

YEAR 12 *Trial Exam Paper*

2018

BIOLOGY

Written examination

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

STUDENT NAME:

QUESTION AND ANSWER BOOK

Structure of book

<i>Section</i>	<i>Number of questions</i>	<i>Number of questions to be answered</i>	<i>Number of marks</i>
A	40	40	40
B	11	11	80
			Total 120

- Students are permitted to bring pens, pencils, highlighters, erasers, sharpeners and rulers into the examination.
- Students are NOT permitted to bring blank sheets of paper and/or correction fluid/tape into the examination.
- Calculators are not allowed in this examination.

Materials provided

- Question and answer book of 43 pages
- Answer sheet for multiple-choice questions

Instructions

- Write your **name** in the box provided above and on the multiple-choice answer sheet.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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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** or that **best answers** 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.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1

The following table shows the concentration of cholesterol (in percentage mass) in the lipid bilayer of a variety of cells and cellular structures.

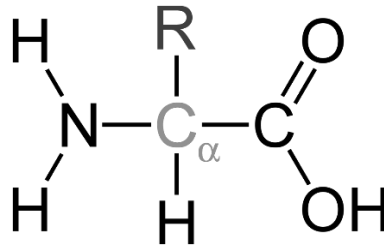
Membrane number	Membrane location	Cholesterol concentration (g per 100 g)
1	plasma membrane of a liver cell	18
2	mitochondrial cristae	4
3	plasma membrane of Schwann cells	27
4	plasma membrane of red blood cells	21

Across which of the plasma membranes would osmosis occur most easily?

- A.** membrane 1
- B.** membrane 2
- C.** membrane 3
- D.** membrane 4

Question 2

The diagram below shows the generic structure of an amino acid, which is one of the monomers that make up proteins. The R in the diagram stands for radical. Radicals are the variable component of amino acids and can vary in length, polarity and acidity.



A scientist has constructed an artificial phospholipid bilayer in which the phospholipids are oriented in the same way as a cellular plasma membrane. The scientist wishes to incorporate some proteins into the central region of the phospholipid bilayer to increase its stability.

Which one of the following attributes should the amino acids that make up this protein have to achieve the specified purpose?

- A. The R group should be long.
- B. The R group should be polar.
- C. The R group should be hydrophilic.
- D. The R group should be hydrophobic.

Question 3

Glucagon is a peptide hormone that is produced by the alpha cells of the pancreas and then released into the circulatory system.

Which one of the following options best describes the pathway of glucagon from after it is synthesised to its release from an alpha cell?

- A. Golgi apparatus, secretory vesicle, plasma membrane
- B. rough endoplasmic reticulum, transport vesicle, plasma membrane
- C. rough endoplasmic reticulum, smooth endoplasmic reticulum, Golgi apparatus
- D. rough endoplasmic reticulum, transport vesicle, Golgi apparatus, secretory vesicle, plasma membrane

Question 4

The blood–brain barrier is a highly selective semipermeable barrier that separates blood in the circulatory system from cerebrospinal fluid in the central nervous system. The effectiveness of the blood–brain barrier relies on a modification so that the cells that make up the capillaries are more tightly packed than in other capillaries. The blood–brain barrier was discovered when blue dye was injected into the bloodstream of an animal and caused all of the tissues – with the exception of the brain and spinal cord – to turn blue.

An appropriate explanation for this result would be that the

- A. blue dye was made up of large hydrophilic molecules and was unable to diffuse across the blood–brain barrier.
- B. cells that make up the walls of a capillary lack a phospholipid bilayer and the blue dye is therefore unable to diffuse across the blood–brain barrier.
- C. cells in the brain and spinal cord did not have a specific receptor for the blue dye to bind to, so the dye did not affect these tissues.
- D. blue dye was broken down by enzymes that are only present in the brain and spinal cord and therefore did not cause a colour change in these tissues.

Question 5

A researcher was studying the structure of a transmembrane protein in the plasma membrane. The researcher observed that the structure of the protein differed in the plasma membrane compared with the polypeptide product at the end of translation.

The change in the conformation of the protein was most likely to have occurred

- A. at the ribosome.
- B. in the Golgi apparatus.
- C. because of a post-translation mutation.
- D. because of being packaged into a secretory vesicle.

Question 6

Proteins have several levels of structure.

The primary structure of a protein is

- A. the first section of the protein to be translated.
- B. the overall three-dimensional structure of the protein.
- C. a linear sequence of amino acids joined by a condensation reaction.
- D. the folding of sections of the polypeptide chain into coils and pleated structures.

Question 7

Consider the role played by the promoter region of a gene.

Which one of the following statements is correct?

- A. The promoter region is the initial section of a functional gene.
- B. The promoter region is the sequence of DNA to which RNA polymerase binds.
- C. The promoter region is a regulatory sequence of DNA to which a repressor protein binds.
- D. The promoter region is a section of DNA that can bind to a signalling molecule and change shape.

Question 8

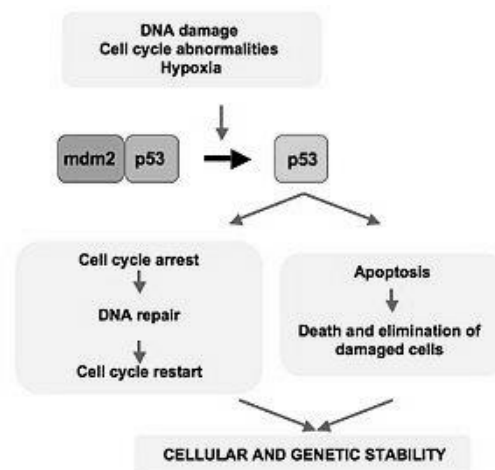
The genetic code contains codons that code for the 20 amino acids that are used to assemble proteins. Humans are believed to produce approximately 20 000 different proteins that perform a wide variety of functions.

This functional diversity of proteins is explained by

- A. multiple codons coding for the same amino acid.
- B. amino acids being assembled into a variety of polypeptide chains.
- C. proteins being able to change shape, which enables them to carry out many different functions.
- D. post-translational modification of a polypeptide enabling it to be folded into several different forms.

Question 9

The p53 gene is responsible for the production of a protein that affects the rate of the cell cycle, as shown in the diagram below.



The role of the p53 gene is correctly described as

- A. structural.
- B. apoptotic.
- C. regulatory.
- D. suppressant.

