP;
- passive: down concentration gradient, *whereas*, active transport: against concentration gradient;
- passive: no pumps needed, *whereas*, active transport: requires protein pumps;

16. **Outline, with an example, the process of exocytosis.** *5 marks*

- vesicles carry material to plasma membrane;
- vesicle fuses with membrane;
- (by joining of) phospholipid bilayers;
- aided by the fluidity of the membrane;
- material released/expelled from the cell;
- membrane flattens;
- name of example e.g. exocytosis of neurotransmitter / exocrine secretion/endocrine secretion / hormone secretion / release of cortical granules;
- outline of example: (in the presence of calcium), neurotransmitter vesicles release their contents into the synapse / hormones released from one cell have an effect on another cell etc.;

1.6: Cell Division

17. **Outline the processes that occur in a cell during interphase, including those needed to prepare for mitosis.** *4 marks*

- DNA replication
- DNA transcription
- enzyme/ protein synthesis
- biochemical reactions/ example of a biochemical reaction
- cell respiration
- growth
- organelles replicated

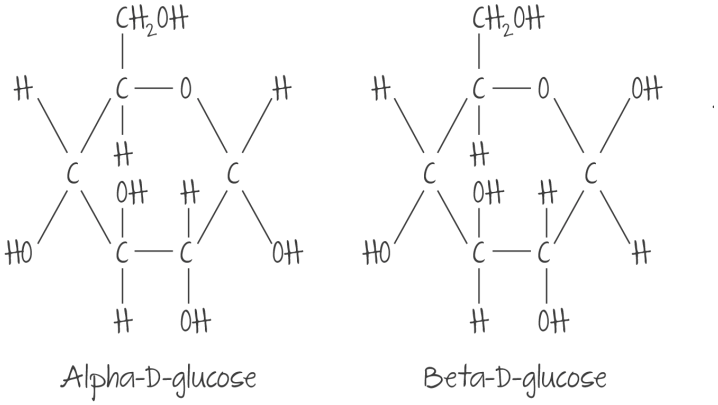
Unit 2: Molecular Biology

2.1: Molecules to Metabolism

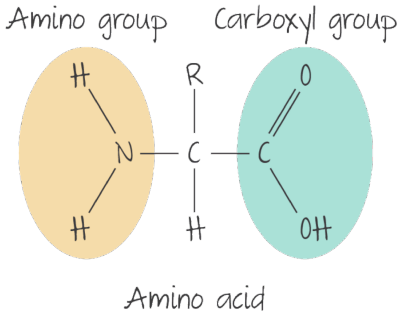
1. **Outline the role of condensation and hydrolysis in the relationship between amino acids and dipeptides.** *4 marks*

   - diagram of peptide bond drawn
   - condensation / dehydration synthesis: water produced (when two amino acids joined)
   - hydrolysis: water needed to break bond
   - dipeptide --> amino acids - hydrolysis occurs
   - amino acids --> dipeptide - condensation occurs

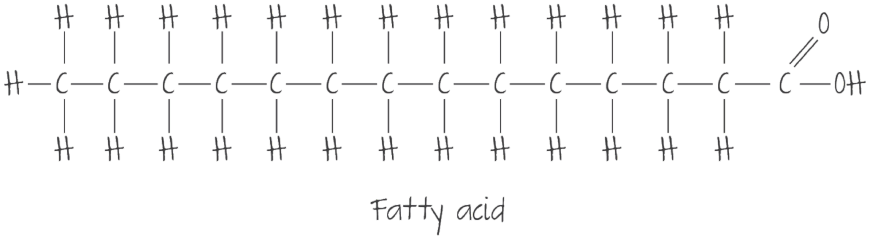
2. **Draw a molecule of α-d-glucose and ß-d-glucose.** *2 marks*



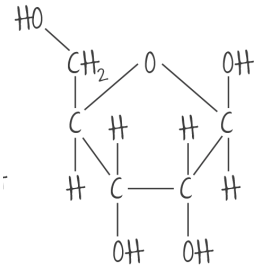
3. **Draw an amino acid.** *1 mark*



4. **Draw a fatty acid.** *1 mark*



5. **Draw a molecule of ribose.** *1 mark.*



Ribose

2.2: Water

6. Outline the thermal, cohesive and solvent properties of water. *5 marks*

- water has a high specific heat capacity;
- a large amount of heat causes a small increase in temperature;
- water has a high latent heat of vaporization;
- a large amount of heat energy is needed to vaporize/evaporate water;
- hydrogen bonds between water molecules make them cohesive/stick together;
- this gives water a high surface tension / explains how water rises up xylem;
- water molecules are polar;
- this makes water a good solvent;

Award 4 max if thermal, cohesive and solvent properties are not all mentioned.

7. **Describe the significance of water to living organisms.** *5 marks*

Each feature or property must be related to living organisms in order to receive a mark. Features may include:

- surface tension - allows some organisms (e.g. insects) to move on water's surface
- polarity / capillarity / adhesion - helps plants transport water
- (excellent) solvent - capable of dissolving substances for transport in organisms
- (excellent) thermal properties (high heat of vaporization) - excellent coolant
- ice floats - lakes / oceans do not freeze, allowing life under the ice
- buoyancy - supports organisms
- structure - turgor in plant cells / hydrostatic pressure
- habitat - place for aquatic organisms to live

2.3: Carbohydrates and lipids

8. **Describe the use of carbohydrates and lipids for energy storage in animals.** *5 marks*

Answers must discuss both carbohydrates and lipids to receive full marks

carbohydrates: 3 max

- stored as glycogen (in liver)
- short-term energy storage
- more easily digested than lipids so energy can be released more quickly
- more soluble in water for easier transport

lipids: 3 max

- stored as fat in animals
- long-term energy storage
- more energy per gram than carbohydrates
- lipids are insoluble in water so less osmotic effect

9. **List three functions of lipids.** *3 marks*

- energy storage / source of energy / respiration substrate
- (heat) insulation
- protection (of internal organs)
- water proofing / cuticle
- buoyancy
- (structural) component of cell membranes
- electrical insulation by myelin sheath
- (steroid) hormones
- glycolipids acting as receptors

2.4: Proteins

10. **List four functions of proteins, giving an example of each.** *4 marks*

name of function and named protein must both be correct for the mark

- storage - zeatin (in corn seeds)/casein (in milk)
- transport - hemoglobin/lipoproteins (in blood)
- hormones - insulin/growth hormone/TSH/FSH/LH
- receptors - hormone receptor/neurotransmitter receptor/receptor in chemoreceptor cell
- movement - actin/myosin
- defense - antibodies/immunoglobin
- enzymes - catalase/RuBP carboxylase
- structure - collagen/keratin/tubulin/fibroin
- electron carriers - cytochromes
- pigments - rhodopsin
- active transport - sodium potassium pumps/calcium pumps
- facilitated diffusion - sodium channels/aquaporins

11. **Describe the structure of proteins.** *9 marks*

- (primary structure is a) chain of amino acids/sequence of amino acids
- (each position is occupied by one of) 20 different amino acids
- linked by peptide bonds
- secondary structure formed by interaction between amino and carboxyl/-NH and -C=O groups
- (weak) hydrogen bonds are formed
- (α-) helix formed / polypeptide coils up
- or (ß-) pleated sheet formed
- tertiary structure is the folding up of the polypeptide
- stabilized by disulfide bridges / hydrogen / ionic / hydrophobic bond
- quaternary structure is where several polypeptide subunits join
- conjugated proteins are proteins which combine with other non-protein molecules
- for example metals / nucleic acids / carbohydrates / lipids

2.5: Enzymes

12. **Lactase is widely used in food processing. Explain three reasons for converting lactose to glucose and galactose during food processing.** *3 marks*

- it allows people who are lactose intolerant/have difficulty digesting lactose to consume milk (products);
- galactose and glucose taste sweeter than lactose reducing need for additional sweetener (in flavored milk products);
- galactose and glucose are more soluble than lactose / gives smoother texture / reduces crystallization in ice cream;
- (bacteria) ferment glucose and galactose more rapidly (than lactose) shortening production time (of yoghurt/cottage cheese);

13. **Simple laboratory experiments show that when the enzyme lactase is mixed with lactose, the initial rate of reaction is highest at 48 °C. In food processing, lactase is used at a much lower temperature, often at 5 °C. Suggest reasons for using lactase at relatively low temperatures.** *2 marks*

- less denaturation / enzymes last longer at lower temperatures;
- lower energy costs / less energy to achieve 5 °C compared to 48 °C;
- reduces bacterial growth / reduces (milk) spoilage;
- to form products more slowly / to control the rate of reaction;

14. **Outline how enzymes catalyze reactions.** *4 marks*

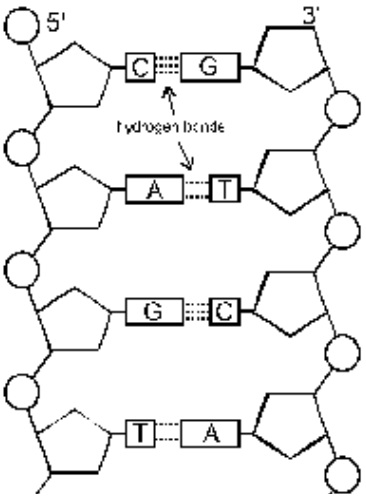
- they increase rate of (chemical) reaction;
- remains unused/unchanged at the end of the reaction;
- substrate joins with enzyme at active site;
- to form enzyme-substrate complex;
- active site/enzyme (usually) specific for a particular substrate;
- enzyme binding with substrate brings reactants closer together to facilitate chemical reactions (such as electron transfer);
- making the substrate more reactive;

15. **Explain the effect of pH on enzyme activity.** *3 marks*

- enzymes have an optimal pH
- lower activity above and below optimum pH / graph showing this
- too acidic / base pH can denature enzyme
- change shape of active site / tertiary structure altered
- substrate cannot bind to active site / enzyme-substrate complex cannot form
- hydrogen / ionic bonds in the enzyme / active site are broken / altered

2.6: Structure of DNA and RNA

18. **Draw a labelled diagram to show four DNA nucleotides, each with a different base, linked together in two strands.** *5 marks*



Award 1 for each of these structures clearly drawn and labelled.

- four nucleotides shown in diagram with one nucleotide clearly labelled;
- base, phosphate and deoxyribose (shown as pentagon) connected between the
- correct carbons and labelled at least once;

- backbone labelled as covalent bond between nucleotides correctly shown as 3 to 5 bond;
- two base pairs linked by hydrogen bonds drawn as dotted lines and labelled;
- two H bonds between A and T and three H bonds between C and G;
- adenine to thymine and cytosine to guanine; do not accept initials of bases
- antiparallel orientation shown;

19. **Explain the structure of the DNA double helix, including its subunits and the way in which they are bonded together.** *8 marks*

- subunits are nucleotides
- one base, one deoxyribose and one phosphate in each nucleotide
- description/ diagram showing base linked to deoxyribose C1 and phosphate to C5
- four different bases - adenine, cytosine, guanine and thymine
- nucleotides linked up with sugar-phosphate bonds
- covalent/ phosphodiester bonds
- two strands (of nucleotides) linked together
- base to base
- A to T and G to C
- hydrogen bonds between bases
- antiparallel strands
- double helix drawn or described

20. **Describe the genetic code.** *6 marks*

- composed of mRNA base triplets
- called codons
- 64 different codons
- each codes for the addition of an amino acid to a growing polypeptide chain
- the genetic code is degenerate
- meaning more than one codon can code for a particular amino acid
- the genetic code is universal
- meaning it is the same in almost all organisms
- (AUG is the) start codon
- some (nonsense) codons code for the end of translation

21. **Explain briefly the advantages and disadvantages of the universality of the genetic code to humans.** *4 marks*

- genetic material can be transferred between species/ between humans
- one species could use a useful gene from another species
- transgenic crop plants/ livestock can be produced
- bacteria/ yeasts can be genetically engineered to make a useful product
- viruses can invade cells and take over their genetic apparatus
- viruses cause disease

22. **Distinguish between RNA and DNA.** *3 marks*

- DNA is double-stranded while RNA is single-stranded;
- DNA contains deoxyribose while RNA contains ribose;
- the base thymine found in DNA is replaced by uracil in RNA;
- one form of DNA (double helix) but several forms of RNA (tRNA, mRNA and rRNA);

23. **Describe the roles of mRNA, tRNA and ribosomes in translation.** *6 marks*

- mRNA with genetic code/ codons
- tRNA with anticodon
- tRNA with amino acid attached
- ribosome with two sub-units
- mRNA held by ribosome
- start codon

- two tRNA molecules attached with mRNA on ribosome
- peptide bond between amino acids on tRNA
- polypeptide forms
- continues until a stop codon is reached
- polypeptide is released

2.8: Cell Respiration

24. **Explain the similarities and differences in anaerobic and aerobic cellular respiration.** *8 marks*

Answers must include both similarities and differences to receive full marks.

- aerobic requires oxygen and anaerobic does not utilize oxygen

similarities: 3 max

- both can start with glucose
- both use glycolysis
- both produce ATP/energy(heat)
- both produce pyruvate
- carbon dioxide is produced
- (both start with glycolosis) aerobic leads to Krebs' cycle and anaerobic leads to fermentation

differences: 5 max

anaerobic:

- (fermentation) produces lactic acid in humans
- (fermentation) produces ethanol and CO2 in yeast
- occurs in cytoplasm of the cell
- recycles NADH (NAD+)

aerobic cellular respiration

- pyruvate transported to mitochondria
- further oxidized to CO2 and water (in Krebs cycle)
- produces a larger amount of ATP (36-38 ATP)/anaerobic produces less ATP (2)
- can use other compounds / lipids / amino acids for energy

25. **Compare how pyruvate is used in human cells when oxygen is available and when oxygen is not available.** *5 marks*

- aerobic cell respiration if oxygen available and anaerobic if unavailable;
- pyruvate enters mitochondrion for aerobic respiration;
- whereas pyruvate stays in the cytoplasm for processing under anaerobic conditions;
- pyruvate converted aerobically into carbon dioxide and water;
- whereas pyruvate converted anaerobically to lactate;
- large ATP yield when oxygen available/from aerobic cell respiration;
- no (further) ATP yield without oxygen;

2.9: Photosynthesis

26. **Outline the effect of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis.** *6 marks*

light:

- rate of photosynthesis increases as light intensity increases
- photosynthetic rate reaches plateau at high light levels

CO2:

- photosynthetic rate reaches plateau at high carbon dioxide levels
- up to a maximum when rate levels off

temperature:

- rate of photosynthesis increases with increase in temperature
- up to optimal level / maximum
- high temperatures reduce the rate of photosynthesis

*Some of the above points may be achieved by means of **annotated** diagrams or graphs.*

27. **Explain how the rate of photosynthesis can be measured.** *7 marks*

- CO2 + H2O --> (CH2O)n + O2/ suitable photosynthesis equation
- amount of CO2 absorbed (per unit time) can be measured
- increase in biomass (per unit time) can be measured
- O2 excretion (per unit time) can be measured

methods for measuring the above:

- volume of O2 (bubbles) produced per unit time can be measured
- dry mass can be measured
- increase in starch concentration in leaves (as measured by iodine)
- use of pH indicator can monitor CO2 uptake in water

- the rate of photosynthesis measured is relative because some of the CO2 is produced by the plant internally through respiration
- the rate of photosynthesis measured is relative because some of the carbohydrates are used internally by the plan for respiration

28. **Explain the role of water in photosynthesis.** *4 marks*

- water is a substrate / reactant / raw material / for photosynthesis / equation for photosynthesis
- water is a source of electrons
- to replace those lost by chlorophyll / photosystem II
- water is a source of H+ needed to produce NADPH + H
- photolysis / splitting / breaking of water
- water for non-cyclic photophosphorylation / ATP production
- water is transparent so photosynthesis can take place underwater / light can penetrate to chloroplasts

Unit 3: Genetics

3.1: Genes

1. **Define the terms *gene* and *allele* and explain how they differ.** *4 marks*

- gene is a heritable factor / unit of inheritance
- gene is composed of DNA
- gene controls a specific characteristic / codes for a polypeptide / protein
- allele is a form of a gene
- alleles of a gene occupy the same gene locus / same position on chromosome
- alleles differ (from each other) by one / a small number of bases(s)/ base pair(s)

2. **Describe the consequences of a base substitution mutation with regards to sickle cell anemia.** *7 marks*

- the sequence of nucleotide bases in DNA codes for the sequence of amino acids in proteins
- DNA is transcribed into mRNA, which is translated into amino acids of protein
- normal (ß chain) hemoglobin gene / DNA produces normal (ß chain) hemoglobin protein / amino acids
- substitution= the replacement of one (or more) nucleotide base with another
- caused by a copying mistake during DNA replication
- as a result of a mutagen / X-rays / chemical / UV radiation / other mutagen
- mutation in normal (ß chain) hemoglobin gene alters the sequence of nucleotide bases
- normal nucleotide sequence = CTC altered to CAC
- resulting in altered mRNA (GAG to GUG) during transcription
- resulting in altered sequence of amino acids in (ß chain) hemoglobin protein (glutamic acid to valine) during translation
- causing red blood cells to change shape / sickle under low oxygen conditions
- causing sickle cells anemia when two copies of the mutated gene are inherited
- producing a sickle cell carrier when one copy of the mutated gene is inherited
- sickle cells anemia reduces oxygen flow to organs, leading to their deterioration

3.2: Chromosomes

3. **Karyograms involve arranging the chromosomes of an individual into pairs. Describe one application of this process, including the way in which the chromosomes are obtained**. *5 marks*

application of karyogram {2 max}

- find gender / test for Down's syndrome / other chromosome abnormality
- identify sex chromosomes / numbers of chromosome 21 / other chromosomes counted
- XX = female and XY = male / third chromosome 21 indicates Down's syndrome / other chromosome abnormality (e.g. Klinefelter's syndrome)

obtaining chromosomes {3 max}

- fetal cells obtained from amniotic fluid / amniocentesis / other named source
- white blood cells obtained
- cells encouraged to divide
- cells accumulated / blocked in metaphase
- prepare slide / chromosomes examined

3.3: Meiosis

4. Compare the processes of mitosis and meiosis. *6 marks*

answers must be pair-wise comparisons to receive any marks.

