Revised AS2 June 2015

Directional selection is one of the processes which accounts for the large diversity of organisms on our planet.

Taxonomy is the study of this diversity with the aim of analysing the similarities and differences between organisms, so that they can be classified. Currently, the five kingdom system is the most widely accepted model for classification of organisms.

(a) Describe the process of directional selection. [5]

(b) Describe the main features of organisms in each of the five kingdoms. [8]

(a) Any **5** from:

- (genetic) variation exists within a population
- individuals at an extreme are more suited (adapted) to the environment/ fitter than others
- adapted individuals survive better/survival of the fittest
- and reproduce/pass on their genes
- frequency of selected feature increases in future generations
- leads to new adaptive norm
- occurs in changing environments

(b) Any **8** from:

- Prokaryotae reproduce by division
- lack a true cell nucleus/membrane-bound organelles/other prokaryote cell feature
- cell wall murein/peptidoglycan
- Protoctista are unicellular or show limited differentiation
- some heterotrophic, others autotrophic
- Fungi are lysotrophic (decomposers)/description of lysotrophy
- consist of hyphae with chitinous cell walls
- Plantae are autotrophs (producers)/description of autotrophy
- possess chloroplasts containing chlorophyll
- possess a cellulose cell wall
- Animalia are heterotrophic/description of heterotrophy
- capable of locomotion
- Fungi, Plantae, Animalia are multicellular
- Protoctista, Fungi, Plantae, Animalia are eukaryotic [13]

At least one from each of the 5 kingdoms (deduct one mark if all kingdoms not represented)

Revised AS2 June 2014

The mammalian circulatory system consists of different types of blood vessels which facilitate the transport and exchange of materials within the organism. In the event of a blood vessel becoming ruptured, a blood clotting mechanism is activated in order to protect against infection and prevent excessive blood loss.

(a) Describe the main structural adaptations found in mammalian blood vessels which facilitate their role in transport and exchange. Explain the purpose of these adaptations. [9]

(b) Outline the sequence of events which leads to the formation of a blood clot following a minor cut to the skin. [4]

(a) Any nine from

- all blood vessels possess squamous endothelium
- providing a smooth lining/reducing friction to aid blood flow

Capillaries have

- walls composed of a single layer of endothelium
- to reduce diffusion distance/maintain permeability/enable diffusion of materials
- a very narrow lumen
- to promote 'single-file' passage of erythrocytes thereby reducing diffusion distance

Arteries have

- numerous elastic fibres in their walls
- allowing distension/stretch and recoil since they are subject to pressure surges from the heart
- a thick layer of muscle in their walls
- to control blood supply to organs/to facilitate vasoconstriction (and vasodilation)
- a narrow lumen
- to maintain high blood pressure/to cope with high blood pressure

Veins have

- large lumen
- to facilitate return of blood to the heart
- pocket valves which close by backward flowing blood being trapped against them
- to ensure unidirectional flow of blood
- fibrous outer layer for protection (arteries/veins) [9]

(b) Any four from

- platelets/thrombocytes adhere to damaged blood vessel wall
- thromboplastins/thrombokinase is released
- so that prothrombin is converted to thrombin
- this causes fibrinogen to be converted to fibrin
- red blood cells trapped in the mesh of fibres
- clotting factors involved/calcium/vitamin K required [4]

8 In intensive agriculture, farmers maximise both the area and the productivity of the land which they farm. However, such practices have been associated with a reduction in biodiversity.

Describe the range of practices used in intensive agriculture, and explain how they can reduce biodiversity on farms. [13]

8 Any thirteen from

- removal of trees/hedgerows/herbaceous strip at field edge
- removes habitats for plants/wildlife corridors
- reseeding/increased use of monoculture
- reduces variety of plant species present in fields
- increased use of (animal) pesticides
- may remove natural predators/non-pest species
- increased use of herbicides
- kills some plant species
- increased use of artificial/nitrogenous fertiliser
- promotes growth of certain plants/causes some plants to be outcompeted
- drainage of wetland/filling in ditches(ponds)
- removes habitat for wetland plants/animals(or by example)
- increased use of slurry
- kills soil organisms
- high stocking rates
- damages hedgerows/overgrazes pasture/favours grass species
- decline of plants *[by any of the above means]* results in less food for animals
- early cropping of grass (for silage)
- removes nesting sites for ground-nesting birds
- other appropriate response [13]

Revised AS2 June 2013

8 Ventilation and circulation are examples of mass transport systems in mammals. In both processes, areas of differential pressure are created to enable mass transport to occur.

