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6. Multicellular organisms benefit from cell specialization and division of labour.
(a) Outline the processes occurring during interphase in the cell cycle. [4]
a. growth/increase in cell size;
b. division of mitochondria/chloroplasts/production of more organelles/number of organelles doubled;
c. replication of DNA/amount of DNA is doubled;
d. transcription of genes/production of mRNA;
e. protein synthesis;
f. cell respiration/production of ATP;

(b) Describe what occurs in a neuron when an action potential is propagated along the axon. [4]
a. sodium ions/Na+ enter/diffuse in;
b. depolarization/membrane potential/voltage changes from negative to positive;
c. potassium channels open AND potassium ions/K+ exit/diffuse out;
d. repolarization/membrane potential/voltage changes back from positive to negative;
e. local current due to diffusion of sodium ions along the neuron;
f. (local currents) cause next sodium channels to open/next part of axon to depolarize;
g. opening of sodium channels triggered when threshold potential/-50mV reached;

(c) Explain how cells in the bloodstream cause a specific immune response. [7]
a. (specific immune response is) production of antibodies in response to a particular pathogen;
b. antibody is specific to/binds to a specific antigen;
c. macrophages/phagocytes engulf/present antigens from pathogens/viruses/bacteria;
d. T lymphocytes activated by antigens/antigen presentation/antigens presented by macrophage;
e. (activated) T lymphocytes activate B lymphocytes;
f. only B lymphocytes that produce antibodies against the antigen/pathogen are activated;
g. (activated) B lymphocytes clone/divide by mitosis to form plasma cells;
h. plasma cells then secrete (large quantity) of an antibody/secrete antibodies of same type;
i. some B lymphocytes/plasma cells form memory cells;
j. memory cells give long lasting immunity/faster response to a disease/pathogen;

n release of polypeptide and mRNA/disassembly of
ribosome complex at stop codon;

7. Water is the medium of life.
(a) Outline how hydrogen bonds form in water. [3]
a water (molecules) are polar/dipolar/have partially positive and negative poles/have δ+ and δ-;
b attraction/bonding between positive and negative (poles);
c hydrogen bond formed between hydrogen and oxygen; Reject if H and O in same molecule
d bond/attraction between different water molecules/intermolecular;

(c) Explain the role of the kidney in osmoregulation. [8]
a water moved/transported in xylem vessels;
b transported under tension/suction/pulled up (in xylem vessels);
c transpiration/loss of water (vapour) generates pulling forces/low pressure/tension;
d tension/pull generated when water evaporates from cell walls (in mesophyll);
e transpiration is loss of water vapour from leaf (surface)/stomata;
f cohesivity/cohesion in water due to hydrogen bonding/attractions between water molecules;
g cohesion/WTTE so chain/column of water (molecules) doesn't break/remains continuous;
h transpiration stream is a column of/flow of water in xylem from roots to leaves;

8. More than 8million different species are alive today but over the course of evolution, more than 4billion may have existed.
(a) Outline the criteria that should be used to assess whether a group of organisms is a species. [3]
a organisms can potentially interbreed;
b to produce fertile offspring;
c same sequence of genes (on chromosomes) / same types of chromosomes;
d similar traits/phenotype/WTTE;
e same chromosome number/karyotype;

(b) Describe the changes that occur in gene pools during speciation. [5]
a gene pool is all genes/alleles in an (interbreeding) population;
b gene pool splits/divides/separated during speciation;
c due to reproductive isolation (of groups within a species);
d temporal/behavioral/geographic isolation (can cause reproductive isolation);
e divergence of gene pools;
f allele frequencies change;
g natural selection different (in the isolated groups so there is divergence);

(a) Explain how chemical energy for use in the cell is generated by electron transport and chemiosmosis. [8]

a. NAD/FAD carries/is reduced by gaining «two» H «atoms»/«two» electrons
b. reduced NAD produced in glycolysis/link reaction/Krebs cycle
c. reduced NAD/FAD delivers electrons/hydrogen «atoms» to ETC
d. ETC is in mitochondrial inner membrane/cristae
e. electrons release energy as they flow along the chain/from carrier to carrier
f. electrons from ETC accepted by oxygen/oxygen is the final electron acceptor
g. proteins in the inner mitochondrial membrane/electron carriers act as proton pumps
h. protons pumped into intermembrane space/proton gradient across inner mitochondrial membrane/proton concentration higher in intermembrane space than in matrix
i. energy «from electrons» used to pump protons into intermembrane space/generate a proton gradient / high H+ concentration is a store of «potential» energy
j. ATP synthase in inner mitochondrial membrane/cristae
k. energy released as protons pass down the gradient/through ATP synthase
l. ATP synthase converts ADP to ATP/phosphorylates ADP
m. oxidative phosphorylation «is ATP production using energy from oxidizing foods»