- Mitosis: one cell division & Meiosis: two divisions / reduction division
- Mitosis: chromosome number does not change & Meiosis: converts diploid to haploid cells
- Mitosis: products genetically identical & Meiosis: products genetically diverse
- Mitosis: separation of sister chromatids in anaphase & Meiosis: separation of homologous chromosomes in anaphase I and sister chromatids in anaphase II
- Mitosis: no crossing over & Meiosis: crossing over in prophase I
- Mitosis: no formation of tetrads / no synapsis & Meiosis: formation of tetrads / synapsis
- Mitosis: produce cells for growth/repair/asexual reproduction & Meiosis: produce sexual cells / gametes for sexual reproduction
- Mitosis: two cells produced & Meiosis: four cells produced
- Mitosis: daughter cells with both copies of chromosomes/random assortment does not occur & Meiosis: random assortment of maternal/ paternal chromosomes
- Mitosis: replication of DNA in interphase & Meiosis: replication of DNA in interphase I
- Mitosis: four phases: prophase, metaphase, anaphase, telophase & Meiosis: same four phases twice

3.4: Inheritance

5. **Outline one example of inheritance involving multiple alleles.** *5 marks*

- multiple alleles means a gene has three or more alleles / more than two alleles
- ABO blood groups / other named example of multiple alleles
- ABO gene has three alleles / equivalent for other example
- IA IB and i shown (at some point in the answer) / equivalent for other example

accept other notation for alleles if clear

- any two of these alleles are present in an individual
- homozygous and heterozygous genotype with phenotypes (shown somewhere)
- all six genotypes with phenotypes given (shown somewhere)
- example / diagram of a cross involving all three alleles

6. **Describe the inheritance of ABO blood groups including an example of the possible outcomes of a homozygous blood group A mother having a child with a blood group O father.** *5 marks*

- example of co-dominance
- multiple alleles / 3 alleles
- (phenotype) O has (genotype) ii
- B can be IB IB or IB i
- A can be IA IA or IA i
- AB is IA IB
- (P are) i i x IA IA
- (gametes) i and IA
- (F1 genotype) IA i
- (F1 phenotype) blood group A

accept other notations if used consistently and if phenotype and genotype are clearly distinguished

7. **Outline sex linkage.** *5 marks*

- gene carried on sex chromosome / X chromosome / Y chromosome
- inheritance different in males than in females
- males have only one X chromosome therefore, only one copy of the gene
- mutation on Y chromosome can only be inherited by males
- women can be carriers if only one X chromosome affected
- example of sex linked characteristics (e.g. hemophilia / color blindness)
- example of cross involving linkage

8. **Explain, using a named example, why many sex-linked diseases occur more frequently in men than women.** *9 marks*

- named example of sex-linked disease
- caused by recessive allele
- on the X chromosome
- example of pair of alleles (e.g. X H and X h) *(reject if alleles do not correspond)*
- females are XX and males are XY
- females have two alleles of the gene and males have only one
- allele causing the disease is rare / uncommon
- probability of females inheriting rare allele twice as low
- calculation of squaring the gene frequency
- female would have to inherit the allele from her father
- who would have suffered from the disease
- so females can carry the gene but still be normal
- but males (with the gene) will have the disease

Unit 4: Ecology

4.1: Species, Communities and ecosystems

Discuss the definition of the term species. *(8 max)*

- a species is a group of organisms
- a species shares a common gene pool
- showing similar morphology / characteristics
- capable of interbreeding
- and producing fertile offspring
- but dissimilar organisms sometimes interbreed
- mule formed by crossing horse and donkey / other example of interspecific hybridization
- interspecific hybrids are sometimes fertile
- sometimes organisms that are very similar will not interbreed
- *Drosophila pseudoobscura* and *persimilis* / other example of sibling species
- reference to the problem of defining fossil species
- reference to the problem of species that only reproduce asexually
- reference to the problem of isolated populations gradually diverging

Compare the ways in which autotrophic, heterotrophic and saprotrophic organisms obtain energy. *(6 max)*

- autotrophs use an external / non-organic energy source

(reject statements suggestion that energy is made)

- (some) autotrophs use light / (some) autotrophs use photosynthesis

- (some) autotrophs use inorganic chemical reactions / (some) autotrophs use chemosynthesis
- heterotrophs obtain energy from other organisms
- heterotrophs (usually) ingest food / consume food
- saprotrophs obtain energy from non-living matter / dead organisms
- saprotrophs are heterotrophs that obtain organic nutrients from dead organisms by external digestion.
- detrivores are heterotrophs that obtain organic nutrients from detritus by internal digestion

4.2: Energy Flow

Explain the shape of the pyramids of energy that are constructed by ecologists to represent energy flow in an ecosystem *(4 max)*

- energy flows up from one trophic level to the next (in a community)
- energy is lost at each stage by waste products/feces/incomplete consumption of organism
- most of the energy is lost through respiration/heat
- each level on the pyramid is about 10%-20% of the one below it/80%-90% of energy lost between levels.

Explain how the flow of energy in the food web differs from the movement of nutrients *(2 max)*

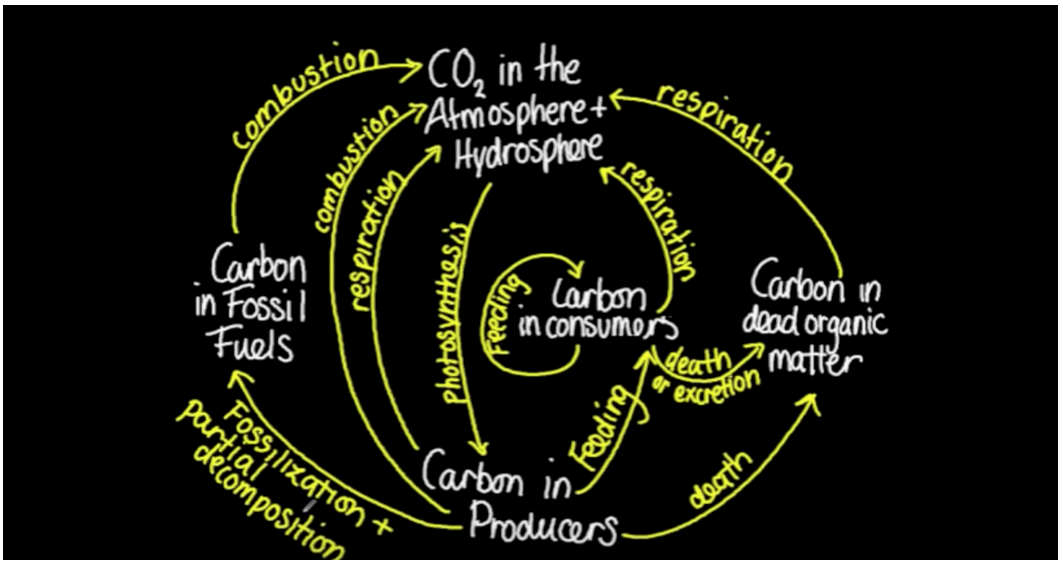
- nutrients are recycled in a food web by saprotrophs;
- whereas energy is dispersed/radiated as heat

4.3: Carbon Cycling

State what carbon fluxes and carbon sinks are and describe how carbon fluxes are measured *(4 max)*

- a carbon flux is the rate of exchange of carbon between the various carbon sinks;
- a carbon sink is a forest, ocean or other natural environment viewed in terms of its ability to absorb carbon dioxide from the atmosphere;
- example of a carbon sink (lithosphere, hydrosphere, atmosphere, biosphere)
- not possible to directly measure the size of carbon sinks and fluxes;
- due to constant changes;
- global carbon fluxes are very large and estimated in gigatonnes per year;

Draw a model of the carbon cycle *(6 max)*



4.4: Greenhouse effect

Describe the greenhouse effect *(5 max)*

- greenhouse effect is the earth's ability to use its atmosphere to retain heat and keep warm even when no sun is hitting the surface;
- short wave radiation emitted by the sun;
- pass through greenhouse gases;
- long wave radiation emitted by earth;
- absorbed by greenhouse gases and reflected back to
- most significant greenhouse gases are carbon dioxide and water vapor;
- methane not significant because of low concentration;

Distinguish between greenhouse effect and enhanced greenhouse effect *(2 max)*

- greenhouse effect is earth's natural ability to retain heat;
- enhanced greenhouse effect is impact on climate from additional heat retained;
- due to increased amounts of greenhouse gases that humans have released.
- enhanced greenhouse effect leads to global warming, greenhouse effect does not.

Unit 5: Evolution and Biodiversity

5.1: Evidence for evolution

Explain how the process of evolution occurs *(8 max)*

- evolution is the cumulative change in the allele frequency of a population over a period of time;
- a population has variations in individuals due to sexual reproduction / meiosis and mutations.
- certain variations give an advantage to some organisms over others in certain environments
- populations/species produce more offspring than the environment can support;
- individuals of the species compete for the same resources;
- the better-adapted organisms tend to survive and reproduce / less adapted organisms tend to die or reproduce fewer offspring
- individuals **that reproduce** pass on their **heritable** characteristics/alleles/genes to their offspring
- natural selection increases the frequency of «heritable» characteristics/alleles/ genes of the better-adapted organisms.
- specific example such as bacterial resistance / peppered moth described;

Discuss the incompleteness of the fossil record and the resulting uncertainties about human evolution. *4 marks*

- few fossils have been found;
- most organisms decompose
- only teeth and bones remain
- require certain conditions for preservation
- earlier cultures did not bury the dead
- acids dissolve teeth/bones
- there are many missing links (fossils of intermediate stages)
- it is difficult to get conclusive evidence / difficult to falsify theories
- theories change radically with one/few discoveries

Outline the evidence for evolution provided by homologous structures. *6 marks*

- homologous structures are those that are similar in shape in different types of organisms;
- structural similarities imply a common ancestry / similar embryonic origin
- homologues structures are used in different ways;
- illustrate adaptive radiation since the same basic structure is adapted to different niches
- certain homologues structures in some species with no apparent function;
- human appendix (homologues with functional appendix in herbivores)
- example of homologues structure is pentadactyl limb in vertebrates (bat's wing and human hand)

4.2: Natural Selection

Explain the evolution of antibiotic resistance in bacteria *(6 max)*

- antibiotics (are chemicals) used to treat bacterial diseases;
- within populations, bacteria vary in their (genetic) resistance to antibiotics/fitness;
- resistance arises by (random) gene mutation;
- when antibiotics are used antibiotic-sensitive bacteria are killed
- (natural) selection favors those with resistance;
- resistant bacteria survive, reproduce and spread the gene / increase allele frequency of resistant bacteria;
- the more an antibiotic is used, the more bacterial resistance/the larger the population of antibiotic-resistant bacteria;
- genes can be transferred to other bacteria by plasmids;
- doctors/vets use different antibiotics but resistance develops to these as well;
- multiple-antibiotic resistant bacteria evolve/it becomes difficult to treat some infections;

Antibiotic resistance in bacteria is an example of evolution in response to environmental change. Using another example, explain how an environmental change can lead to evolution. *8 marks*

- natural selection (in correct context);
- better-adapted individuals survive/more likely to survive;
- more reproduction/genes passed on by better adapted individuals;
- example is peppered moths; (accept even if remainder of answer is invalid)
- dominant peppered phenotype decreased during the industrial revolution;
- due to increased soot production that made the trees black in color;
- thus peppered moths with the peppered phenotype could not camouflage on trees;
- were hunted as a result;
- recessive black phenotype increased during the industrial revolution;
- black peppered moths could camouflage better;
- therefore not hunted and preferred by natural selection;

Briefly explain the theory of evolution by natural selection. *4 marks*

- parents produce more offspring than survive
- there is competition among members of a species for survival/struggle for existence
- species show variation
- certain variations will give a selective advantage/survival of fittest
- depending on environment
- these variations will be passed on to the next generation
- leading to change in allele frequency

Outline one modern example of observed evolution by natural selection. *3 marks*

- beaks of Galapagos finches
- competition for food
- change in numbers/proportion of birds with different sized beaks

5.3: Classification of Biodiversity

Outline the international system used for naming species of living organisms. *(4 max)*

- binomial system
- devised by Linnaeus
- the first name is the genus name
- the second name is the species name
- genus name can be abbreviated
- genus consists of a group of (closely related) species
- upper case for first letter of genus name and the rest of the binomial is lower case
- *Sequoia sempervirens* / other example
- first published name is the correct one
- local / colloquial names can be very confusing / helps international communication

Outline the advantages to scientists of the binomial system for naming species. *(4 max)*

- international system
- naming system decided upon by congress;
- all scientists use the same names for species;
- misunderstandings due to language differences can be avoided
- double names are easy to remember and use
- first name is genus name and shows which other species are closely related

Name the levels and the specific taxa in the hierarchy of classification using humans as an example. *(2 max)*

- (Kingdom) Animalia
- (Phylum) Chordata
- (Sub-phylum) Vertebrata
- (Class) Mammalia
- (Order) Primata
- (Family) Hominidae
- (Genus) *Homo*
- (Species) *sapiens*

(4 to 6 correct 1 mark, 7 to 8 correct 2 marks. Award 1 if 7 to 8 correct but incorrect order.)

Outline the six different kingdoms of living organisms. *6 marks*

Award 1 mark for correct identification and description

Domains and Kingdoms

Domain	Bacteria	Archaea	Eukarya			
Kingdom	Bacteria	Archaea	Protista	Fungi	Plantae	Animalia
Example						
Characteristics	Bacteria are simple unicellular organisms.	Archaea are simple unicellular organisms that often live in extreme environments.	Protists are unicellular and are more complex than bacteria or archaea.	Fungi are unicellular or multicellular and absorb food.	Plants are multicellular and make their own food.	Animals are multicellular and take in their food.

Outline the structural differences which characterize bryophytes, filicinophytes, coniferophytes and angiospermophytes. *9 marks*

	Appearance	Max. Size	Reproduction	Memorandum
Bryophyta (mosses)	Small, furry, no vasculature. Cover rocks, trees, etc. in wet areas.	50cm	Spores, from sporangia on stalk capsules.	Chlorophyte = Covers phloor (floor)
Filicinophyta (ferns)	**Non-woody**. Leaves in sections, may be curled up.	15m	Spores, from sporangia under leaves.	Filicinophyta = Ferns
Coniferophyta (conifers/pines)	**Woody** trees with needle-like leaves and cones.	100m	Seeds stored and released from female cones.	Conifer = Cones
Angiospermophyta (flowering plants)	Roots, stems and leaves. Produce flowers.	100m	Spores, distributed through fruits. Flowers for pollination.	Angiosperm = Pollen → flowers

Outline the structural differences which characterizeporifera, cnidaria, platyhelminthes, annelida, mollusca and arthropoda. *9 marks*

	Symmetry	Digestive Tract	Segmentation	Other Features
Porifera (sponges)	None	No mouth or anus (filter feeders)	None	Porifera (porous), attached to rocks/ coral
Cnidaria (jellies & anemones)	Radial	Mouth, no anus	None	Tentacles around mouth, may have stinging cells
Platyhelminthes (flat worms)	Bilateral	Mouth, no anus	None	Many flatworms are parasites
Annelida (segmented worms)	Bilateral	Mouth & anus	Highly segmented	Often bristly Includes earthworms and leeches
Mollusca	Bilateral	Mouth & anus	Not visible	Very diverse, including snails, squid
Arthropoda	Bilateral	Mouth & anus	Segmented	Exoskeletons Jointed limbs

Discuss how biochemical variations can be used as an evolutionary clock. *5 marks*

methods of using evolutionary clocks: 3 max

- differences in nucleotide base sequences / DNA / amino acid sequences / proteins
- accumulate gradually over time
- differences accumulate at (roughly) predictable rates
- therefore the number of differences can be used as a clock
- to measure the time since two divergent groups shared a common ancestor
- example; e.g. amino acid sequences in globin genes

problems with using evolutionary clocks: 2 max

- however variations are partly due to mutations
- which are unpredictable chance events
- so there must be caution in interpreting data
- establish a variety of molecular clocks for reliability

Distinguish, with examples, between *analogous* and *homologous* characterisitcs *4 marks*

analogous characteristics: 2 marks max

- analogous characteristics are structures with a common function
- but a different evolutionary origin
- example: dolphin fins and shark fins

homologous characteristics: 2 marks max

- homologous characteristics are structures that have a common evolutionary origin
- even if they have different functions
- example: dolphin forelimbs and human arms

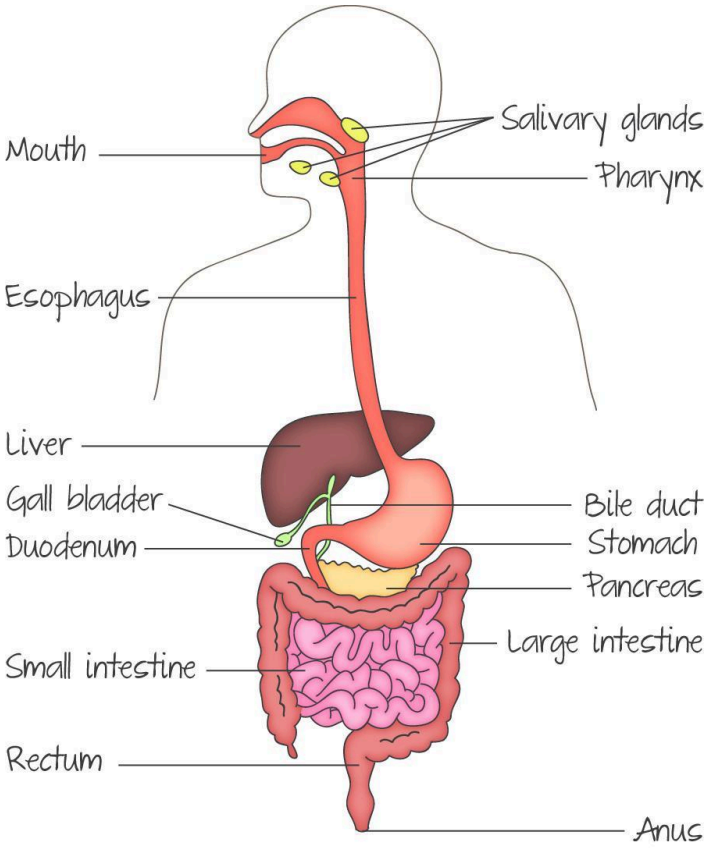
Unit 6: Human Physiology

6.1: Structure of the Digestive System

1. **Draw a labeled diagram of the human digestive system.** *5 marks*

*Award one mark for every **two** of the following structures clearly drawn and labeled correctly. Connections between organs must be correct for full marks*

- mouth/ teeth/ tongue
- esophagus
- stomach
- small intestine
- large intestine/colon
- anus
- rectum
- sphincters
- salivary glands
- liver
- pancreas
- gall bladder



2. **Describe the role of enzymes in the digestion of proteins, carbohydrates and lipids in humans.** *6 marks*

Award one mark per role.