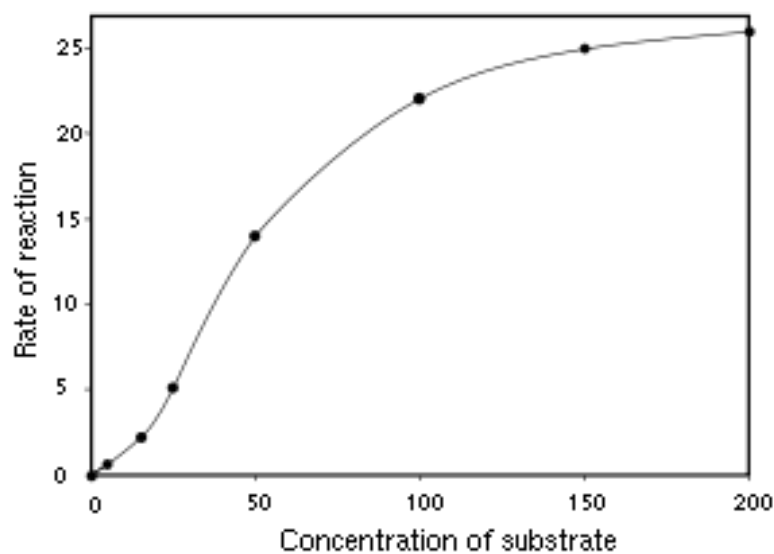
Question 10

Enzymes can act as organic catalysts because they

- A. remove energy from a substrate molecule.
- B. increase the kinetic energy of a chemical reaction.
- C. lower the activation energy of a chemical reaction.
- D. facilitate the release of heat to provide optimum conditions.

Question 11

The graph below shows the effect that changing the concentration of a substrate will have on the rate of a catalysed reaction.

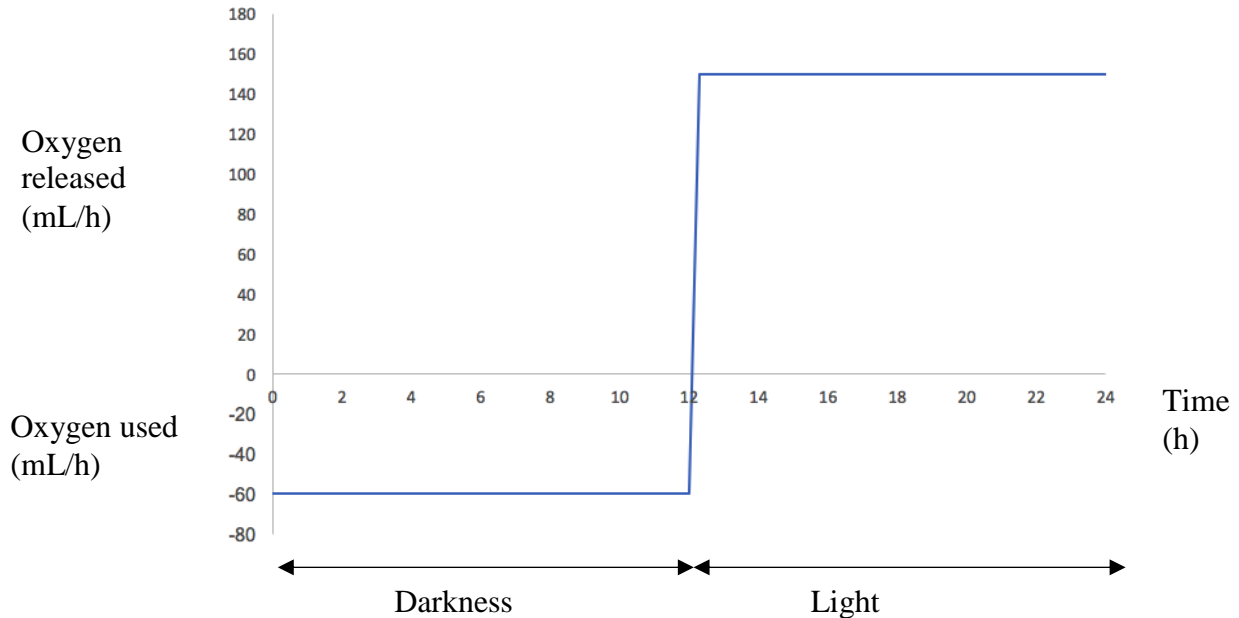


Which one of the following conclusions can be made based on the graph?

- A. The rate of this reaction will never exceed 25 units.
- B. The reaction ceases when the substrate concentration exceeds 200 units.
- C. The rate of the chemical reaction will increase if an additional 1.0 mL of enzyme were to be added to the solution.
- D. When the concentration of the substrate is 150 units, the substrate concentration begins to limit the rate of the reaction.

Question 12

A plant was placed into a sealed box with a data probe that monitored the use and release of oxygen gas over a period of 24 hours. The plant was placed in constant darkness for 12 hours and then in constant light for a subsequent period of 12 hours. The data was used to produce the following graph.



If the rate of aerobic cellular respiration remained constant, which one of the following is the volume of oxygen gas used by the plant during the 24-hour period?

- A. 60 mL
- B. 200 mL
- C. 720 mL
- D. 1440 mL

Question 13

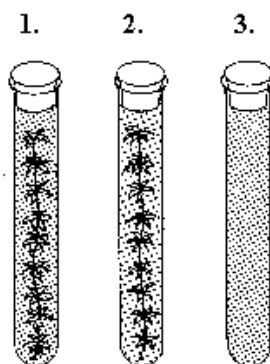
Consider the role played by light in the light-dependent stage of photosynthesis.

Which one of the following statements is correct?

- A. Light is the source of electrons that provide the energy needed to produce ATP.
- B. Light provides the energy that is absorbed by chlorophyll, which facilitates the light-dependent stage.
- C. Light provides the heat required to split water molecules into hydrogen ions and oxygen gas.
- D. Light breaks down ATP molecules, releasing the energy required for NADPH to be moved from the grana to the stroma.

Use the following information to answer Questions 14 and 15.

The following experiment was set up to test the rate of photosynthesis. Elodea (a type of aquatic plant) was used and each of the test tubes was left under a light for 10 minutes. The amount of oxygen produced in each test tube was recorded.



Test tube #	Condition	Result
1	deoxygenated water and a piece of elodea	12 units of oxygen were produced
2	deoxygenated water, a piece of elodea and 2 g of sodium bicarbonate (an inorganic substance that has the chemical formula NaHCO_3 and breaks down to produce CO_2 in solution)	27 units of oxygen were produced
3	deoxygenated water only	no oxygen was produced

Question 14

The purpose of including test tube 3 in the experiment was to

- A. increase the sample size being tested.
- B. enable the effect of the dependent variable to be established.
- C. prove that supplying sodium bicarbonate to elodea plants causes them to produce carbon dioxide.
- D. prove that any oxygen present at the end of the experiment must have been produced by the elodea plants.

Question 15

Which one of the following reasons accurately explains the difference in the results in test tubes 1 and 2?

- A. Sodium bicarbonate is a toxin that decreased the rate of photosynthesis.
- B. Sodium bicarbonate acted as a nutrient that improved the ability of the elodea in test tube 2 to carry out photosynthesis.
- C. Sodium bicarbonate provided the elodea in test tube 2 with an additional source of carbon dioxide and increased the rate of photosynthesis.
- D. Sodium bicarbonate acted as a coenzyme that activated the chlorophyll in the elodea in test tube 2 and caused the rate of photosynthesis to increase.