(b) Outline four different functions of membrane proteins. [4]
a. receptor/binding site for hormone/neurotransmitter
b. cell-to-cell communication / cell recognition
c. channels «for passive transport» / facilitated diffusion
d. pumps / active transport
e. cell adhesion
f. «immobilized» enzymes/enzymes embedded in the membrane
g. electron transport / electron carriers

(c) Distinguish between anabolism, catabolism and metabolism. [3]
a. metabolism is all enzyme-catalyzed reactions in a cell/organism/is anabolism plus catabolism
b. anabolism is synthesis of polymers/complex/larger molecules/larger substances «from smaller molecules/monomers»
c. catabolism is breaking down «complex» molecules/substances «into simpler/smaller ones/into monomers»

6. Defence occurs on the micro and macro levels.
(a) Describe the functioning of immunoglobulins. [3]
a. «immumoglobulins are/function as» antibodies
b. variety of binding sites / variable regions for binding
c. specific to antigens on bacteria/viruses/pathogens
d. constant region aids destruction of the bacteria/virus/pathogen
e. attracts phagocytes/macrophages to engulf pathogen
f. bursting pathogen cells/agglutination/neutralizing toxins/other example of the action of antibodies

(b) Describe what happens in alveoli. [4]
a. gas exchange
b. oxygen diffuses from air to blood and carbon dioxide diffuses from blood to air
c. oxygen binds to hemoglobin in red blood cells
d. pressure inside/volume of alveoli increases/decreases / air enters/exits alveoli during inspiration/expiration/ventilation
e. blood flow through capillaries / concentration gradients of gases/oxygen/CO2 maintained
f. type II pneumocytes secrete fluid/surfactant / secretion of surfactant to prevent sides of alveolus adhering

(c) Distinguish between the composition of the blood of the renal artery and the blood of the renal vein. [3]
a. less urea/excretory waste products/creatinine in renal vein
b. less oxygen in the renal vein
c. more carbon dioxide in renal vein
d. less glucose in renal vein
e. concentration of sodium ions/chloride ions/pH at normal level in the renal vein whereas it is variable in renal artery
f. solute concentration/osmolarity/water balance at normal level in the renal vein whereas it is variable in renal artery

8. In ecosystems, energy is used to convert inorganic compounds into organic matter. Energy enters ecosystems through producers.
(a) Explain the processes by which light energy is converted into chemical energy. [8]
a. plants/producers/autotrophs convert light to chemical energy by photosynthesis
b. chlorophyll/photosynthetic pigments absorb light
c. electrons are excited/raised to higher energy level
d. excited electrons pass along chain of electron carriers
e. energy from electrons used to pump protons across thylakoid membrane/into thylakoid space
f. chemiosmosis/proton gradient used to make ATP
g. ATP synthase generates ATP
h. pigments arranged in photosystems
i. electrons from Photosystem II flow via the electron chain to Photosystem I
j. electrons from Photosystem I are used to reduce NADP
k. ATP and reduced NADP used in the light independent reactions/Calvin cycle
l. carbohydrate/glucose/carbon compounds produced containing energy

(b) Producers extract phosphates and nitrates from soil. Outline how these ions are used in the synthesis of organic molecules. [3]

a. by photosynthesis / using energy from light
b. attached to carbon compounds
c. phosphates used to make phospholipids/nucleotides/nucleic acids/DNA/RNA/ATP

d. nitrates are used to make amino acids/proteins/nucleotides/nucleic acids/DNA/RNA/ATP
e. transported from roots to leaves (in xylem)

(c) Describe how energy flows through and is used by organisms in ecosystems. [4]
a. producers/plants/autotrophs obtain energy from light/sun/inorganic sources
b. food contains energy / energy passed in the form of food/carbon compounds (along food chains/between trophic levels)
c. consumers obtain energy from other organisms/from previous trophic level This mark point distinguishes consumers from producers.
d. energy released (in organisms) by (cell) respiration Reject energy used in respiration.
e. ATP produced
f. energy/ATP used for biosynthesis/movement/active transport/other valid use of ATP
g. less energy available / energy lost at each trophic level

may 2016 tz0
5.
(a) Outline the action of enzymes. [4]
a. catalyse/speed up reactions
b. substrate-specific
c. lower the activation energy «of a chemical reaction»
d. substrate collides with/binds to active site
e. enzyme–substrate complex formed OR transition state formed OR bonds in substrate weakened