Examples of specific enzymes:

- protease/trypsin/pepsin/chymotrypsin/other named protease digest proteins into polypeptides/ dipeptides/ amino acids/ peptides
- lipase digest lipids into glycerol/ fatty acids
- amylase digest polysaccharides into disaccharides/ monosaccharides

Enzymes must match products.

- speed up/ catalyze reactions/ increased efficiency
- lower the (activation) energy required for digestive reactions to occur
- occurs at body temperature
- require optimum pH
- enzymes are specific
- digestive enzymes carry out hydrolytic processes

3. **State the sources, substrate, product, and optimum pH conditions for the enzyme amylase.** *3 marks*

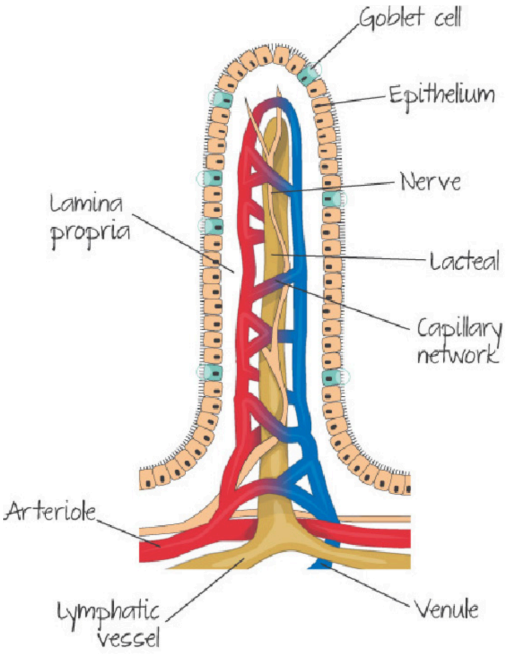
- *source*: salivary glands/pancreas

- *substrate*: starch/ glycogen (*do not accept carbohydrate*)
- *product*: maltose/ disaccharide
- *optimum pH*: 7-8/ neutral - slightly alkaline

4. **Draw a diagram of a villus in vertical section.** *5 marks*

Award one mark for each of the following structures clearly drawn and labeled correctly.

- lymph vessel
- arteriole
- venule
- (central) lacteal
- capillary network
- epithelial layer/ lining/ epithelium
- microvilli
- goblet cells



5. **Explain how the structure of the villi in the small intestine are related to absorption of digested food.** *3 marks*

Award marks for a clearly drawn and correctly labelled diagram.

- large surface area by microvilli / protrusion of exposed parts
- epithelium only one layer thick
- protein channels allow facilitated diffusion and active transport
- mitochondria provide ATP
- blood capillaries close to epithelium/ surface
- absorption of glucose/ amino acids
- lacteal / lymphatic vessel in center to absorb fats
- tight junctions assist in controlling absorption

6. **Describe the role of enzymes in digestion with reference to two named examples.** *5 marks*

- large food molecules must be broken down
- such as carbohydrates/ proteins, *etc.*
- by hydrolysis of bonds / to form monomers
- in preparation for absorption
- rate of reaction at body temperature too slow
- enzymes increase the of breakdown / act as catalysts
- first enzyme example - name, substrate and product
- second enzyme example - name, substrate and product

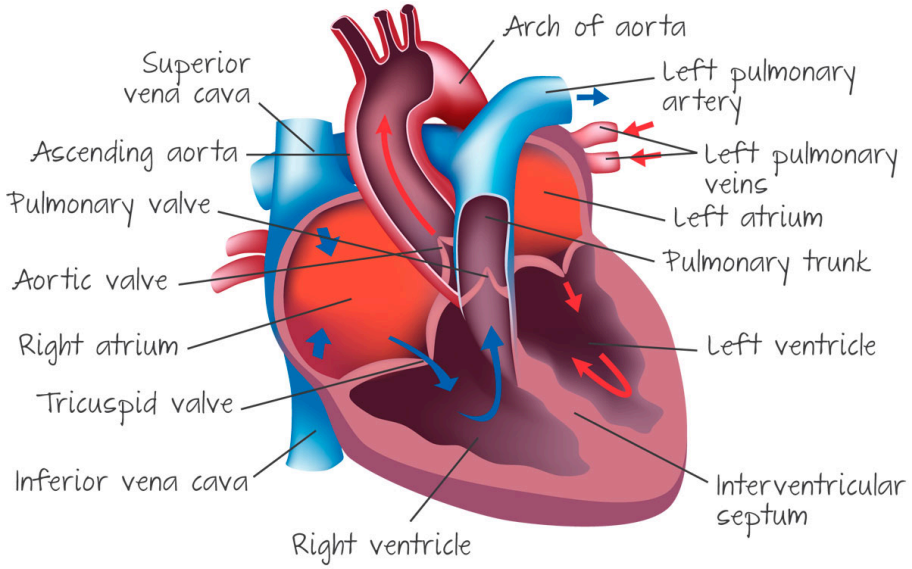
6.2: The Blood System

7. **Draw a labelled diagram to show the internal structure of the heart.** *6 marks*

Award one mark for each of the following structures clearly drawn and labelled correctly in a diagram of the heart

- left and right ventricles
- left and right atria
- atrioventricular valves / bicuspid / mitral and tricuspid valves
- semilunar valves
- aorta and vena cava
- pulmonary artery and pulmonary vein
- ventricle thicker than atria
- left ventricle wall thicker than right ventricle wall

*Do not award marks for a diagram with only the ventricles **or** atria. However, it is not necessary to show the cordae tendinae.*



8. **Draw a labelled diagram of the heart showing all four chambers, associated blood vessels and valves.** *5 marks*

Award one mark for each structure clearly drawn and correctly labelled. Schematic diagrams are acceptable.

- right and left ventricles – not connected shown larger than atria;
- right and left atrium – not connected, thinner walls than ventricles;
- right ventricle has thinner walls than left ventricle / vice versa;
- atrio-ventricular valves / tricuspid and bicuspid valves – shown between atria and ventricles;
- aorta and pulmonary artery – shown leaving the appropriate ventricle with semilunar valves shown;
- pulmonary vein and vena cava – shown entering appropriate atrium;

Vessels must join unambiguously to correct chamber.

9. **Outline the events that occur within the heart, which cause blood to move around the body.** *6 marks*

- blood is collected in the atria
- blood is pumped from the atria to the ventricles
- opened atrio-ventricular valves allow flow from the atria to the ventricles
- closed semi-lunar valves prevent backflow from the arteries to the ventricles
- blood is pumped out from the ventricles to the arteries
- open semi-lunar valves allow flow from ventricles to arteries
- closed atrio-ventricular valves prevent backflow to the atria
- pressure generated by the heart causes blood to move around the body
- pacemaker (SAN) initiates each heartbeat

10. **Explain the relationship between the structure and function of arteries, capillaries and veins.** *9 marks*

(*3 marks maximum for information on arteries.*)

- carry blood away from the heart
- have thick walls to withstand high pressure / prevent bursting
- have muscle fibers to generate the pulse / help pump blood / even out blood flow
- have elastic fibers to help generate pulse / allow artery wall to stretch / recoil

(*3 marks maximum for information on capillaries.*)

- allow exchange of oxygen/carbon dioxide/ nutrients/waste products from tissues/cells
- have a thin wall to allow (rapid) diffusion / movement in / out
- have pores / porous walls to allow phagocytes / tissue fluid to leave
- are narrow so can penetrate all parts of tissues / bigger total surface area

(*3 marks maximum for information on veins.*)

- carry blood back to the heart / from the tissues
- have thinner walls because the pressure is low / to allow them to be squeezed
- have fewer muscle / elastic fibers because there is no pulse / because pressure is low
- have valves to prevent backflow

11. **Blood is a liquid tissue containing glucose, urea, plasma proteins and other components. List the other components of blood.** *5 marks*

- plasma/water;
- dissolved gases / CO2 / O2;
- erythrocytes / red blood cells;
- leucocytes / white blood cells;
- lymphocytes and phagocytes;
- platelets;
- hormones / named hormone(s);
- amino acids / albumin / antibodies;
- salts / minerals / ions other named solute in plasma apart from glucose, urea and plasma proteins;

6.3: Defense Against Infectious Diseases

12. **Outline how the skin and mucous membranes prevent entry of pathogens into the body.** *5 marks*

*To receive full marks, responses must have **two** answers for each.*

skin: 3 max

- lower pH/ acid to keep bacteria from growing/ chemical barrier
- fatty acids/ waxes antimicrobial
- physical barrier to prevent entry/ dry skin inhibits bacterial growths
- bacteria on skin/ mucous membranes prevent other bacteria from growing
- antimicrobial/ lysozyme in sweat and saliva (mucous membrane) to keep bacterial growth in check

mucous membranes: 3 max

- mucous traps bacteria/ sticky/ mucous slightly acidic *e.g. vagina*
- cilia sweep mucous up to be swallowed to kill bacteria
- contain macrophages/ phagocytes

13. **Discuss the benefits and dangers of vaccination.** *7 marks*

Benefits: 4 max

- immunity results
- can limit pandemics/epidemics/spread of (infectious) diseases;
- diseases can be eradicated/smallpox eliminated;
- reduces mortality/deaths due to disease;
- can protect vulnerable groups/young/old/with other conditions;
- decrease crippling effects of diseases (such as polio);decreased health care costs;

Dangers: 4 max

- may produce (mild) symptoms of the disease;
- human error in preparation/storage/administration of vaccine;
- individual may react badly to vaccine / defective immune system /
- hypersensitive/allergic reaction;
- immunity may not be life-long/booster required;
- possible toxic effects of mercury-based preservatives;

14. **Outline the principle of immunity.** *6 marks*

- immunity is the ability of an organism to resist infection;
- due to presence of (specific) antibodies;
- immunity can be active or passive;
- passive due to receiving antibodies from external sources/across placenta/from breast milk/injection;
- active results from facing an infection directly/through vaccination;
- pathogen/foreign cell invades body;
- leads to clonal selection/formation of B memory cells;
- B-cells produce specific antibodies;
- if same pathogen enters body again memory cells activated/stimulated to divide;
- antibodies produced faster and in greater amounts;

15. **Define the terms active and passive immunity.** *2 marks*

- active immunity - production of antibodies by the organism itself

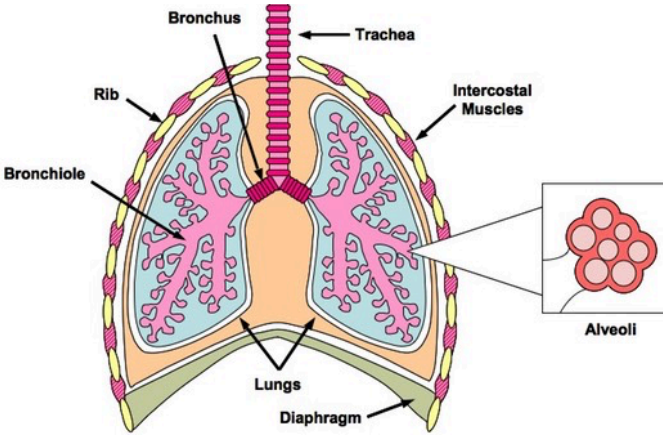
- passive immunity - acquisition of antibodies from another organism / from elsewhere

6.4: Gas exchange

16. **Draw a simple diagram of the gas exchange system in humans.** *5 marks*

For a diagram of the whole gas exchange system, award 1 mark for each of the following structures clearly drawn and labeled correctly.

- trachea
- lungs
- bronchi
- bronchioles
- lungs (2 must be shown)
- intercostal muscles between ribs
- diaphragm



For a diagram of an alveolus only, award 1 mark for each of the following structures clearly drawn and labeled correctly.

- alveolus
- bronchiole

17. **Describe the mechanism of ventilation in the human lung.** *5 marks*

- consists of inhaling and exhaling air / exchanging stale air with fresh air (with the environment)
- external intercostal muscles contract moving the rib cage up/out
- diaphragm contracts
- increase volume of thorax / lowers lung pressure relative to air pressure / pulls air in
- diaphragm relaxes
- abdominal muscles contract
- internal intercostal muscles contract moving the rib cage down/in
- force air out / decreases volume of thorax / raise lung pressure relative to air pressure

18. **Describe the need for a ventilation system.** *6 marks*

- (small) animals obtain oxygen (by diffusion) through skin / in humans (large) animals skin is ineffective for ventilation
- humans are large / have a small ratio of surface area:volume
- so need ventilation system to increase surface area
- to maintain a concentration gradient in alveoli
- as oxygen is used in respiration (and carbon dioxide is produced)
- gaseous exchange occurs between air in alveoli and blood capillaries
- alveoli have high ratio of surface area:volume (to facilitate ventilation)
- to bring in fresh air (and remove stale air)

19. **Explain the need for, and mechanism of, ventilation of the lungs in humans.** *8 marks*

- draws fresh air / oxygen into the lungs
- removal / excretion of carbon dioxide
- maintains concentration gradient of oxygen / carbon dioxide / respiratory gases

- diaphragm contracts
- (external) intercostal muscles contract
- increased volume (of thorax / thoracic cavity)
- decreasing air pressure in lungs
- air rushes in down air pressure gradient

- converse of the above causes exhalation
- abdominal muscles contract during active exhalation
- elastic recoil of lungs helps exhalation

20. **Many processes in living organisms, including ventilation and gas exchange, involve moving materials. State the differences between ventilation and gas exchange in humans.** *4 marks*

ventilation: 2 max

- movement of air
- movement in and out of the lungs
- caused by muscles
- an active process
- involves mass flow / involves flow along air passages

gas exchange 2 max

- movement of carbon dioxide and oxygen
- (occurs when) oxygen moves from lungs / alveoli to red blood cells / carbon dioxide moves to lungs / alveoli from red blood cells
- (occurs when) oxygen moves from red blood cells to tissues / carbon dioxide moves to red blood cells from tissues
- a passive process / diffusion
- takes place across a surface

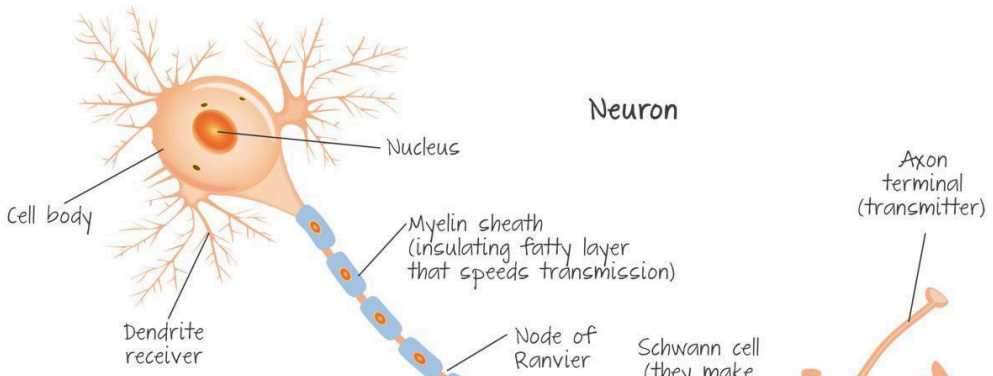
6.5: Neurons and Synapses

21. **Outline the general organization of the nervous system.** *4 marks*

- formed of central nervous system
- brain and spinal cord
- peripheral nervous system divided into voluntary and autonomic nervous systems
- autonomic nervous system consists of sympathetic and parasympathetic nervous system
- voluntary nervous system has motor and sensory neurons

22. **Draw a diagram to show the structure of a motor neuron.** *5 marks*

- cell body drawn and labelled with a nucleus shown inside *(reject if cell body not drawn at end of axon)*
- axon drawn at least three times as long as the diameter of the cell body and labelled
- Schwann cells / myelin sheath drawn and labelled
- gaps in the myelin sheath drawn and labeled
- at least five dendrites drawn leading to the cell body labelled
- at least two motor end plates / buttons / synaptic knobs / synaptic terminals drawn and labelled



23. **Outline the changes that lead to the depolarization of an axon as an action potential travels along a neuron.** *5 marks*