(a) Outline the sequence of events which leads to the creation of areas of differential pressure during inspiration. [3]

(b) Describe in detail the sequence of events, following the return of blood to the heart from the lungs, which leads to the creation of high pressure in the aorta. Your answer should include both the stimulation of heart muscle and the changes that take place within the chambers of the heart. [10]

8 (a) Any three points

- diaphragm muscles contract and diaphragm moves down
- intercostal muscles contract pulling rib cage up/out
- causing volume of thorax to increase
- resulting in thoracic/lung pressure decreasing below atmospheric pressure [3]

(b) Any ten points

- impulse originates from the sino-atrial node (SAN)/pacemaker
- wave of excitation reaches left atrium
- atrial systole occurs causing increasing pressure
- blood is pushed into left ventricle via the bicuspid valve
- ventricular pressure rises due to infilling of blood
- left ventricle not stimulated by an impulse direct from the atrium
- results in a time delay to allow complete atrial emptying
- wave of excitation reaches atrio-ventricular node (AVN)
- spreads down the bundle of His into Purkyne fibres
- ventricular systole occurs
- from the apex of the heart
- ventricular pressure exceeds atrial pressure so bicuspid valve closes
- ventricular pressure exceeds aortic pressure so semi-lunar valve opens
- blood flows into aorta causing an increase in pressure
- semi-lunar valves close as aortic pressure now exceeds ventricular pressure [10]

9 Animals and plants are adapted to the environment in which they live and their populations are capable of remaining adapted even when the environment changes.

(a) Describe the environment to which xerophytic plants are adapted and explain the features which allow them to be adapted. [6]

(b) Explain how natural selection maintains the adaptiveness of a population in both stable and changing environments. [7]

9 (a) Any six points

- xerophytes are adapted to living in habitats with restricted water availability/where water loss might be excessive (where water loss needs to be reduced)
- conditions may be arid (dry)/windy/frozen soil/sandy (soil with low water content)
- possess a thick cuticle which increases the efficiency of the waterproofing layer/decreases cuticular transpiration
- very small leaves reduce surface area (-to-volume ratio)/reduce number of stomata
- few stomata reduces the main route for transpiration
- stomata sunken in leaf/leaf covered by hairs/leaf rolled (with stomata on the inside) deflects air currents/allows humid air to build up outside the stomata (reducing the diffusion gradient out of the leaf) **[any two points]**
- water storage cells/succulent leaves provide water stores for use during periods of drought
- leaves adapted as spines prevent grazing and the exposure of tissue to evaporation
- extensive shallow root system/deep network of roots allow greater uptake of water when it becomes available
- other appropriate response [6]

(b) Any seven points

- organisms within a population are variable
- some are better adapted to their environment/habitat/some individuals are fitter
- differential survival of the better adapted individuals
- leading to reproductive success/the fittest leave more offspring
- when the feature is inheritable/genetically determined this influences future generations
- in a stable (non-changing) environment stabilising selection may occur
- selection of the adaptive norm (modal form)/selection against extreme forms
- in a changing environment directional selection may occur
- one (extreme) variant may be selected for/previous adaptive norm selected against
- frequency of selected variant may increase
- leading to new adaptive norm [7]

Revised AS2 June 2012

8 Give an account of the role of the following components of blood and explain any adaptations which they might have.

- Erythrocytes (red blood cells)
- White blood cells (polymorphs, monocytes and lymphocytes)
- Platelets and plasma proteins [13]

8 Any thirteen points

Erythrocytes:
- main role is to carry oxygen/contain haemoglobin
- no nucleus/organelles means there is more room for haemoglobin *[not simply 'no nucleus' – some explanation is necessary]*
- biconcave (disc) shape increases their surface area to volume ratio *[not simply 'increases surface area']*
- thinness means that haemoglobin is close to the (gas exchange) membrane/ cell surface
- to maximise the uptake/release of oxygen
- small size (diameter 8 μm) enables them to move easily through capillaries

White blood cells:
- main role is to fight infection
- polymorphs (microphages) (can migrate out of capillaries to) carry out phagocytosis
- monocytes also carry out phagocytosis/monocytes move out of capillaries to form macrophages/monocytes are longer lived
- phagocytosis involves the engulfing/endocytosis of bacteria (or viruses) and their subsequent digestion
- lymphocytes (B-lymphocytes) are involved in production of antibodies *[don't allow T-lymphocytes here]*
- T-lymphocytes are involved with cell-mediated immunity/kill cells infected by bacteria or viruses *[no detail of how they do this is required]*

Platelets and plasma proteins:
- platelets are involved in blood clotting
- damaged blood vessels cause platelets to break down/rupture/activate
- so that they release thromboplastin (and other clotting agents) activate/ platelets contain thromboplastin
- thromboplastin causes the conversion of prothrombin into thrombin
- which, in turn, causes the conversion of (soluble) fibrinogen into fibrin
- (insoluble) fibrin forms a threadlike mesh that covers the wound/traps escaping blood cells/prevents further loss of blood [13]

8 **(a)** Give an account of the role of surface area and volume in the metabolism of an organism and the effect of increasing body size on the relationship between these two factors. [5]

(b) Using the lungs and the blood system as examples, explain how mammals have compensated for increasing body size. [8]

8 **(a)** **Any five points**

- the volume of a body represents the bulk of its metabolically active tissue
- the greater the volume, the greater the need for metabolites/the greater the production of wastes (allow converse)
- metabolites are usually supplied by the surrounding environment
- the surface of a body is the interface with its surrounding environment
- the greater the surface area of a body the more metabolites can be absorbed/wastes can be excreted
- as an organism increases in size its volume increases proportionally more than its surface area/its SA to vol. ratios decreases (allow converse)
- illustration of this with 'cube measurements'
- for a larger organism, the absorptive ability needs to be increased to meet the increased demand [5]

