ACCESS EDUCATION

Victorian Certificate of Education
2017 Trial Paper

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	70
			Total 110

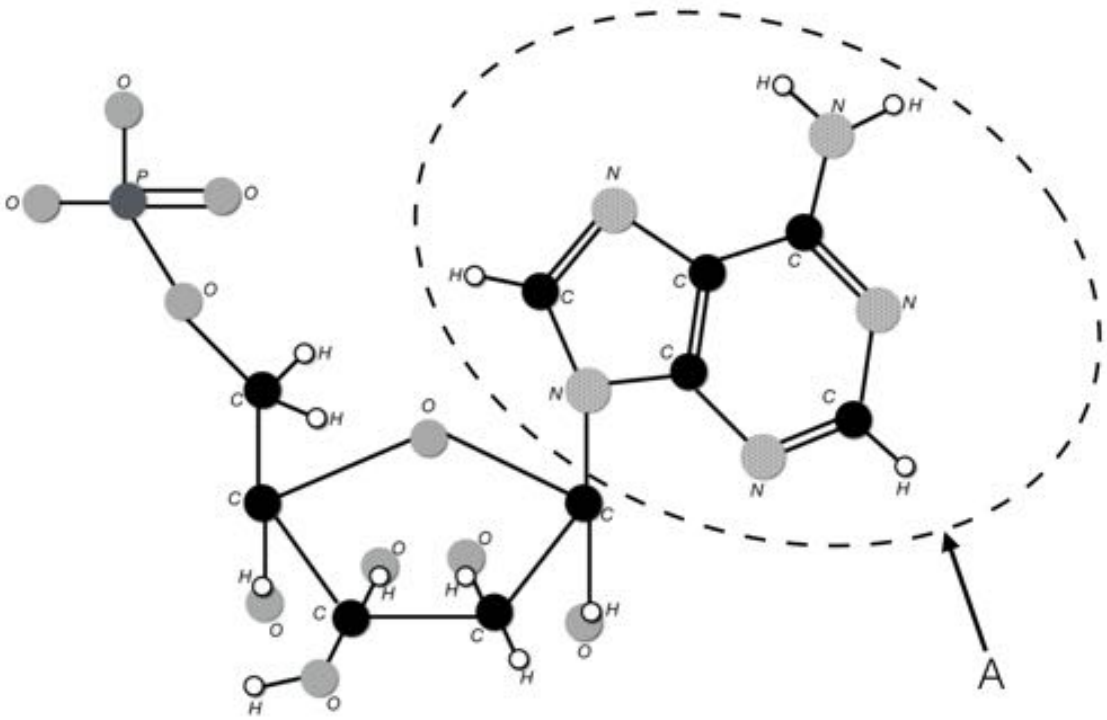
SECTION A – Multiple-choice questions

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.

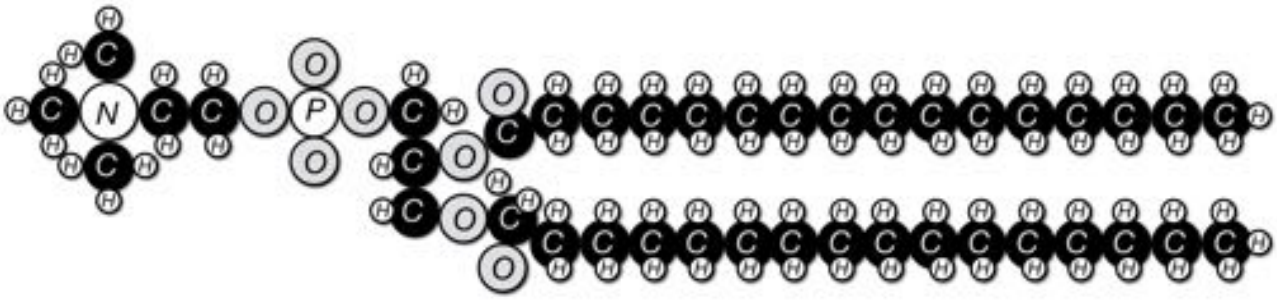
Question 1
All nucleic acids contain
A. carbon, oxygen and hydrogen.
B. carbon, oxygen, nitrogen and hydrogen.
C. carbon, hydrogen, oxygen, nitrogen and phosphorus.
D. carbon, oxygen, nitrogen and sulfur.

Question 2
The molecule shown below is a nucleotide



The part of the molecule enclosed within the area labelled A, is
A. A 5-carbon deoxyribose sugar.
B. A 5-carbon ribose sugar.
C. Adenine.
D. An amine group.

Question 3
The molecule depicted below is found in all living cells.

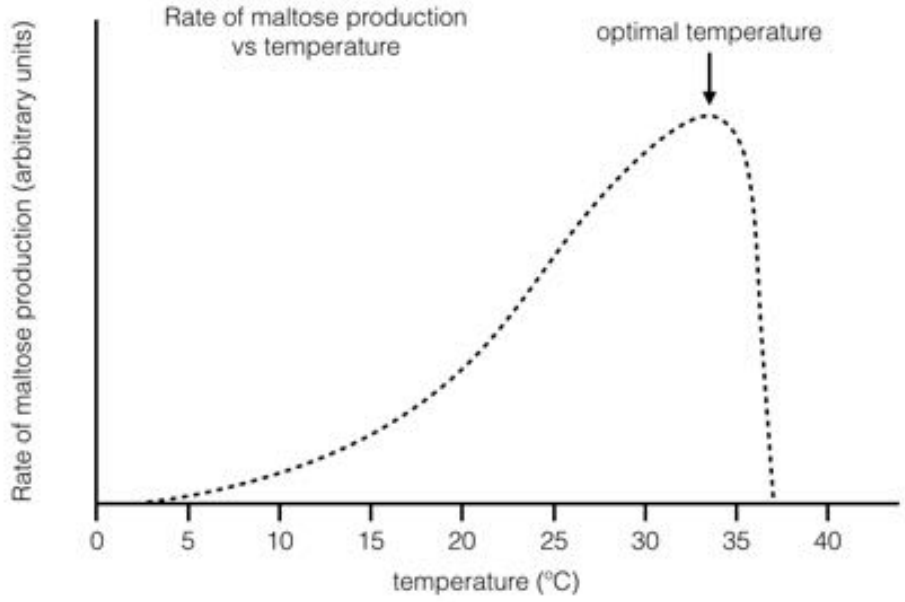


The molecule is
A. a nucleotide.
B. a triglyceride.
C. a phospholipid.
D. an amino acid.

Question 4
The active transport of potassium ions into the root cells of a potato plant
A. requires the potato plant to use ATP.
B. moves the potassium ions down a concentration gradient.
C. involves potassium moving through a channel protein.
D. takes place by simple diffusion.

Question 5

The enzyme β-amylase converts starch to maltose, a disaccharide. The graph below shows the rate of a reaction catalysed by β-amylase.



Four test tubes, each containing a solution of β-amylase were prepared as follows:

- Test tube 1 was cooled to 5ºC then heated to 30ºC then cooled to 25ºC
- Test tube 2 was cooled to 5ºC then heated to 40ºC then cooled to 25ºC
- Test tube 3 was heated to 40ºC then cooled to 0ºC then heated to 25ºC
- Test tube 4 was heated to 30ºC then cooled to 0ºC then heated to 25ºC

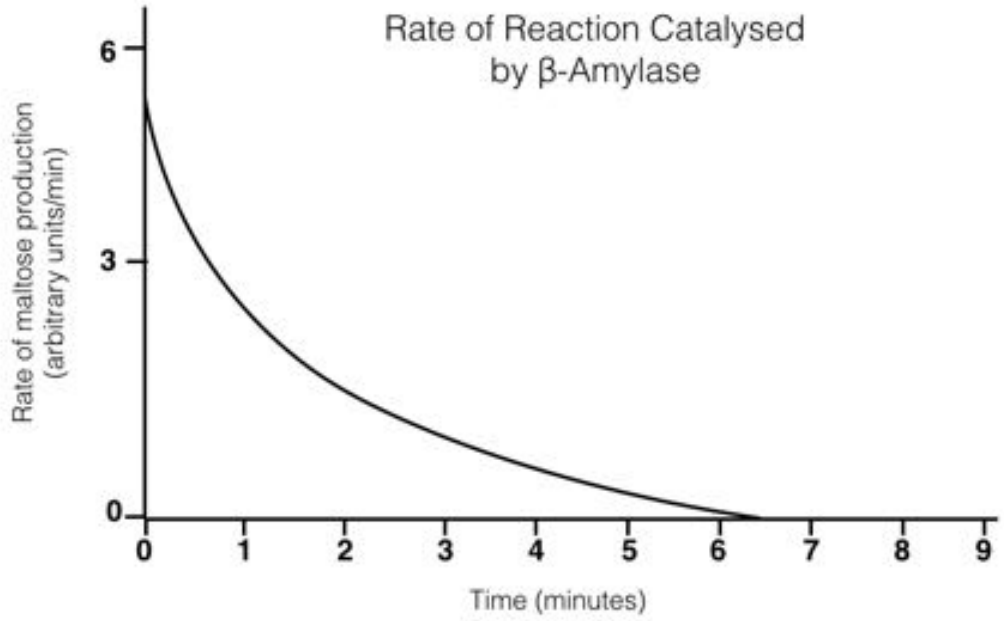
Following treatment, an equal amount of starch solution was added to each test tube. The test tubes were then incubated at 25ºC for 5 minutes. The concentration of maltose was then measured in each test tube.

