ACCESS EDUCATION

Victorian Certificate of Education
2018 Trial Paper

Letter

STUDENT NUMBER | | | | | | | | | |

STUDENT NAME _____

BIOLOGY
Written examination

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	40	40	40
B	11	11	80
			Total 120

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** for the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Question 1

Which of the following is an example of tertiary protein structure?

A. A β-pleated sheet within a channel protein.

B. The shape of the active site of a caspase.

C. A collagen fibre comprising three helical polypeptide chains.

D. The amino acid sequence in an immunoglobulin.

Question 2

Escherichia coli and some other species of bacteria that inhabit the human intestine, contain an operon called the lac operon which contains three genes, lacZ, lacY and lacA, together with a promoter region, an operator region and a terminator region. When lactose is available to the cell, the product of the lacZ gene alters it to create allolactose, which binds to a repressor protein changing its shape and causing it to detach from the lac operon. In the absence of allolactose, the repressor protein prevents the expression of lacZ, lacY and lacA by binding to

A. the promoter.

B. the operator.

C. the terminator.

D. the lacA gene.

Question 3

Galactosides are a group of disaccharides that contain the simple sugar galactose. The most well-known galactoside is lactose. Lactose can only enter the cell of *E. coli* bacteria through a trans-membrane carrier protein called β-galactoside permease, which is the gene product of the lacY gene.

Based on the information given, and your understanding of cell biology, it is reasonable to conclude that

A. lactose enters the cell by active transport.

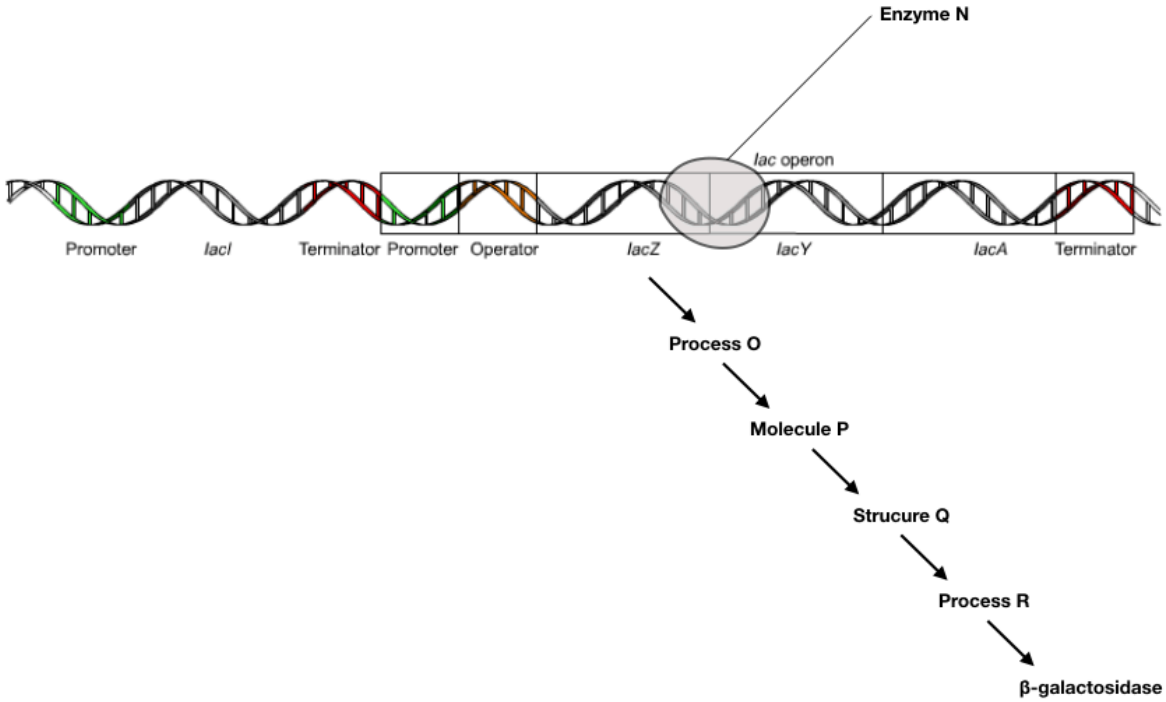
B. β-galactoside permease is a lipid.

C. lactose is non-polar.

D. lactose is larger than glucose.

Question 4

The flow chart below represents the expression of the lacZ gene, which results in the production of the enzyme β-galactosidase.



The labels in the diagram could be replaced as follows:

A. Enzyme N – DNA polymerase.

B. Process O – Translation.

C. Molecule P – mRNA.

D. Structure Q – Rough endoplasmic reticulum.

Question 5

The retroviral enzyme reverse transcriptase, transcribes mRNA backwards into DNA. It is often used by scientists who want to express a particular protein in a bacterial cell. Human cells which function to produce a protein such as a peptide hormone have a high concentration of mRNA for that protein. The mRNA can be isolated and then reverse-transcribed to DNA (called 'complementary DNA' or 'cDNA') which is inserted into a plasmid vector.

When comparing cDNA to its equivalent chromosomal DNA It would be reasonable to expect that

A. cDNA contains uracil whereas DNA contains thymine.

B. cDNA contains fewer base pairs than the equivalent chromosomal DNA.

C. the polypeptide produced from cDNA is different to that produced from chromosomal DNA.

D. cDNA contains ribose, whereas chromosomal DNA contains deoxyribose.

Question 6

The genetic code is said to be degenerate. This is seen in the fact that

A. there are 64 codons but only 20 different amino acids.

B. AUG codes for 'start' and also for the amino acid methionine.

C. GUC always codes for valine.

D. every codon contains three nucleobases.

Question 7

Epinephrine is a protein hormone produced in the adrenal glands and secreted directly into the bloodstream. Epinephrine leaves the cells of the adrenal glands by

A. facilitated diffusion

B. exocytosis.

C. simple diffusion

D. active transport

Question 8

A group of students completed an experiment to test their hypothesis that the rate of photosynthesis is greater when light intensity is greater.

They punched 40 discs out of a spinach leaf and placed 20 in each of two small beakers containing 2% sodium bicarbonate solution. The sodium bicarbonate provides a source of carbon dioxide. Both beakers were then exposed to a light source, but the light intensity in beaker 2 was higher than the light intensity in beaker 1.

Photosynthesis, occurring in the discs of leaf tissue, results in the production of oxygen gas which makes the discs buoyant, causing them to float to the top of the beaker. The students used a stopwatch to measure the time taken for the leaf discs to reach the top of the beaker and averaged the results for each beaker.

In the experiment conducted by the students, the leaf discs in beaker 1 floated to the top of the beaker faster on average than those in beaker 2. The students concluded that their hypothesis had been supported.

Which of the following is a limitation of their experiment?

A. a stopwatch is not a very accurate way to measure the time taken for the leaf discs to float.

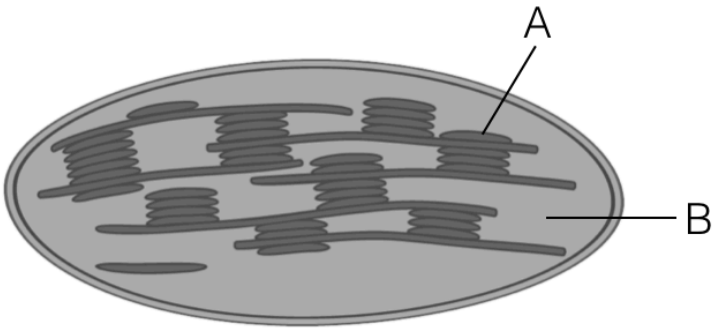
B. they only used spinach leaves so, the results may not be representative of other plant species.