(b) **Eight points (with a maximum five points from each area)**

Maximising absorption in lungs

- in the lungs the bronchi subdivide repeatedly into smaller bronchioles (each ending in a cluster of alveoli)
- the alveoli provide a large surface area for gas exchange
- the alveolar walls/capillary walls are composed of squamous epithelium
- which makes a short diffusion distance
- capillary walls are closely associated with alveolar walls
- ventilation/blood flow ensures there is always a diffusion gradient
- moisture inside the alveoli allows oxygen to dissolve prior to diffusion
- a dense network (large surface) of blood capillaries (surrounding each alveolus) provides a large surface area

Maximising delivery to tissues

- arteries deliver blood carrying oxygen/nutrients to the metabolically active cells
- arteries divide into a dense network of blood capillaries that permeate all tissues
- so that no body cell is more than a couple of cells away from a capillary
- capillary walls are very thin so that diffusion is easy
- there is a large surface area over which metabolites can diffuse rapidly into all cells/over which wastes can be removed from tissues
- red blood cells are biconcave discs increasing surface area (exposed to haemoglobin)
- haemoglobin is an efficient carrier of oxygen/has a high affinity for O_2
- the heart pumps blood to all tissues (parts of body)
- benefits of double circulation
- vasoconstriction/vasodilation controls blood flow to different organs [8]

8 Give an account of the processes involved in the movement of water through a plant, to include:

- the uptake of water into and through the root
- the movement of water through the stem
- the movement of water through and out of the leaf [13]

8 Any thirteen points

The movement of water into and through the root:
- root hairs provide a large surface area for the uptake of water (by osmosis)
- uptake into the root is from high (outside) to low water potential/movement through the root tissues is along a water potential gradient
- water moves through plant tissues via the apoplast or symplast pathway
- most water moves via the apoplast pathway/movement through the apoplast is faster
- the apoplast pathway involves water moving (by capillarity) along the cellulose walls
- water may also move through the cytoplasm of cells via the symplast pathway
- which are directly connected by plasmodesmata

Allow once only

- water may not pass through the endodermis by the apoplast pathway/must pass through the endodermis via the symplast pathway
- since the Casparian strip/suberin prevents passage through the cell walls/ apoplast pathway
- water passing through the endodermis via the symplast pathway comes under the control of the cells' metabolism

The movement of water through the stem:
- water is essentially pumped into the xylem in the root
- causing a root pressure
- water creeps along the walls of xylem vessels by capillarity
- because of the adhesive properties of water
- water molecules also attract neighbouring water molecules/there is cohesion in the water column
- the forces of adhesion and cohesion are caused by the polarity of water molecules
- the whole water column is moved upwards because of a negative pressure in the leaf
- due to water being drawn out of xylem vessels in the leaf

The movement of water through and out of the leaf:
- the evaporation of water from the mesophyll surface/into air space system
- and subsequent diffusion through open stomata
- causes water to be drawn through the mesophyll cells (mostly apoplast pathway)
- water moves through plant tissues via the apoplast or symplast pathway
- most water moves via the apoplast pathway/movement through the apoplast is faster
- the apoplast pathway involves water moving by capillarity along the cellulose walls
- water may also move through the cytoplasm of cells via the symplast pathway
- which are directly connected by plasmodesmata

Allow once only

- the mesophyll cells ultimately draw water out of the leaf's xylem vessels

[13]

9 *Quality of written communication is awarded a maximum of 2 marks in this section.* [2]

(a) Give an account of the structure of haemoglobin and its role in absorbing oxygen in the lungs. [5]

(b) Explain how oxygen is supplied to strenuously exercising muscle. [8]

9 (a) Any five from

- haemoglobin is a conjugated protein/contains haem groups
- haem is an iron-containing prosthetic group
- each haemoglobin molecule has four haem groups, each capable of carrying oxygen/can carry four oxygen molecules
- the percentage saturation of the haemoglobin with oxygen depends on the partial pressure of oxgen (allow by example)
- reference to S-shaped dissociation curve (allow diagram)
- cooperative loading/the effect of initial binding facilitating subsequent binding
- because binding of oxygen twists the polypeptide
- in the lungs, ppO_2 is high
- in the lungs/at high ppO_2, almost all the haemoglobin is carrying oxygen/is in the form of oxyhaemoglobin [5]

(b) Any eight from

- strenuously exercising muscle has a high rate of respiration
- increased rate of respiration consumes (more) oxygen/reduces the ppO_2
- a reduced ppO_2 causes dissociation/unloading of oxygen from the (oxy)haemoglobin
- increased rate of respiration also increases $ppCO_2$ (reduces pH)/ increases temperature (produces heat)
- increased $ppCO_2$ reduces the oxygen-carrying ability of the haemoglobin (dissociation curve moves to the right)
- so more oxygen is released/unloaded
- this is called the Bohr effect
- the Bohr effect is caused by carbon dioxide combining with the haemoglobin and bringing about a change in structure (which means that it loses some affinity for oxygen)
- the Bohr shift is also caused by an increase in temperature
- muscle (red muscle) may contain myoglobin
- which has a very high affinity for oxygen/acts as a store of oxygen
- releasing oxygen when the ppO_2 becomes especially low
- this allows aerobic respiration to continue/delays the onset of anaerobic respiration [8]