It is reasonable to expect that

A. test tube 1 would contain a higher concentration of maltose than test tube 4.
B. there would be no maltose produced in test tubes 2 and 3.
C. only test tube 1 would contain maltose.
D. all the test tubes would show the presence of maltose except test tube 3.

Question 6

An experiment was conducted in which β-amylase was added to a solution containing starch and water. The concentration of maltose present in the solution was measured at the time the β-amylase was added (time 0) and each minute after that, for a total of nine minutes. Because maltose is the product of the digestion of starch by β-amylase, its changing concentration can be used to infer the rate of reaction. The inferred rate of reaction over the 9 minutes of the experiment is represented in the graph below.



From this data, it is reasonable to conclude that

A. by 6 minutes the reaction had stopped.
B. at 0 minutes the enzyme is at its optimal temperature.
C. by 7 minutes, the enzyme was saturated with substrate.
D. the concentration of maltose in the solution was higher at 4 minutes than at 3 minutes.

Question 7

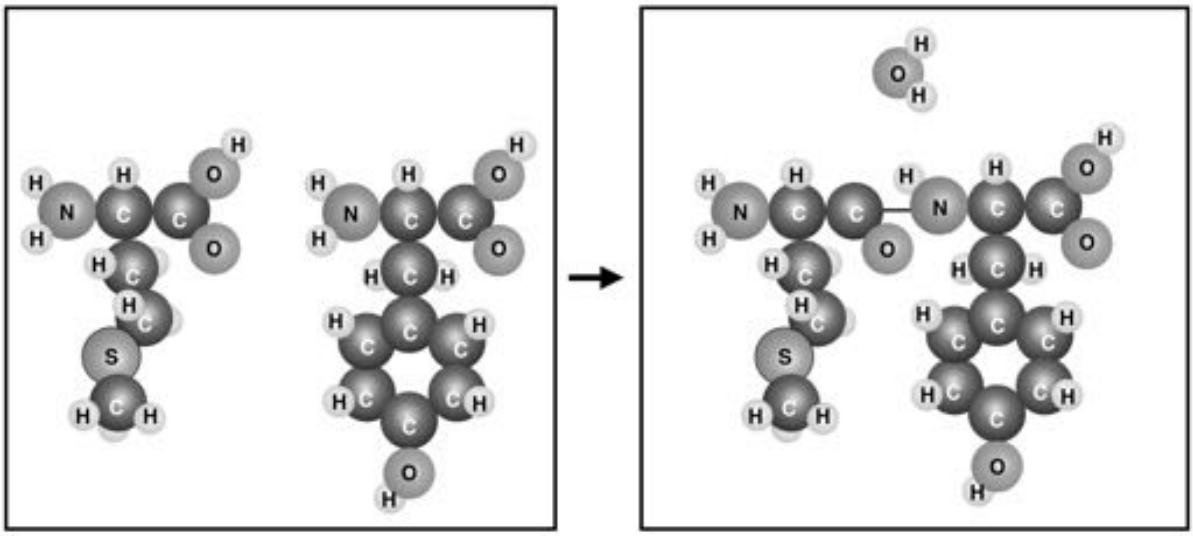
An alpha helix (α-helix) is a section of a polypeptide which has a coiled structure, like a spring.

An α-helix is an example of a protein's:

A. primary structure.
B. secondary structure.
C. tertiary structure.
D. quaternary structure.

Question 8

The illustration below, depicts two amino acids forming a peptide bond.

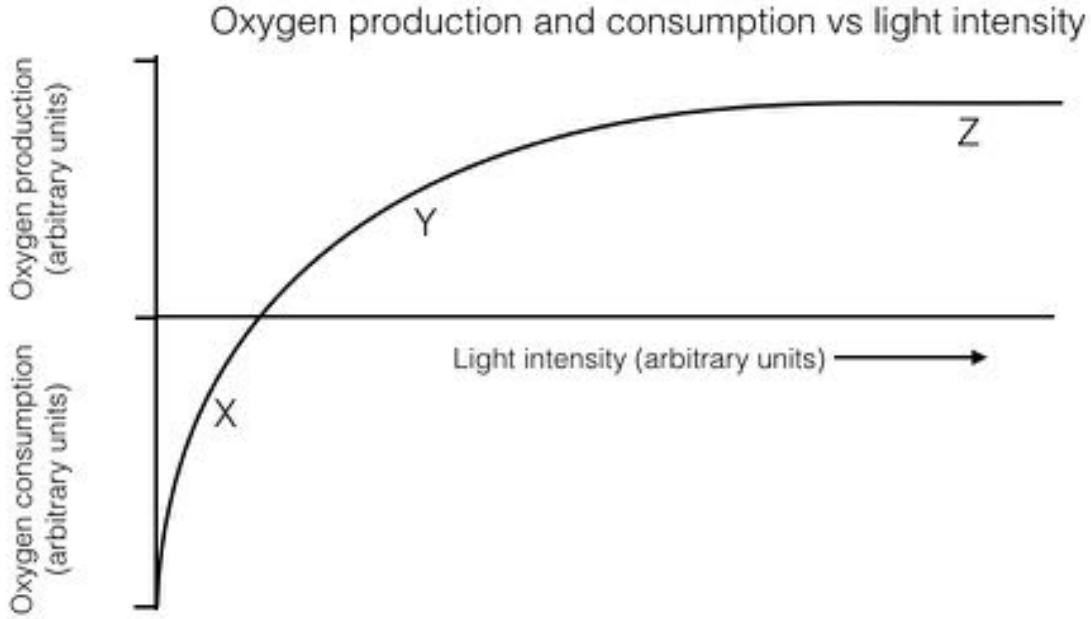


The bond illustrated is commonly referred to as a condensation bond because

A. the peptide formed is smaller than the sum of the two amino acids from which is was formed.
B. water is produced as a by-product.
C. it is a bond between two amino acids.
D. electrons are shared between the nitrogen of one amino acid and the carbon of the other.

Question 9

The relationship between oxygen production, oxygen consumption and light intensity in a *Begonia* plant is shown in the graph below.



Consider the points X, Y and Z marked on the graph. Which of the following statements is most accurate?

A. Light intensity is the limiting factor at Z.
B. Giving the plant more CO_2 at Y would increase the rate of photosynthesis.
C. Both cellular respiration and photosynthesis are occurring at X.
D. There is a net uptake of CO_2 at X.

Question 10
In aerobic cellular respiration,
A. glycolysis takes place in the mitochondria.
B. ATP is produced in the citric acid cycle.
C. electron transport produces NADPH.
D. the process begins with the uptake of 12 H_2O molecules.

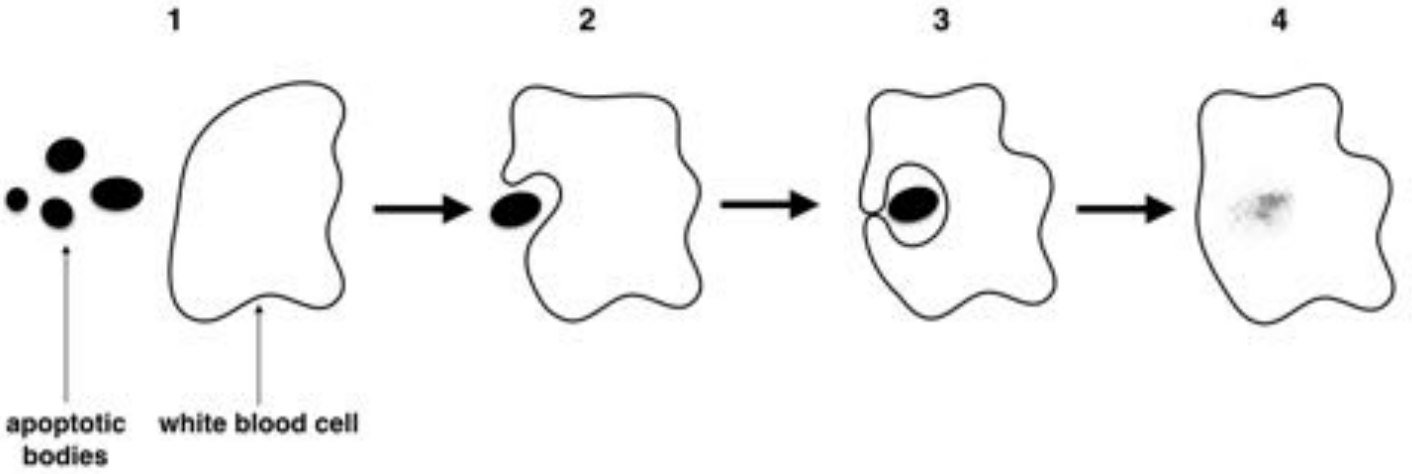
Question 11
Apoptosis or programmed cell death, is a biochemical pathway that results in the death of a cell. Which of the following is not characteristic of a cell undergoing apoptosis?
A. "blebbing": the cell membrane shows irregular budding.
B. "cell shrinkage": the cell gets smaller and loses its shape.
C. "chromatin condensation": the nuclear DNA forms patches against the nuclear membrane.
D. "lysis": the plasma membrane is ruptured, spilling the contents of the cytoplasm.