- local currents / ions diffuse from adjacent depolarized section of axon
- resting / membrane potential reduced
- voltage-gated ion channels affected
- sodium channels open
- sodium diffuses in / moves in rapidly
- therefore fewer positive charges outside and more inside / inside becomes positive relative to outside / membrane polarity reversed
- before depolarization outside was positive relative to inside
- when some sodium gates open entry of Na+ causes more sodium gates to open
- membrane potential rises from -70mV to +40 mV (-+ 10 mV)

(Award no marks for statements about potassium movement and repolarization)

24. **Explain how the nerve impulse passes along a neuron.** *8 marks*

- in resting potential
- sodium is pumped out by the active transport and potassium in
- a concentration gradient builds up electrical potential / voltage
- negative inside compared to outside
- when impulse passes / action potential
- must pass threshold level
- sodium channels open and ions diffuse into neuron
- membrane depolarized
- potassium diffuse out across membrane through ion channels
- active transport of ions once more
- slower in un-myelinated neuron than in myelinated
- an action potential in one part of the neuron causes the action potential to develop in the next section

25. **Explain how a non-myelinated neuron can maintain a resting potential and undergo an action potential.** *9 marks*

- resting potential is a charge difference across the membrane / -70mV
- inside negative compared to the outside
- active transport of ions across the membrane / pumps using ATP
- positively charged sodium ions / Na+ are pumped out
- fewer K+ are pumped in / 2 K+ compared to 3 Na+
- neuron contains negatively charged organic ions
- membrane allows little / no diffusion of ions
- to create action potential sodium ion channels open
- sodium ions move into the neuron
- therefore there is depolarization / membrane polarization is reversed
- this causes similar changes further on along the neuron
- reference to diffusion of ions / local currents
- potassium ion channels open after the sodium ion channels
- potassium diffuses out causing some repolarization

26. **Explain how a nerve impulse is transmitted from a neuron to a muscle.** *8 marks*

- impulse reaches the motor end plates / synaptic knobs / buttons / synaptic terminals
- synaptic vesicles contain neurotransmitter / acetylcholine
- calcium enters through the presynaptic membrane
- calcium causes the vesicle to move to and fuse with the membrane / causes exocytosis
- neurotransmitter / acetylcholine released into the synaptic cleft
- postsynaptic membrane

- binds to receptor sites
- causes depolarization of the muscle fiber membrane / postsynaptic membrane
- by opening sodium gates
- threshold of stimulation must be reached / all or nothing effect
- enzyme / acetylcholinesterase breaks down the neurotransmitter / acetylcholine
- depolarization causes sarcoplasmic reticulum to release calcium ions
- calcium ions cause / enable muscle contraction

27. **Describe the principles of synaptic transmission in the nervous system.** *6 marks*

- nerve impulse reaches pre-synaptic knob / membrane
- calcium ions / Ca+2 enter pre-synaptic neuron / knob
- vesicles with neurotransmitter / acetylcholine release contents
- neurotransmitter diffuses across synapse / synaptic cleft
- binds to receptors on post-synaptic neuron / membrane
- sodium ions / Na+ enter post-synaptic neuron / sodium channels open
- depolarization / action potential / nerve impulse (in post synaptic neuron)
- calcium ions / Ca+2 pumped back into synaptic cleft / synapse
- neurotransmitter broken down

28. **Explain the process of synaptic transmission.** *7 marks*

- presynaptic neurons pass stimulus / potential to postsynaptic neurons
- presynaptic neuron releases neurotransmitter into synaptic cleft
- process involves exocytosis
- exocytosis requires Ca+2 entry into presynaptic neuron
- neurotransmitter binds with postsynaptic membrane receptor
- neurotransmitter binding can cause postsynaptic membrane ion channel to open / increase / change permeability of post-synaptic membrane
- increase / change permeability of post-synaptic membrane
- open channel allows specific ions to enter / exit post-synaptic membrane
- depolarization / hyperpolarization can result in / initiate action potential
- outcome depends on type of postsynaptic receptor and type of channel opened ; reference to excitatory and inhibitory synapses
- Na+ passing to the inside of the post-synaptic neuron (usually) causes depolarization
- Cl- passing to the outside of the post-synaptic neuron (usually) causes hyperpolarization
- (some) neurotransmitters are destroyed by enzymes

Accept any of the above points if accurately illustrated in a diagram.

6.6: Hormones, Homeostasis and Reproduction

29. **Describe homeostasis in relation to blood glucose concentration in humans.** *6 marks*

- homeostasis is maintaining internal environment at constant levels/within narrow limits
- homeostasis involves both nervous and endocrine systems
- low blood glucose triggers glucagon release
- glucagon is produced å-islet cells in pancreas
- glycogen is converted to glucose
- high blood glucose concentration triggers insulin release
- insulin produced by ß-islet cells in pancreas
- glucose taken up by (liver/muscle) cells
- glucose converted to glycogen
- blood glucose levels controlled by negative feedback
- correct reference to lowering or raising blood glucose levels

30. **Define, with examples, the term homeostasis.** *4 marks*

- keeping conditions constant/ within narrow limits
- within the body/ internal environment
- *e.g.*, temperature in humans kept at 37 degrees C/ other example
- *e.g.*, blood sugar/ glucose in humans kept within limits/ other example

31. **Explain how blood glucose concentration is controlled in humans.** *9 marks*

- homeostasis maintains the internal blood glucose levels between narrow limits
- 70-110 mg glucose per 100 ml blood
- blood glucose level is maintained by negative feedback
- islets in pancreas monitor blood glucose levels
- after meal blood glucose increases
- high blood glucose stimulates release of insulin
- (release of insulin) by pancreatic islets/ by ß-cells
- causes muscles/ adipose tissue and liver to store glycogen
- glucose stored in the form of glycogen (in muscle/ liver)
- storage lowers blood glucose levels
- if blood glucose levels drops glucagon secreted
- secrete glucagon by pancreatic islets/ by å-cells
- this causes liver to break down glycogen (to glucose)
- glycogen breakdown causes blood glucose level increase

32. **Describe how pancreatic cells directly affect blood glucose levels.** *5 marks*

- α cells (of pancreas) produce glucagon;
- glucagon promotes release of glucose/breakdown of glycogen by liver cells;
- glucagon secreted when blood glucose levels are low / raises blood glucose levels;
- β cells (of pancreas) produce insulin;
- insulin promotes glucose uptake/storage of glycogen by liver/body/muscle cells;
- insulin secreted when blood glucose levels are high / lowers blood glucose levels;
- negative feedback mechanism;

Do not accept answers implying that insulin or glucagon catalyze glucose-glycogen conversions directly. Award 3 max if the response suggests that the hypothalamus has a role in regulation of blood glucose.

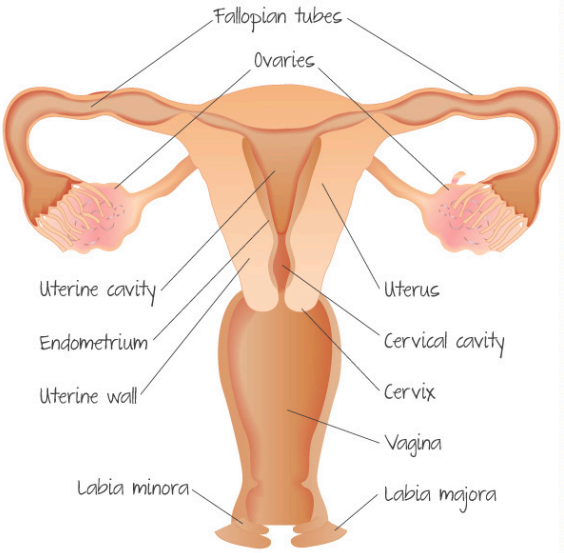
33. **Describe the response of the human body to low external temperatures.** *4 marks*

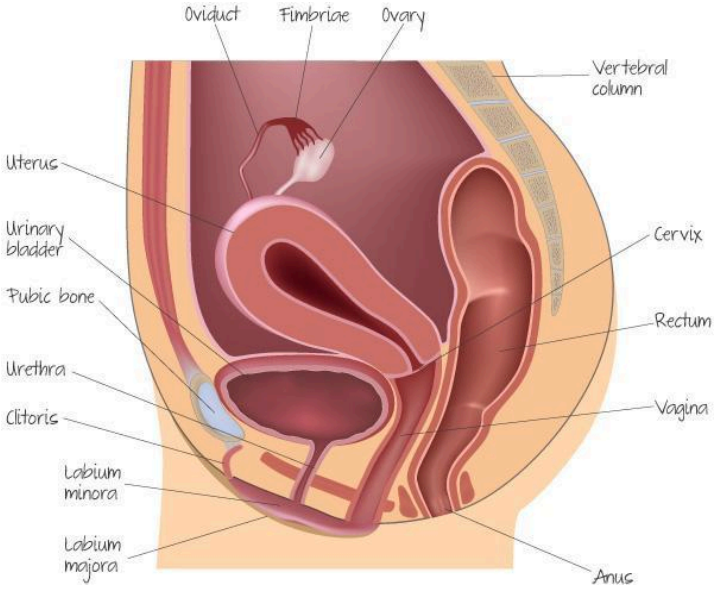
- thermoreceptors/ sensory input
- hypothalamus acts as a thermostat
- metabolic rate increases
- shivering / goose bumps / hairs raising / sweat glands inactive
- vasoconstriction of skin arterioles
- blood flow from extremities is reduced / blood flow to internal organs is increased
- increased activity
- heat is transferred in blood

34. **Label the female reproductive system.** *7 marks.*

- Ovaries
- Oviduct/Fallopian tubes
- Cervix / Cervical cavity
- Uterus / Uterine cavity
- Labium minora
- Labium majora

- Vagina



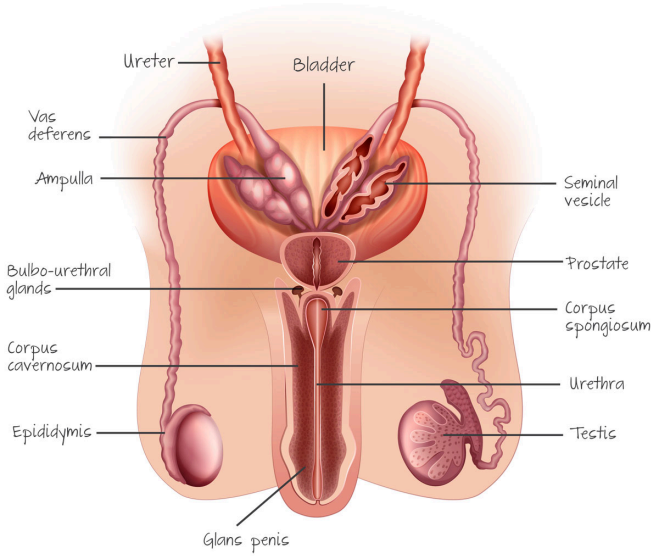


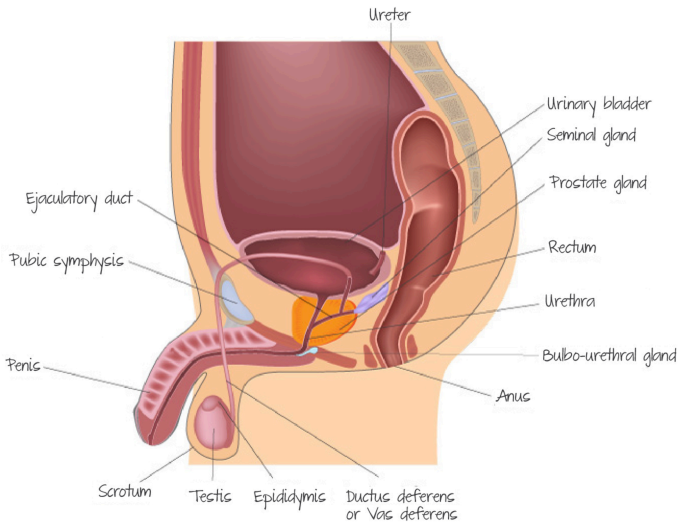
35. **Explain the functions of the parts of the female reproductive system.** *4 marks*

- *Ovary:* Produces eggs, estrogen and progesterone;
- *Oviduct:* Collects eggs from ovary and carries them to the uterus;
- *Uterus:* Provides protection, food, oxygen and removal of waste products during pregnancy;
- Cervix: Blocks entry to the uterus during pregnancy and dilates during birth;

36. **Label the male reproductive system.** *8 marks.*

- Glans penis
- Urethra
- Prostate Gland
- Scrotum
- Testis
- Epididymis
- Ductus deferens
- Seminal gland
- Vas deferens
- Urinary bladder





37. **Explain the functions of the male parts of the reproductive system.** *5 marks*

- *Penis:* Penetrates the vagina to deposit semen close to the cervix;
- *Urethra:* Transfers semen during ejaculation and passage of urine during urination;
- *Seminal vesicle:* Produces a sugar-rich fluid that provides spem with a source of energy to help them move;
- *Sperm duct:* Transfers sperm during ejaculation;
- *Epididymis:* Stores sperm until ejaculation;
- *Testis:* Sperm and testerone production

- *Prostate gland:* Produces an alkaline fluid, rich in proteins which, together with seminal vesicles' secretion and sperm, makes semen;

38. **Explain the role of hormones in the regulation of the menstrual cycle.** *8 marks*

- FSH (Follicle Stimulating Hormone) and LH (Luteinizing Hormone) are produced by the pituitary gland;
- Estrogen and progesterone are produced by the ovary;
- FSH stimulates the ovary to promote development of a follicle;
- The developing follicles secrete estrogen, which inhibits FSH (negative feedback);
- Estrogen stimulates the growth of endometrium;
- Estrogen stimulates LH secretion (positive feedback);
- LH stimulates follicle growth and triggers ovulation;
- The secondary oocyte leaves the ovary and follicle becomes corpus luteum;
- The corpus luteum secretes estrogen and progesterone;
- Estrogen and progesterone maintain the endometrium;
- Estrogen and progesterone inhibit LH and FSH (negative feedback);
- After two weeks, the corpus luteum degenerates and the progesterone and estrogen levels fall;
- This triggers menstrual bleeding and the loss of the endometrium;
- The pituitary gland secretes FSH and LH, as they are no longer inhibited;
- Menstrual cycle continues;

Unit 7: Nucleic Acids

7.1 DNA Structure and Replication

1. **Outline the structure of the nucleosomes in eukaryotic chromosomes.** *4 marks*

    - contain histones
    - eight histone molecules form a cluster in a nucleosome
    - DNA strand is wound around the histones
    - wound around twice in each nucleosome
    - (another) histone molecule holds the nucleosome(s) together
    -

2. **Most of the DNA of a human cell is contained in the nucleus. Distinguish between unique and highly repetitive sequences in nuclear DNA.** *5 marks*

    *Award 1 for each **pair** of statements in a table, and 1 for any statement below the table.*

    ***U**=Unique sequences; **H**= Highly repetitive sequences*

    - U: occur once in genome; H: occur many times;
    - U: long base sequences; H: short sequences/5–300 bases;
    - U: (may be) genes; H: not genes;
    - U: (may be) translated/coding sequences; H: never translated;
    - U: small differences between individuals; H: can vary greatly;
    - U: exons (are unique sequences); H: introns (may be repetitive);
    - U: smaller proportion of genome; H: higher proportion of genome;
    - satellite DNA is repetitive;
    - repetitive sequences are used for profiling;
    - prokaryotes do not (usually) contain repetitive sequences;

3. **Explain how the process of DNA replication depends on the structure of DNA.** *9 marks*

    - DNA molecule is double (stranded)
    - hydrogen bonds linking the two strands are weak/ can be broken
    - DNA can split into two strands
    - split by helicase
    - helicase moves progressively down the molecules
    - backbones are linked by covalent/ strong bonds
    - strands do not therefore break/ base sequence conserved
    - reference to semi-conservative replication
    - base pairing/ sequences are complementary
    - A=T and C=G
    - the two original strands therefore carry the same information
    - the two new strands have the same base sequence as the two original ones
    - the strands have polarity
    - base/ nucleotides added in 5` to 3` direction
    - the two strands have opposite polarity
    - discontinuous segments/ Okazaki fragments added to one strand
    - DNA ligase needed to connect the segments

4. **Explain the process of DNA replication.** *8 marks*

    Accept any of the points above shown on an annotated diagram.

- occurs during (S phase of) interphase/in preparation for mitosis/cell division;
- DNA replication is semi-conservative;
- unwinding of double helix / separation of strands by helicase (at replication origin);
- hydrogen bonds between two strands are broken;
- each strand of parent DNA used as template for synthesis;
- synthesis continuous on leading strand but not continuous on lagging strand;
- leading to formation of Okazaki fragments (on lagging strand);
- synthesis occurs in 5 3direction;
- RNA primer synthesized on parent DNA using RNA primase;
- DNA polymerase III adds the nucleotides (to the 3 end)
- added according to complementary base pairing;
- adenine pairs with thymine and cytosine pairs with guanine; (Both pairings required. Do not accept letters alone.)
- DNA polymerase I removes the RNA primers and replaces them with DNA;
- DNA ligase joins Okazaki fragments;
- as deoxynucleoside triphosphate joins with growing DNA chain, two phosphates
- broken off releasing energy to form bond;

5. **State a role for each of four different named enzymes in DNA replication.** *6 marks*

Award 1 mark for any two of the following up to 2 marks maximum.