Question 16

Viruses are described as non-cellular pathogens because they

- A. do not contain any nucleic acids.
- B. cannot reproduce outside a host cell.
- C. are unable to produce antigenic proteins.
- D. do not have membrane-bound organelles.

Question 17

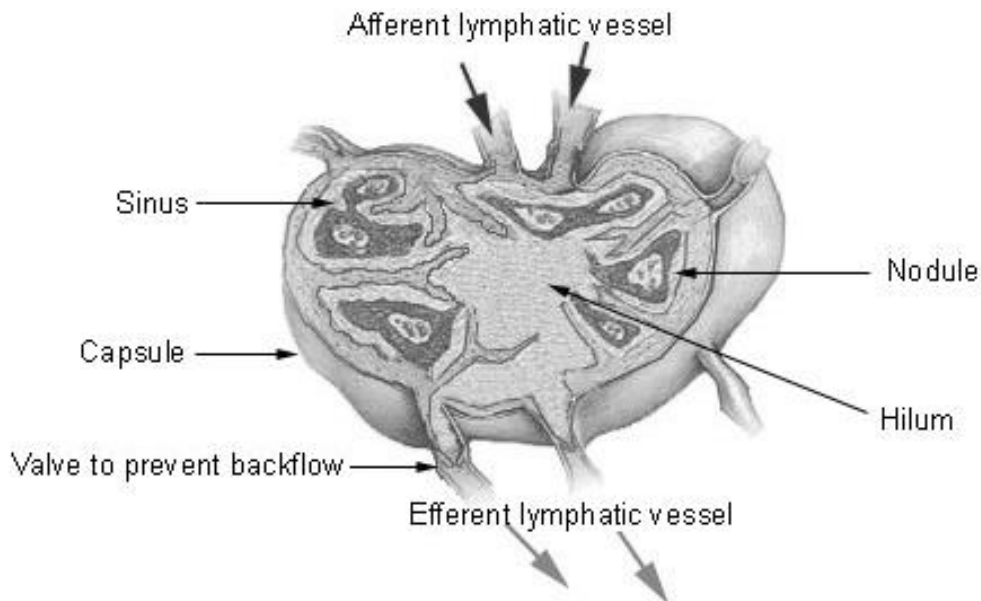
Lysosomes are organelles found in the cytoplasm of some eukaryotic cells. These organelles contain enzymes enclosed by a membrane.

Large numbers of lysosomes would be most likely to occur in cells that are

- A. carrying out mitosis.
- B. producing antibodies.
- C. carrying out apoptosis.
- D. carrying out phagocytosis.

Use the following information to answer Questions 18 and 19.

The following diagram shows a lymph node and indicates the direction that the lymph fluid flows through the node.



Source: SEER Training Modules, Cancer Registration & Surveillance Modules, U. S. National Institutes of Health, National Cancer Institute. Accessed 4 January 2018. <https://training.seer.cancer.gov/>

Question 18

Lymph fluid enters a lymph node through the afferent vessel and then passes through a sub-capsular area that contains macrophages and dendritic cells.

Which one of the following statements explains the importance of these cells in this position?

- A. They can present antigens directly to B plasma cells.
- B. They can catalyse clonal expansion of B plasma cells.
- C. They can recognise foreign antigens present in lymph fluid.
- D. They can filter lymph fluid before it exits the lymph node through the efferent vessel.

Question 19

Which one of the following statements correctly describes the nature of lymph nodes?

- A. They are a type of primary lymphatic tissue because they contain lymph vessels.
- B. They are a type of primary lymphatic tissue because this is where stem cells develop into mature cells.
- C. They are a type of secondary lymphatic tissue because the fluid that flows through the nodes originated in the circulatory system.
- D. They are a type of secondary lymphatic tissue because they maintain a population of lymphocytes that is activated to carry out a specific immune response.

Question 20

Cancer cells, like all other cells, require nutrients, oxygen and a means of eliminating waste products. This means that they must develop a blood supply. As new cancerous cells are produced, they secrete a vascular endothelial growth factor (VEGF) that enables the development of blood vessels. One form of treatment for cancer involves the production of a monoclonal antibody that binds to VEGF.

Which one of the following statements describes the effect of these monoclonal antibodies?

- A. They block the VEGF protein from binding to the tumour cells.
- B. They bind to and neutralise VEGF preventing the development of blood vessels.
- C. They bind to VEGF receptors on the walls of capillaries causing them to atrophy.
- D. They bind to the VEGF receptor on the tumour cells, causing the tumour cells to shrink.

Question 21

Anthocyanins are water-soluble pigments that cause the petals of flowers to become red, blue or purple depending on the pH of the soil that the plants are growing in.

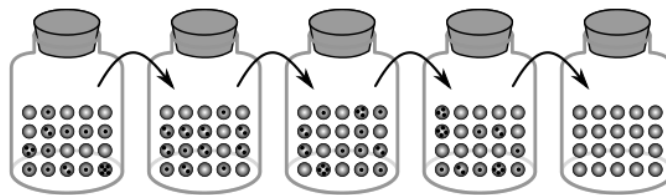
A population of plants all produce purple flowers. However, a new plant of the same species appeared in this population and produced yellow flowers. The other plants in the population continued to produce purple flowers.

The most likely explanation for a single plant producing yellow flowers is that

- A. a repressor protein bound to the gene that codes for anthocyanin.
- B. a point mutation produced a new allele that codes for a yellow pigment.
- C. the plant that produced the yellow flowers was a hybrid between the purple flowering species and a yellow flowering species.
- D. the plant that produced the yellow flowers was observed after a rainfall had occurred and all of the pigment had been washed out of the petals.

Question 22

The diagram below shows a change in allele frequency caused by genetic drift over five generations. Each circular pattern represents a different allele.



Source: David Eccles, 2013, CC BY-SA 3.0 license
<https://creativecommons.org/licenses/by-sa/3.0/>

Which one of the following would have the greatest impact on the observed change in allele frequency?

- A. A mutation occurred.
- B. The population is small.
- C. A strong selection pressure occurred.
- D. All poorly adapted individuals in the population died.

SECTION A – continued
TURN OVER

Use the following information to answer Questions 23 and 24.

Przewalski's horses, also known as the Mongolian wild horse or Asian wild horse, once ranged across parts of Europe and central Asia, but as a result of hunting, the species had become critically endangered by 1960. Captive breeding programs were later established in eight countries, and by 2004 the population had increased to 1500 worldwide.

Question 23

The decline in numbers of the Przewalski horse population is an example of

- A. inbreeding.
- B. selective breeding.
- C. the founder effect.
- D. a population bottleneck.