C. they only completed the experiment once.

D. the different light intensities, may have caused unequal heating of the bicarbonate solution.

Question 9

The image below shows the structure of a chloroplast.



Source: Shutterstock

It is true to say that

A. the Calvin cycle happens in B.
B. carbon dioxide is used in A.
C. chlorophyll is found in region B.
D. NADPH is used in A.

Question 10

Anaerobic respiration in yeast cells

A. produces lactic acid.
B. is more efficient than aerobic cellular respiration.
C. requires oxygen.
D. results in the production of carbon dioxide.

Question 11

A purpose of photosynthesis in a fern plant is to

A. make sugars to use in cellular respiration.
B. produce oxygen for animals to breathe.
C. remove carbon dioxide from the atmosphere to reduce the greenhouse effect.
D. remove water from the soil to prevent the water table from rising.

Question 12

Chlorophyll A most readily absorbs

A. green and yellow light.
B. orange and yellow light.
C. green and blue light.
D. blue and red light.

Question 13

Which of the following does NOT provide evidence for the bacterial origin of mitochondria?

A. The chromosomes of both bacteria and mitochondria are circular.

B. Both bacteria and mitochondria contain a single chromosome.

C. Neither bacterial nor mitochondrial genes contain introns.

D. Cytosine pairs with guanine in both bacterial and mitochondrial DNA.

Question 14

The rate of oxygen production in broad bean plants was measured in a controlled experiment, at a light intensity of 50,000 lux and at 100,000 lux. The results of the experiment showed no significant difference between the rate of oxygen production at each light intensity. The most likely reason for this observation is that

A. oxygen production occurs in the light-independent stage of photosynthesis.

B. the difference between 50,000 and 100,000 lux is negligible.

C. carbon dioxide was the limiting factor in this situation.

D. cellular respiration was still occurring in the cells of the plant at 100,000 lux.

Question 15

The intrinsic apoptotic pathway, leads to programmed cell death in response to cell stress. This pathway

A. is triggered by proteins leaking from the mitochondria of the cell.

B. can be initiated by 'death ligands' secreted by natural killer (NK) cells.

C. does not involve the activation of caspases.

D. causes the cell to rupture and spill its contents into surrounding tissues.

Question 16

The electron carrier NADH is a product of which chemical process?

A. The light independent stage of photosynthesis.

B. The electron transport chain.

C. Glycolysis.

D. The light dependent stage of photosynthesis.

Question 17

Glucagon is a peptide hormone produced in the α cells of the islets of Langerhans within the pancreas. Glucagon travels from the pancreas in general circulation in the blood and stimulates liver and skeletal muscle cells to release glucose into the bloodstream. This is an example of what kind of signalling?

A. Autocrine signalling.

B. Endocrine signalling.

C. Paracrine signalling.

D. Exocrine signalling.

Question 18

Carol was shifting timber from one part of her back yard to another when she got a splinter embedded deep in her thumb. A few hours later, the area was very tender, red and swollen. The redness and swelling are the result of the action of which chemical compounds?

A. Interleukins.

B. Immunoglobulins.

C. Histamines.

D. Interferons.

Question 19

Which of the following lists stages of the extrinsic apoptotic pathway in the correct order?

A. ①Activation of caspase 3 – ② binding of death ligand to FasL receptor – ③ blebbing.

B. ① Blebbing – ② Binding of death ligand to FasL receptor – ③ Activation of caspase 3.

C. ① Binding of death ligand to FasL receptor – ② Blebbing – ③ Activation of caspase 3.

D. ① Binding of death ligand to FasL receptor – ② Activation of caspase 3 — ③ Blebbing.

Question 20

Testosterone is a steroid hormone. Like other steroid hormones, testosterone

A. is non-polar.

B. is lipophobic.

C. is inorganic.

D. contains amino acids.

Question 21

Systemic lupus erythematosus is an autoimmune disorder which affects connective tissues in the body. Connective tissues include the skin, mucous membranes, tendons, ligaments, cartilage and blood. A patient with inflamed skin and joints, was suspected of suffering systemic lupus erythematosus.

Confirming this diagnosis, would most likely involve testing for the presence of

A. histamines in the ligaments of the joints.

B. mast cells in the skin.

C. autoantibodies in the blood.

D. viral proteins on the surface of mucous membranes.

Question 22

Autoimmune diseases such as systemic lupus erythematosus, are thought to be caused by

A. the inability of T cell receptors to bind to complementary antigens.

B. the inability of neutrophils to distinguish between self and non-self.

C. a failure in apoptosis following division of hematopoietic stem cells in the thymus gland.

D. the overproduction of IgE antibodies by plasma cells.

Question 23

An example of a cell involved in the human innate immune response is a

A. macrophage.

B. cytotoxic T lymphocyte.

C. plasma cell.

D. helper T cell.

Question 24

Helper T cells are integral to the immune response, because they stimulate B lymphocytes by secreting

A. cytokines.

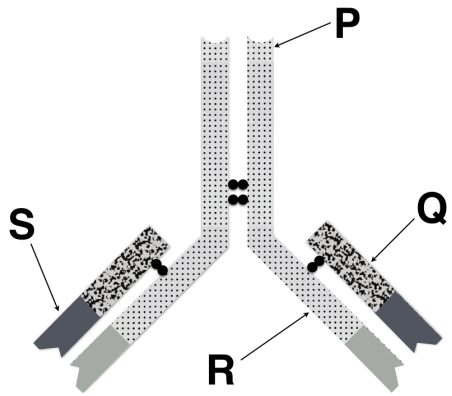
B. histamines.

C. antibodies.

D. neurotransmitters.

Question 25

The diagram below is a stylized representation of an IgG immunoglobulin.



A single hematopoietic stem cell in the bone marrow gives rise to many B cells. The immunoglobulins on the surface of each B cell will differ in region

A. P.

B. Q.

C. R.

D. S.

Question 26

In Australia, adults wishing to be immunised against hepatitis B receive a course of two vaccinations, 6 months apart. The immune response following the second vaccination is faster than that following the first vaccination because at the time the vaccine is administered the body contains a higher concentration of

A. memory B cells.

B. plasma cells

C. antibodies

D. vaccine

Question 27

TNFα (tumor necrosis factor alpha) is a cytokine produced by macrophages, natural killer cells and several other immune cells. TNF is encoded by the gene TNFA which is located on the short arm of chromosome 6. The TNFA gene is 6 kilobases long and contains 4 exons. Which of the following mutations to TNFA is most likely to result in a significant change to the function of TNF?

A. A single base insertion in the first intron

B. A single base substitution in the first exon

C. A single base deletion in the fourth exon.

D. A block insertion of 100 bases in the third intron

Question 28

The gene GLP-1, located on the long arm of human chromosome 2, contains the coded instructions for the synthesis of glucagon.

Glucagon is a peptide hormone, important in the regulation of blood glucose concentration. When blood glucose concentration falls, the beta cells of the pancreas respond by increasing expression of GLP-1. As a result, these beta cells secrete more glucagon, which stimulates liver cells to release glucose into the blood.

From this information it is possible to conclude that GLP-1

A. is a structural gene.

B. is an operon.

C. is a regulatory gene.

D. is an exon.

Question 29

Natural selection operating in a population

A. acts on the genotype of individuals.

B. decreases genetic diversity in the population.

C. favours individuals which are camouflaged with their environment.

D. causes genetic drift.

Question 30

The codon table below can be used to determine the sequence of amino acids encoded by a sequence of nucleotides.

First Position	Second Position: U	Second Position: C	Second Position: A	Second Position: G	Third Position
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	START / Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

The following DNA base sequence is from the template strand of a gene.