- helicase
- DNA polymerase / DNA polymerase III
- RNA primase
- DNA polymerase I
- (DNA) ligase

Award 1 mark for one function for each of the named enzymes.

helicase

- splits/ breaks hydrogen bonds/ uncoils DNA/ unwinds DNA

(DNA) polymerase III

- adds nucleotides (in 5' to 3' direction) extending existing strand

(RNA) primase

- synthesizes a short RNA primer (which is later removed) on DNA

(DNA) polymerase I

- replaces RNA primer with DNA

(DNA) ligase

- joins Okazaki fragments/ fragments on lagging strand/ makes sugar-phosphate bonds between fragments

e7.1: Transcription and Gene Expression

6. **Explain transcription.** *8 marks*

- Transcription is the copying of a strand of DNA into mRNA
- RNA polymerase binds to promoter region of DNA
- Anti-sense strand is used as a template
- RNA polymerase unwinds the DNA helix and separates the strands
- Nucleoside triphosphates pair with complementary bases on DNA
- Adenine to Thymine, Cytosine to Guanine, and Uracil to Adenine
- Bases are added at a 3' end / strand grows in a 5' to 3' direction
- RNA nucleotides covalently join together forming a sugar-phosphate backbone
- RNA polymerase separates from DNA when terminator sequence is reaches
- Introns have to be removed in eukaryotes to form mature mRNA
- RNA detaches from the template and DNA rewinds

7. **Compare the processes of DNA replication and transcription.** *9 marks*

- both involve unwinding the helix
- both involve separating the two strands
- both involve breaking hydrogen bonds between bases
- both involve complementary base pairing
- both involve C pairing with G
- both work in a 5` --> 3` direction
- both involve linking/ polymerization of nucleotides
- replication with DNA nucleotides and transcription with RNA nucleotides
- details of ribose/ deoxyribose difference
- adenine pairing with uracil instead of thymine
- only one strand copied not both
- no ligase/ no Okazaki fragments with transcription
- DNA or RNA polymerase
- both require a start signal
- but this signal is different for each
- transcription has only one starting point
- but replication has multiple starting points
- replication gives two DNA molecules whilst transcription gives mRNA

7.3: Translation

8. **Outline the structure of tRNA.** *5 marks*

Accept any of the points above if clearly explained using a suitably labelled diagram

- tRNA is composed of one chain of (RNA) nucleotides
- tRNA has a position/end/site attaching an amino acid (*reject tRNA contains an amino acid*)
- at the 3' terminal / consisting of CCA/ACC
- tRNA has an anticodon
- anticodon of **three** bases which are not base paired / single stranded / forming part of a loop
- tRNA has double stranded sections formed by base pairing
- double stranded sections can be helical
- tRNA has (three) loops (sometimes with an extra small loop)
- tRNA has a distinctive three dimensional / clover leaf shape

9. **Outline the structure of a ribosome.** *4 marks*

- small subunit and large subunit;
- mRNA binding site on small subunit;
- three tRNA binding sites / A, P and E tRNA binding sites;
- protein and RNA composition (in both subunits);

10. **Explain the process of translation.** *9 marks*

- translation involves initiation, elongation/translocation and termination;
- mRNA binds to the small sub-unit of the ribosome;
- ribosome slides along mRNA to the start codon;
- anticodon of tRNA pairs with codon on mRNA:
- complementary base pairing (between codon and anticodon);
- (anticodon of) tRNA with methionine pairs with start codon / AUG is the start codon;
- second tRNA pairs with next codon;
- peptide bond forms between amino acids;
- ribosome moves along the mRNA by one codon;
- movement in 5 to 3 direction;
- tRNA that has lost its amino acid detaches;
- another tRNA pairs with the next codon/moves into A site;
- tRNA activating enzymes;
- link amino acids to specific tRNA;
- stop codon (eventually) reached;

11. **Compare DNA transcription with translation.** *4 marks*

- both in 5` to 3` direction
- both require ATP
- DNA is transcribed and mRNA is translated
- transcription produces RNA and translation produces polypeptides/ protein
- RNA polymerase for transcription and ribosomes for translation/ ribosomes in translation only
- transcription in the nucleus (of eukaryotes) and translation in the cytoplasm/ at ER
- tRNA needed for translation but not transcription

Unit 8: Metabolism, cell respiration and photosynthesis

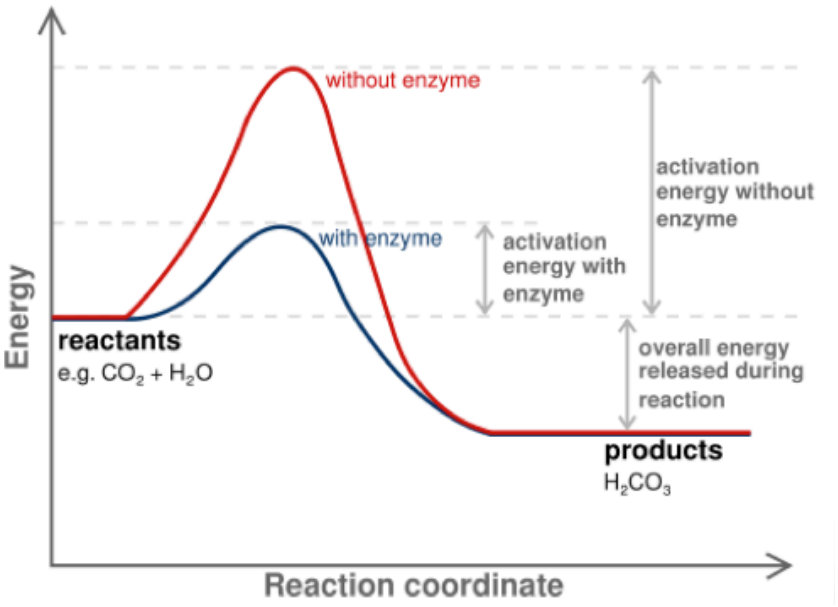
8.1: Metabolism

1. **Compare the induced fit model of enzyme activity with the lock and key model.** *4 marks*

   - in both models substrate binds to active site
   - substrate fits active site exactly in lock and key, whereas fit is not exact in induced fit
   - substrate / active site changes shape in induced fit, whereas active site does not change shape in lock and key
   - in both models an enzyme - substrate complex is formed
   - in lock and key binding reduces, whereas in the induced fit change to substrate reduces activation energy
   - lock and key model explains narrow specificity, whereas induced fit allows broader specificity
   - induced fit explains competitive inhibition, whereas lock and key does not

2. **Draw graphs to show the effect of enzymes on the activation energy of chemical reactions** *5 marks*

   - vertical axis with energy label **and** horizontal axis with time label
   - labels showing reactant / substrate and product
   - labeled line showing correct shape and curve without enzyme
   - labeled line showing correct shape and curve with enzyme
   - labels for activation energy with **and** without enzymes



3. **Explain, using one named example, the effect of a competitive inhibitor on enzyme activity.** *6 marks*

- competitive inhibitor has similar shape/structure to the substrate
- therefore it fits to the active site
- no reaction is catalyzed so the inhibitor remains bound
- substrate cannot bind as long as the inhibitor remains bound
- only one active site per enzyme molecule
- substrate and inhibitor compete for the active site
- therefore high substrate concentrations can overcome the inhibition
- as substrate is used up ratio of inhibitor to substrate rises
- named example of inhibitor plus inhibited enzyme / process / substrate
-

4. **Explain how proteins act as enzymes, including control by feedback inhibition in allosteric enzymes.** *9 marks*

- enzymes are globular proteins
- there is an active site
- substrate(s) binds to active site
- shape of substrate (and active site) changed / induced fit
- bonds in substrate weakened
- activation energy reduced
- sketch of energy levels in a reaction to show reduced activation energy
- in feedback inhibition a (end) product binds to the enzyme
- end-product is a substance produced in last / later stage of a pathway
- modulator / inhibitor / effector / product binds at the allosteric site / site away from the active site
- binding causes the enzyme / active site to change shape
- substrate no longer fits the active site
- the higher the concentration of end-product the lower the enzyme activity
- enzyme catalyzes the first / early reaction in pathway so whole pathway is inhibited
- prevents build-up of intermediates
- allosteric inhibition is non-competitive

8.2: Cell respiration

5. **Outline the process of glycolysis.** *5 marks*

- occurs in cytoplasm;
- hexose is phosphorylated using ATP;
- hexose phosphate is split into two triose phosphates;
- oxidation by removal of hydrogen; (do not accept hydrogen ions/protons)
- conversion of NAD to NADH (+H+);
- net gain of two ATP / two ATP used and four ATP produced;
- pyruvate produced at the end of glycolysis;

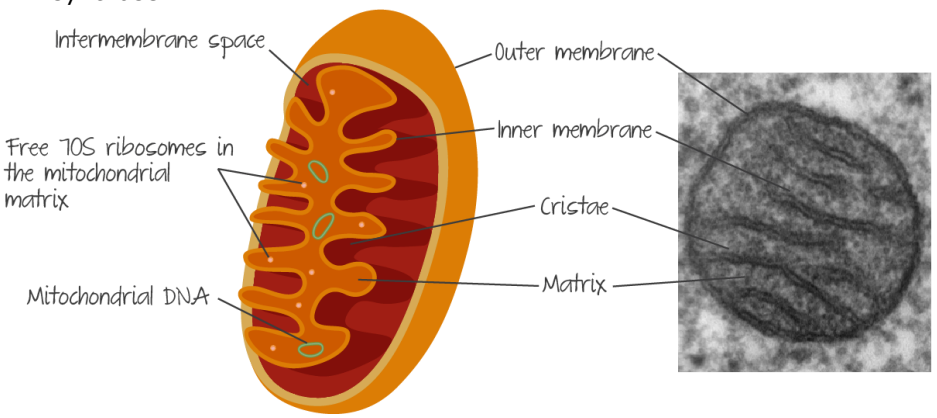
Accept glucose/fructose/6C sugar instead of hexose. Accept 3C sugar/glyceraldehyde instead of triose.

6. **Draw the structure of a mitochondrion as seen in an electron microscope.** *5 marks*

Award 1 mark for each of the following structures clearly drawn and labelled correctly.

- outer membrane
- intermembrane space / outer compartment
- inner membrane
- matrix
- cristae
- ribosome
- naked / circular DNA

- ATP synthase



Do not accept plasma membrane.

7. **Explain how the structure of the mitochondrion allows it to carry out its function efficiently.** *8 marks*

- membranes to compartmentalize / separate from processes in the cytoplasm
- small size gives large surface are to volume ratio
- large surface area to volume ratio allows rapid uptake / release of materials
- matrix contains enzymes of the Krebs cycle / matrix carries out Krebs cycle
- inner membrane invaginated / in folded / forms cristae to increase the surface area
- large surface area gives more space for electron transport chain / oxidative phosphorylation
- inner membrane contains ATP synthetase / ATPase / stalked particles that make ATP
- (narrow) gap between inner and outer membranes / intermembrane space (*must be stated or labeled*)
- pH / H+ / proton concentration gradient rapidly established / steeper
- chemiosmosis therefore more efficient / chemiosmosis can occur
- inner membrane contains the electron transport pathway
- DNA present to act as genetic material
- ribosomes for protein synthesis
- some proteins do not need to be imported

8. **Explain the reactions that occur in the matrix of the mitochondrion that are part of aerobic respiration.** *8 marks*

- pyruvate is decarboxylated/ CO2 removed
- link reaction/ pyruvate combined with CoA/acetyl CoA formed
- pyruvate is oxidized/ hydrogen removed
- reduction of NAD/ formation of NADH + H+
- whole conversion called oxidative decarboxylation
- Krebs cycle
- C2 + C4 ---> C6
- C6 ---> C5 giving off CO2
- C5 ---> C4 giving off CO2
- hydrogen atoms removed collected by hydrogen-carrying molecules (NADH, FADH2)
- ATP formed by substrate level phosphorylation
- oxygen accepts electrons/ oxygen combines with hydrogen
- total yield per turn of Krebs cycle = 2 CO2,, 3 NADH + H+, 1 FADH2, 1 ATP (directly produced)

9. **Explain the process of aerobic respiration.** *8 marks*

- by glycolysis, glucose is broken down into pyruvate (two molecules) in the cytoplasm
- with a small yield of ATP/ net yield of 2 ATP
- and NADH + H+/ NADH
- aerobic respiration in the presence of oxygen
- pyruvate converted to acetyl CoA
- by oxidative decarboxylation / NADH and CO2 formed
- fatty acids / lipids converted to acetyl CoA
- acetyl groups enter the Krebs cycle *(accept acetyl CoA)*
- Krebs cycle yields a small amount of ATP/ one ATP per cycle
- and FADH2/ FADH + H+/ NADH /NADH + H+/ reduced compounds/ electron collecting molecules
- these molecules pass electrons to electron transport chain *(reject donates H+)*
- oxygen is final electron acceptor/ water produced
- electron transport chain linked to creation of an electrochemical gradient
- electrochemical gradient/ chemiosmosis powers creation of ATP
- through ATPase/synthase/synthetase

Accept any appropriate terminology for NAD and FAD.

10. **Outline the role of oxygen in providing cells with energy.** *6 marks*

(Award 1 mark for any of the below; up to 6 marks max.)

- needed for aerobic (but not anaerobic) resp./simple equation for aerobic resp.
- used in oxidative phosphorylation
- oxygen accepts electrons at the end of the ETC
- also accepts protons to form water / water formed using oxygen
- allows more electrons along the ETC
- allows NAD to be regenerated / reduced NAD to be oxidized
- allows ATP production
- allows a high yield of ATP from glucose in respiration / 32-38 instead of 2

11. **Explain how chemiosmosis assists in ATP production during oxidative phosphorylation.** *9 marks*

- occurs during aerobic respiration;
- oxidative phosphorylation occurs during the electron transport chain;
- hydrogen/electrons are passed between carriers;
- releasing energy;
- finally join with oxygen (to produce water);
- occurs in cristae of mitochondria;
- chemiosmosis is the movement of protons/hydrogen ions;
- protons move/are moved against their concentration gradient;
- into the space between the two membranes;
- protons flow back to the matrix;
- through the ATP synthase/synthetase (enzyme);
- energy is released which produces more ATP/combines ADP and Pi;

12. **Describe the central role of acetyl (ethanoyl) CoA in carbohydrate and fat metabolism.** *5 marks*

- acetyl CoA enters Krebs cycle
- glucose / carbohydrates converted to pyruvate in glycolysis
- pyruvate enters mitochondria
- pyruvate converted to acetyl CoA
- by oxidative decarboxylation / hydrogen and CO2 removed
- fats enter mitochondria
- fats oxidized to acetyl CoA / oxidation of fatty acids / fats converted to acetyl CoA

8.3: Photosynthesis

13. **Explain the effect of light intensity and temperature on the rate of photosynthesis.** *8 marks*

- both light and temperature can be limiting factors;
- other factors can be limiting;
- graph showing increase and plateau with increasing light / description of this;
- graph showing increase and decrease with increasing temperature / description of this;

light:

- affects the light-dependent stage;
- at low intensities insufficient ATP;
- and insufficient NADPH + H+ produced;
- this stops the Calvin cycle operating (at maximum rate);

temperature:

- affects light-independent stage / Calvin cycle;
- temperature affects enzyme activity;
- less active at low temperatures / maximum rate at high temperatures;
- but will then be denatured (as temperature rises further);

Award 5 max if only one condition is discussed.

14. **Outline the light-dependent reactions of photosynthesis.** *6 marks*

- (chlorophyll/antenna) in photosystem II absorbs light;
- absorbing light/photo activation produces an excited/high-energy/free electron;
- electron passed along a series of carriers;
- reduction of NADP / generates NADPH + H+ ;
- absorption of light in photosystem II provides electron for photosystem I;
- photolysis of water produces 2 H /O ;
- called non-cyclic photophosphorylation;
- in cyclic photophosphorylation electron returns to chlorophyll;
- generates ATP by H+ diffusing across thylakoid membrane / by chemiosmosis / through ATP synthetase/synthase;

15. **Explain photophosphorylation in terms of chemiosmosis.** *8 marks*

- chemiosmosis is synthesis of ATP coupled to electron transport and proton movement
- photophosphorylation is the production of ATP with energy from light
- light energy causes photolysis/splitting of water
- electrons energized (from chlorophyll)/photo activation
- photolysis provides (replacement) electrons for those lost from excited chlorophyll
- photolysis provides protons/H+ (for thylakoid gradient)
- electron transport (carriers on membrane of thylakoid)
- causes pumping of protons/H+ across thylakoid membrane/ into thylakoid space
- protons/H+ accumulate in thylakoid space/proton gradient set up
- protons/H+ move down concentration gradient
- into stroma
- flow through ATPase/synthetase
- leading to ATP formation

16. **Explain the reactions involving the use of light energy that occur in the thylakoids of the chloroplast.** *8 marks*

- chlorophyll / photosystem absorbs light
- electron raised to higher energy level / photo activated
- splitting of water/photolysis replaces electron
- passing of excited electrons between chlorophyll molecules in photosystems
- electron passed from photosystem II to carriers (in thylakoid membrane)
- production of ATP in this way is called photophosphorylation
- electron causes pumping of protons into the thylakoid
- proton gradient used by ATPase to drive ATP production
- electron passes to photosystem I at end of carrier chain
- electron re-excited and emitted by photosystem I
- electron passed to / used to reduce NADP+
- NADPH + H+ / reduced NADP produced
- cyclic photophosphorylation using photosystem I electron and ATPase only

Accept any of the above points if clearly drawn and correctly labelled in a diagram.