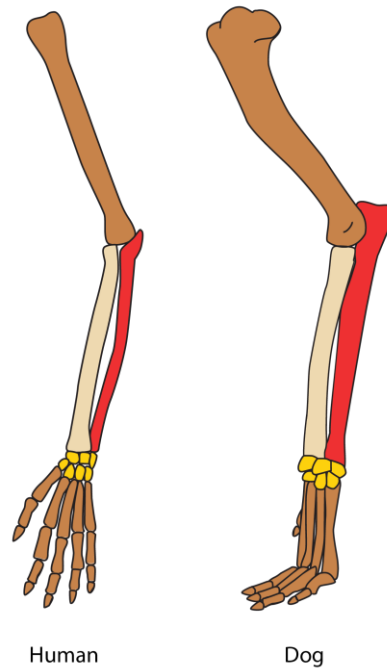
Question 24

The horses from the captive breeding program were genetically tested before being released into the Gobi Desert. Which one of the following findings would have been most likely?

- A. The genetic diversity of the species was low.
- B. Phenotypic variation in the species was high.
- C. The incidence of genetically inherited diseases was high.
- D. All horses produced by the captive breeding program were genetically identical.

Question 25

The comparison of anatomical structures can be used to support the theory of evolution. The diagram below shows the structure of a human hand and arm compared with the forelimb of a dog.



These structures are referred to as being homologous, which means that

- A. both structures fulfil the same function.
- B. humans and dogs share a recent common ancestor.
- C. the bones in each of the limbs are structurally identical.
- D. both structures formed due to the impact of similar environmental selection pressures.

Question 26

Evidence suggests a rapid increase in biodiversity occurred once animal life migrated from the oceans to the land.

This could be explained by

- A. additional niches becoming available to animals.
- B. survival conditions being better on land than in water.
- C. climate change having a greater impact on land than in water.
- D. the oceans providing stable conditions that limited the requirement for evolution to occur.

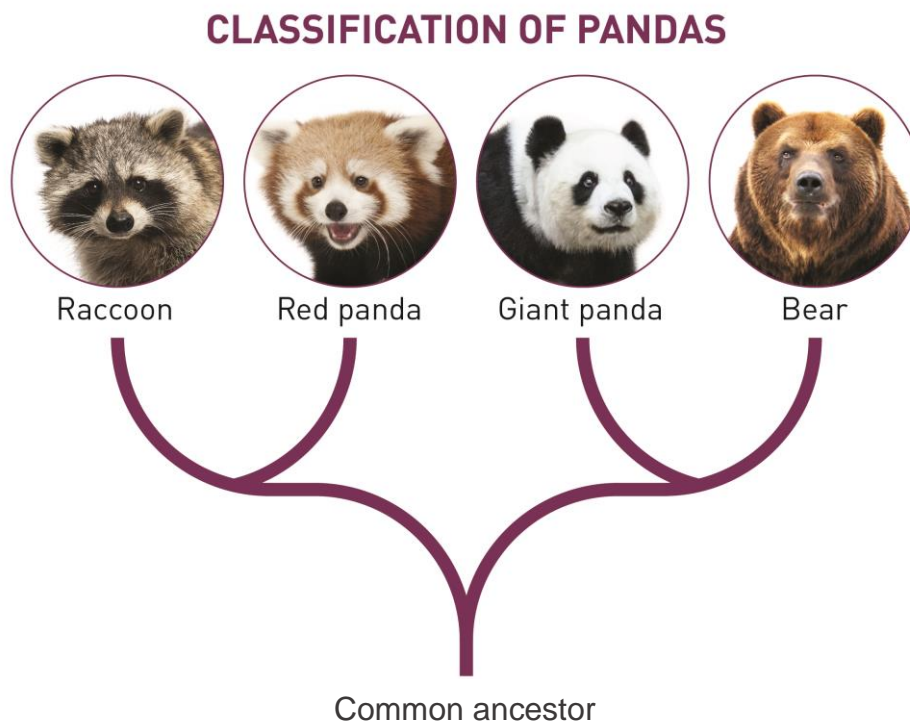
Question 27

During the last ice age, two ocean islands were connected by a land bridge that later melted and separated the islands. Both islands were initially colonised by the same plants and animals. Which one of the following species is most likely to experience conditions that enable divergence to occur?

- A. pandan, a tree that produces floating seeds
- B. milkweed, a plant that produces airborne seeds
- C. sand verbena, a plant that produces sticky seeds
- D. coco de mer, a plant that produces large heavy seeds

Question 28

The diagram below shows an overview of the relatedness between raccoons, red pandas, great pandas and bears.

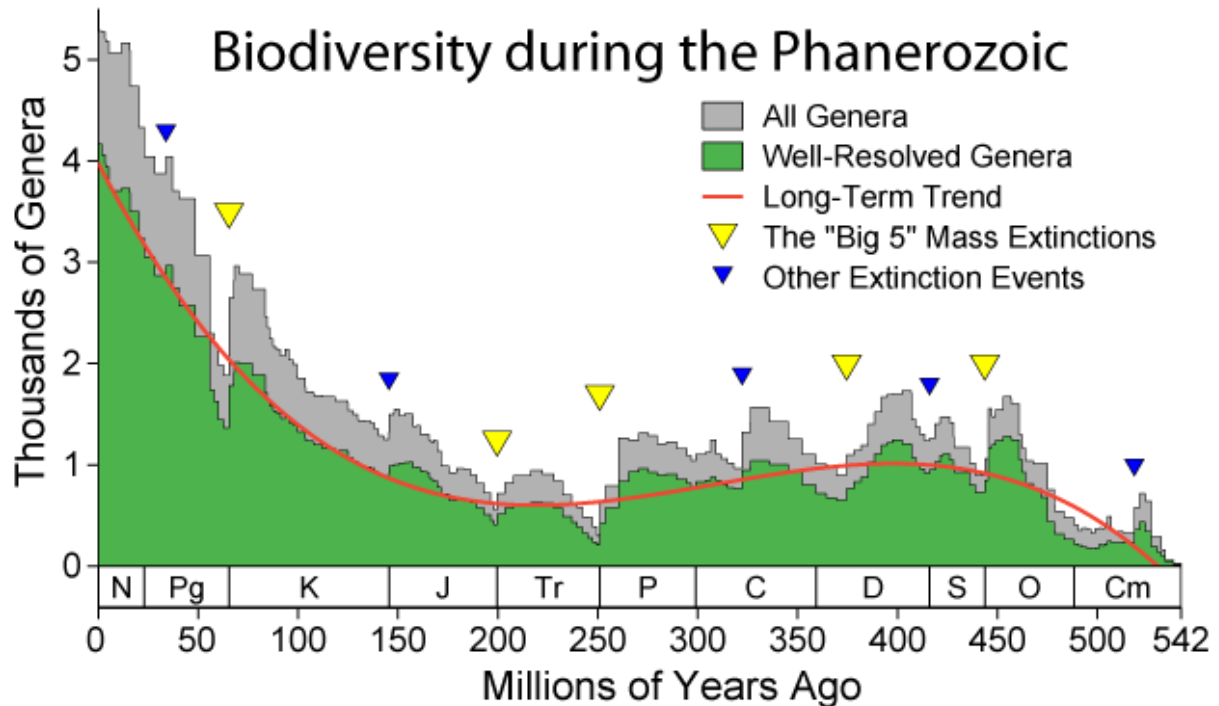


Both species of panda are specialist feeders that only eat bamboo and have developed a false thumb that helps them to do so. Based on the data supplied

- A. these adaptations occurred independently in both species.
- B. both species share a recent common ancestor that had both of these traits.
- C. both species have the same DNA that codes for these traits.
- D. both species have the same adaptations because they are both members of the panda species.