Question 12
The genetic code is said to be "degenerate". An example of this is the fact that
A. CCU and CCC both code for proline.
B. GGU only codes for glycine.
C. CUC codes for leucine in all living species.
D. Adenine pairs with Uracil in mRNA but with Thymine in DNA.

Question 13
The genetic code is also said to be 'universal'. An example of this is the fact that
A. All living things have a genetic code made up of the same four bases (A, T, C and G).
B. both animal hormones and plant growth regulators travel in the organism's circulatory system.
C. UCA codes for serine in both bacteria and monkeys.
D. Each codon encodes a specific amino acid.

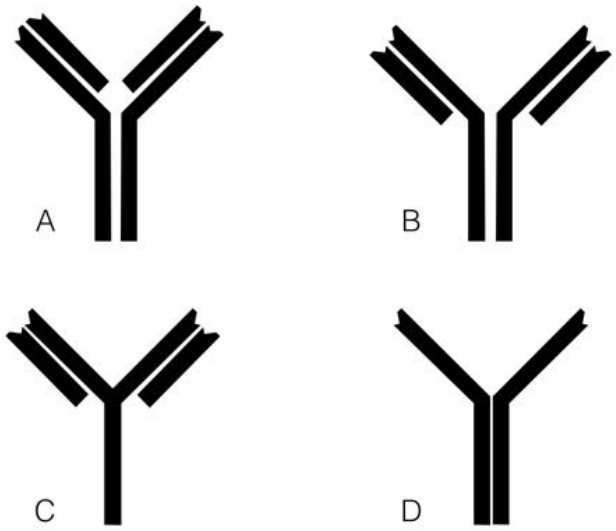
Question 14
Vaccination involves introducing a small amount of antigen from a pathogen to a host, to induce the host to produce antibodies against that antigen. In this way, if the host later encounters the pathogen, an immune response is rapid. A person who has been vaccinated
A. has artificial active immunity to the pathogen.
B. has artificial passive immunity to the pathogen.
C. has natural active immunity to the pathogen.
D. has artificial active immunity to the pathogen.

Question 15
The diagram below illustrates a sequence of events that take place following apoptosis.



The white blood cell depicted could be
A. a cytotoxic T cell.
B. a helper T cell.
C. a neutrophil.
D. a natural killer (NK) cell.

Question 16
Which of the following diagrams best represents the structure of an IgG antibody?



A. diagram A
B. diagram B
C. diagram C
D. diagram D

Question 17
Examples of the innate immune response include
A. the release of antibodies by plasma cells.
B. the release of histamines from mast cells.
C. the release of cytokines from helper T cells.
D. the release of a death ligand by cytotoxic T cells.

Question 18
The overproduction of IgE antibodies by plasma cells, is thought to contribute to
A. neurodegenerative diseases.
B. cancer.
C. autoimmune disorders.
D. hypersensitivity disorders.

Question 19
When conducting a scientific experiment, the variable that the researcher deliberately manipulates is called
A. a control.
B. a dependent variable.
C. an independent variable.
D. an extraneous variable.

Question 20
Plant hormones resemble animal hormones in that they
A. are made of peptides or steroids.
B. travel in general circulation throughout the plant body.
C. are secreted by endocrine glands.
D. are organic.

Question 21
Cytochrome c is a protein of about 100 amino acids found in the mitochondria of all animals. Although the gene for cytochrome c exists in the genome of all animals, there are numerous genetic differences between species. Many mutations have taken place in the cytochrome c gene throughout evolutionary history. Some of these mutations have been conserved while others will have made the cytochrome c protein non-functional and have not been conserved.

If a mutation takes place in the cytochrome c gene, it is most likely to be conserved if the mutation is
A. a single-base deletion.
B. a block mutation.
C. a single-base substitution.
D. a frameshift mutation.

Question 22
Selective breeding in a herd of cattle will most likely result in
A. decreased genetic diversity in the herd.
B. increased genetic diversity in the herd.
C. increased fitness in the herd.
D. herd immunity.

Question 23
A disadvantageous trait will disappear most quickly from a population if
A. there is no selection pressure.
B. the trait is dominant..
C. the trait is polygenic.
D. the rate of gene flow into the population is high.

Question 24
The karyotype below was prepared from the cells of a human.

Source: Wikimedia commons

The karyotype demonstrates an example of
A. a male cell with aneuploidy.
B. a female cell with polyploidy.
C. a normal male cell.
D. a female cell with aneuploidy.

Question 25

The spotted cuscus *(Spilocuscus maculatus)* is a large phalanger; a possum-like marsupial found in the dense rainforests of New Guinea. Males vary in colour from red-brown to black, and have white blotches. Females are usually grey. There is considerable variation in colour between individuals, and in the size and distribution of white blotches. Pure-white cuscuses are known to exist in captivity, but are uncommon in the wild because they are more conspicuous to the New Guinea harpy eagle (*Harpyopsis novaegineae)* which feeds almost entirely on phalangers. With respect to the spotted cuscus, the New Guinea harpy eagle is

Source: Wikimedia commons

A. a selection pressure.
B. a natural selection.
C. a selecting agent.
D. an isolating mechanism.

Question 26

Although whales are completely aquatic, it is understood by biologists that they have evolved from a terrestrial ancestor, which walked on land. One piece of evidence supporting this claim, is that whales have a pelvis. The function of a pelvis in a terrestrial mammal, is to articulate the hind legs with the spine. Since whales do not have hind legs, they do not need a pelvis. Furthermore, unlike the pelvis of terrestrial mammals, the pelvis of the whale is not connected to the spine at all. It serves no function.

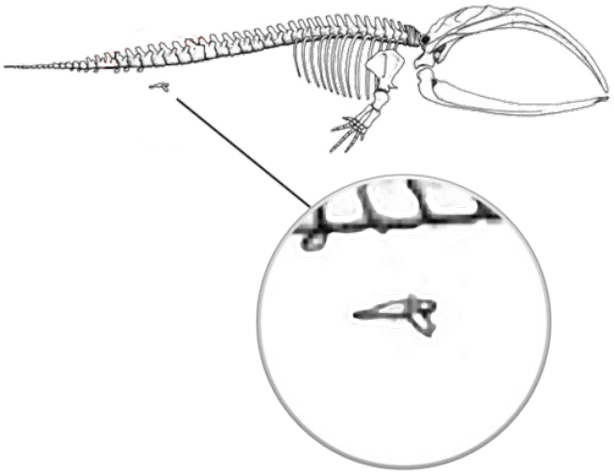


Image adapted with permission from Wikimedia Commons.

A feature of an animal which performs no function, but has been inherited from an ancestor in which it did have a function, is called

A. an analogous structure.
B. a vestigial structure.
C. a homologous structure.
D. an evolutionary hangover.

Question 27
The DNA base sequence of the same region of the rhodopsin gene in four species of grass (family Poaceae) were compared.

The Base sequences are listed below:

Sorghum halepense	GAA GGG GCG CCG TAC CAA TTA CGT GAA TGG GGG
Cynodon dactylon	GTA GGC GCG CCG TAG CAA TTA AGT GAA TGG GGA
Paspallum notatum	GAA AGG GCG CCG TAG CAA TTA CGT GAT TGG GGG
Zea mays	GAA GGG GCG CCG TAG TAA TTA CGT GAA TGG GGG

Based on this evidence, it is reasonable to conclude that the grass species which share the most recent common ancestor are most likely

A. *Zea mays* and *Sorghum halepense*.
B. *Cynodon dactylon* and *Zea mays*.
C. *Paspallum notatum* and *Zea mays*.
D. *Cynodon dactylon* and *Sorghum halepense*.