17. **Outline the light-independent reactions of photosynthesis.** *8 marks*

Award 1 mark for any of the below; up to a maximum of 8 marks)

- reactions take place in the stroma
- carbon dioxide reacts with RuBP
- catalyzed by RuBP carboxylase
- GP formed
- GP converted to triose phosphate
- reduction reaction involving use of NADPH + H+
- energy from ATP also needed from this conversion
- triose phosphate converted to glucose(phosphate)/starch
- RuBP regenerated from triose phosphate
- Calvin cycle

18. **Explain why the light-independent reactions of photosynthesis can only continue for a short time in darkness.** *6 marks*

Award 1 mark for any of the below; up to a maximum of 6 marks)

- light independent reaction involve ATP/NADPH + H+ / intermediates which are made in light dependent reactions
- supply of ATP/NADPH + H+ / intermediates used up / runs out in the dark
- ATP **and** NADPH + H+
- GP therefore not reduced / converted to triose phosphate
- RuBP therefore not regenerated
- carbon dioxide fixation therefore stops
- GP accumulates
- stomata close in the dark
- carbon dioxide is therefore not absorbed

19. **Explain how the light-independent reactions of photosynthesis rely on light-dependent reactions.** *8 marks*

- light-independent reaction fixes CO2
- to make glycerate 3-phosphate
- to triose phosphate / phosphoglyceraldehyde /glyceraldehyde 3-phosphate
- using NADPH
- ATP needed to regenerate RuBP
- ATP is made in light-dependent reactions
- light causes photo activation / excitation of electrons
- flow of electrons causes pumping of protons into thylakoid membrane

- electrons are passed to NADP/NADP+
- NADPH produced in the light dependent reactions

20. **Outline the formation of carbohydrate molecules in photosynthesis starting from the absorption of light energy.** *6 marks*

light-dependent reaction: 3 max

- chlorophyll absorbs light (energy)/photons
- electron activated/excited
- electron passed down electron carriers
- ATP produced
- NADP+ reduced/ reduced NADP produced/ NADPH produced

light-independent reaction: 3 max

- CO2 fixed by/reacts with 5C molecule (RuBP)
- RuBisCo/ribulose bisphosphate carboxylase/RuBP carboxylase catalyzes reaction
- (two) 3C molecules/ glycerate 3-phosphate/GP produced
- reduced NADP and ATP used to reduce glycerate 3-phosphate/GP
- triose phosphate/TP produced

21. **Compare the structure of a chloroplast and a mitochondrion in relation to function.** *8 marks*

similarities:

- both are double membrane organelles
- both contain DNA
- both contain ribosomes
- both have an electron transport chain
- both produce ATP by chemiosmosis
- both contain ATP synthase /ATPase
- *3 max for labelled diagrams without the similarities stated*

chloroplast:

- site of photosynthesis
- third membrane system / thylakoid membranes
- photosynthetic pigments/chlorophyll to absorb light
- light generated ATP production
- H+ gradient across thylakoid membrane

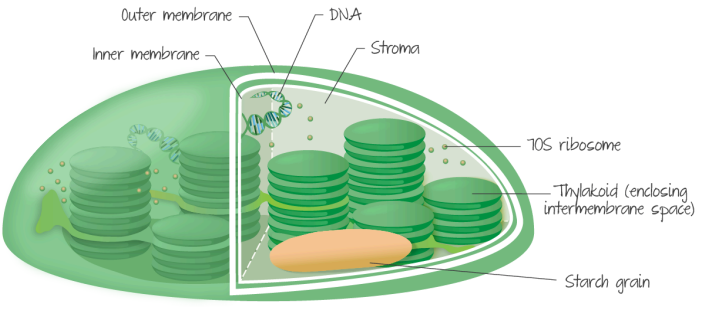
mitochondrion:

- site of respiration
- ATP production by oxidation of organic molecules / fats / amino acids
- H+ gradient across inner membrane

22. **Draw a labelled diagram of the structure of a chloroplast as seen with an electron microscope.** *4 marks*

Award [1] for each of the following clearly drawn and correctly labelled. Label lines must be unambiguous in terms of what they are indicating.

- double/inner and outer membrane/envelope – shown as two concentric continuous lines close together;



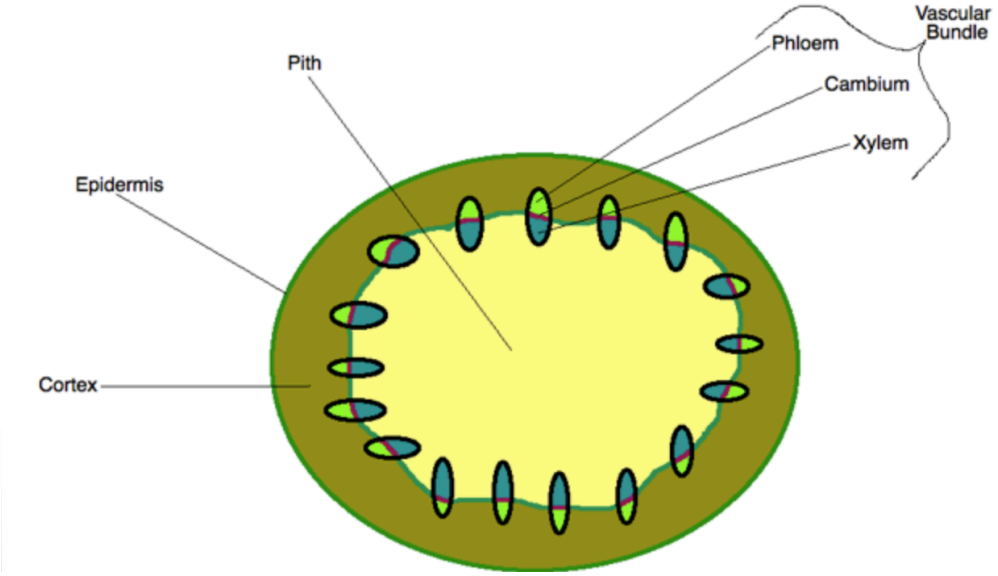
- granum/grana – shown as a stack of several disc-shaped subunits;
- (intergranal) lamella – shown continuous with thylakoid membrane;
- thylakoid – one of the flattened sacs;
- stroma;
- (70S) ribosomes/(circular) DNA / lipid globules / starch granules / thylakoid space;

Unit 9: Plant Biology

9.1: Transport in the Xylem of Plants

The main parts of growing plants are roots, stems and leaves. Draw a plan diagram to show the arrangement of tissues in the stem of a dicotyledonous plant. *5 marks Award [1] for each of these structures clearly drawn and labeled.*

- epidermis shown on the outside with thickness less than 10 % of overall diameter;
- cortex labeled between the outer layer of the stem and the vascular bundles;
- xylem shown on the inner side of the vascular bundles;
- phloem shown on outer side of the vascular bundles;
- vascular bundle with some way of indicating the entire structure;
- pith shown in center;
- cambium shown between xylem and phloem;

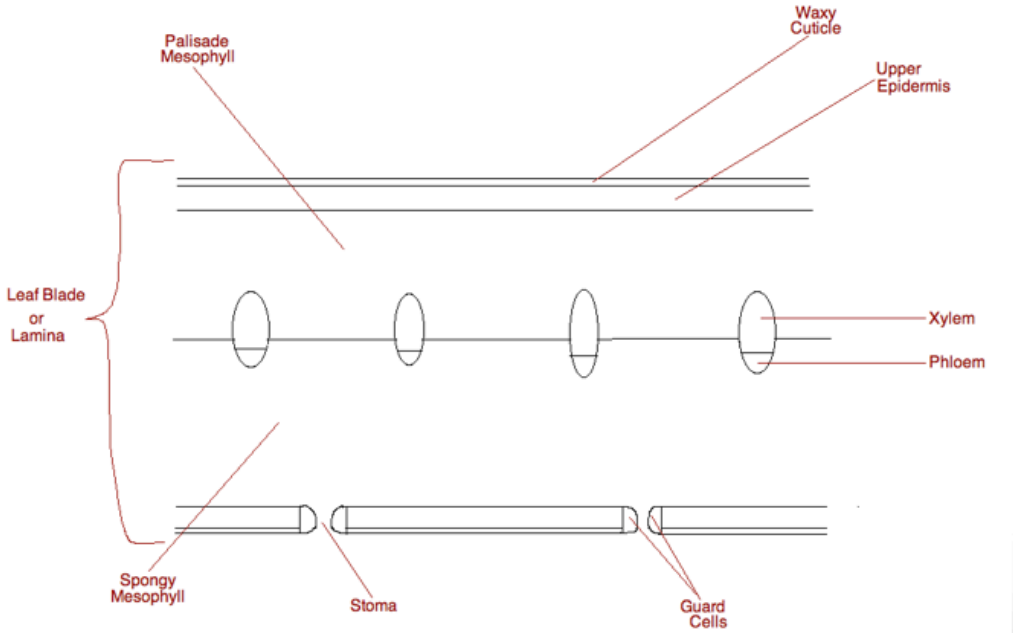


Draw a labeled diagram showing the tissues present in a dicotyledonous leaf. *4 marks*

*Award **1** for each structure clearly drawn and correctly labeled. Accept a plan diagram without individual cells.*

- upper and lower epidermis;
- palisade mesophyll under upper epidermis
- 3 to 1
- 2 of leaf thickness;
- spongy mesophyll/layer in lower half of leaf;
- vein showing separate areas of xylem above phloem;
- stoma/stomata labeled in (lower) epidermis;
- two guard cells; (at least one must be labeled for mark)

Explain the functions of the different tissues of a leaf. *8 marks*



Function must be given to award mark.

- cuticle (produced by epidermis) prevents water loss
- epidermis protects cells inside the leaf
- stomata (in epidermis) for gas exchange
- palisade parenchyma / mesophyll / layer for photosynthesis
- spongy parenchyma / mesophyll / layer for photosynthesis
- air spaces for diffusion of O2 / CO2 / gases
- spongy mesophyll for gas exchange / absorption of CO2
- xylem transports water / mineral salts / ions to the leaves
- phloem transports products of photosynthesis / sugars (to flowers / new leaves / stem / roots / fruit)
- stomata allow transpiration (which helps transport of mineral nutrients)
- guard cells open and close stomata
- guard cells close stomata to reduce transpiration

Outline the adaptations of plant roots for absorption of mineral ions from the soil. *5 marks*

- mineral ions are absorbed by active transport;
- large surface area;
- branching (increases surface area);
- root hairs;
- root hair cells have carrier protein/ion pumps (in their plasma membrane);
- (many) mitochondria in root (hair) cells;
- to provide ATP for active transport;
- connections with fungi in the soil/fungal hyphae;

Describe the process of mineral ion uptake into roots. *5 marks*

- absorbed by root hairs / through epidermis
- root hairs increase the surface area for absorption
- uses active transport / uses ATP / uses energy
- use of proteins / pumps to move ions across membrane
- against concentration gradient / diffusion gradients into cell / root
- can enter cell wall space / be drawn through cell walls / apoplastic pathway
- selective / only specific ions absorbed

Describe how water is carried by the transpiration stream. *7 marks*

- transpiration is water loss (from plant) by evaporation;
- flow of water through xylem from roots to leaves is the transpiration stream;
- evaporation from spongy mesophyll cells;
- replaced by osmosis from the xylem;
- (diffusion of water vapor) through stomata;
- water lost replaced from xylem / clear diagram showing movement of water from xylem through cell(s) (walls) to air space;
- water pulled out of xylem creates suction/low pressure/tension; transpiration pull results;
- water molecules stick together/are cohesive;
- due to hydrogen bonding/polarity of water molecules;
- xylem vessels are thin (hollow) tubes;
- adhesion between water and xylem due to polarity of water molecules;
- creates continuous column/transpiration stream;

Explain how abiotic factors affect the rate of transpiration in a terrestrial plant. *8 marks*

- less transpiration as (atmospheric) humidity rises
- smaller concentration gradient (of water vapor)

- more transpiration as temperature rises
- faster diffusion / more kinetic energy (of water molecules)
- faster evaporation (due to more latent heat available)

- more transpiration as wind (speed) increases
- humid air / water vapor blown away from the leaf
- increasing the concentration gradient (of water vapor)

- more transpiration in the light
- due to light causing stomata to open
- wider opening with brighter light hence more transpiration
- CAM plants opposite
- narrower stomata with high carbon dioxide concentration hence less transpiration

List three abiotic factors which affect the rate of transpiration in a typical mesophytic plant. *3 marks*

- light
- temperature
- wind
- humidity

Explain how wind affects the rate of transpiration from a leaf. *5 marks*

- wind blows air / water vapor away from the leaf
- water vapor that has diffused out of the stomata is carried away
- low humidity maintained near the leaf without wind air becomes saturated
- large water concentration gradient between inside and outside the leaf
- rapid diffusion of water vapor therefore rapid transpiration
- no effect if the air brought by the wind is already saturated

Outline adaptations of xerophytes. *4 marks*

- xerophytes are plants that live in dry conditions;
- reduced leaves/spines to prevent water loss (by transpiration);
- rolled leaves to prevent water loss / stomata on the inside / sunken stomata;
- thick waxy cuticle/hairs on leaves to prevent water loss (by transpiration);

- reduced stomata to prevent water loss (by transpiration) / stomata on one side of leaf;
- deep/widespread roots to obtain more water;
- special tissue for storing water;
- take in carbon dioxide at night / CAM plant to prevent water loss;

9.2: Transport in the Phloem of Plants

Outline the role of the phloem in the active translocation of biochemicals. *5 marks*

- living tissue
- composed of companion cells / sieve tube members
- companion cells involved in ATP production
- sucrose / amino acids / assimilate / products of photosynthesis transported
- bi-directional transport
- source / leaves to sink / fruits / roots /storage organs / named storage organ
- pressure flow hypothesis / movement of water into phloem causes transport

9.3: Growth in Plants

Explain the role of auxin in phototropism. *8 marks*

Accept clearly annotated diagrams for phototropism marking points.

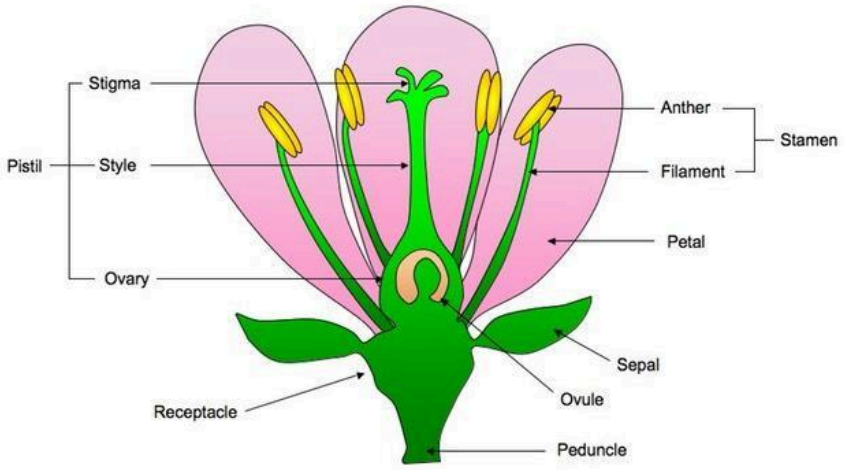
- auxin is a plant hormone;
- produced by the tip of the stem/shoot tip;
- causes transport of hydrogen ions from cytoplasm to cell wall;
- decrease in pH / H+ pumping breaks bonds between cell wall fibers;
- makes cell walls flexible/extensible/plastic/softens cell walls;
- auxin makes cells enlarge/grow;
- gene expression also altered by auxin to promote cell growth;
- (positive) phototropism is growth towards light;
- shoot tip senses direction of (brightest) light;
- auxin moved to side of stem with least light/darker side
- causes cells on dark side to elongate/cells on dark side grow faster;

9.4: Reproduction in Plants

Draw the structure of a dicotyledonous animal-pollinated flower. *6 marks*

*Award **1** for each of the following structures clearly drawn and labelled correctly.*

- petals
- sepal
- stigma
- style
- ovary
- stamen / anther and filament
- receptacle / nectary



Explain the conditions needed for seed germination. 4 *marks*

- water needed
- water causes swelling which bursts the testa / seed coat / water softens the testa / seed coat
- water mobilizes soluble food reserves / enzymes / medium for metabolic processes
- water rehydrates cells / tissues
- water transports hydrolyzed food reserves
- water transports growth promoters / hormones
- water dilutes / washes out growth inhibitors

- oxygen needed
- oxygen required for (aerobic) respiration
- which provides ATP for metabolic activity

- warmth increases enzyme activity *(reject enzymes denatured)*
- fire breaks down inhibitors
- chilling breaks down inhibitors
- light breaks down inhibitors / stimulates germination in some species
- degradation of testa makes it more permeable to water / gases

Explain how flowering is controlled in long-day and short-day plants. *7 marks*

- flowering affected by light;
- phytochrome;
- exists in two (interconvertible) forms/Pfr and Pr;
- Pr (red absorbing/660 nm) converted to Pfr (far-red/730 nm absorbing) in red or day light;
- sunlight contains more red than far red light so Pfr predominates during the day;
- gradual reversion of Pfr to Pr occurs in darkness;
- Pfr is active form / Pr is inactive form;
- in long-day plants, flowering induced by dark periods shorter than a critical length / occurs when day is longer than a critical length;
- enough Pfr remains in long-day plants at end of short nights to stimulate flowering;
- Pfr acts as promoter of flowering in long-day plants;
- short-day plants induced to flower by dark periods longer than a critical length/days shorter than a critical value;
- at end of long nights enough Pfr has been converted to Pr to allow flowering to occur;
- Pfr acts as inhibitor of flowering in short-day plants;

Unit 10: Genetics and Evolution

10.1: Meiosis

Describe the process of meiosis. *8 marks*

- **Interphase** □ G1, S and G2 phases
- **Prophase I**
  - Chromosomes pair up in homologous pairs
  - Crossing over results in the exchange of genetic material between non-sister chromatids.
  - Nuclear membrane breaks down
  - Spindle microtubules stretch out from each pole to the equator
- **Metaphase I**
  - Homologous chromosomes line up at the equator
  - Spindle fibers attach to the chromosomes.
- **Anaphase I**
  - Homologues chromosomes are separated and pulled to opposite poles.
  - Cell membrane starts to prepare for separation at the equator.
- **Telophase I**
  - Nuclear membrane reforms around each daughter nucleus.
  - Each chromosome from a homologous pair are found at opposite poles.