Use the following information to answer Questions 29 and 30.

The diagram below shows data relating to changes in biodiversity that occurred during the Phanerozoic Eon.



Source: Robert A Rohde, 2006,
CC BY-SA 3.0 license

<https://creativecommons.org/licenses/by-sa/3.0/deed.en>

Question 29

Which one of the following conclusions can be made based on information in the graph?

- A. Mass extinctions occur at predictable intervals.
- B. The trend line shows that the rate of extinctions is decreasing.
- C. Extinction events are followed by a period of rapid evolution.
- D. Mass extinctions always occur as a result of species overpopulation.

Question 30

It is hypothesised that approximately 440 million years ago the world was largely covered with warm seas. This was then followed by an ice age during which sea levels dropped dramatically.

Which one of the following species would be most likely to experience a change in conditions that contributed to mass extinctions?

- A. species that lived permanently attached to rocks on rock platforms
- B. species that lived in a deep-sea environment
- C. species that evolved to live in shallow water
- D. species that evolved to live in cold environments

Question 31

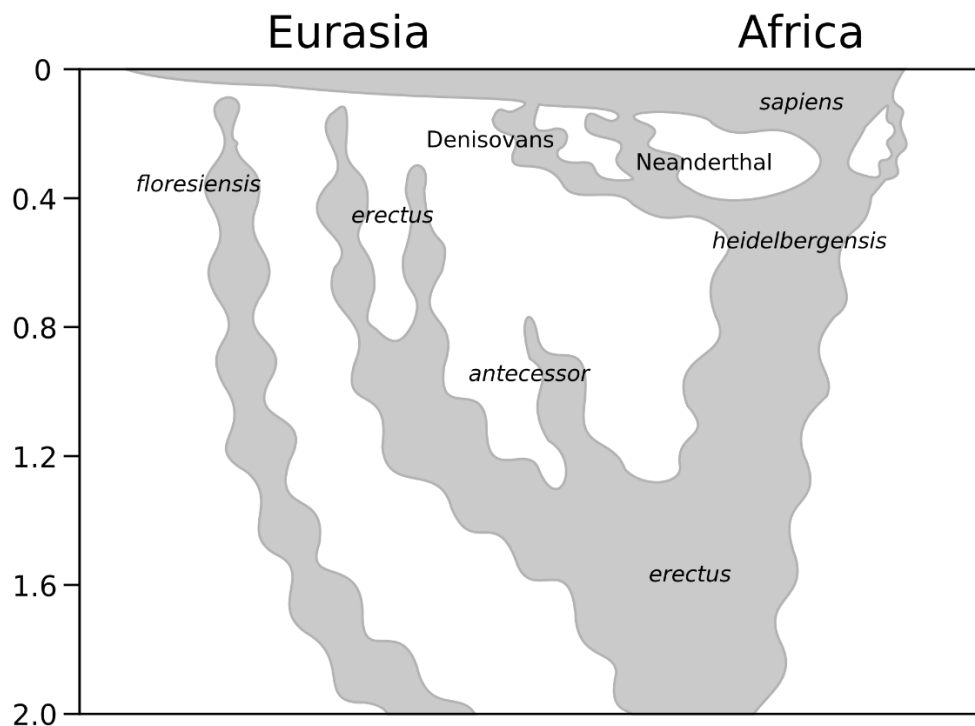
Mitochondrial DNA is used as a molecular clock.

The most important feature of mitochondrial DNA that enables it to be used for this function instead of genomic DNA is that

- A. mitochondrial DNA is smaller than genomic DNA.
- B. mitochondrial DNA recombines more regularly than genomic DNA.
- C. the number of exons is greater in mitochondrial DNA than in genomic DNA.
- D. the rate of mutations in mitochondrial DNA is more reliable than that of genomic DNA.

Question 32

The diagram below shows a model of the geographic distribution of the *Homo* genus hominins over the last 2 million years.



Source: Hans Weingartz, 2014,
CC BY-SA 3.0 DE license

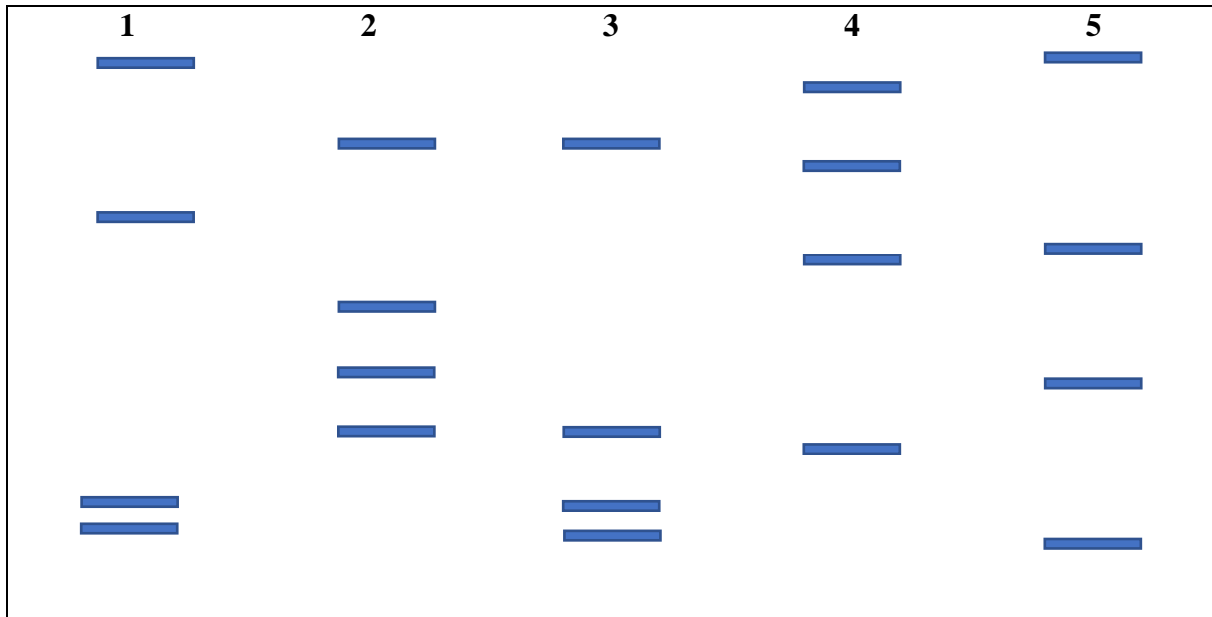
<https://creativecommons.org/licenses/by-sa/3.0/de/deed.en>

Which one of the following conclusions could be made based on the data in this diagram?