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AGT ATG AAT CCT AGA ACC
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Based on this diagram and your understanding of gene expression and mutations, it is true to say that

A. The same amino acid chain would be encoded by the DNA sequence TCG ATA GAA CCC TCG ATA.

B. A silent mutation would occur if the 17th base were replaced by a T.

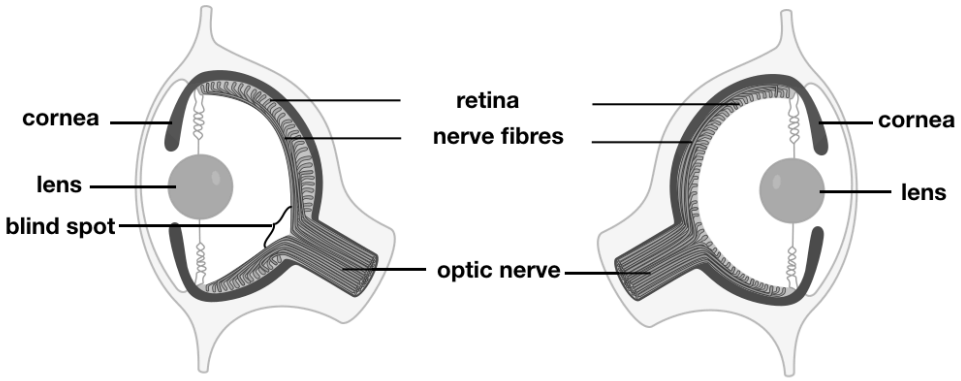
C. If a T were inserted between the fifth and sixth base, the amino acid sequence would be lengthened.

D. The second amino acid in the sequence would be unaffected by a deletion of the sixth base.

Question 31

Although cephalopods (octopuses, squids, cuttlefishes and nautiluses) are mollusks, and are related to snails and clams, their eyes are strikingly similar to those of vertebrates (mammals, birds, reptiles, amphibians and fishes). Like vertebrate eyes, the eyes of cephalopods contain a retina, optic nerve, lens and cornea.

Other mollusks such as gastropods (snails and slugs) and bivalves (clams, mussels, etc.) have very simple "eyes", which do not resemble the eyes of vertebrates, and which can detect light but do not allow the animal to see an image, the way vertebrates and cephalopods can.



Vertebrate eye (left), cephalopod eye (right), source: Wikimedia commons

The similarity between the cephalopod eye and the vertebrate eye provides an example of

A. analogous structures.

B. homologous structures.

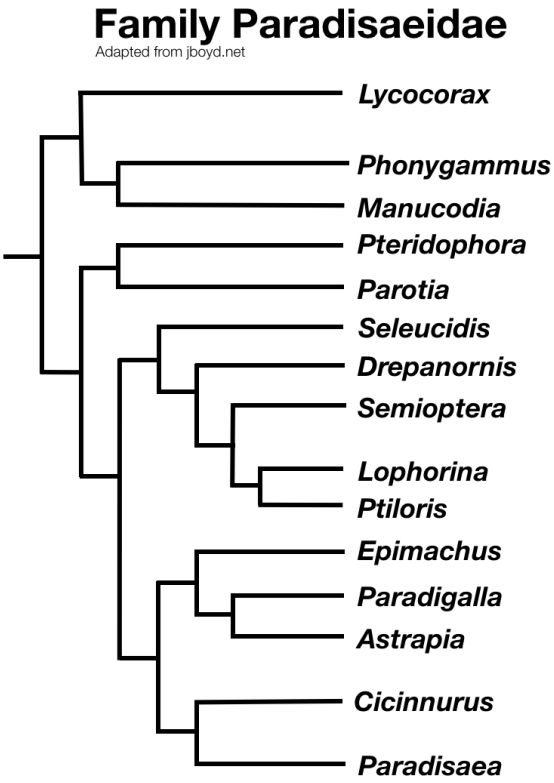
C. divergent evolution.

D. vestigial structures.

Question 32

Family Paradisaeidae is a family of birds (commonly called the "birds of paradise") comprising 42 species in 15 genera. Thirty-eight of the forty-two species are found only on the island of New Guinea. The Trumpet manucode (*Phonygammus keraudrenii*) and the Magnificent riflebird (*Ptiloris magnificus*) are native to both New Guinea and Australia. Victoria's riflebird (*Ptiloris victoriae*) and the Paradise riflebird (*Ptiloris paradiseus*) are found only in Australia.

The diagram below shows a phylogenetic tree of family Paradisaeidae.



Paradise riflebird
Ptiloris paradiseus

According to the information presented above, it is possible to conclude that the paradise riflebird

A. is more closely related to the trumpet manucode, than to birds in genus *Lycocorax.*

B. evolved in Australia before Gondwana broke apart.

C. is more closely related to Victoria's riflebird than to the magnificent riflebird.

D. has more DNA in common with birds from genus *Seleucidus* than those in genus *Epimachus*.

Question 33

Island fox
Urocyon littoralis

Source: Shutterstock

The Island fox (*Urocyon littoralis*) is a tiny fox, about the size of a domestic cat. It is native to the Channel Islands, about 20 km off the coast of California.

It is believed that the ancestors of the island fox, arrived on the Channel Islands more than 10,000 years ago, during the last ice age, when the seas were much lower. Despite its small size, the island fox looks very much like its closest relative, the much larger North American gray fox (*Urocyon cinereoargenteus*).

A recent DNA study has shown that genetic diversity in the gene pool of *Urocyon littoralis* is less than 0.01%, making it the least genetically diverse species known to science.

Based on this information it is NOT reasonable to suggest that

A. There are selection pressures operating on the population of island fox.

B. The lack of diversity in the island fox is due to genetic drift.

C. Gene flow has occurred between the island fox and grey fox populations throughout the last 10,000 years.

D. The island fox is in danger of extinction.

Question 34

CrimTrac is the Australian Police national criminal investigation DNA database. DNA is routinely collected from suspects in serious crime investigations. From collected DNA samples, ten regions (nine STR loci plus the sex-indicating marker Amelogenin) are amplified using PCR.

In order to create a DNA profile for entry into the CrimTrac database, how many different DNA primers are required?

A. 9.

B. 10.

C. 18.

D. 20.

Question 35

According to the Out of Africa hypothesis

A. *Homo neanderthalensis* evolved in Africa.

B. *Homo heidelbergensis* evolved before *Homo erectus.*

C. *Homo erectus* is the ancestor of both *Homo sapiens* and *Homo neanderthalensis.*

D. the oldest fossils of *Homo sapiens* are found in Eurasia.

Question 36

The white-throated guenon (*Certhopithecus erythrogaster)* is a very rare tree-dwelling primate belonging to family *Cercopithecidae*. Based on this information, it is possible to conclude that it

A. is nocturnal.

B. has forward-facing eyes.

C. lacks colour vision.

D. has sharp, curved claws.

Question 37

In gel electrophoresis, DNA moves

A. Toward the positive electrode, due to its phosphate groups.

B. Toward the negative electrode, due to its nitrogenous bases.

C. Toward the positive electrode because it is acidic.

D. Toward the negative electrode, because it contains deoxyribose.

Question 38

The Australian Government Department of Health website, has a page which reads as follows:

> **"Community immunity**
>
> If enough people in a community are immunised against an infectious disease, there is less of the disease in the community which makes it harder for the disease to spread. Immunisation protects both people who are vaccinated and also helps the entire community. It helps protect those who are too young to be vaccinated and those who can't be vaccinated for medical reasons.**"**

The biological term for what is described above as community immunity is

A. passive immunity.

B. active immunity.

C. induced immunity.

D. herd immunity.

Question 39

DNA profiling in Australia involves the amplification of STRs (short tandem repeats). STRs are particularly useful for this purpose, because

A. STRs are located within the coding regions of genes.

B. STRs are easier to amplify using PCR, than most DNA regions.

C. STRs are less polymorphic than most DNA regions.

D. STRs have higher mutation rates than most regions of DNA.

Question 40

CGN-89564-2 (sold as Flavr Savr™) is a tomato; the first commercially grown 'genetically engineered' food to be licensed for human consumption. To create the Flavr Savr™ Calgene Inc. inserted a synthetic antisense (complementary) version of the gene for polygalacturonase into the genome of a tomato. Polygalacturonase is the enzyme responsible for the breakdown of pectin in the cell walls of fruits, causing rotting. The antisense version of the polygalacturonase gene, is transcribed to mRNA along with the normal version of the polygalacturonase gene. The two complementary mRNA molecules subsequently bind to each other, preventing either from entering a ribosome. In this way the antisense gene suppresses the synthesis of polygalacturonase. As a result, Flavr Savr™ tomatoes ripen normally, developing natural tomato flavour and colour but stay fresh and firm for a much longer time.