- **Brief interphase** without the S phase

- **Prophase II**
  - Spindle microtubules stretch out from each pole
  - Nuclear membrane breaks down.
  - No crossing over
- **Metaphase II**
  - Chromosomes in each cell line up at the equator
  - Spindle microtubules attach to the centromere of each chromosome
- **Anaphase II**
  - Sister chromatids pulled to opposite poles in both cells.
- **Telophase II**
  - Nuclear membrane reforms around four sets of daughter chromosomes

- **Cytokinesis follows** □ Four daughter cells produced

Outline the formation of chiasmata during crossing over. *5 marks*

- Crossing over/chiasmata formed during prophase I of meiosis
- Pairing of homologous chromosomes/synapsis
- Chromatids break (at same point) **(do not accept chromatids overlap)**
- Non-sister chromatids join up/swap/exchange alleles/parts
- X shaped structure formed / chiasmata are X-shaped structures
- Chiasmata formed at position where crossing over occurred
- Chiasmata become visible when homologous chromosomes unpair
- Chiasmata holds homologous chromosomes together (until anaphase)

Explain how an error in meiosis can lead to Down syndrome. *8 marks*

Accept the points below in an appropriately annotated diagram.

- non-disjunction;
- chromosomes/chromatids do not separate / go to same pole;
- non-separation of (homologous) chromosomes during anaphase I;
- due to incorrect spindle attachment;
- non-separation of chromatids during anaphase II;

- due to centromeres not dividing;
- occurs during gamete/sperm/egg formation;
- less common in sperm than egg formation / function of parents' age;
- Down syndrome due to extra chromosome 21;
- sperm/egg/gamete receives two chromosomes of same type;
- zygote/offspring with three chromosomes of same type / trisomy / total 47 chromosomes;

10.2: Inheritance

Describe how human skin color is determined genetically.

- skin color is an example of polygenic inheritance
- many/more than two genes contribute to a person's skin color
- due to the amount of melanin in the skin
- combination of alleles determines the phenotype
- allows for range of skin colors / continuous variation of skin color
- phenotypes do not follow simple mendelian ratios of dominance and recessiveness
- the environment also affects gene expression of skin color / sunlight/UV light stimulate melanin production
- the more recessive alleles there are, the lighter the skin color

Calculate and predict genotypic and phenotypic ratios of offspring of dihybrid crosses involving unlinked autosomal genes. *3 marks.*

Example: *Dihybrid cross between plants with tall, purple flowers*

Let T = tall plant allele (dominant)
Let t = short plant allele (recessive)

Let P = purple flower allele (dominant)
Let p = white flower allele (recessive)

P Generation: TtPp (tall purple flowers) × TtPp (tall purple flowers)

Gametes: TP : Tp : tP : tp × TP : Tp : tP : tp

	TP	Tp	tP	tp
TP	TTPP tall ; purple	TTPp tall ; purple	TtPP tall ; purple	TtPp tall ; purple
Tp	TTPp tall ; purple	TTpp tall ; white	TtPp tall ; purple	Ttpp tall ; white
tP	TtPP tall ; purple	TtPp tall ; purple	ttPP short ; purple	ttPp short ; purple
tp	TtPp tall ; purple	Ttpp tall ; white	ttPp short ; purple	ttpp short ; white

F_1 Generation:

Genotype: Refer to Punnett grid

Phenotype: 9 tall purple : 3 tall white : 3 short purple : 1 short white

- Phenotypic ratio is 9:3:3:1

Identify which of the offspring in dihybrid crosses are recombinants

Recombination = the reassortment of alleles into combinations different from those of the parents as a result of independent assortment, crossing over and fertilization.

- Heterozygous test cross: $\left(\frac{b^+\ vg^+}{b\ vg} \times \frac{b\ vg}{b\ vg}\right)$
- Recombinants: $\frac{b^+\ vg}{b\ vg} + \frac{b\ vg^+}{b\ vg}$

10.3: Gene pools and speciation

Discuss evolution by gradualism and punctuated equilibrium

- Both describe the pace/speed/rate of evolution
- Gradualism suggests that evolution occurs over a long time
- Gradualism changes are slow/steady over time
- Gradualism would occur when there is little change in the environment
- Punctuated equilibrium implies long periods with no change
- Punctuated equilibrium implies short periods with great change
- Punctuated equilibrium occurs when there are great changes in the environment
- Example; (e.g.: in times of volcanic activity/meteorite impact/great climate change/ OWTTE)
- Generally accepted that both ideas take place in evolution.

Outline allopatric and sympatric speciation. *4 marks*

- speciation is the formation of a new species by the splitting of an existing species;
- allopatric speciation caused by geographical separation;
- sympatric speciation occurring within the same habitat caused by different niches / caused by courtship/feeding differences/behavioral differences;
- both processes lead to isolation of sub-populations;
- isolation favors certain genetic variations (within a species);
- over time this leads to genetic barriers/speciation;

Both allopatric and sympatric speciation must be mentioned. 3 max if only one mentioned.

Discuss the theory that evolution occurs by punctuated equilibrium. *3 marks*

- long periods where there was no (apparent) change/stasis
- short periods of rapid evolution
- periods of mass extinctions leading to opportunities/caused by environmental disruption/rapid environmental change in short periods
- supported by lack of fossils showing gradual changes
- an example of such environmental disruption (meteors, earthquakes, volcanoes, *etc.*)
- alternative theory is gradualism
- punctuated equilibrium is based on fossil evidence rather than biochemical evidence

Explain how polyploidy can contribute to speciation. *4 marks*

Polyploidy

- having more than 2 (complete) chromosome sets/description of polyploidy;
- happens through chromosome mutation / non disjunction;
- occurs more frequently in plants than animals;

Contribution to speciation

- polyploids cannot reproduce with original species / meiosis fails / chromosomes cannot pair;
- creates reproductive barrier;
- but can self-fertilize / reproduce with similar individuals;
- thus forming a new species;
- new species formed by sympatric speciation;

Unit 11: Animal Physiology

11.1: Antibody Production and Vaccination

Explain the role of antibody production with regard to vaccinations. *8 marks*

- vaccine injected into body / ingested
- containing killed / weakened pathogen / fragments of pathogen / toxins
- macrophages ingest antigen / antigen presenting cells ingest antigen
- T-helper cells bind to macrophages
- T-helper cells stimulated / activated

- antigen binds to B-cells
- activated T-helper cells then bind to B-cells
- activation of B-cells
- which divide / undergo mitosis to form clones of (plasma) cells

- B-cells / plasma cells produce antibodies
- memory cells produced
- second / booster shot sometimes given
- more antibodies and faster response / graph to show this
- antibodies are specific to antigen

Explain the production of antibodies against a pathogen. *8 marks*

- antigen/pathogen engulfed by macrophage (by endocytosis)
- presentation of antigen by macrophage on membrane/MHC protein
- helper T-cell binds to macrophage
- helper T-cell activated
- activated helper T-cell binds to (inactive) B-cell
- B-cell is activated by helper T-cell
- B-cells start to divide/clone
- plasma cells formed/grow
- plasma cell increase numbers of rough ER/Golgi apparatus
- B cells/ clone / plasma cells begin to produce antibodies to the specific antigen
- antibodies secreted/ pass out through membrane (by exocytosis)
- memory cells give long-term immunity/ allow rapid antibody production

Explain why antibiotics are used to treat bacterial but not viral diseases. *2 marks*

No credit for answers that state antibiotic means against life nor for the statement that viruses are not alive.

- antibiotics block metabolic pathways in bacteria / inhibit cell wall formation / protein synthesis
- viruses use host cell metabolic pathways / do not possess a cell wall and so are not affected by antibiotics
- antibiotics are not used to treat viral diseases because they are ineffective and may harm helpful bacteria

Describe the production of monoclonal antibodies. *2 marks*

- (B) lymphocyte obtained that produces the desired antibody
- (B) lymphocyte fused with myeloma / tumor cells
- (hybridism) cells formed in this way are cultured to produce antibodies

Outline the role of fibrinogen. *2 marks*

- soluble substance that can be converted to insoluble substance
- converted to fibrin (in cuts)
- helps to form a **clot**
- to seal a cut / prevent more blood loss / prevent entry of infection

Describe the processes involved in blood clotting. *6 marks*

- cells/tissue is damaged/cut/bruised;
- damaged cells/platelets release clotting factors;
- (clotting factors cause the) production of thrombin;
- blood plasma contains soluble fibrinogen;
- fibrinogen converted into fibrin;
- by thrombin;
- forms a net of fibers trapping blood cells;
- forming a clot / prevents blood loss / entry of bacteria/pathogens;
- cascade of reactions/series of stages prevent accidental clotting/speed up clotting;

Explain the role of antibody production and the principle of vaccination in immunity. *8 marks*

antibody production:

- exposure to antigen
- leads to activation of (helper) T-cells
- leads to clonal selection / activation of specific type of B-cell
- production of plasma cells
- specific antibody produced
- memory cells produced which provide long lasting immunity

principle of vaccination:

- artificial exposure to antigen / artificial active immunity
- use dead / attenuated pathogen / protein material
- first vaccination produces lymphocytes specific to antigen
- booster shot causes more intense response / graph to show this
- immunity to disease before actually contracting the disease

Polio is a viral disease which affects the nervous system. Describe the different ways in which the body could acquire immunity to this disease. *6 marks*

- natural immunity by catching the diseases
- antigen presentation by macrophages/MHC proteins
- helper T-cells activated
- lymphocytes/ B-cells react forming antibodies
- clonal selection/ multiply when they encounter antigen
- polyclonal if more than one clone formed
- memory cells formed
- natural passive immunity by placenta/ breast feeding
- artificial active by vaccination/ Sabin vaccine/ Salk vaccine
- artificial passive by injection of antibodies

Discuss the cause, transmission and social implication of AIDS *8 marks*

the answer must include at least one reference to cause, transmission, and social implications in order to receive full marks

cause:

- acquired immunodeficiency syndrome
- caused by HIV/ human immunodeficiency virus

- retrovirus/ RNA to DNA
- enters (and lowers number of) T-helper cells
- less antibodies produced/ immune system disabled/ weakened
- body vulnerable to pathogens (opportunistic infections)

transmission

- transmission through body fluids/ does not live long outside the body
- through sexual intercourse
- sharing of infected needles
- mother to fetus/ across placenta
- blood transfusions
- blood products/ factor VIII used to treat hemophiliacs

social implications

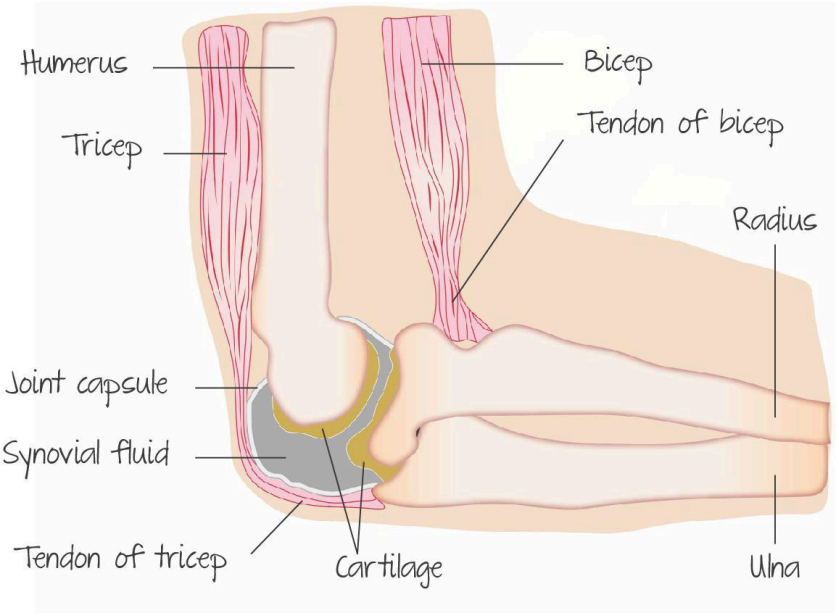
- families and friends suffer grief
- great costs/ reduction in workforce/ economic implications
- discrimination/social stigma
- increase in number of orphans/ family structure/ stability affected
- reduces promiscuity/ encourages use of condoms

Tuberculosis is a disease of the ventilation system. Explain how white blood cells attack the pathogens that cause this disease. *8 marks*

- B-cells/ lymphocytes produce antibodies
- antigen recognized
- antigen can be protein in cell wall of pathogen
- macrophage presentation of antigen
- clone formed/ division of cells
- T-helper cells assist
- formation of antigen-antibody complex (neutralization/agglutination/precipitation)
- phagocytes engulf
- ingest by endocytosis
- kills pathogen
- digested by lysosomes
- formation of memory cells

11.2: Movement

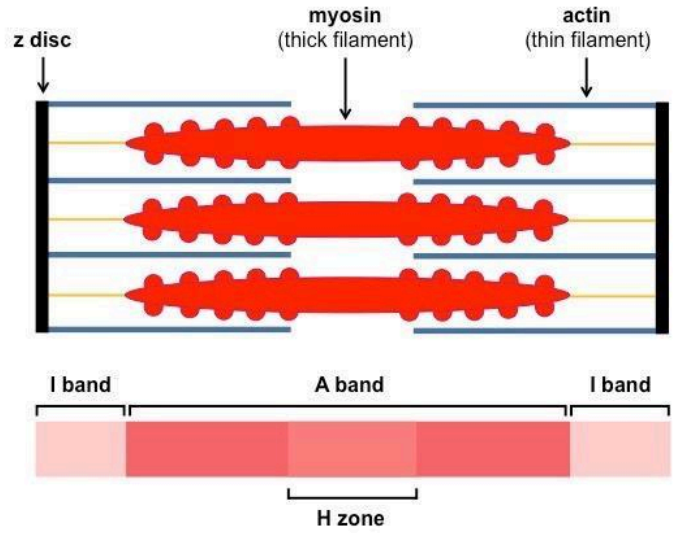
Label a diagram of the human elbow. *8 marks*



Draw a labelled diagram to show the structure of a sarcomere. *8 marks*

Award [1] for each structure clearly drawn and correctly labelled.

- Sarcomere – clearly indicated between Z lines;
- Z lines;
- actin filaments attached to Z line;
- myosin filaments with heads;
- (two) light bands; dark band;



Explain how a skeletal muscle contracts. *8 marks*

- Muscles are made up of myofibrils which contain repeating units called sarcomeres
- Sarcomeres contain actin filaments and myosin filaments
- Actin fibers are thin and myosin fibers are thick;
- Arriving action potential causes release of Ca2+ from sarcoplasmic
- Ca2+ binds to troponin causing tropomyosin to be released
- Exposing binding sites on actin
- ATP binds to myosin heads releasing them
- ATP hydrolysed and is split into ADP + Pi
- ATP causes myosin heads to change shape
- Myosin heads bind to exposed actin binding sites
- Myosin heads move actin (releasing ADP + Pi)
- Myosin filaments move actin filaments towards center of sarcomere
- Sliding of actin and myosin filaments shortens the sarcomere, contracting the muscle

Explain how a muscle fiber contracts, following depolarization of its plasma membrane. *8 marks*

- Calcium released from sarcoplasmic reticulum
- Calcium binds to troponin
- Troponin with calcium bound makes tropomyosin move
- Movement of tropomyosin exposes binding sites (for myosin) on actin
- Contraction of muscle fibers is due to the sliding of filaments (over each other)
- Myosin heads bind to / form cross bridges with actin
- ATP binds to the myosin heads causing them to detach from the binding sites
- Hydrolysis of ATP / conversion of ATP to ADP causes myosin heads to move

- Myosin heads reattach to actin further along
- Myosin pushes actin / actin pushed towards the centre of the sarcomere / shortening of sarcomere

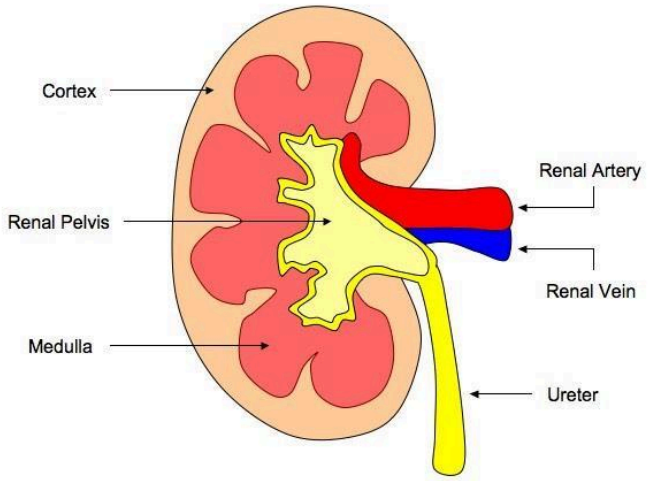
Explain how the contraction of skeletal muscle is controlled by the nervous system. *4 marks*

- Controlled by (motor areas of) the cerebral cortex
- Impulse sent via motor neuron
- Impulse crosses synapse
- Increase of calcium in muscles
- Sliding of actin and myosin
- Causes contraction of muscle fibers

11.3: The Kidney and Osmoregulation

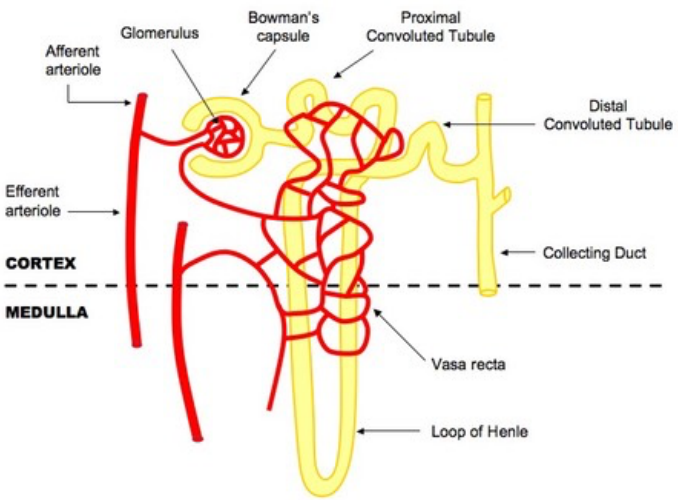
Label the structure of a kidney. *6 marks.*

- Cortex;
- Renal Pelvis;
- Medulla;
- Renal Artery;
- Renal Vein;
- Ureter;



Label and Annotate the structure of the nephron. *8 marks.*

- *Afferent arteriole:* Brings blood to the nephron to be filtered
- *Efferent arteriole:* Removes blood from nephron (minus filtered components)
- *Glomerulus:* Capillary tuft where filtration occurs
- *Bowman's Capsule:* First part of nephron where filtrate is collected
- *Proximal Convoluted Tubule:* Where selective reabsorption occurs
- *Loop of Henle:* Important for establishing a salt gradient in the medulla
- *Distal Convoluted Tubule:* Final site of selective reabsorption
- *Collecting Duct:* Feeds into ureter and is where osmoregulation occurs
- *Vasa Recta:* Blood network that reabsorbs components from the filtrate



Distinguish between the composition of the blood of the renal artery and the blood of the renal vein. *3 marks.*

- less urea/excretory waste products/creatinine in renal vein
- less oxygen in the renal vein / more carbon dioxide in renal vein
- less glucose in renal vein
- concentration of sodium ions/chloride ions/pH at normal level in the renal vein whereas it is variable in renal artery
- solute concentration/osmolarity/water balance at normal level in the renal vein whereas it is variable in renal artery

Explain the process of ultrafiltration. *2 marks.*

- blood (in the glomerulus) under high pressure caused by difference in diameter of (afferent and efferent) arterioles;
- fluid plasma and small molecules forced into kidney tubule/Bowman's capsule/ through fenestrations/basal membrane;
- which prevent larger molecules/blood cells from passing through;

Explain how the structure of the nephron and its associated blood vessels enable the kidney to carry out its functions. *8 marks.*

- Osmoregulation / excretion of nitrogenous waste/urea «is a function of the» kidney
- Ultrafiltration in the glomerulus/smaller molecules filtered out in the glomerulus
  OR
- capillary walls/glomerulus permeable to smaller molecules
  Reject ultrafiltration in the Bowman's capsule.