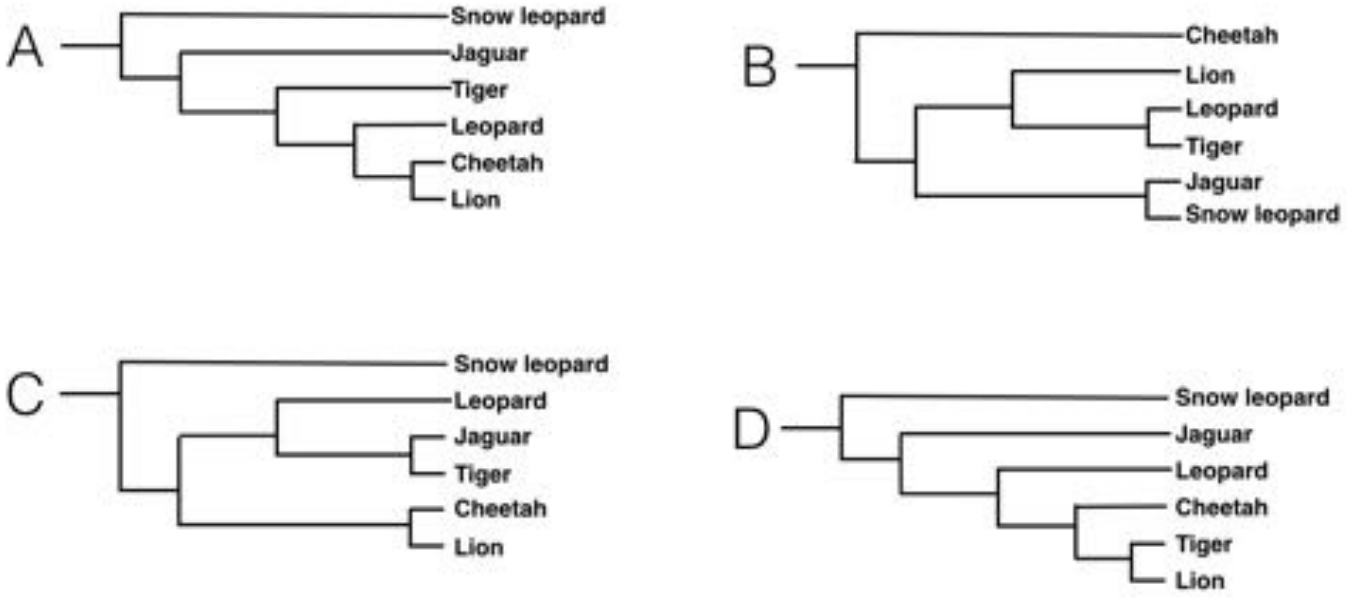
Question 28
There is no single defining characteristic of class Primates. Instead, primates are defined by the possession of a combination of features. Which of the following lists features which are common to all primates?

A. They have flat fingernails, large brains and walk on two legs.
B. They have forward-facing eyes, an opposable thumb and a prominent heel bone.
C. They have a long gestation period, flat fingernails and live in social groups.
D. They have opposable thumbs, large brains and grasping feet.

Question 29
Mitochondrial DNA (mtDNA) is more useful than nuclear DNA in studying human ancestry because

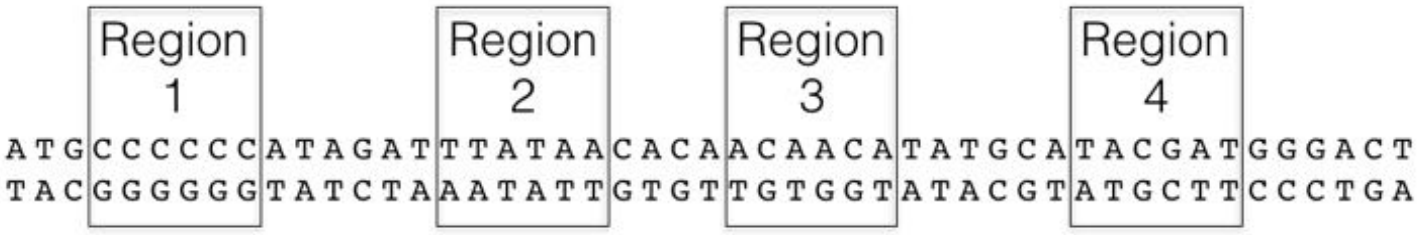
A. mutation is the only source of new alleles in mtDNA.
B. mtDNA is not subject to crossing over.
C. the mutation rate in non-coding mtDNA is much slower than in non-coding nuclear DNA.
D. mtDNA is inherited only through the paternal line.

Question 30
In which of the following cladograms shows the cheetah to be most closely related to the leopard?



A. cladogram A
B. cladogram B
C. cladogram C
D. cladogram D

Question 31
The base sequence of a section of DNA is shown below. In which labelled region, is it most likely that a restriction endonuclease, able to cut it, would exist?

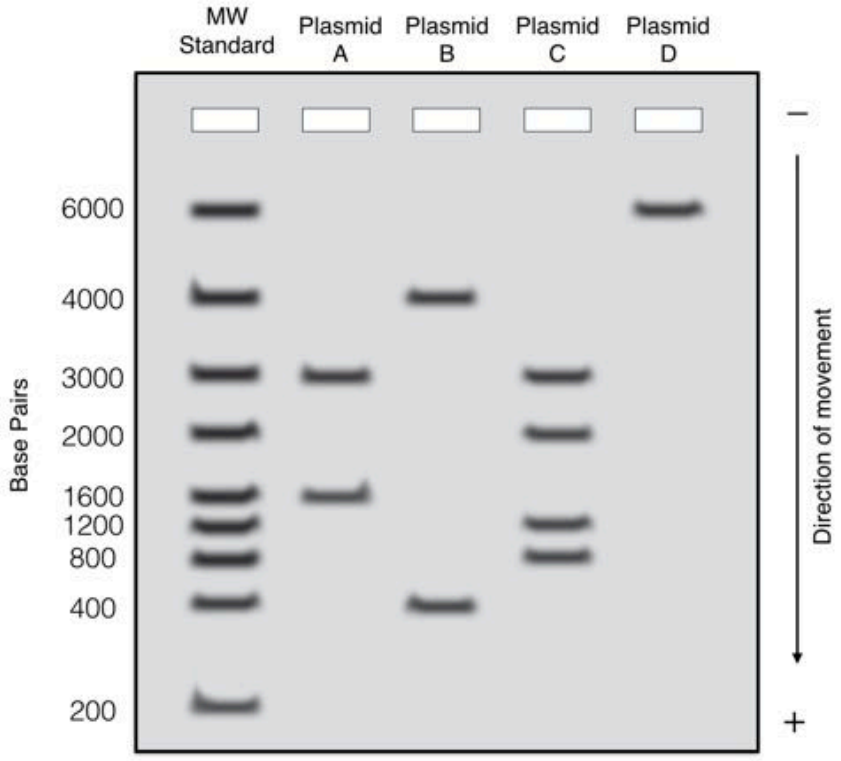


A. Region 1
B. Region 2
C. Region 3
D. Region 4

Question 32
A single DNA microsatellite was amplified using PCR (Polymerase Chain Reaction). After 8 cycles, how many copies of the microsatellite will there be?

A. 8
B. 16
C. 256
D. 1024

Question 33
Four different plasmids, were each incubated with the restriction enzyme Eag1. Each of the plasmids were then sorted on an electrophoresis gel. The results are shown below.

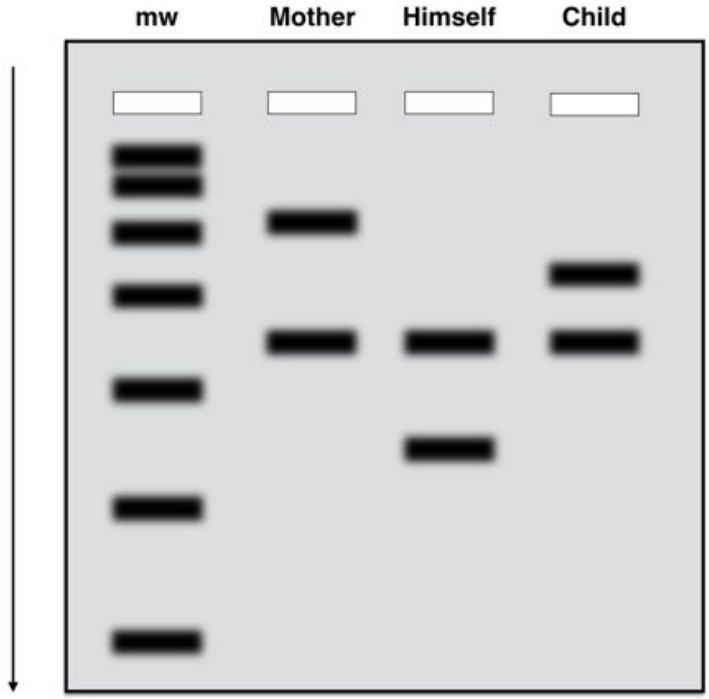


Based on the results shown in the gel, it is most reasonable to conclude that

A. Plasmid D must be longer than Plasmid C.
B. There are three restriction sites in Plasmid C.
C. It is unknown whether Plasmid D has any restriction sites.
D. Plasmid B is longer than Plasmid A.