9 The relationships between the various factors affecting the rate of gas exchange are expressed in Fick's Law:

$$\text{Rate of diffusion} \propto \frac{\text{Surface area} \times \text{Concentration gradient}}{\text{Diffusion distance}}$$

(a) Explain the influence of each factor on the rate of diffusion. [3]

(b) With reference to these factors, describe how the mammalian lung is adapted to maximise gaseous exchange. [10]

9 **(a)** Increasing surface area increases the diffusion rate;
a large (steep) concentration gradient increases the rate of diffusion;
decreasing diffusion distance increases diffusion rate/increased diffusion distance reduces the effectiveness of a large surface area and large diffusion gradient; [3]

(b) **Any 10 from**

Large surface area for the exchange surface is achieved by:
- large numbers of alveoli
- spherical shape of the alveoli/sacculation of their sacs
- extensive network of blood capillaries
- the presence of surfactant prevents collapse of the alveoli (which would reduce surface area)
- large surface area of red blood cells to pick up oxygen
- red blood cells have a large surface area due to their biconcave disc structure

Large (steep) concentration gradient is maintained by:
- ventilation of the lungs 'freshens' the air in the alveoli
- increases concentration of oxygen in the alveolus/decreases carbon dioxide concentration
- blood brought back to the alveolus has a low concentration of oxygen/ high concentration of carbon dioxide
- this allows diffusion of oxygen into blood/carbon dioxide out of the blood
- additionally there is a rich blood supply
- blood loaded with oxygen is quickly removed/haemoglobin has a high affinity for oxygen (at rich partial pressure of oxygen in the lung) *(allow converse for carbon dioxide)*

Short diffusion distance is achieved by:
- single layer of cells lining the alveolus/capillary
- squamous (flattened) epithelium of the alveoli (reduces the thickness of the walls)
- squamous endothelium of the capillaries reduces the thickness of the walls
- capillaries and alveolar walls being very close to each other
- red blood cells within the capillary are close to the endothelial cells

[10]

9 (a) Describe the process of transpiration. [3]

(b) Explain how the following factors influence the rate of transpiration.

- Temperature
- Humidity
- Wind speed [10]

9 (a) Any three from

- transpiration is the evaporation of water/water loss from the aerial parts of a plant
- by evaporation from the moist surfaces of mesophyll cells
- drawn up to the leaf via the xylem/drawn across the leaf by the apoplast pathway
- and the subsequent diffusion from sub-stomatal air spaces out of the leaf
- stomatal pores are the main site of water loss in the leaf with a small amount of water being lost via cuticular evaporation [3]

(b) Ten points to include at least three from each section

Temperature:
- an increase in temperature causes an increase in transpiration
- at higher temperatures the water molecules gain more kinetic energy
- as a result it is easier for the water to evaporate from the mesophyll surfaces
- and diffusion out of the leaf is faster
- high temperature causes water stress/wilting of the leaf

Humidity:
- an increase in humidity causes a decrease in transpiration
- the concentration gradient between the outside air and the air inside the leaf decreases/diffusion shells builds up
- there is no diffusion without a diffusion gradient
- water will then not evaporate from the mesophyll cell surfaces
- as water vapour builds up in the sub-stomatal air space

Wind speed:
- an increase in air speed over the leaf causes an increase in transpiration
- the concentration gradient between the outside air and the air inside the leaf increases/diffusion shells dispersed/water vapour blown away from leaf
- maintaining a large (steep) diffusion gradient
- water evaporates rapidly into the sub-stomatal air spaces in a suitable ambient temperature

- stomatal pores close to conserve water **[Allow once in either section]**

[10]

8 Give an account of the co-ordinated sequence of events which result in the flow of blood through the heart during one cardiac cycle. [15]

8 Any thirteen points

Atrial systole:
- excitation wave is initiated at the SA-node/cardiac muscle myogenic
- electrical impulses discharged across atrial muscle triggers atrial systole
- the remaining blood is forced into the ventricles/atrial systole "tops up" the ventricle
- electrical impulses cannot pass directly to the ventricle muscle (because of a sheet of non-conducting fibrous connective tissue between the atria and the ventricles)
- ensures ventricular systole follows atrial systole

Ventricular systole:
- AV-node "picks-up" the impulses from the atrial muscle
- impulses pass along the Bundle of His and Purkinje fibres to the ventricle wall
- ventricular systole increases pressure within the ventricles
- blood pressure increases from the base of the ventricles
- blood is forced against the AV-valves which close (not just closed must relate to above)
- the chordae tendinae prevent the AV-valves blowing inside out (so preventing reflux of blood into the atria)
- closure of the AV-valves causes the first heart sound
- semilunar valves are blown open
- blood exits the ventricles via the pulmonary artery/aorta