The term which best describes the Flavr Savr™ tomato is

A. genetically modified.

B. transgenic.

C. transformed.

D. recombinant.

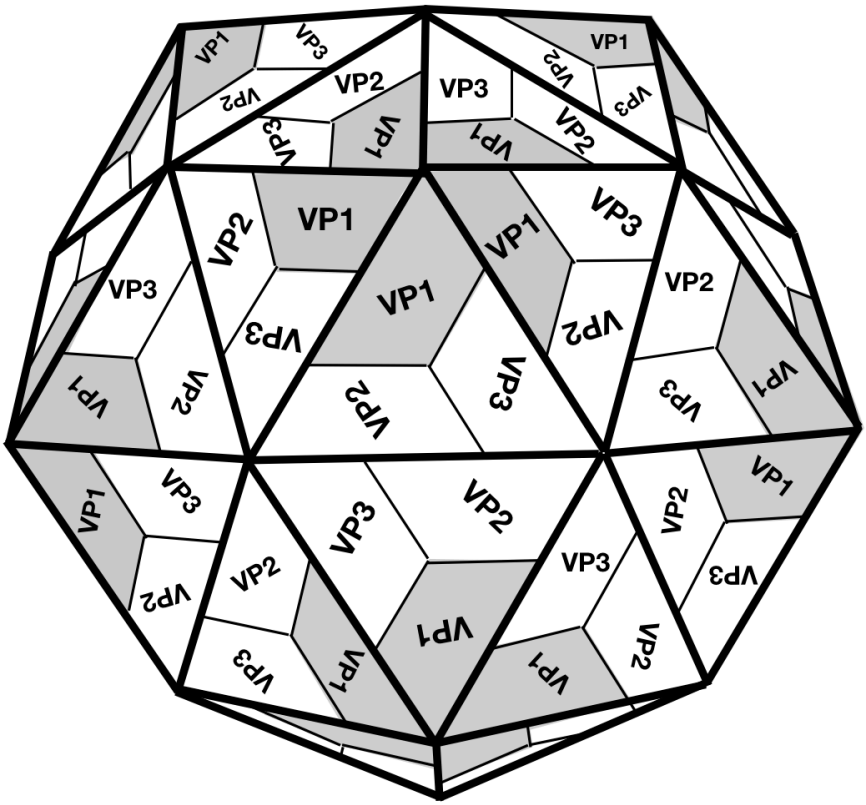
SECTION B – Short-answer questions

Instructions for Section B

Answer **all** questions in the spaces provided. Write using black or blue pen.

Question 1 (14 marks)

Human rhinovirus (HRV) is the virus that causes the common cold in humans. There are more than 100 different known serotypes (strains) of HRV. The outer surface of the viral capsid is composed of three different proteins (VP1, VP2 and VP3), which form a soccer ball-like icosahedron, enclosing the viral RNA and several enzymes including reverse transcriptase and integrase.



For a rhinovirus particle to infect a target cell, it must first attach to its plasma membrane. It does this by binding to ICAM-1 (inter-cellular adhesion molecule 1), which is a glycoprotein found on the outer membrane of many cells in the human upper respiratory tract.

ICAM-1 binds to a 'canyon' in the viral capsid, between VP1 and VP3. The binding of ICAM-1 with the canyon 'tricks' the cell into engulfing the virus, bringing it into the cell, where its RNA and enzymes are released.

Reverse transcriptase transcribes the viral RNA backwards into double-stranded complementary DNA (cDNA). Integrase splices this cDNA into the host cell's own DNA where it is expressed, using the cells own organelles and enzymes.

a. When a person is infected with measles, he or she develops an immunity to the measles virus, making it unlikely they will develop the symptoms of the disease again. Explain why, in contrast to measles, some people 'catch a cold' every year or two.

2 marks

b. By what cellular process does a human cell 'engulf' a rhinovirus particle?

1 mark

c. ICAM-1 is a glycoprotein. What is a glycoprotein?

1 mark

d. What feature of ICAM-1 causes it to bind to the canyon between VP1 and VP3?

1 mark

e. What characteristic of the plasma membrane, enables the cell to engulf a large foreign body such as a virus, without being ruptured.

1 mark

f. Once a cell has been infected with HRV it begins synthesising VP1, VP2 and VP3. Of what monomers are these made?

1 mark

g. Name one of the human cell's *organelles* that plays a part in the expression of the viral DNA and describe the role it plays in gene expression. 2 marks

h. Name one of the human cell's *enzymes* that is involved in the expression of the viral DNA and describe the role it plays in gene expression. 2 marks

i. Scientists are currently seeking to develop a rationally designed therapeutic drug to treat the common cold.

i. Based on the information above, suggest one potential molecular target for a successful designed drug against the common cold. 1 mark

ii. Explain how a drug designed for the target you have identified, would help in the treatment of the common cold. 2 marks

Question 2 (9 marks)

Cancer has been linked to genetic changes in cells which reduce the rate of apoptosis. Malignant cells usually change in ways which should trigger apoptosis, but when this fails to happen, the unchecked cell can divide rapidly forming a tumor, which may metastasise and spread.

The causes of failed apoptosis are the subject of intense study by cell biologists. Numerous mechanisms have been identified.

One mechanism which has been shown to suppress apoptosis is the 'down-regulation' (reduced synthesis) of caspases within the cell.

a. What role do caspases play in apoptosis? 1 mark

_____

_____

b. Explain how the down-regulation of caspases in a cell may lead to a failure in apoptosis. 1 mark

_____

_____

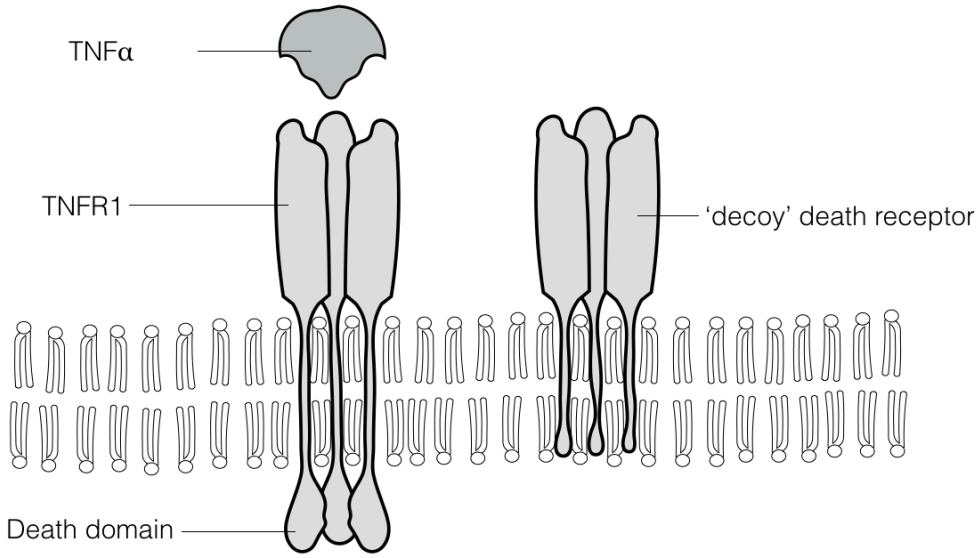
_____

_____

Another cause of failed apoptosis in some cancer cells is a reduced sensitivity of the cell to death ligands.