Question 34
DNA ligase is useful in recombinant DNA technology because it can
A. form phosphodiester bonds between the 3' OH group on one nucleotide and the phosphate on another.
B. form covalent bonds between complementary nucleotide bases.
C. cut DNA at specific base sequences.
D. proof-read DNA and make corrections to point mutations.

Question 35
A biology teacher suspected that he was not the father of the child his wife had recently given birth to. He collected a hair sample from his wife, the child and himself. After school the next day, he used PCR to amplify the D13S317 STR locus on (Chromosome 13), from DNA extracted from the hair follicle of each sample. He then ran the samples on an electrophoresis gel, and obtained the following results.



What conclusion is reasonable to draw from the results?

A. He is the father.
B. He is not the father.
C. He is probably the father but additional STRs should be tested to be certain.
D. The results provide no useful information about whether he is the father.

Question 36
PCR involves adding DNA to a "PCR mixture" of Taq polymerase, deoxynucleotides with the bases Adenine, Thymine, Cytosine and Guanine, and magnesium chloride ($MgCl_2$). These ingredients are added to Tris, which is a 'buffer' which resists changes in pH.

For what reason is it necessary to prevent the pH of the PCR mixture from changing?
A. Nucleotides are very sensitive to changes in pH.
B. $MgCl_2$ is very sensitive to changes in pH.
C. A high pH would prevent the temperature from reaching 95ºC.
D. Taq polymerase is very sensitive to changes in pH.

Question 37
The first 'genetically engineered' crop product to be commercialised was the FLAVR SAVR® tomato, in the 1980s.

When tomatoes ripen, an enzyme called polygalacturonase is synthesised. Polygalacturonase digests the pectin in the cell walls of the fruit, causing it to soften. In 1987 biotechnologists at Calgene Inc. identified the gene responsible for encoding polygalacturonase, synthesised a reverse-orientation (or "antisense") copy of the gene, and inserted this antisense copy into the genome of a tomato cell. The process was named "antisense genetic engineering".

When FLAVR SAVR® tomatoes ripen, mRNA transcribed from the polygalacturonase gene and complementary mRNA transcribed from the antisense-polygalacturonase gene encounter and bind to each other, forming double-stranded mRNA which is unable to be translated.

In this way, the presence of the antisense polygalacturonase gene, prevents the synthesis of polygalacturonase, and as a result, ripening FLAVR SAVR® tomatoes develop the full flavours of a tomato, but do not soften, remaining crisp and easy to transport.

Based on this information and your knowledge of genetics, what term best describes the FLAVR SAVR® tomato?
A. genetically modified
B. transgenic
C. transformed
D. transfected

Question 38
Rocephin® (ceftriaxone) is a cephalosporin antibiotic. Which of the following diseases is Rocephin® most likely to be effective in treating?
A. fungal meningitis
B. bacterial meningitis
C. viral meningitis
D. amoebic meningitis

Question 39

In 2009, swine flu was a new strain of the influenza virus H1N1. Swine flu was first identified in Veracruz, Mexico, where many people were infected, so much so that clinics in some areas of Mexico City were overwhelmed by infected people. The Mexican government attempted to prevent the spread of the disease by closing many public facilities. Likewise, governments around the world advised against non-essential travel to Mexico. Nevertheless, by April the first cases were reported in Europe, and by late April spread of the disease was so great that the World Health Organisation stopped counting cases, and announced that swine flu was a "public health emergency of international concern". By October 2009, President Obama had declared swine flu a "national emergency" in the United States.

In all, more than 43 million cases of swine flu were reported, including 5000 in Australia. More than 14,000 people died from the disease.

The 2009 swine flu can best be described as

A. an outbreak.
B. an epidemic.
C. a pandemic.
D. an endemic.

Question 40

Relenza® is a rationally-designed therapeutic drug, developed by the CSIRO in Australia to treat influenza. The drug is a 'release phase inhibitor'. It binds to neuraminidase; an enzyme on the surface of influenza virus particles, preventing newly formed virus particles from leaving the host cell to infect other cells. In this way, the lytic cycle of the virus is impeded, giving the immune system more time to overcome the infection.

Relenza® is called a 'rationally designed drug' because

A. Relenza® has a shape that is complementary to the shape of the neuraminidase enzyme.
B. Relenza® has complementary charges to those of neuraminidase.
C. scientists first discovered the structure of neuraminidase, then created Relenza® to block it.
D. Relenza® is not a naturally occurring compound.

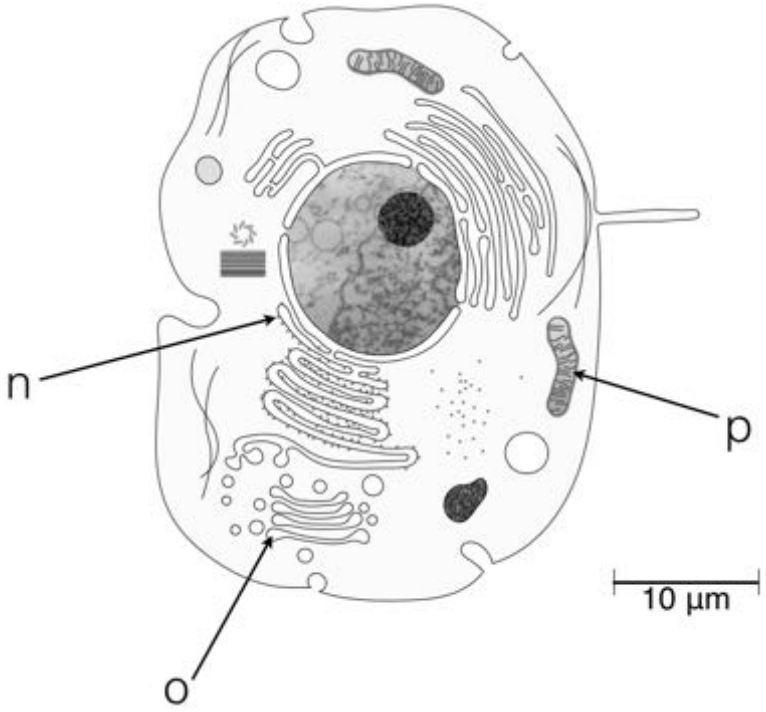
SECTION B – Short-answer questions

Instructions for Section B

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

Question 1 (6 marks)

The image shown below depicts an animal cell. Three structures in the cell are labelled n, o and p.

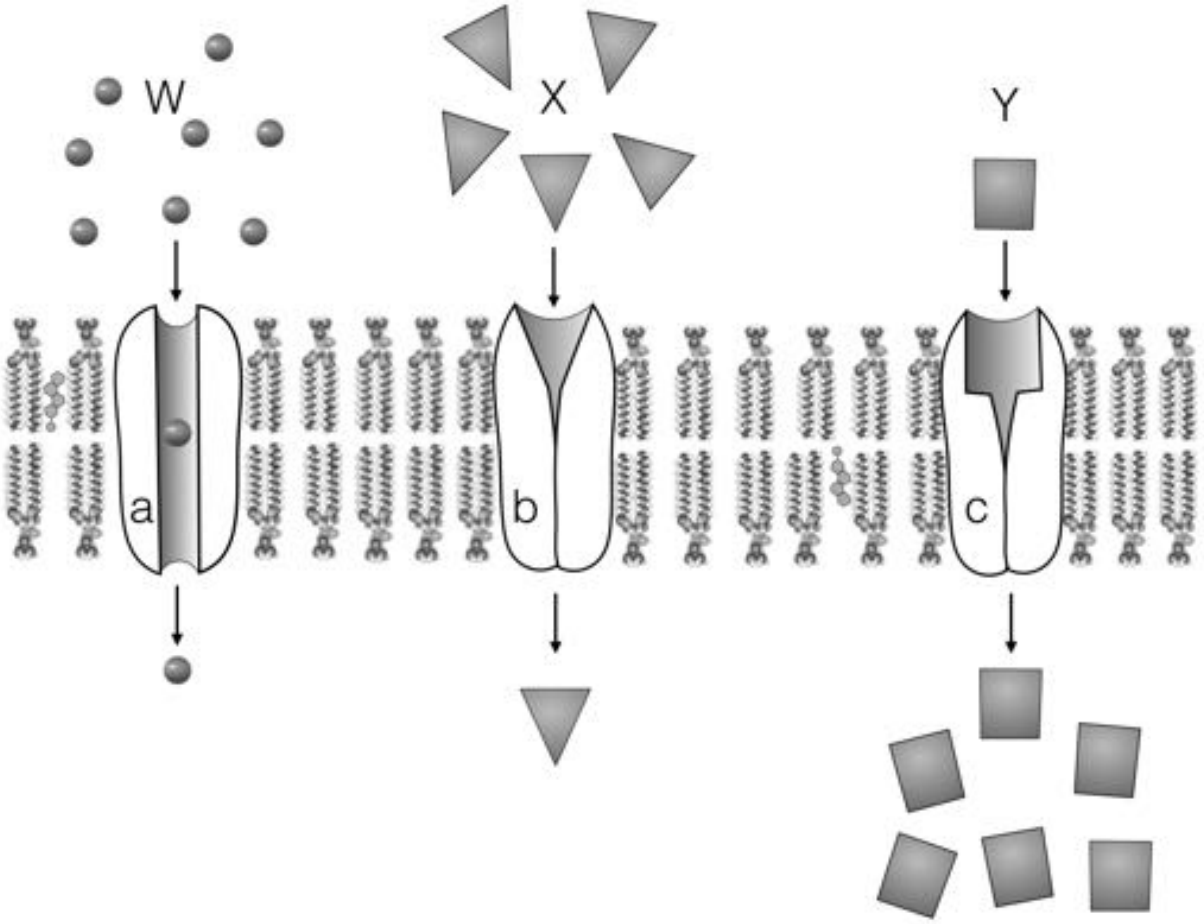


3 marks

a. Complete the following table by naming each of the organelles listed, and describing a specific role played by each organelle, that contributes to the export of a protein product from the cell.