Diastole:
- ventricular diastole results in a decrease in pressure within the ventricles
- semilunar valves close as "pockets" fill with blood/ventricular pressure is less than the pressure in the artery
- closure of the semilunar valves causes second heart sound
- reflux of blood into the ventricles is prevented
- blood returns to the atria from the venae cavae or pulmonary veins (also during ventricular systole)
- as atria fill with blood, pressure increases/the AV-valves are pushed open during atrial diastole
- blood moves from atria to ventricles [13]

8 Give an account of the processes involved in the movement of water through a plant. [10]

8 **At least four points from each section**

Movement of water across the root:

- root hair cells maximises the surface area for water uptake by the roots/water moves through the root tissue via an osmotic gradient
- most water moves through the root tissues via the apoplast pathway/movement through the apoplast is faster
- moving by capillarity along the cellulose walls
- water may also move through the cytoplasm of cells via the symplast pathway
- which are directly connected by plasmodesmata
- water may not pass through the endodermis by the apoplast pathway
- since it is prevented from doing so by the Casparian strip
- as the Casparian strip contains a waterproof material/suberin
- water passing through the endodermis via the symplast pathway comes under the control of the cell's metabolism/offers selectivity/control of what enters

Movement of water through stem and leaf:

- water is essentially pumped into the xylem in the root
- causing a root pressure
- water moves along the walls of xylem vessels by capillarity
- because of the adhesive properties of water
- water molecules also attract neighbouring water molecules
- so that there is cohesion in the water column/an unbroken water column
- the forces of adhesion and cohesion are caused by the polarity of water molecules
- the whole water column is moved upwards because of a negative pressure in the leaf/cohesion-tension
- due to water being drawn out of xylem vessels in the leaf
- pits allow for lateral movement of water
- the evaporation of water from the mesophyll surface
- and subsequent diffusion through open stomata/loss of water from the aerial parts of the plant is known as transpiration
- causes water to be drawn through the mesophyll cells (mostly by the apoplast pathway) and ultimately out of the leaf's xylem vessels [10]

AS2 June 2008

8 Give an account of how exchange or absorption is facilitated by each of the following surfaces.

- Alveoli
- Villi [10]

8 Ten points (with at least four from each section)

Alveoli:

- alveoli represent a large surface area/70m^2 in an adult human
- outer surface contains surfactant (from septal cells) that lowers the surface tension and helps maintain maximum surface area for gas exchange by preventing alveolar walls sticking together following expiration
- alveoli are lined by a squamous epithelium/flattened cells
- this thin layer decreases the diffusion distance of gases
- the outer surface is kept moist
- since gases must first be dissolved before diffusing through the surface layer
- have air pumped to and from the surface/are ventilated during inspiration/ expiration
- and are surrounded by blood capillaries of the circulatory system
- which maintain concentration gradients

Villi:

- villi are finger-like projections of the ileum (mucosa) and so represent a large surface area
- the epithelial layer has a convoluted membrane forming microvilli/a brush border
- which greatly increases the surface area of the ileum
- increased area of membrane provides more protein carriers for absorption (facilitated diffusion/active transport)
- villi are lined by columnar epithelial cells
- many mitochondria present in the columnar epithelium provide ATP for active transport
- each villus possesses a network of blood capillaries
- which absorb the products of digestion/sugars/amino acids
- and a lacteal which absorbs fats
- the capillaries and lacteals represent mass flow systems which maintain diffusion gradients
- the movement of the villi (muscularis mucosa) enhances diffusion gradients for absorption [10]

AS2 January 2008

8 Give an account of the following transport systems in plants.

- Phloem
- Xylem [10]

8 Ten points (with at least four from each section)

Phloem:

- both tissues are forms of vascular tissue with phloem on the outside of the vascular bundle
- phloem is the tissue responsible for the transport of sugars and other organic substances
- the transport elements in phloem are the sieve tube elements
- the end walls of which are perforated/form sieve plates
- since sieve tube elements lie end-to-end (forming a tube) these facilitate transport
- sieve tube elements have a thin lining of cytoplasm and no nucleus/tonoplast
- next to each element is a companion cell, translocation relies on their metabolism
- movement through the sieve tubes may take place by mass flow/from source to sink or example
- movement is both up and down the plant
- phloem also contains parenchyma/fibres for support
- phloem is a living tissue

Xylem:

- xylem is the tissue responsible for the transport of water and mineral ions
- the conducting cells in xylem are the vessels
- which have a lignified secondary wall
- in mature xylem this is often pitted (or reticulate) to allow lateral movement of water into surrounding tissues
- in protoxylem (in growing regions) lignification is annular/spiral
- to allow for extension in the region of growth
- lignification prevents the vessels from collapsing/waterproof
- under the negative pressure generated by transpiration
- this pulls water up the xylem/movement unidirectional
- transport in vessels is also aided by forces of adhesion and cohesion/root pressure
- xylem also contains parenchyma/fibres/tracheids
- dead tissue/hollow/no cell contents
- no cross walls allows for a continuous column of water [10]