- A. All hominins are descended from *Homo erectus*.
- B. All hominins migrated from Africa into Eurasia.
- C. Denisovans and Neanderthals are more closely related to each other than either are to *Homo sapiens*.
- D. *Homo erectus* and *Homo heidelbergensis* coexisted in Africa between 400 000 and 800 000 years ago.

Question 33

A woman with a child marries a man. The couple then have a child of their own, after which they adopt a third child. Genetic fingerprinting was carried out and the results are shown below. Lane 1 contains the woman's DNA; lane 2 contains the man's DNA; and lanes 3, 4 and 5 contain the children's DNA.



Use the information provided to identify each of the children as being the woman's child, the couple's child or the adopted child.

	Lane 3	Lane 4	Lane 5
A.	woman's child	couple's child	adopted child
B.	adopted child	couple's child	woman's child
C.	couple's child	woman's child	adopted child
D.	couple's child	adopted child	woman's child

Question 34

Bacillus thuringiensis is a bacterium that produces a protein that disrupts the digestive system of certain insects and ultimately causes their death. The gene that codes for the production of this protein has been inserted into crop plants, producing a genetically modified pest-resistant strain of plants.

Which one of the following statements identifies a social issue associated with the production of this crop?

- A.** People will choose not to eat any foods that contain ingredients from the genetically modified plants.
- B.** The yield of the crop from the genetically modified plants will be higher than that from the unmodified plants.
- C.** Cross-pollination will occur between the genetically modified plants and unmodified plants of the same species.
- D.** The genetically modified plants might produce a new type of protein that triggers allergies or anaphylaxis in people consuming them for the first time.

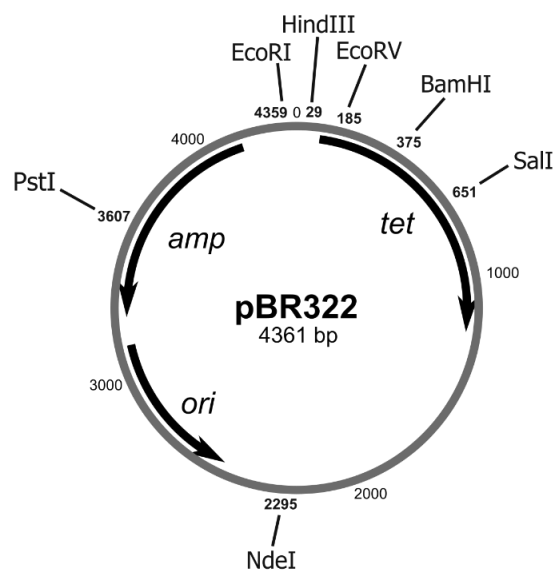
Question 35

The role of DNA ligase in gene splicing is to

- A. join DNA fragments.
- B. transfer DNA from one species to another.
- C. increase the rate at which gene cloning occurs.
- D. make multiple copies of a template piece of DNA.

Question 36

The diagram below shows a map of a laboratory plasmid. The section marked 'amp' codes for ampicillin resistance, the section marked 'tet' codes for tetracycline resistance and the section marked 'ori' is the origin of replication.



The plasmid map also shows recognition sites for multiple restriction enzymes (also called endonucleases).

How is the presence of multiple different recognition sites of most benefit to genetic engineers?

- A. They can cut the plasmid into multiple sections using a single endonuclease.
- B. They can insert the plasmid into multiple host cells.
- C. They can insert multiple genes into a single plasmid.
- D. They are more likely to be able to insert foreign DNA into the plasmid.

Question 37

For the polymerase chain reaction (PCR) to be carried out, a PCR mix needs to be assembled and placed into a thermocycler.

Which one of the following would be expected to occur if the PCR mix did not contain primers?

- A. The annealing stage of PCR would not begin.
- B. There would be no effect on the rate of PCR.
- C. PCR would occur at a slower rate than normal.
- D. PCR would begin and then cease at the end of the first cycle.

Question 38

Which one of the following options correctly defines an epidemic disease?

- A. a mutation of an existing disease
- B. a global outbreak of a disease
- C. a disease that occurs suddenly and spreads rapidly
- D. a lethal disease that occurs at random intervals

Question 39

Bacteria are frequently unable to survive in the presence of heavy metals, such as gold, copper and lead. However, the bacterium *Cupriavidus metallidurans* can survive in high concentrations of gold. The gene responsible for gold resistance was isolated and inserted into the genome of other bacteria of the same species.

The correct term used to describe the bacterial cells into which the gene had been inserted is

- A. transgenic.
- B. transfected.
- C. genetically altered.
- D. genetically modified.

Question 40

The introduction and common use of antibiotics has led to the evolution of antibiotic-resistant bacteria. Most infections of *Staphylococcus aureus* can be treated using antibiotics, but a strain called MRSA (methicillin-resistant *Staphylococcus aureus*) cannot.

If people ceased using antibiotics, which one of the following results would be expected to occur to MRSA populations?

- A. MRSA would become extinct.
- B. Populations of MRSA would be unaffected.
- C. The incidence of antibiotic resistance would continue to increase.
- D. The proportion of bacteria that are sensitive to antibiotics would increase.

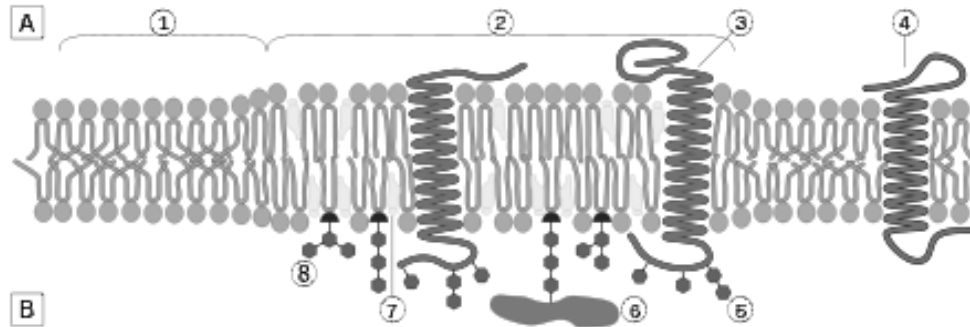
**END OF SECTION A
TURN OVER**

SECTION B

Instructions for Section B
 Answer **all** questions in the spaces provided. Write using a blue or black pen.
 Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1 (5 marks)

The diagram below shows a plasma membrane of a cell.