- Basement membrane/filtration slits/podocytes act as filter/prevent loss of «large» «proteins»/prevent loss of blood cells
- High «blood» pressure in glomerulus due to larger afferent than efferent arteriole
- «Selective» reabsorption of glucose/useful substances in proximal convoluted tubule

- Microvilli/coiling/convolutions give large surface area
  OR
- pump proteins to reabsorb specific solutes «in proximal convoluted tubule»

- Water reabsorbed in descending limb «of loop of Henle»
- ***OR***
- descending limb permeable to water

- Active transport/active pumping of sodium ions/Na+ out of ascending limb «from filtrate to medulla»
- Ascending limb is impermeable to water
- Loop of Henle creates solute gradient/high solute concentration/hypertonic conditions in medulla
- Distal convoluted tubule adjusts pH/adjusts concentration of Na+/K+/H+
- Water reabsorbed in collecting duct
- Collecting duct permeability to water varies due to number of aquaporins/ADH
- Osmoregulation by varying the amount of water reabsorbed «in the collecting duct»

Explain osmoregulation in the kidney. *8 marks.*

- Osmoregulation takes place in the Loop of Henle and the collecting duct;
- In the medulla;

Loop of Henle

- Descending limb is permeable to water but not to Na^+ ions;
- Ascending limb is permeable to Na^+ ions but not to water;
- Na^+ ions are pumped out of the ascending limb into the medulla;
- Generating osmotic potential between the nephron and the medulla;
- Some water leaves descending loop by osmosis;
- Output is reduced volume, reduced salt concentration;

Collecting duct

- Filtrate enters collecting duct from the distal convoluted tubule;
- Countercurrent flow of blood in capillaries and filtrate in duct maintains concentration gradient - osmosis of water into blood;
- Dehydration (detected by hypothalamus) leads to the release of ADH (by pituitary);
- ADH opens aquaporins (water channels) in walls of duct;
- Increase transfer of water into blood, therefore hypertonic urine;
- Excess water in blood leads to break down of aquaporins and hypotonic urine.

Explain why diabetes could be detected through the analysis of urine. *8 marks.*

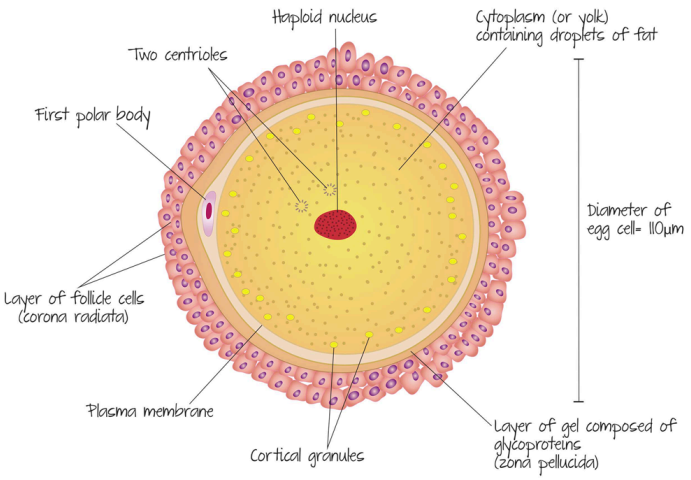
- urine of diabetics contains glucose;
- whereas urine of non-diabetics contains no glucose;
- glomerular filtrate contains glucose / glucose filtered out;
- glucose (normally) reabsorbed from filtrate/into blood;
- through wall of / in the proximal convoluted tubules;
- blood glucose concentration higher than normal in diabetics;
- reabsorption not completed / pumps cannot reabsorb all glucose in diabetics;
- glucose in urine can be detected using test strips;
- type I diabetes is lack of insulin secretion / lack of β cells;
- type II diabetes is body cells not responding to insulin / not absorbing glucose;

11.4: Sexual Reproduction

Label the structures of the mature egg. *7 marks.*

Award [1] for each structure clearly drawn and correctly labelled.

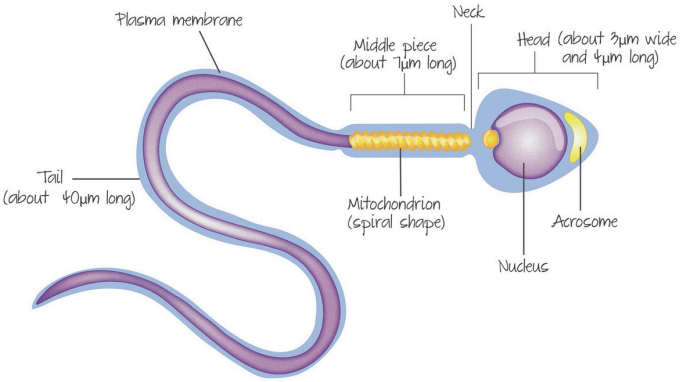
- Follicle cells
- Zona pellucida
- 1st polar body
- nucleus
- nucleolus
- cytoplasm



Label the structures of the mature sperm. *4 marks.*

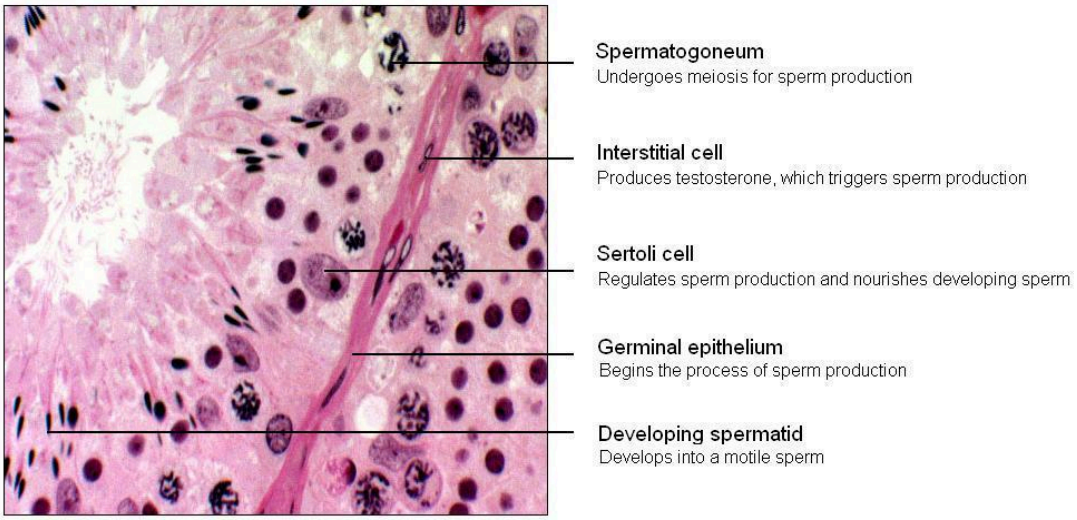
Award [1] for each structure clearly drawn and correctly labelled.

- Acrosome
- Head
- Nucleus
- Midpiece (motor) with mitochondria
- Flagellum

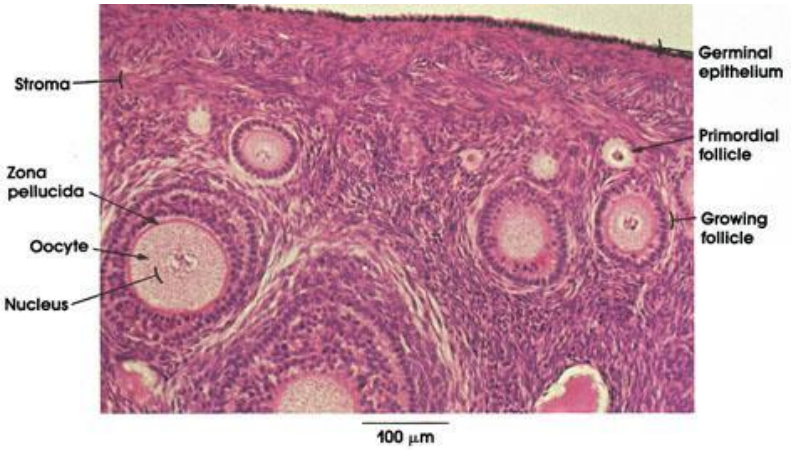


Annotate this light micrograph of testis tissue. *3 marks.*

Award [1] for every structure correctly labelled

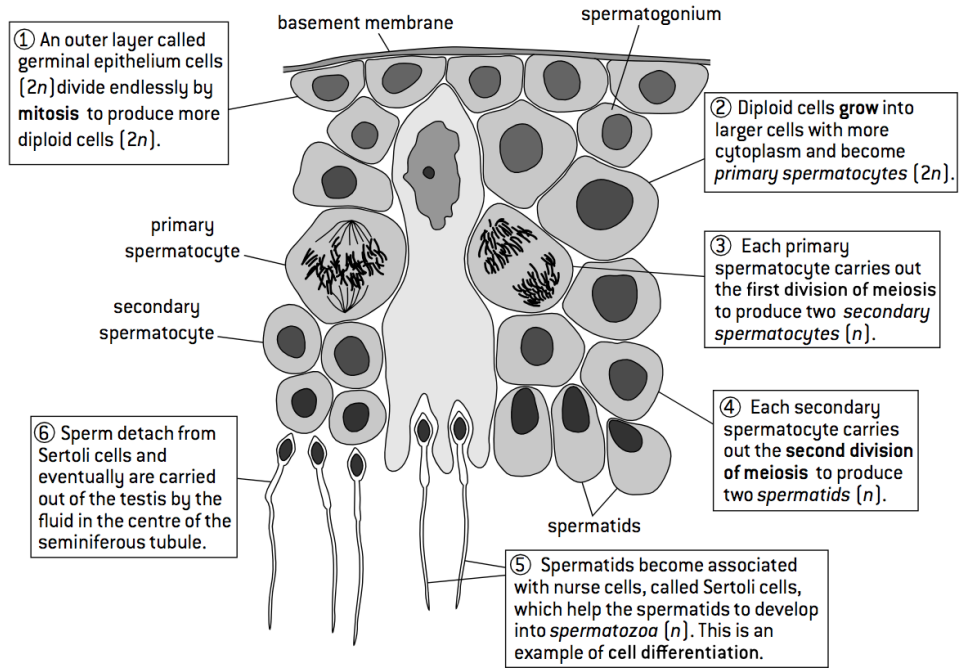


Annotate this light micrograph of ovary tissue. *3 marks.*



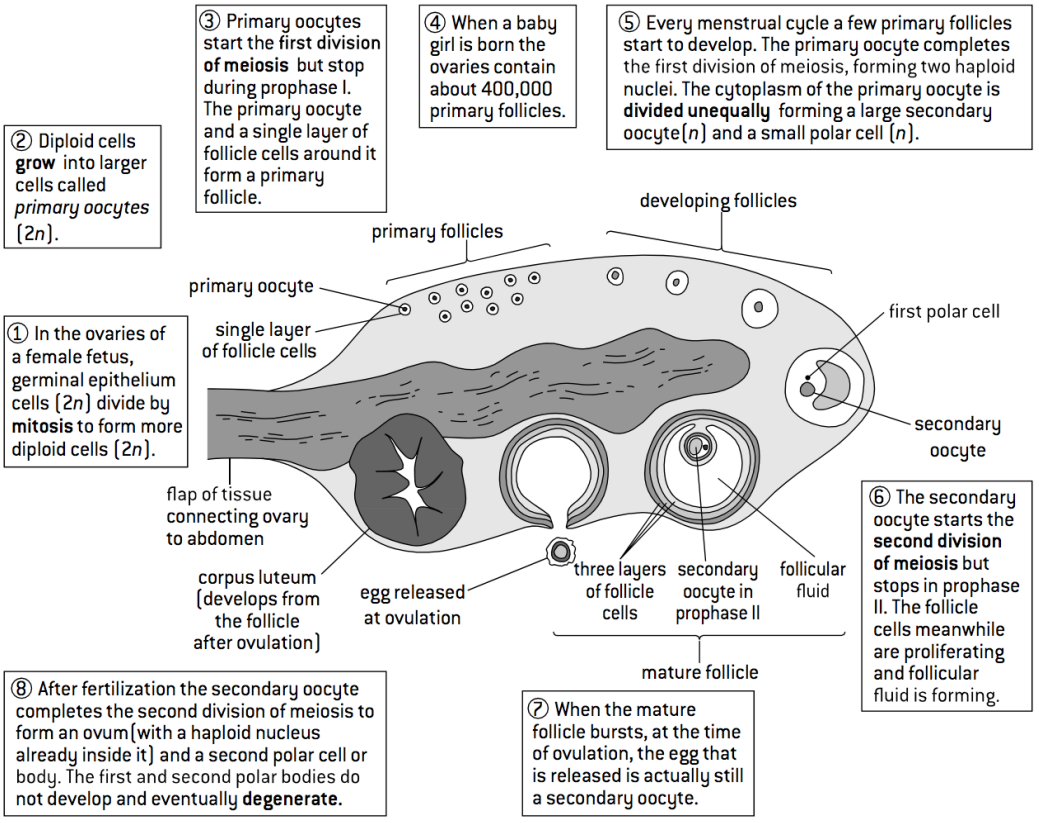
STAGES IN SPERMATOGENESIS

The five stages of spermatogenesis are shown in this diagram of cells in the wall of the seminiferous tubule.



Explain the process of spermatogenesis in the testes. *6 marks.*

Explain Oogenesis. *8 marks.*



Compare spermatogenesis and oogenesis. *8 marks.*

Spermatogenesis	**Oogenesis**
Four gametes produced per primary cell.	**One** gamete produced per primary cell.
Formation of gametes is **constant** after puberty.	Formation of gametes happens **once a month** after puberty.
Two meiotic divisions.	**Two** meiotic divisions.
Gametes released via **ejaculation.**	Gametes released via ovulation, controlled by LH.
Millions of gametes released at a time.	**One** gamete released at a time.
FSH, LH, testosterone involved in gamete production	**FSH, LH, Estrogen, Progesterone** involved in gamete
Gametes produced in the **testes**	Gametes produced in the **ovary.**

Explain the stages of fertilization. *10 marks.*

- sperm are attracted by a chemical signal and swim up the oviduct to reach the egg;
- fertilization is only successful if many sperm reach the egg;
- the first sperm to break through the layers of follicle cells binds to the zona pellucida;
- this triggers the acrosomal reaction;

- the content of the acrosome are released by the separation of the acrosomal cap from the sperm;
- hydrolytic enzymes from the acrosome digest a route for the sperm through the zona pellucida;
- this allows sperm to reach the plasma membrane of the egg;

- the plasma membranes of the sperm and egg fuse;
- the sperm enters the egg and joins the egg nucleus;
- this triggers the cortical reaction;

- small vesicles called cortical granules fuse to the plasma membrane of the egg;
- cortical granules release their contents into the egg by exocytosis;
- enzymes from the cortical granules cause the cross-linking of glycoproteins in the zona pellucida;
- this leads to the hardening of the zona pellucida which prevents polyspermy;

- the nuclei of the sperm and egg carry out mitosis to produce a two-cell embryo;

Outline the process of birth. *8 marks.*

- Levels of progesterone fall;
- Levels of estrogen rise;
- Falling progesterone makes the uterus sensitive to oxytocin;
- Rising estrogen levels trigger initial uterine contractions;
- Oxytocin maintains uterine contractions;
- Contraction of uterus causes release of oxytocin;
- Contractions therefore become more frequent (positive feedback);
- Contractions become stronger;