AS2 January 2007

8 Give an account of the adaptations and roles of the following blood vessels in the mammalian circulatory system.

- Arteries
- Capillaries
- Veins [10]

8 Ten points (with at least three from each section)

Arteries:

- three layers
- carry blood under high pressure
- have much elastic tissue to withstand pressure/smooth out pulse waves
- carry blood to organs/away from the heart
- contain much muscle tissue
- to control blood flow to organs/skeletal muscle (vasoconstriction)
- as a result have a thick wall/tunica media
- small lumen helps maintain pressure

Capillaries:

- wall consists of a pavement/thin endothelium only
- thin wall reduces diffusion distance
- represent a huge surface area
- tissue fluid formed at arterial end
- due to high (hydrostatic) pressure
- supply oxygen/glucose/metabolites to the tissues
- proteins too large to leave the blood stream/fluid reabsorbed at the venule end
- permeable to polymorphs
- very small lumen assists diffusion (slows blood flow, distorts red blood cells increasing their surface area)

Veins:

- three layers
- carry blood back to the heart
- under low pressure/non-pulsatile
- have a large lumen (less resistance to blood flow)
- and valves (to ensure one-way flow)
- surrounding muscle pump system aids blood flow
- thin wall
- tunica media contains less fibrous tissue [10]

8 Give an account of the roles of haemoglobin and myoglobin in providing respiring tissues with oxygen. [10]

8 Ten points (with at least three from each part)

Haemoglobin:

- haemoglobin is a conjugated/quaternary protein (with haem/iron groups capable of carrying oxygen)
- each haemoglobin molecule can carry four oxygen molecules
- red blood cells are packed with haemoglobin
- haemoglobin exhibits co-operative binding of oxygen/when first oxygen binds the polypeptide chains open up exposing other three haem groups/sigmoid shaped oxygen dissociation curve
- in the lungs, where the partial pressure of oxygen is high, almost all the haemoglobin is carrying oxygen/is in the form of oxyhaemoglobin
- (in actively metabolising tissues) where oxygen is consumed, oxyhaemoglobin dissociates, releasing oxygen
- the first oxygen is not readily released, but once it is other oxygen molecules unload more readily
- at higher carbon dioxide partial pressures, more oxygen will be released by oxyhaemoglobin/less oxygen will remain attached to the haemoglobin, the Bohr effect/oxygen dissociation moves to the right
- its significance is that actively respiring tissue (such as exercising muscle) will increase the carbon dioxide partial pressure which, in turn, will promote the release of more oxygen
- the Bohr effect is caused by carbon dioxide combining with the haemoglobin and bringing about a change in structure which means that it loses some affinity for oxygen
- localised increase in temperature, also a product of actively respiring tissue (such as exercising muscle), will cause the oxygen dissociation curve to move to the right

Myoglobin:

- myoglobin is a conjugated protein with haem groups capable of carrying oxygen
- each myoglobin molecule can carry one oxygen molecule
- red muscle contains myoglobin
- myoglobin has a much higher affinity for oxygen/taking oxygen from oxyhaemoglobin
- at low oxygen partial pressures (while haemoglobin might be mostly dissociated), myoglobin is still well saturated/the dissociation curve lies well to the left
- myoglobin only dissociates when the oxygen partial pressure reaches very low levels
- such as happens during strenuous exercise
- essentially myoglobin acts as an oxygen reserve in muscle tissue
- maintians aerobic respiration for longer [10]

AS2 June 2005

8 Give an account of the adaptations of leaves in the following types of plants.

- mesophytes (with general adaptations)
- xerophytes (adapted to dry conditions)
- hydrophytes (adapted to aquatic life) [10]

8 Ten points (with at least three from each section)

Mesophytes (with general adaptations):

- mesophytic leaves have a large surface area allowing efficient absorption of sunlight
- the leaves are thin so photosynthesising cells are not far from the leaf surface where gas exchange and light absorption occur
- the waxy cuticle reduces water loss through the epidermis
- epidermis (upper) is transparent to allow transmission of light to the palisade layer below
- cells in the palisade mesophyll are closely packed together/contain numerous chloroplasts for maximal light absorption
- the spongy mesophyll contain air spaces to facilitate the movement of carbon dioxide through the leaf
- gas exchange between these air spaces and the atmosphere can occur via stomata in the lower epidermis
- guard cells close the stomata at night to reduce water loss
- transport tissues are common, allowing water to be brought to the photosynthesising cells (in the xylem)/products of photosynthesis to be transported away from the photosynthesising cells (in the phloem)
- lignified tissues (e.g. sclerenchyma) are common to provide support

Xerophytes (adapted to dry conditions):

- xerophytes frequently have a reduced surface area/reduced number of stomata to reduce transpirational water loss
- they often possess a thick waxy cuticle to reduce water loss
- there may be a multiple upper epidermal layer to protect the mesophyll cells from the effects of water loss
- the leaf may be curled maintaining a high humidity outside the stomata/ preventing air flow over the stomata
- hairs on the lower surface also reduce air flow over the stomata
- the stomata may be sunken in the epidermis, again to reduce air flow/ maintain a high humidity outside stomatal pores
- reversal of stomatal rhythm in some plants
- leaves may be succulent to store water (for periods of drought)