Label	Organelle name	Description of specific role played by organelle in the export of a protein product from the cell
n		
o		
p		

The diagram below, shows the movement of three types of compounds (W, X and Y) via specific transmembrane proteins (a, b and c) across a biological membrane. In each case the arrow indicates the direction of movement.



b. What name is given to the movement of molecule "Y"? 1 mark

_____

c. Does protein "a" require ATP to move compound "W" across the membrane? Explain your answer. 1 mark

_____

_____

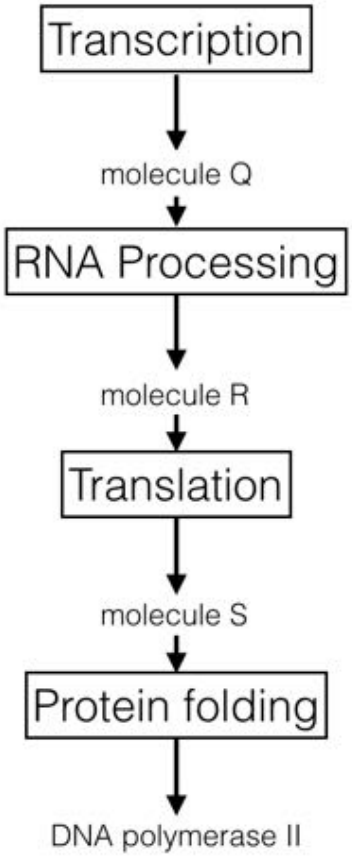
d. What name is given to protein "b"? 1 mark

_____

Question 2 (6 marks)

Lysozyme is an enzyme comprising a single polypeptide chain. Lysozyme is found naturally in human secretions such as tears and milk. It plays an important part in the body's defence against disease because it digests peptidoglycan which is the major component of gram-positive bacterial cell walls.

The flowchart below shows the steps involved in the synthesis of lysozyme.



a. What is the name of molecule "Q"?

1 mark

_____

b. Name a difference between molecule "Q" and molecule "R".

1 mark

_____

c. Describe the steps that take place during translation.

3 marks

d. What level of protein structure does molecule "S" have?

1 mark

Question 3 (9 marks)

Cancer is linked to a failure in apoptosis. Understanding the relationship between cancer and apoptosis is currently the subject of intense research.

a. Explain how a malfunction in apoptosis can contribute to the development of cancer.

1 mark

b. Apoptosis involves an ordered sequence of chemical changes within the cell, which involves proteins modifying other proteins, which in turn modify yet other proteins. What general name is applied to such an ordered sequence of molecular interactions within a cell.

1 mark

c. The final stages of apoptosis results in the activation of enzymes that cut the actin filaments comprising the cytoskeleton. What name is given to the enzymes that cut the cytoskeleton?

1 mark

d. A traditional treatment for cancer is radiation therapy which involves using high-energy radiation to kill cancer cells. While the treatment can be effective in reducing the size of tumors, high level radiation can cause significant side effects in patients including fatigue, skin problems and nausea. One modern treatment for cancer involves the use of monoclonal antibodies, which are joined to a radioactive particle.

2 marks

i. Explain how the use of monoclonal antibodies can reduce side effects for the patient, while still being effective against cancer cells.

ii. Radiation attached to monoclonal antibodies, is effective against cancer, because it stimulates apoptosis in cells. Is this likely to stimulate the extrinsic or intrinsic apoptotic pathway. Explain your answer.

2 marks

e. What type of biomacromolecule are monoclonal antibodies made of?

1 mark

f. Natural Killer Cells can kill cancer cells by secreting a death ligand, which binds to the FasR receptor on the surface of a target cell. Some cancer cells have been shown to actively resist attack by Natural Killer Cells by secreting a soluble form of the FasR receptor. Explain how secretion of soluble FasR prevents the destruction of the cell by NK cells.

2 marks

Question 4 (11 marks)

In March 2017, there was an outbreak of yellow fever in Brazil. The Australian Government Department of Health advised all Australians travelling to Brazil to be vaccinated at least 10 days prior to travel.

Yellow fever is a viral disease caused by an RNA virus in genus *Flavivirus*. This virus infects liver cells (hepatocytes) and dendritic cells. It is transmitted from person to person by the bite of female mosquitos, *Aedes aegypti*.

The symptoms of yellow fever include fever, loss of appetite, nausea, muscle pains and headache. The disease begins suddenly and is short-lived. In most cases, patients fully recover in about three days. In about 15% of cases however, the disease enters a second phase characterized by liver damage, yellow skin (jaundice), bleeding in the eyes and digestive tract. 35% of patients exhibiting these symptoms die.

Aedes aegypti

Death is caused by tissue damage resulting from a "cytokine storm". A cytokine storm occurs when dendritic cells are stimulated to secrete large numbers of cytokines. These cytokines attract macrophages and other immune cells to the site of infection. In addition, the cytokines activate those immune cells, stimulating them to produce even more cytokines. Normally, the body keeps this feedback loop in check, but in some circumstances, such as with a yellow fever infection, the reaction becomes uncontrolled, and too many immune cells are activated in a single place within the body, where they cause tissue damage.

There is no known cure for yellow fever. Several treatments which are effective in the treatment of other diseases are ineffective in the treatment of yellow fever. These include passive immunisation following infection, treatment with antiviral drugs and treatment with interferons. Antibiotics are also ineffective against yellow fever.

a. Explain why treatment with antibiotics is unlikely to be effective in the treatment of yellow fever.

1 mark

_____

_____

b. Explain what treating a patient with "passive immunisation following infection" would involve.

_____

1 mark

_____

c. Suggest why treatment with passive immunisation following infection may not be effective against yellow fever.

1 mark

d. Name a cell, other than macrophages and dendritic cells, that secretes cytokines.

1 mark

e. Explain how vaccination, prior to infection can prevent yellow fever.

2 marks

f. Although administration of interferons has not been shown to be effective against yellow fever, it is effective against other viral diseases like hepatitis B. Explain how interferons might act as an effective therapy for some viral diseases?

1 mark

g. Explain why the Australian Government Department of Health recommends a 10-day waiting period between vaccination for yellow fever, and travel to Brazil.

2 mark

h. The vaccine given for yellow fever is an attenuated yellow fever virus. Define "attenuated virus".

1 mark

i. Other than vaccination, suggest one other precaution travelers to Brazil should take to avoid infection by yellow fever.

1 mark

Question 5 (11 marks)

Cystic Fibrosis is a disease that results from the inability of cells to regulate the movement of chloride ions across cell membranes. The Disease results from the inability of the cells to produce a properly-functioning CFTR protein. (CFTR stands for "Cystic Fibrosis Transmembrane Regulator"). The precise location of the CFTR gene is known. Its locus is on Chromosome 7, at position q31.31

The base sequence of the CFTR gene is also known. Below is a transcript of a small section of the messenger RNA (mRNA) copy of the gene, comprising exons 11-13. In total, there are 6129 bases and 27 exons in the messenger RNA encoding the CFTR protein.

Exon 1

AUG AAU UGG AAG CAA AUG ACA
UCA CAG CAG GUC AGA GAA AAA
GGG UUG AGC GGC AGG CAC CCA
GAG UAG UAG GUC UUU GGC AUU
AGG AGC UUG AGC CCA GAC GGC
CCU AGC AGG GAC CCC AGC GCC
CGA GAG ACC AUG CAG AGG UCG
CCU CUG GAA AAG GCC AGC GUU
GUC UCC AAA CUU UUU UUC **A**AG

Exon 2

AUG CUG GAC CAG ACC AAU UUU
GAG GAA A**G**G AUA CAG ACA GCG
CCU GGA AUU GUC AGA CAU AUA
CCA AAU CCC UUC UGU UGA UUC
UGC UGA CAA UCU AUC UGA AAA
AUU GGA AAG

a. Describe a feature of the first codon (AUG) that enables us to know that this is mRNA and not DNA?