TNFR1 is one of a number of transmembrane proteins which act as death ligand receptors on the surface of cells. If a molecular change is detected in a cell, natural killer (NK) cells and macrophages secrete a 'death ligand' called TNFα (TNF alpha) which binds to TNFR1, causing a conformational change to the 'death domain' inside the cell. This change in shape, initiates a signal cascade within the cell, resulting in apoptosis.

Many cancer cells have been found to express fewer TNFR1 proteins on their surface. Other cancer cells have been found to possess 'decoy death receptors' in addition to normal TNFR1 receptors. Decoy death receptors are proteins on the outer membrane surface with binding sites specific to the death ligand, but which lack a death domain inside the cell.



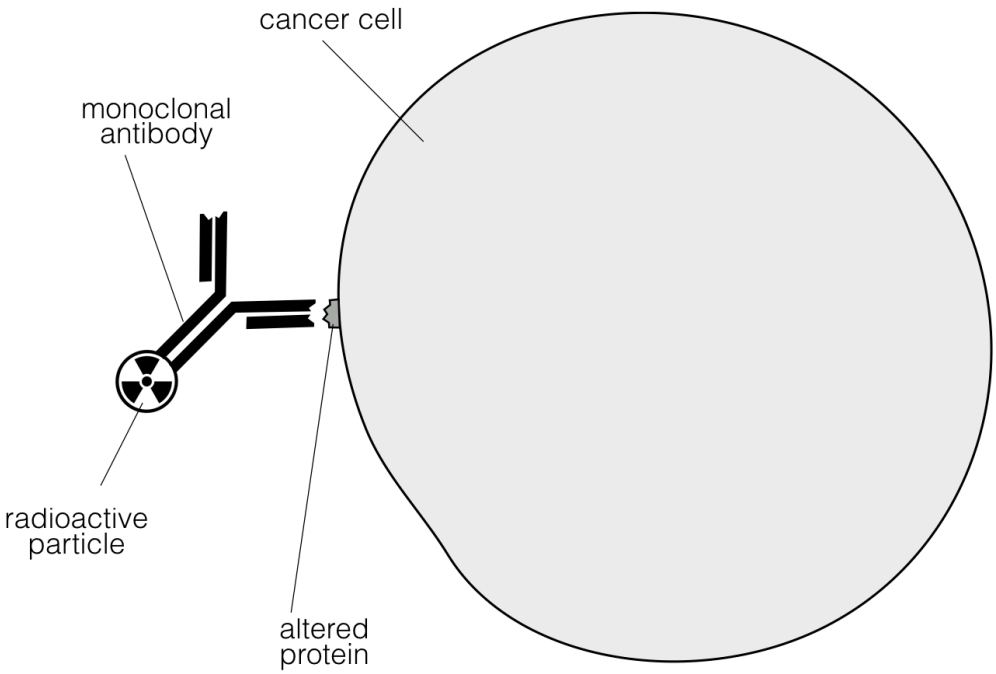
c. Other than natural killer (NK) cells and macrophages, name another type of cell that expresses death ligands. 1 mark

d. Explain what is meant by the term 'signal cascade'? 1 mark

e. Explain how a reduced number of TNFR1 receptors on the surface of a cancer cell may lead to the failure of a cancer cell to die by apoptosis. 1 mark

f. Explain how the presence of decoy death receptors in addition to TNFR1 receptors may lead to a failure in apoptosis. 1 mark

One approach to the treatment of some types of cancer involves the use of monoclonal antibodies carrying radioactive particles. Monoclonal antibodies are molecules, produced in a laboratory, which have an antigen-binding site, specific to an altered protein expressed on the surface of cancer cells. Each monoclonal antibody is bound to a radioactive particle which will damage any cells in close proximity, stimulating the intrinsic (mitochondrial) apoptotic pathway in those cells.



g. Describe one advantage of attaching radioactive particles to monoclonal antibodies, compared to traditional radiotherapy. 1 mark

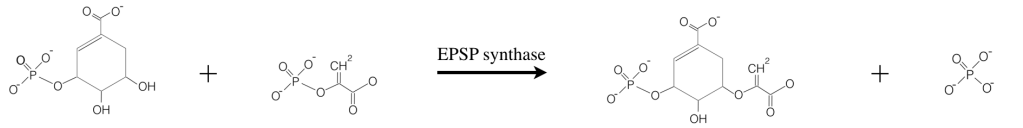
h. Explain why the use of monoclonal antibodies as described above, is more likely to be effective if the failure of apoptosis in the cancer cell is due to a reduced sensitivity to death ligands, than to a down-regulation of caspases.

2 marks

Question 3 (12 marks)

Glyphosate is a broad-spectrum weed killer sold throughout Australia as Roundup®. It acts as a competitive inhibitor for the enzyme 5-enolpyruvyl-shikimate 3 phosphate synthase (EPSP synthase).

The reaction catalysed by EPSP synthase can be represented as follows:



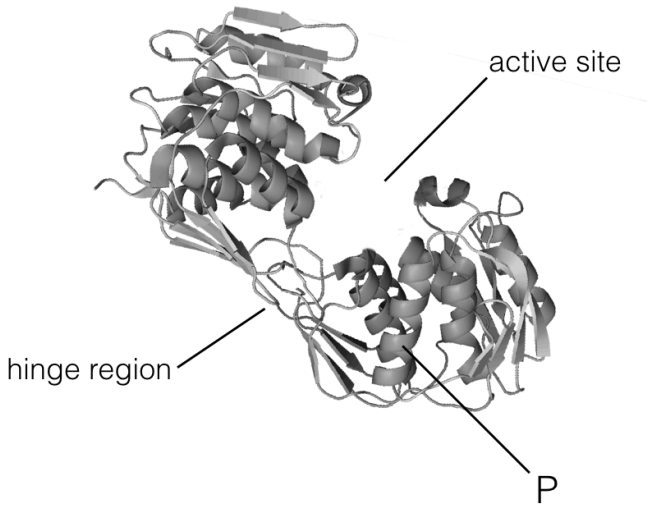
Phosphoenolpyruvate + 3 phosphoshikimate → 5-enolpyruvylshikimate-3-phosphate + Phosphate

5-enolpyruvylshikimate-3-phosphate (EPSP) is an essential component of the amino acids tryptophan (trp), tyrosine (tyr) and phenylalanine (phe).

a. Explain at a molecular level, how Roundup® causes the death of weeds.

2 marks

The EPSP synthase enzyme contains a single polypeptide chain with two sides. When substrates bind to the active site of the enzyme, the two sides of the enzyme hinge closed, bringing the substrates into alignment, and clamping them together.