Hydrophytes (adapted to aquatic life):

- little waxy cuticle is present in the leaves as there is no need to reduce water loss
- stomata are found on the upper surface of floating leaves so providing an entry to gases from the air (a much richer source of gases than water)
- hydrophytes run no risk of dehydration
- large air space system may be present to provide the leaves with buoyancy/facilitates gaseous exchange
- xylem is poorly developed as water transport is not a problem and the surrounding water provides support [10]

8 Give an account of how a mammal obtains and then delivers oxygen to the tissues.
In your account you should describe each of the following processes.

- uptake of oxygen in the lungs
- delivery of oxygen by the blood circulatory system
- release of oxygen to the tissues [10]

8 Ten points (with at least three from each section).

Uptake of oxygen in the lungs:
- ventilation
- maintaining concentration of gradient of respiratory gases
- oxygen passes across the alveolar wall by diffusion since its partial pressure/concentration is higher in the alveolar air
- the alveolar wall is well adapted for this diffusion since it consists of a thin squamous epithelium/moist lining aids diffusion of respiratory gas/ role of surfactant
- so providing a very short distance over which diffusion has to occur
- the alveoli also provide a huge surface area over which uptake of oxygen can take place
- the capillaries are in intimate contact with the alveoli and also have a thin endothelium/red blood cells in contact for longer
- at the oxygen partial pressure in the lungs the haemoglobin becomes fully saturated (oxyhaemoglobin)
- haemoglobin exhibits an enhanced uptake of O_2

Delivery of oxygen by the blood circulatory system:
- oxygenated blood carried back to heart via pulmonary vein
- oxygenated blood pumped to body from left ventricle/via aorta
- haemoglobin has a high affinity/loads readily with O_2
- each haemoglobin carries 4 O_2
- oxygen is carried by haemoglobin packaged in red blood cells
- the red blood cells are well adapted for this role since they are very small (8 μm)/they have no nucleus
- the surface area to volume ratio is further enhanced by their biconcave shape
- blood viscosity is lowered with the haemoglobin in cells (rather than in the plasma)

Release of oxygen to the tissues:
- the partial pressure of oxygen in the tissues is low
- since it is used in respiration
- when oxyhaemoglobin arrives in the tissues it dissociates releasing oxygen
- this is enhanced by the Bohr effect
- due to the higher carbon dioxide partial pressure in the tissues/increased temperature in the tissues
- oxygen diffuses through the thin walls of the capillary networks within the tissues/the capillary networks represent a huge surface area over which diffusion occurs [10]

8 Give an account of the role of the following components of blood.

- red blood cells
- white blood cells
- platelets [10]

8 Ten points (with at least two from each component)

Red blood cells:

- red blood cells main role is to carry oxygen
- to do this effectively they are extremely small (about 10 μm in diameter)/ biconcave discs
- thus they have a relatively very large surface area to volume ratio/ and are able to pass through the minutely small capillaries
- they are packed with haemoglobin molecules/mature cells have no nucleus
- oxygen combines with haemoglobin in a reversible reaction forming oxyhaemoglobin/haemoglobin is a quarternary protein with four polypeptides, each haem combines with an oxygen molecule/co-operative binding takes place
- at high partial pressures of oxygen (in the lungs) haemoglobin has a high affinity (loading occurs) for oxygen
- at low partial pressures of oxygen (in a respiring tissue) haemoglobin has a low affinity (uploading occurs) for oxygen
- most oxygen is delivered to tissues with low ppO_2 and relatively high $ppCO_2$/high temperature (Bohr effect)
- haemoglobin packaged in cells means that this abundant protein does not influence the solute potential of the blood
- red blood cells are also involved in the carriage of small amounts of carbon dioxide/hameoglobin acts as a buffer

White blood cells:

- white blood cells provide defence against infection
- there are different types of white blood cells, including lymphocytes, polymorphs and monocytes
- lymphocytes are involved in the production of antibodies
- T-lymphocytes are involved in cell-mediated immunity and the destruction of bacteria, etc.
- polymorphs/monocytes are phagocytic cells/cells which accumulate at sites of infection
- ingest invading bacteria, etc.

Platelets:

- platelets are involved in blood clotting
- platelets become sticky/break down when they pass through a damaged blood vessel
- substances collectively called thromboplastin are released when tissues are damaged
- thromboplastin sets in motion a series of events leading to the formation of a blood clot/directly converts prothrombin (a blood protein) to thrombin
- resulting in the conversion of fibrinogen (a blood protein) to fibrin
- a network of fibrin traps red blood cells
- an external clot forms a scab which prevents further blood loss and infection
- many factors inhibit clotting, when these fail a thrombosis results, (a clot in an intact blood vessel, usually a vein)/an internal clot in an artery results in lack of oxygen to the tissue supplied [10]

8 Give an account of the movement of water in plants. Your account should include an explanation of each of the following.