Source: Artur Jan Fijałkowski, 2006
 CC BY-SA 2.5 license
<https://creativecommons.org/licenses/by-sa/2.5/deed.en>

a. Is the cytosol in location A or B? Provide a reason to support your answer.

1 mark

b. Most human cells need glucose to carry out a metabolic reaction.

Explain why glucose cannot diffuse across the plasma membrane and describe the role that structure 4 plays in enabling cells to obtain glucose from the circulatory system.

2 marks

- c. The main roles of the plasma membrane are to separate the internal environment of the cell from the external environment and to regulate the movement of substances into and out of the cell. However, components of the plasma membrane such as structure 8 also play a role in immunity.

Describe what type of substance structure 8 is and discuss the role played by structure 8.

2 marks

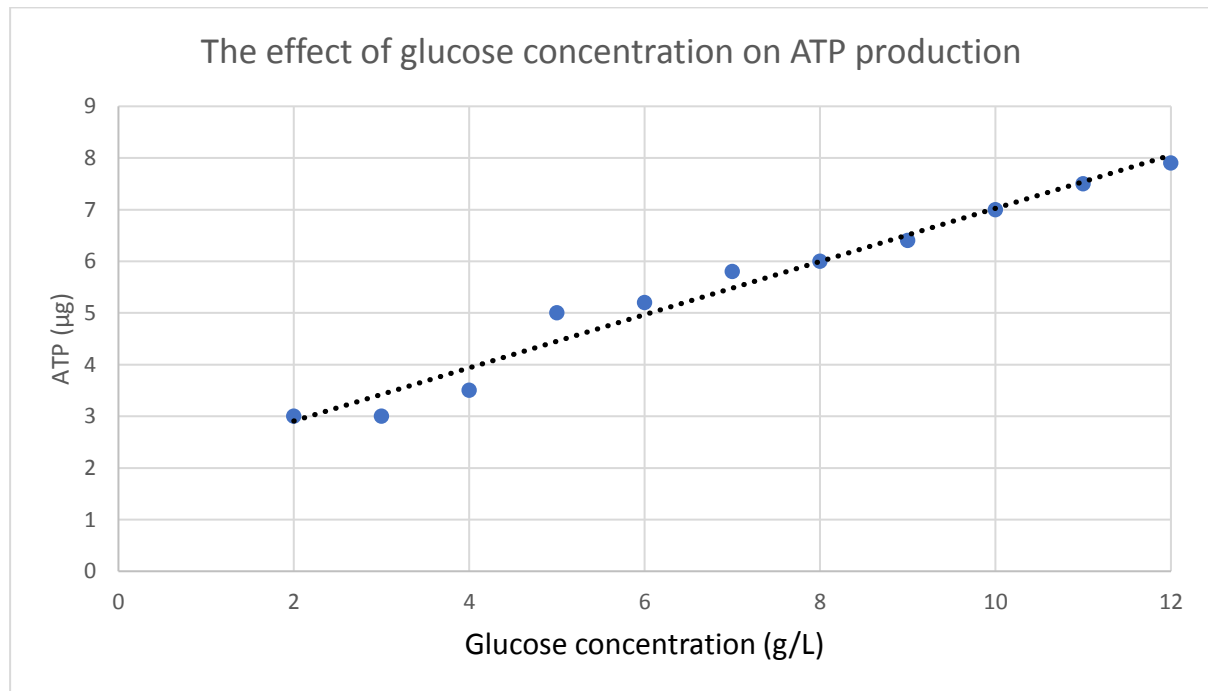
Question 2 (9 marks)

A researcher carries out an experiment to test the effect that altering glucose concentration has on ATP production in muscle cells. This was accomplished by placing samples of muscle cells into sealed tissue culture flasks (as shown in the image below). Each sample of muscle cells was provided with a nutrient solution that contained a different concentration of glucose.



Source: Thermo Fisher Scientific

The amount of ATP produced in each condition was recorded and used to construct the graph shown below.



- a. Explain why the experimenter chose to use muscle cells in this experiment.

1 mark

- b. Name the independent variable in this experiment.

1 mark

c. Name the dependent variable in this experiment.

1 mark

d. Name a specific variable that would need to be controlled in this experiment. Explain why this variable would need to be controlled.

2 marks

e. Describe the trend that is shown in the graph. Explain why this trend occurs.

2 marks

f. The researcher found that when the glucose concentration was 0 g/L, ATP production was 1.5 μg . The researcher did not include this data on their graph because they believed it was an error.

Instead of leaving the information off the graph, what should the researcher have done to increase the validity of their results? Explain why this action should have been taken.

2 marks

Question 3 (8 marks)

The sequence of the first part of an exon in a piece of pre-mRNA has the following sequence:

AUGCUC AUCGAGCCG

The pre-mRNA molecule will be modified to produce mRNA, which will then be translated to produce a polypeptide known as protein X.

- a.** Explain the difference between an exon and an intron.

1 mark

- b.** Other than splicing the exons, name two types of post-transcriptional modification of the pre-mRNA.

2 marks

- c.** Give one difference between the structures of (i) DNA and mRNA, and (ii) mRNA and tRNA.

2 marks

(i) DNA and mRNA _____

(ii) mRNA and tRNA _____

- d.** When the exons are spliced together, adjacent nucleotides need to be joined in the mRNA molecule. Name the type of reaction that joins these adjacent nucleotides.

1 mark

- e. A company wishes to patent the sequence of DNA that codes for the production of protein X but they need to change the sequence of the exon to do so.

As previously supplied, the sequence of the pre-mRNA is:

AUGCUC AUCGAGCCG

Explain the feature of the genetic code that would enable the company to do this. Identify one alteration that could be made to the sequence of the pre-mRNA that would not affect the structure of the protein. Use the codon table below to assist in answering this question.