EPSP synthase. Source: modified from Wikimedia

b. Does glyphosate inhibit the EPSP synthase enzyme by binding to its active site or to another region of the enzyme? Explain your answer. 1 mark

c. Does EPSP synthase have quaternary structure? Explain your answer. 1 mark

d. What name is given to the spiral-shaped structure labelled P? 1 mark

In 1996 Scientists at Monsanto Co discovered a colony of agrobacteria (*Agrobacterium tumefaciens*) surviving in a waste-fed column at a glyphosate production facility. Although agrobacteria are usually killed by glyphosate, these cells contained a resistant version of CPSP synthase (which they named CP4 CPSPS). The scientists subsequently transferred the allele for CP4 CPSPS into the cells of several species of agricultural crops, including canola, which is sold in Australia under the name Roundup Ready® canola.

e. In what way must CP4 CPSPS differ from (normal) CPSP synthase? 1 mark

f. What advantage would there be to a farmer, in sowing Roundup Ready® canola? 2 marks

g. Suggest one issue arising from the use of Roundup Ready® canola by some farmers? 1 marks

h. Explain the process by which a colony of agrobacteria evolved to become resistant to Roundup® in the glyphosate production facility. 3 marks

Question 4 (11 marks)

In January 2018 a 24-year-old man in Tamworth, NSW, was bitten on the finger by an eastern brown snake (*Pseudonaja textilis*) whilst attempting to remove the snake from his dog's mouth. The man was taken to hospital by a relative. There, doctors attempted to resuscitate him and administered an antivenom, but he died just 40 minutes after being bitten.

The eastern brown snake is one of the most common snakes in Victoria, the second most venomous land snake in the world, and is responsible for 60% of snake bite deaths in Australia. In most cases, people envenomated by an eastern brown snake, experience no symptoms for up to fifteen minutes. Then, once symptoms begin to appear, they proceed with terrifying rapidity.

The venom of the eastern brown snake contains three toxins:

- ***Textilotoxin*** is a presynaptic neurotoxin that blocks the release of the neurotransmitter acetylcholine from neurons.
- ***Pseudonajatoxin*** is a postsynaptic neurotoxin which irreversibly binds to acetylcholine receptors on neurons and muscle cells.
- ***Prothrombin activator*** is a coagulant, which causes blood clotting.

The symptoms of envenomation by the eastern brown snake include paralysis, and cardiac arrest.

a. Choose one toxin within the venom of the eastern brown snake and explain how this toxin may contribute to cardiac arrest ('heart attack') in a snake bite victim. 2 marks

Toxin:

_____

Explanation:

_____

_____

_____

_____

_____

_____

_____

_____

b. Apart from paralysis and cardiac arrest, suggest one other symptom you would expect due to textilotoxin in a person bitten by an eastern brown snake. Explain why textilotoxin would cause the symptom you have described.

2 marks

An antivenom is available for the venom of the eastern brown snake. Brown snakes are 'milked' for their venom which is then injected in tiny doses to horses at a facility in Heathcote, Victoria. The horses are unharmed by the venom because they have developed an immunity due to previous exposure. Antibodies are collected from the horse blood and used as an antivenom for snake bite victims.

When the antivenom is administered to a patient, the antibodies in the antivenom circulate throughout the patient's body mopping up the toxins, preventing them from causing their biological effects on the tissues of the patient.

c. What type of immunity do the horses at the Heathcote facility have to snake venom? Explain your answer.

2 marks

A recent study in Australia showed that 25% of patients given antivenom experienced an immediate, acute allergic reaction to horse proteins in the serum. Almost 11% experienced an anaphylactic reaction requiring an injection of adrenaline. More than 5% went into 'anaphylactic shock'; an allergic reaction so severe that without medical treatment it was life-threatening.

d. Describe what happens in a patient's body to cause an anaphylactic reaction following the administration of antivenom.

2 marks

Sometimes when a snake bites a person, it does not release venom. A bite without envenomation is known as a 'dry bite'. It is often difficult to tell whether a bite was dry or venomous. The envenomation rate varies from species to species. On average, 25% of snake bites are dry bites.

The eastern brown snake has an unusually low envenomation rate. Approximately 80% of the time little or no venom is released. Even when venom is released, sometimes very little gets into the victim. The eastern brown snake has very short fangs, so unless the snake gets a good grip, often much of the venom runs over the skin surface, not into the bite wound.

When a patient is bitten by a snake, doctors will closely monitor the patient for signs of envenomation. Only if symptoms begin to appear will they administer a dose of antivenom.

e. Suggest why doctors might wait for symptoms to appear, before administering antivenom.

1 mark

Because eastern brown snakes have very short fangs, their venom is rarely injected into the bloodstream, but instead into the lymphatic system.

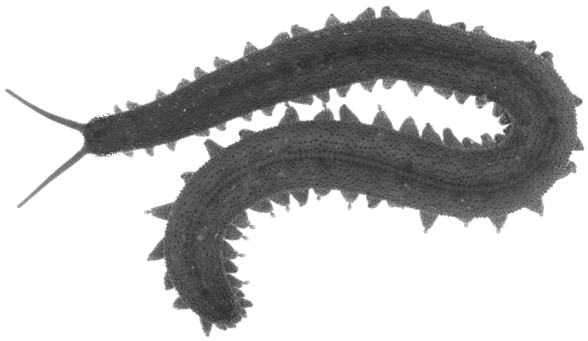
f. Describe one way in which the lymphatic system is important in an immune response.

1 mark

g. Explain why it is important, using a splint, to immobilise the limb of a person who has been bitten by an eastern brown snake.

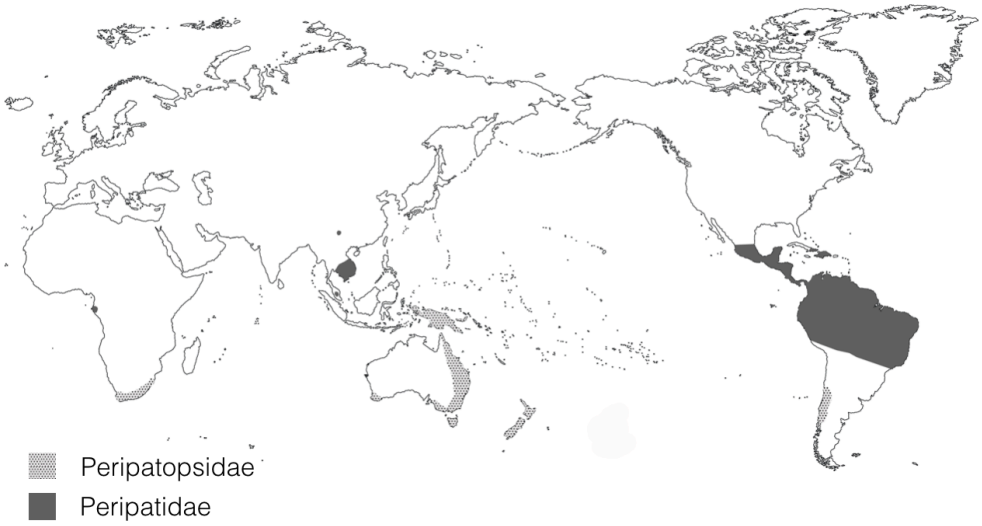
Question 5 (4 marks)

Velvet worms (Phylum Onychophora) are long, soft-bodied, slow-moving animals related to arthropods. They have many short 'stub feet' called oncopods. Onychophora is the only animal phylum which is entirely restricted to terrestrial environments.



Source: Shutterstock

There are two families of velvet worms: Peripatidae and Peripatopsidae. Peripatopsidae is found south of the equator, in Australia, New Zealand, Papua New Guinea, South Africa and South America. Peripatidae are found in Central and South America, the Caribbean islands, South-east Asia and a small region in Gabon, West Africa. The global distribution of velvet worms is shown in the map below.