- movement through the apoplast and symplast
- the cohesion–tension theory
- the role of transpiration [10]

8 Ten points, with at least two from each section

Movement through plant tissues:

- water moves into root hair cells by osmosis because of higher water potential in soil solution and lower water potential in a root hair cell
- water moves across the root cortex along a gradient of water potential
- most water moves via the apoplast pathway/movement through the apoplast is faster
- moving by capillarity along the cellulose walls
- water may also move through the cytoplasm of cells via the symplast pathway
- which are directly connected by plasmodesmata
- water may not pass through the endodermis by the apoplast pathway
- since it is prevented from doing so by the Casparian strip
- water passing through the endodermis via the symplast pathway comes under the control of the cells' metabolism

Movement through xylem tissue:

- active transport of minerals from endodermis into xylem
- decreases the solute potential in xylem/creates an osmotic gradient from endodermis into xylem
- influx of water into xylem creates hydrostatic pressure (root pressure)
- because of the adhesive properties of water they stick to the xylem wall
- this prevents the water column falling back
- water molecules attract neighbouring water molecules
- so that there is cohesion
- this prevents cavitation of the column
- the forces of adhesion and cohesion are caused by the polarity of water molecules
- the whole water column is moved upwards because of a tension in the leaf
- due to water being drawn out of xylem vessels in the leaf

Movement through the leaf:

- the evaporation of water from the mesophyll surface
- and subsequent diffusion
- through open stomata
- causes water to be drawn through the mesophyll cells (mostly apoplast pathway) and ultimately out of the leaf's xylem vessels
- producing the transpiration stream
- causing tension in the xylem

[10]

AS2 January 2003

9 Give an account of the structure and function of the mesophytic leaf. Include in your account an explanation of the following processes.

- photosynthesis
- transpiration
- transport into and out of the leaf [13]

9 Thirteen points with at least five points on structure and two points on each functional aspect

Structure:
- large surface area to maximise light harvesting
- covered by a layer of epidermis (in which cells lack chloroplasts)
- which has a waxy cuticle on the outer surface
- the inner tissue – the mesophyll – is differentiated into the upper palisade mesophyll and the lower spongy mesophyll
- the palisade mesophyll consists of tightly packed cylindrical cells
- the spongy mesophyll consists of loosely packed irregularly shaped cells with large air spaces between them
- palisade mesophyll cells have many more chloroplasts than the spongy mesophyll
- within the mesophyll layers there are vascular bundles
- veins/vascular bundles help support the leaf
- the lower epidermis particularly has pores known as stomata
- each stoma is bordered by a pair of guard cells which control its aperture
- the leaf is thin to minimise diffusion distances for photosynthetic gases

Photosynthesis:
- the palisade layer contains large numbers of chloroplasts
- the stomata are open during the day when photosynthesis can take place
- to facilitate the supply of carbon dioxide for photosynthesis
- the air spaces of the spongy layer allow the ready diffusion of carbon dioxide through the mesophyll

Transpiration:
- the waxy cuticle limits the loss of water by transpiration
- most transpiration takes place via open stomata during the day
- water evaporates from the moist surface of mesophyll cells
- the large surface area of the spongy mesophyll facilitates water loss
- causing water to be drawn out of xylem vessels
- moving along the cell walls/apoplast pathway
- stomata close at night to limit the total loss of water
- stomata can be closed in times of water shortage

Transport into and out of the leaf:
- xylem transports water and ions to the leaf
- apart from being transpired some water is used in photosynthesis
- manufactured organic substances are moved into the phloem sieve tubes
- which transport them to storage and actively growing regions of the plant

[13]

8 Give an account of the features of the gas exchange surface in a mammal and explain how these result in efficient gas exchange. [13]

8 Any thirteen points

- gas exchange takes place by diffusion
- diffusion is proportional to $\frac{\text{surface area} \times \text{concentration difference}}{\text{thickness of membrane}}$
- large surface area
- increases number of molecules that can diffuse through the surface at any one moment (and so speeds up rate of gas exchange)
- adaptation to increase surface area/alveoli in mammals (70 m^2 in an adult human)
- thin surface/wall
- so that diffusion pathway is very short
- alveoli have thin, flat cells/squamous epithelium (no more than 0.5 μm thick)
- surface ventilated
- maintains concentration gradients
- high oxygen concentration in the alveoli
- low carbon dioxide concentration in the alveoli
- oxygen moves out of alveoli and carbon dioxide moves into alveoli
- alveolar walls are fully permeable
- allowing oxygen to pass into the alveolar cells
- walls of alveoli that are in contact with the air are moist
- oxygen dissolves in this liquid before diffusing across the alveolar wall
- and into red blood cell/combine with haemoglobin
- the liquid also contains surfactant
- which reduces surface tension
- prevents the alveoli collapsing
- surface vascularised/covered by a network of blood capillaries
- maintain concentration gradients
- for collection of oxygen and delivery of carbon dioxide
- capillaries also provide a large surface area for exchange
- close to provide short diffusion distance
- capillaries have thin walls/pavement epithelium [13]