1 mark

b. A molecular biologist used the enzyme reverse transcriptase to transcribe the mRNA of these two exons into cDNA (complementary DNA). Describe a significant difference between this cDNA and the original chromosomal DNA in the gene from which the mRNA was transcribed.

1 mark

c. Write out the first twelve cDNA bases that would be transcribed from exon 2 by reverse transcriptase.

1 mark

d. Reverse transcriptase is an enzyme derived from certain viruses. What kind of viruses contain reverse transcriptase?

1 mark

e. Several mutations are known to exist in the CFTR gene in some families. Two such mutations are indicated in the transcript above.

i. The first mutation, called 182delT, involves the deletion of the third last base in exon 1. By referring to the genetic code table on the next page, explain what change this mutation will have on the amino acid sequence in the polypeptide.

2 marks

ii. The second mutation, called G27X, involves the substitution of Uracil for Guanine in the 29th base of exon 2. What effect will this have on the amino acid sequence in the polypeptide?

1 mark

_____

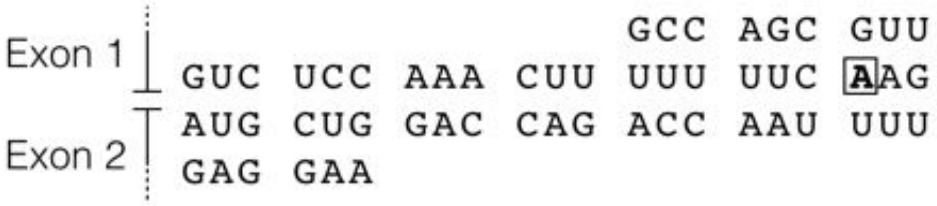
_____

_____

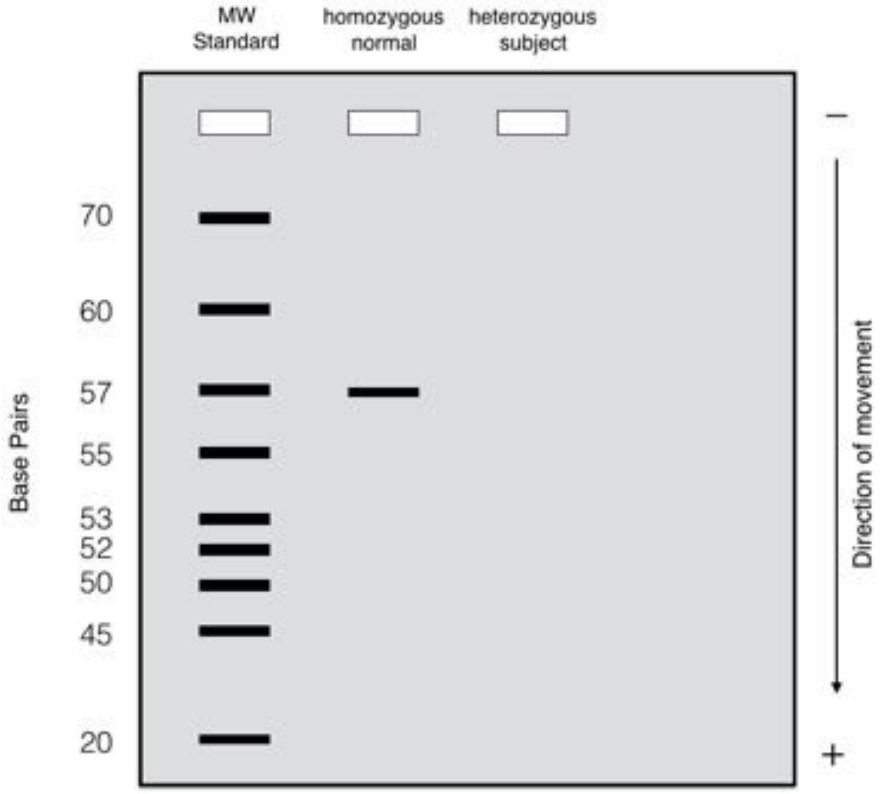
Second Position

First Position	U	C	A	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

In families affected by the 182delT mutation, a genetic screening test is now available which makes it possible for people who do not suffer from cystic fibrosis, to find out whether they are heterozygous for the 182delT mutation. The test is performed by amplifying the codon known to contain the 182delT locus plus nine codons either side (19 codons altogether as shown below).



The amplified DNA is then sorted on an electrophoresis gel, as shown in the diagram below.



f. Complete the diagram by showing what would be expected to appear in the gel for a subject who is heterozygous for the 182delT mutation. 1 mark

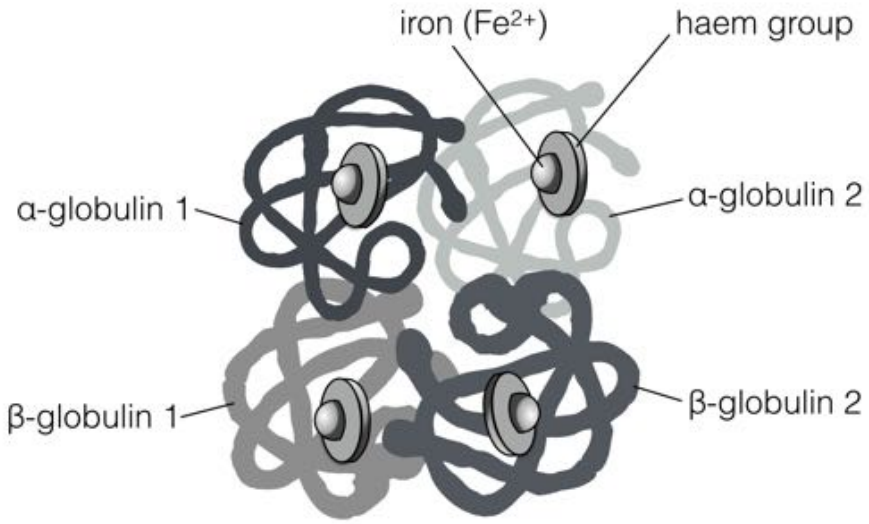
g. Explain why nine codons either side of the mutation must be amplified, and not just the codon which is known to be the locus of the mutation.

1 mark

h. Explain whether the same procedure would be useful to test the carrier status of a person in a family with the G27X mutation.

2 marks

Question 6 (10 marks)
Haemoglobin (Hb) is a metalloprotein comprising four polypeptide chains: two α-globin and two β-globin chains, plus four haem groups, each containing iron.



Haemoglobin is found in the red blood cells of all vertebrates except one family of fishes – the Channichthyidae, or "icefish" which are found in the cold waters surrounding Antarctica. It is estimated that 90% of the fish in the icy waters surrounding Antarctica are icefish.

Although the Channichthyidae lack haemoglobin in their blood, there is evidence that the ancestors of icefish did have haemoglobin in their blood because a small remnant of the gene for β-globin is still present in the icefish genome.

a. It is believed that the loss of haemoglobin in the ancestors of the icefish was due to a mutation in the DNA of the fish. Name the kind of mutation which could have caused the loss of a large portion of the β-globin gene. Explain your answer.

2 marks

The absence of haemoglobin in the blood makes the transport of oxygen throughout the body ten times less efficient. In most species of fish, the loss of haemoglobin would be fatal. One reason icefishes have been able to survive without haemoglobin is that the near-freezing water they inhabit contains a much higher concentration of dissolved oxygen than warmer oceanic water. Despite this, icefish have several adaptations that help them to overcome the problems caused by a lack of haemoglobin. They have:

- unusually large hearts,
- blood vessels with a large diameter,
- a high blood volume,
- a rapid heart rate,

- skin that can absorb oxygen in addition to the gills.

b. Using the information above, explain how natural selection could have led to the icefish having unusually large hearts.

4 marks

c. Name the biochemical process occurring in the cells of the icefish that requires oxygen?

1 mark

d. In addition to lacking haemoglobin, icefishes lack red blood cells, which without haemoglobin, would be non-functional. It is thought that the loss of red blood cells occurred following the loss of haemoglobin, and was an advantage to the icefishes.

One advantage conferred by the loss of red blood cells, is that blood without red blood cells is thinner and more fluid which is seen to be an advantage in near-freezing water. Suggest another advantage to the icefishes of not producing red blood cells.

1 mark

_____

_____

e. If global warming causes the temperature of the oceans to rise, what do you expect will happen to the Channichthyidae? Explain your answer.