Source: modified from Douch, J., University of Melbourne

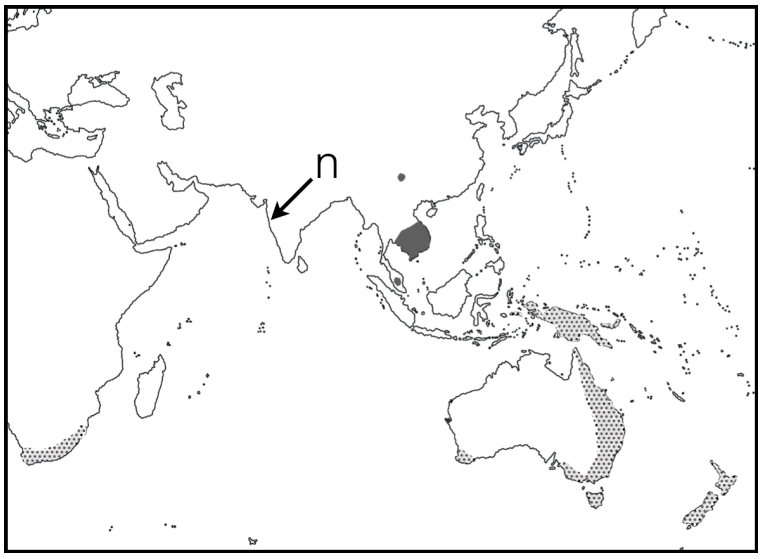
a. Given that all velvet worms are terrestrial, explain how it is possible to explain the occurrence of Peripatopsidae in both Australia and Africa.

1 mark

b. Suggest why both families (Peripatopsidae and Peripatidae) are found in South America, but only Peripatopsidae is found in Australia.

2 marks

A species of velvet worm was recently discovered in India, in the region labelled n below.



Source: modified from Douch, J., University of Melbourne

c. Explain whether it is possible that this species belongs to family Peripatopsidae. 1 mark

Question 6 (8 marks)

Tarsiers (family Tarsiidae) and lorises (family Lorisidae) are small, nocturnal, tree-dwelling primates, found in parts of South East Asia, including the Philippines, Indonesia and Malaysia. Both have large eyes, round heads and short snouts. Both live in small family groups and are very timid and quiet. Tarsiers are entirely carnivorous, eating insects, reptiles and birds. Lorises also eat insects, reptiles and birds but also feed on fruits and other vegetation.

Due to their physical resemblance, similar behaviour and distribution, it had long been assumed that lorises and tarsiers are closely related. Very few fossils of tarsiers and lorises have ever been found.

Recent DNA tests, however, provide evidence that lorises and tarsiers do not share a recent common ancestor. It is now understood that lorises are more closely related to the ring-tailed lemur of Madagascar (off the east coast of Africa), than they are to tarsiers. It is thought that lorises diverged from lemurs approximately 56 million years ago, whereas tarsiers diverged from lemurs 63 million years ago.

The ring-tailed lemur of Madagascar (pictured below right) is much larger, spends considerable time on the ground, eats mostly fruit and leaves, is diurnal (active during daylight), very social, vocal and is not at all timid!

Philippine Tarsier
Carlito syrichta

Slow Loris
Nycticebus coucang

Ring-tailed Lemur
Lemur catta

Source: Shutterstock

a. Tarsiers and lorises have independently evolved many similar features, which were not features of their common ancestor. What name is given to features that have evolved to become very similar, in unrelated groups of organisms? 1 mark

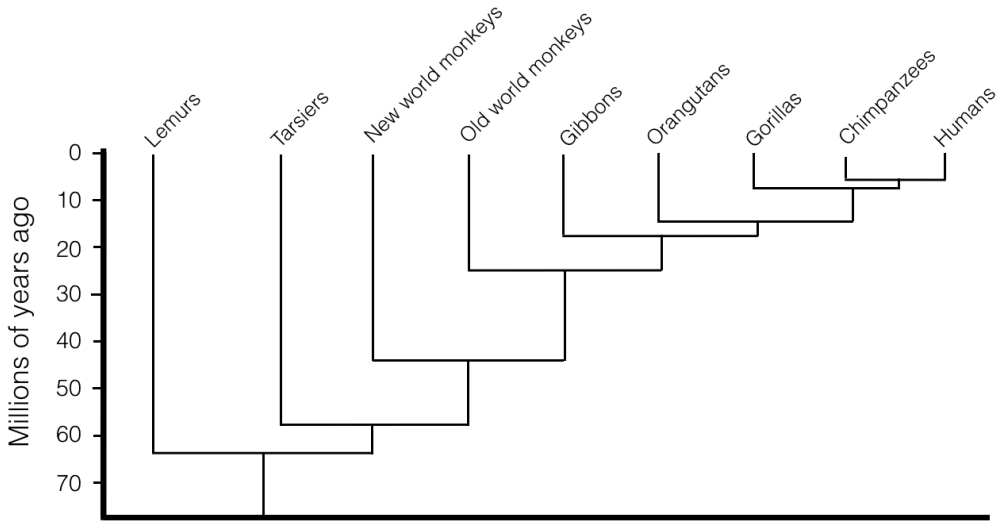
_____

b. Explain how lorises and tarsiers, could have independently evolved strikingly similar features.

2 marks

c. On the phylogenetic tree below, add 'Lorises' and draw a line to represent their phylogenic position in the tree.

1 mark



d. Describe the laboratory process used by molecular biologists to compare the DNA of lorises, lemurs and tarsiers, to determine which animals are more closely related.

2 marks

e. When the scientists compared the DNA of lorises, tarsiers and lemurs, would they have compared coding DNA or non-coding DNA? Explain your answer. 1 mark

f. Suggest why the fossil record of lorises and tarsiers is poor. 1 mark

Question 7 (4 marks)

In Australia, Women under the age of 70 who are diagnosed with ovarian cancer are offered genetic testing to look for the presence of the BRCA1 and BRCA2 gene mutations. BRCA1 and BRCA2 are tumor suppressor genes. Mutations to these genes have been linked to ovarian and breast cancer.

Nancy, a 63-year-old grandmother was diagnosed with ovarian cancer. The cancer had not spread to other organs. Following surgery to remove her ovary, she was offered a genetic test for the BRCA1 and BRCA2 mutations. She decided to be tested, and the results revealed that she does have the BRCA2 gene mutation.

a. Suggest one possible advantage *to Nancy* of knowing that she has the BRCA2 mutation. 1 mark

b. Suggest one possible advantage to *others in the community*, of Nancy knowing that she has the BRCA2 gene mutation. 1 mark

c. Suggest one possible disadvantage *to Nancy*, of knowing that she has the BRCA2 mutation. 1 mark

Before deciding to have the test, Nancy was referred to a genetic counsellor. After discussing options with the counsellor, but before agreeing to the genetic test, Nancy discussed the decision with her family.

Her daughter Claire, said that she would prefer if Nancy were *not* tested, and insisted that if she was, she did not want to know the results. Nancy's other two daughters and son encouraged her to be tested.

d. Suggest a reason that Claire may not want to know the results of Nancy's genetic test. 1 mark

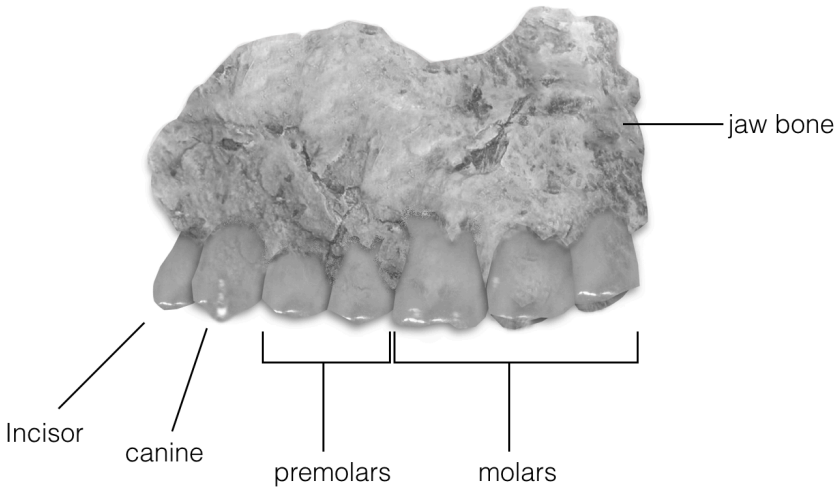
Question 8 (5 marks)

Homo sapiens evolved in Africa at least 300,000 years ago. The oldest fossils of *Homo sapiens*, were found in Morocco, and dated 300,000 years old. Fossils 195,000 years old have been found at two locations in Ethiopia.