(c) Many genetic diseases are due to recessive alleles of autosomal genes that code for an enzyme. Using a Punnett grid, explain how parents who do not show signs of such a disease can produce a child with the disease. [4]

6.
(a) Draw a labelled diagram that shows the positions of proteins within the cell membrane. [3]
a. phospholipid bilayer drawn and labelled with at least one protein labelled and drawn embedded either in one or both halves of the bilayer
b. integral/intrinsic/transmembrane/carrier/pump/channel/pore protein labelled and shown crossing the membrane
c. extrinsic/peripheral protein labelled and shown on membrane surface/not embedded in bilayer
d. glycoprotein labelled and shown integral and with a clear carbohydrate region projecting out on one side of the membrane

(b) Outline the effects of putting plant tissue in a hypertonic solution. [4]
a. hypertonic solution has more solutes/higher solute concentration «than the

(c) Outline outcomes of the human genome project. [4]
a. complete human DNA/chromosomes sequenced;
b. identification of all human genes / find position/map (all) human genes;
c. find/discover protein structures/functions;
d. find evidence for evolutionary relationships/human origins/ancestors;
e. find mutations/base substitutions/single nucleotide polymorphisms;
f. find genes causing/increasing chance of/develop test for/screen for diseases;
g. develop new drugs (based on base sequences) / new gene therapies;
h. tailor medication to individual genetic variation / pharmacogenomics;
i. promote international co-operation/global endeavours;

6.
(a) Draw a labelled diagram to show the structure of a motor neuron. [4]
a. cell body – star shaped body at end of neuron with nucleus inside;
b. dendrites – as multiple long/narrow protrusions from the cell body;
c. axon – at least three times as long as the cell body not including the dendrites;
d. myelin sheath/Schwann cells – surrounding the axon;
e. nodes of Ranvier – periodic gaps in myelin sheath;
f. motor end plates – shown as buttons at the end of multiple branches of axon;

(c) Active skeletal muscle requires a good supply of oxygen. Outline the mechanism of ventilation in the lungs. [6]
during inhalation:
a. external intercostal muscles contract moving rib cage up and out;
b. diaphragm contracts becoming lower/flatter;
c. increase in volume and decrease in pressure (of thorax);
d. air flows into lungs as atmospheric pressure is higher;
during exhalation:
e. internal intercostal muscles contract so ribs move in and down;
f. diaphragm relaxes and returns to domed shape;
g. decrease in volume and (therefore) increase in pressure (of thorax);
h. air moves out until pressure in lungs falls/is equal to atmospheric pressure;
i. abdominal muscles can be used to make a stronger/forced exhalation

7.
(a) Draw a labelled diagram to show the structure of the plasma membrane. [5]
a. phospholipid bilayer – with head and tails;
b. hydrophilic/phosphate/polar heads and hydrophobic/hydrocarbon/fatty acid/non-polar tails labelled;
c. integral/intrinsic protein – embedded in the phospholipid bilayer;
d. protein channel – integral protein showing clear channel/pore;
e. peripheral/extrinsic protein – not protruding into the hydrophobic region;

j. random recombination of alleles during fertilization (leads to variation);
k. different phenotypes among members of the same population;
l. natural selection may lead to enhanced survival of recombinants;

(c) Accurate transmission of base sequences to offspring depends on successful gamete production. Describe how spermatogenesis occurs in humans. [6]
a. germinal cells / spermatogonia undergo mitosis to keep a supply of germinal cells present;
b. some germinal cells / spermatogonia grow larger to become primary spermatocytes;
c. primary spermatocytes go through meiosis I;
d. to form secondary spermatocytes;
e. these secondary spermatocytes go through meiosis II;
f. to produce spermatids;
g. spermatids differentiate/grow a tail and reduce their cytoplasm
h. spermatids associated with nurse cells (Sertoli cells);
i. sperm detach from Sertoli cells and enter lumen of the seminiferous tubule;
j. testosterone stimulates sperm production;

6.
(b) Describe the action of the heart in pumping blood. [5]
a. (both) atria collect blood (from veins);
b. sinoatrial/SA node sends impulses to muscle/fibres initiating contraction;
c. blood is pushed to ventricles by contraction of atria/atrial systole;
d. AV (atrioventricular) valves are open (as atria contract);
e. semilunar valves are closed so that ventricles fill with blood;
f. ventricles contract / ventricular systole;
g. AV (atrioventricular) valves close (preventing backflow);
h. (blood is pushed through the) semilunar valves/pulmonary artery and aorta;
i. when ventricles relax /diastole, semilunar valves close preventing backflow of blood;