_____

2 marks

_____

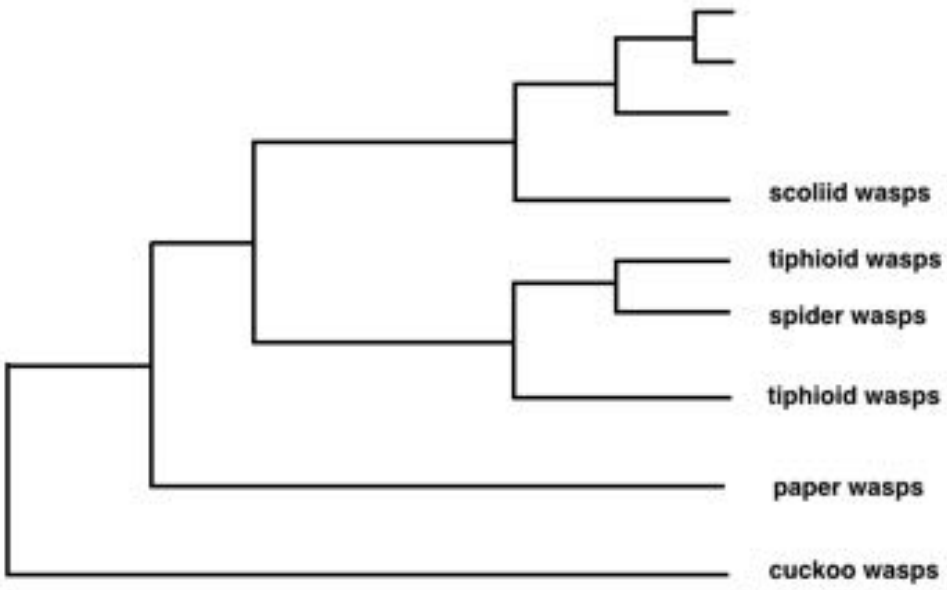
_____

Question 7 (9 marks)
Hymenoptera is a large order of insects. It comprises more than 90 families and 15,000 species, including ants, bees and wasps.

In 2013, in the largest study of its kind, entomologists sequenced and compared the DNA of 308 genes in representatives of 9 Hymenopteran families, to determine their phylogenetic relationships.

The findings of the study challenged some previously held assumptions about the evolutionary relationships within the order, and led to the reclassification of some insect families. One surprise finding involved ants and bees. The findings of the study indicate that bees are more closely related to ants than they are to all wasp families except the cockroach wasps.

a. The scientists conducting the 2013 study, published the following cladogram to represent the surprising findings of their research. Using the information presented above, complete the cladogram by filling in ants, bees and cockroach wasps. 1 mark



b. **i.** Are paper wasps more closely related to cuckoo wasps, or to bees?

1 mark

_____

ii. Explain your answer.

1 mark

_____

_____

c. Suggest why the scientists have represented tiphioid wasps in two places on the cladogram?

2 marks

Female insects in most families of Apocrita possess an 'ovipositor' through which eggs are laid. The ovipositor is typically long and sharp; used to pierce the skin of a caterpillar or other host, into which the eggs are deposited. Fossil evidence suggests that the ancestor of all hymenopterans had a long ovipositor like that still found in most families, including scoliid wasps, tiphioid wasps and cuckoo wasps.

In ants, bees, spider wasps, cockroach wasps and paper wasps the ovipositor has been modified into a stinger, used to inject venom into prey. These insects do not lay their eggs into a caterpillar host.

Previously it was assumed that all hymenopterans with a sting, had shared a common ancestor with a sting. The 2013 study, however, suggests that a sting may have evolved more than once in the order.

Female scoliid wasp (Source: Wikimedia commons)

d. Are the stingers in bees and spider wasps likely to be analogous or homologous? Explain.

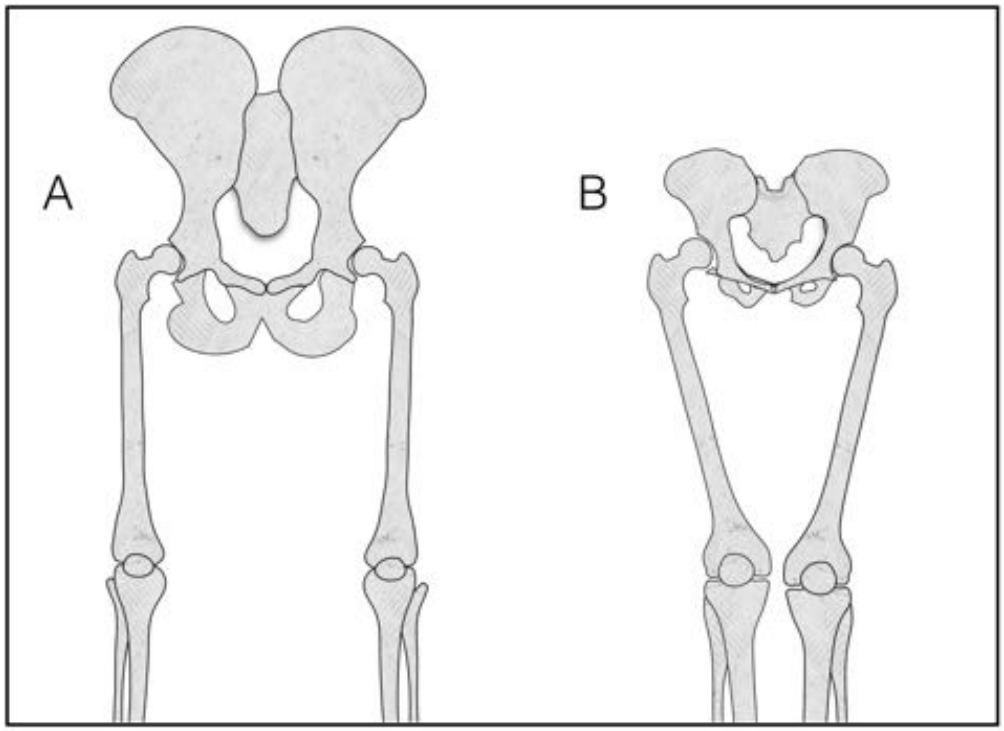
2 mark

e. Are the stingers in bees and ants likely to be analogous or homologous? Explain.

2 mark

Question 8 (10 marks)

The diagram below shows the arrangement of bones in the pelvis and legs of a neanderthal (*Homo neanderthalensis*) and a chimpanzee (*Pan troglodytes*). The drawings are not to scale.



a. **i.** Which drawing, drawing A or drawing B represents the Neanderthal?

1 mark

_____

ii. Describe a feature of the neanderthal skeleton that enabled you to decide which skeleton belongs to *Homo neanderthalensis*, and explain the evolutionary significance of that feature.

Feature:

1 mark

_____

Explanation

1 mark

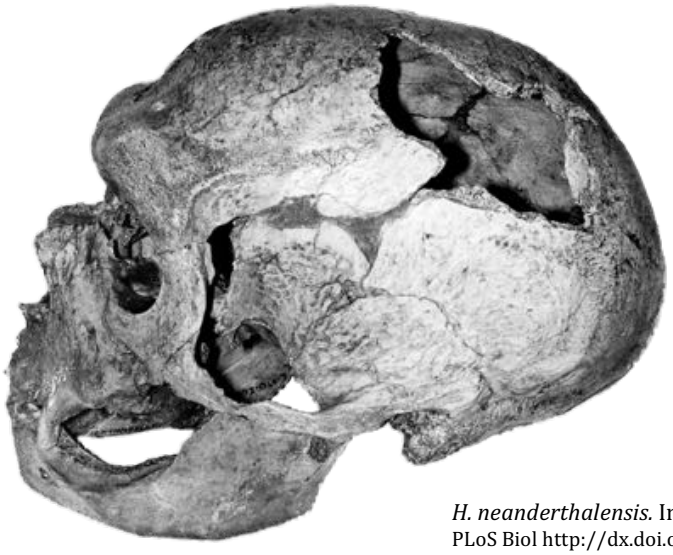
_____

_____

b. The feet of *Homo neanderthalensis* and *Pan troglodytes* are not shown in the drawings. Describe one difference you would expect to see in the feet, had they been shown in the drawings.

1 mark

The image below is a photograph of a fossil Neanderthal (*Homo neanderthalensis*).



H. neanderthalensis. Image adapted with permission: PLoS Biol http://dx.doi.org/10.1371/journal.pbio.0020080

c. Is the Neanderthal fossil more likely to have been discovered by a paleontologist in Kenya (East Africa) or in France (Western Europe)? Explain your answer.

2 mark

d. Describe two anatomical features of the fossil which would have enabled the paleontologist to have distinguished it from a fossil *Homo sapiens* skull. 2 mark

e. The fossil has been dated to 42 million years old. Name an absolute dating method which was likely to have been used on the fossil to arrive at this conclusion. 1 mark

Homo sapiens evolved before *Homo neanderthalensis* became extinct and both coexisted in Europe and Asia. There is evidence from our own genome, that modern humans contain some neanderthal DNA. This indicates that during the time *H. sapiens* and *H. neanderthalensis* coexisted, they could interbreed. The small contribution of Neanderthal DNA to the human genome however, indicates that while interbreeding was biologically possible between the two species, it was uncommon.

f. Suggest a reason why interbreeding may have been uncommon between *H. sapiens* and *H. neanderthalensis*. 1 mark

END OF QUESTION AND ANSWER BOOK