According to the Out of Africa hypothesis, the ancestors of all living non-African humans can be traced to a single group of *Homo sapiens* which first migrated from Africa to Europe and Asia about 100,000 years ago, replacing humans (Neanderthals and Denisovans) which lived there.

Source: modified from Wikipedia

In January 2018, paleontologists reported the discovery of a *Homo sapiens* fossil, in Misliya Cave at Mount Carmel, Israel. The fossil, named 'Mislya-1', contained a well-preserved fragment of maxilla (upper jaw bone) and seven complete teeth. Mislya-1 was dated to between 177,000 and 194,000 years old, using three different dating methods. The oldest *H. sapiens* fossil previously found outside Africa, was approximately 100,000 years old and found in Daoxian, China.



Drawing of the Misliya fossil. Source: Andrew Douch

DNA obtained from Mislya-1 was also analysed. It provided strong evidence to indicate that the Misliya *H. sapiens* were NOT the ancestors of any living human populations.

a. Identify one anatomical feature of the fossil that indicates the fossil is from a member of genus *Homo* and not *Australopithecus.* Describe how the feature would differ in *Australopithecus*. 2 marks

b. Describe one method which scientists may have used to date the fossil to 177,000 – 194,000 years. 1 mark

c. Based on the information presented above, when did the ancestors of modern Chinese people leave Africa? 1 mark

d. Explain whether this new fossil discovery refutes the Out of Africa hypothesis. 1 mark

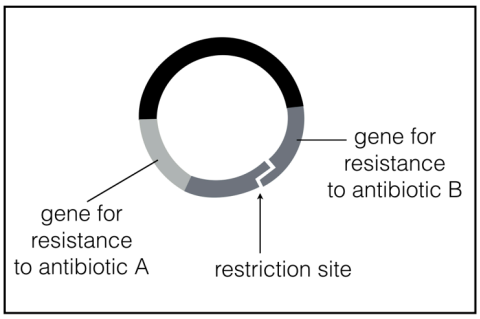
Question 9 (13 marks)

Gene therapy can be used to treat an individual with a recessive genetic disorder such as severe combined immunodeficiency (SCID). The process involves inserting a normal (or 'wild type') allele into the cells of a person with two defective alleles of the gene. Most clinical trials of gene therapies have employed a virus as a vector for the wild type allele.

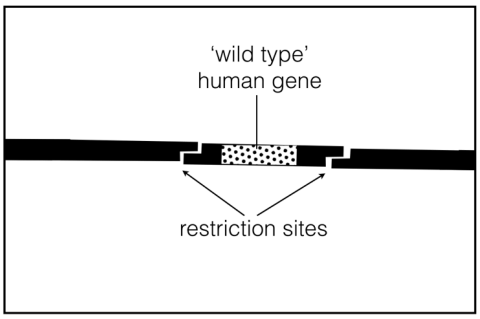
a. Explain why a virus is an ideal potential vector for gene therapy.

1 mark

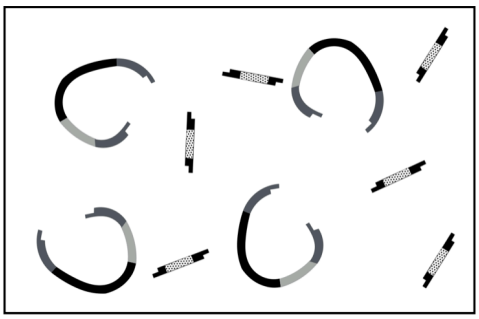
The first step in developing a successful gene therapy is to make many copies of the 'wild type' allele for the normal, dominant phenotype. This is done by gene cloning. Gene cloning begins with cutting a gene from human DNA using a restriction enzyme, then splicing it into a bacterial plasmid. This process is summarised in the diagrams below. A small percentage of the plasmids will successfully incorporate the human DNA fragment.



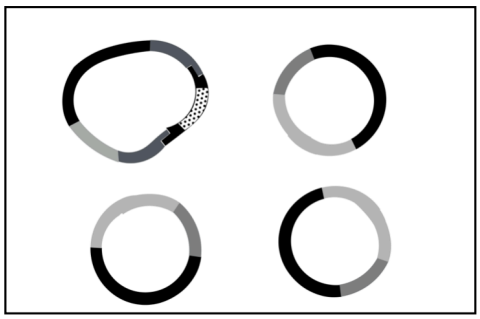
1. Plasmids cut with restriction enzyme



2. Human DNA cut with restriction enzyme



3. Plasmids mixed with human DNA



4. Some plasmids incorporate human DNA

The restriction enzyme used in the application above cuts DNA at a recognition site which is a specific 6-base palindromic sequence.

b. Explain what 'palindromic sequence' means. In your answer, give an example of a 6-base palindromic sequence.

2 marks

c. Explain why both the plasmid and human DNA must be cut using the same restriction enzyme.

1 mark

Once the DNA and plasmids have each been cut, they are heated to inactivate the restriction enzymes, then mixed together in the presence of the enzyme DNA ligase.

d. Explain how heating inactivates the restriction enzymes.

1 mark

e. Why is it important to inactivate the restriction enzymes?

1 mark

f. What is the function of DNA ligase in this context?

1 mark

g. What term describes a plasmid into which DNA from another source (in this case, a human) has been spliced?

1 mark

_____

The plasmid, now carrying the human gene, is then introduced into a mixture containing bacteria. The bacteria are made 'competent' to take up plasmids using either a chemical treatment or electroporation.

If a bacterium takes up a plasmid, it will reproduce the plasmid making many copies of the human gene.

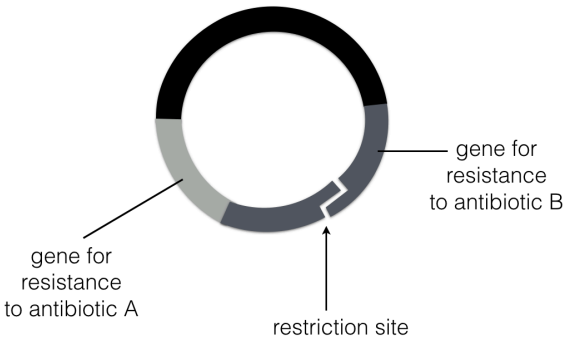
h. What term describes a bacterium which has taken up a plasmid containing DNA from another source?

1 mark

_____

Most bacteria do not take up a plasmid. Depending on (a) the species of bacteria, (b) the technique used to make them competent and (c) the size of the plasmids, as few as one bacterium in a million might take up a plasmid. Moreover, most bacteria which do take up a plasmid, take up one which does not contain the human DNA fragment.

The plasmids used in the way described, contain two genes for resistance, each to a different antibiotic.



i. Given that only a small percentage of bacteria will take up a plasmid, explain how scientists are able to identify those bacteria which have taken up a plasmid.

2 marks

_____

_____

_____

_____

_____

j. Explain why the scientists use a plasmid with a gene for resistance to antibiotic B.

2 marks

END OF QUESTION AND ANSWER BOOK