(c) All parts of the body change the composition of the blood. Explain how the nephron changes the composition of blood. [7]
a. higher nitrogen/urea as blood enters nephron/Bowman's capsule than when it leaves the nephron (in the renal vein);
b. most small soluble molecules/glucose/nutrients/ions are removed from blood in Bowman's capsule;
c. through ultrafiltration;
d. proteins / blood cells / large molecules remain in the blood;
e. as filtrate moves through the nephron (tubule), water is returned to the blood (by osmosis);
f. glucose/nutrients is returned to blood by active transport (and diffusion) / selective reabsorption;
g. in the proximal convoluted tubule;

e. curve intersecting horizontal axis at a value above zero;
f. arrows added to axes or student annotates axis with “rate of photosynthesis increases” and “light intensity increases”

(c) Using a named example of a genetically modified crop, discuss the specific ethical issues of its use. [6]
a. named example of verified genetically modified crop; eg, Bt corn / golden rice;
Example must be verifiable.
b. specific gene added / new protein synthesized by the crop plant / specific modification; eg gene from Bacillus thuringiensis / cry protein;
c. biological effect of the modification; eg, makes the plant toxic to (herbivorous) insects / insect pests / corn borers;
[2 max] for benefits and [2 max] for harmful effects / costs;
d. a benefit of specific genetic modification; eg, increased crop yields / less land needed;
e. a second benefit of this specific modification; eg, reduced need for use of chemical pesticides;
f. a harmful effect of specific genetic modification; ingestion of toxin by nontarget species;
g. another specific harmful effect; eg, concerns about contamination of neighbouring non-GMO crops affecting trade;

8.
(a) Explain how minerals move into plants. [8]
a. minerals bound to soil particles;
b. examples of three nutrients from: phosphate, nitrate, magnesium, iron, calcium, potassium, sodium, magnesium;
c. minerals dissolve in water;
d. mass flow causes movement of minerals with movement of water through soil;
e. minerals diffuse down a concentration gradient towards roots (as the mineral concentration next to the roots is continuously decreasing);
f. minerals enter the plant through roots;
g. by active transport / use of ATP;
h. branching of roots increases surface area for absorption of minerals;
i. root hairs increase surface area (for the absorption of minerals);
j. hypha of (mutualistic) fungi may enhance movement of selected ions into roots / increase surface area;
k. root hairs have many mitochondria to provide energy/ATP for active transport;
l. export of H+ creates electrochemical gradient / displaces ions bound to soil/clay;
m. that causes positive mineral ions to diffuse into (root) cells;
n. negative mineral ions cross membrane linked to H+ ions moving down (H+) gradient;

(b) Outline the conditions needed for the germination of a typical seed. [3]
a. water to rehydrate the seed / activate metabolic processes;

liver;
gall bladder – connected to the small intestine (via bile duct);
pancreas – connected to small intestine (via pancreatic duct);

(c) Explain how the kidney helps to retain useful substances in the blood and eliminate substances which the body does not need. [8]
ultrafiltration occurs in the glomerulus;
basement membrane acts as a filter;
preventing proteins/cells from passing;
(filtered) substances pass to the Bowman's capsule;
to proximal convoluted tubule (PCT);
(where there is) selective reabsorption;
(in PCT) all glucose/amino acids are reabsorbed;
(in PCT most) water reabsorbed;
surrounding the loop of Henle, is an area of high solute concentration;
in distal convoluted tubule, ions are exchanged between filtrate and blood;
collecting duct has role in osmoregulation;
ADH regulates the amount of water reabsorbed;
substances not reabsorbed are eliminated as urine;

6.
(a) Describe the production of semen. [6]
sperm produced by meiosis;
in testis/seminiferous tubules;
sperm are stored/mature in the epididymis;
sperm able to swim;
seminal vesicles add fluid;
(seminal) fluid rich in fructose;
prostate gland adds fluids;
fluid rich in proteolytic enzymes/citric acid/acid phosphatase/lipids/minerals;
(semen) contains basic amines/alkaline substances;
which neutralizes acid/hostile environment of the vagina;

7.
(a) Define the terms chromosome, gene, allele and genome. [4]
chromosome: structure formed by DNA and proteins;
gene: a heritable factor that controls a specific characteristic;
allele: one specific form of a gene occupying the same gene locus as other alleles of the gene;
genome: the whole of the genetic information of an organism;