	U	C	A	G	
U	UUU Phenylalanine	UCU Serine	UAU Tyrosine	UGU Cysteine	U
	UUC Phenylalanine	UCC Serine	UAC Tyrosine	UGC Cysteine	C
	UUA Leucine	UCA Serine	UAA Stop	UGA Stop	A
	UUG Leucine	UCG Serine	UAG Stop	UGG Tryptophan	G
C	CUU Leucine	CCU Proline	CAU Histidine	CGU Arginine	U
	CUC Leucine	CCC Proline	CAC Histidine	CGC Arginine	C
	CUA Leucine	CCA Proline	CAA Glutamine	CGA Arginine	A
	CUG Leucine	CCG Proline	CAG Glutamine	CGG Arginine	G
A	AUU Isoleucine	ACU Threonine	AAU Asparagine	AGU Serine	U
	AUC Isoleucine	ACC Threonine	AAC Asparagine	AGC Serine	C
	AUA Isoleucine	ACA Threonine	AAA Lysine	AGA Arginine	A
	AUG Methionine (Start)	ACG Threonine	AAG Lysine	AGG Arginine	G
G	GUU Valine	GCU Alanine	GAU Aspartic Acid	GGU Glycine	U
	GUC Valine	GCC Alanine	GAC Aspartic Acid	GGC Glycine	C
	GUA Valine	GCA Alanine	GAA Glutamic Acid	GGA Glycine	A
	GUG Valine	GCG Alanine	GAG Glutamic Acid	GGG Glycine	G

2 marks

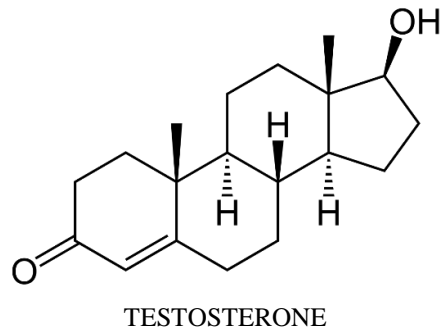
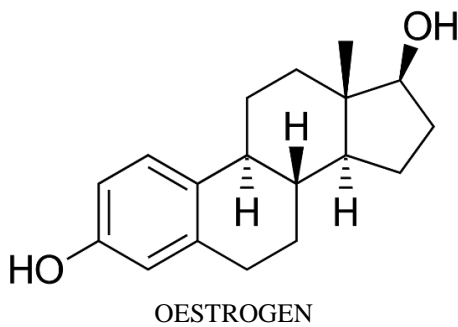
Question 4 (9 marks)

Oestrogen is a steroid hormone that affects the rate of transcription in target cells. Oestrogen also affects the rate of cell division in some target cells, such as those in breast tissue.

- a.** Explain how a receptor for oestrogen becomes activated and discuss how activation of the receptor affects the target cell.

3 marks

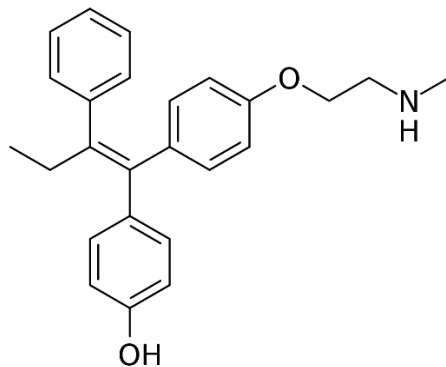
The diagram below compares the structure of oestrogen with the structure of testosterone.



- b.** Explain in detail why the cellular response to testosterone differs from that of oestrogen.

3 marks

Oestrogen is the main hormone that stimulates breast growth during puberty and has been found to play a role in the development of some types of breast cancer. Although there is a range of treatments for breast cancer, rational drug design has been used to produce the synthetic drug tamoxifen, which is converted in the body to the active form endoxifen. The structure of endoxifen is shown below.



Endoxifen

- c. Explain how the use of tamoxifen has been useful in treating breast cancer by reducing the growth rate of breast tumour cells. Include a brief comparison of the individual components of each molecule in your answer.

3 marks

Question 5 (10 marks)

The table below contains the medical history of a family with relation to their experience with chicken pox. This history was compiled after the two oldest children were exposed to an individual with chicken pox and subsequently developed symptoms.

Family member	History of chicken pox	Vaccination history
father (aged 29 years)	has never had chicken pox	vaccinated at the age of 18 months
mother (aged 27 years)	had chicken pox when aged 10	no vaccination
child 1 (aged 7 years)	has never had chicken pox	no vaccination
child 2 (aged 5 years)	has never had chicken pox	no vaccination
child 3 (aged 15 months)	has never had chicken pox	no vaccination

- a.** The parents performed some research and decided that it was unlikely that they would develop chicken pox.

Explain why each of the parents concluded that they were not at risk of developing chicken pox.

2 marks

- b.** As a result of their two older children being exposed to chicken pox, the parents decided that they wished their three children to be vaccinated. They were advised that it would not be necessary to vaccinate the two older children, but that the youngest child should be vaccinated.

Explain why this advice was provided.

2 marks

The National Immunisation Program Schedule lists the vaccines that should be administered to a child between birth and the age of 4 years. One of the vaccines in the schedule contains chicken pox antigens. This vaccine is administered at the age of 18 months.

- c. Describe in detail the series of events that occur after a child has been exposed to the chicken pox antigens in the vaccine up to the point where a specific response occurs.

3 marks

- d. The parents are concerned that administering the vaccine to their youngest child will cause this child to develop a milder form of the disease. Explain why this belief is incorrect.

1 mark

- e. Before their two oldest children were exposed to chicken pox, the parents had decided not to have their children vaccinated. Discuss how and why this decision can affect the ability of infectious diseases, such as chicken pox, to spread through the community.

2 marks

Question 6 (6 marks)

The island of Manhattan is part of New York. As shown in the map below, the island is split into three areas: uptown and downtown, which are mainly residential areas, and midtown, which is the commercial district. The types of buildings and resources available in each area differ.



Source: Aaron Titus, 2014

European rats were accidentally introduced to Manhattan by boat during the mid-1700s. Rats have a generation time of approximately three months and can increase in numbers very quickly. The results of a study released in 2017 have shown that rats generally only move a few blocks during their lifetime and that the populations of rats in the uptown and downtown areas are now genetically distinct.

- a. Discuss the impact that the midtown area has had on facilitating the diversity between the uptown and downtown populations of rats.

2 marks

- b.** Explain the effect on the gene pool of each population from the rats only travelling short distances during their lifespan.

1 mark

- c.** It has been hypothesised that the process of speciation has already begun to occur in these rats.

Provide an overview of how speciation is occurring in Manhattan rats.

3 marks

Question 7 (7 marks)

Cytochrome c is a protein that plays an important role in the electron transport chain in mitochondria.

The coding sequences of DNA for cytochrome c in six different species were compared and the number of nucleotide differences between each pair of species was ascertained. These are shown in the table below.

	Human	Rat	Mouse	Chicken	Fruit fly	Yeast
Human	0	34	31	58	87	110
Rat		0	9	53	83	117
Mouse			0	58	77	119
Chicken				0	92	119
Fruit fly					0	123
Yeast						0

- a. The data in this table only reflects the differences between the coding regions of DNA. Give a reason why the researchers did not include information about the non-coding regions of DNA.

1 mark

- b. The degree of molecular homology can be determined by comparing similarities in the DNA, RNA or proteins from different species. According to some sources, the degree of DNA homology is a more accurate measure of the degree of relatedness between species than protein homology.

Give **two** reasons that could be used to support this claim.

2 marks

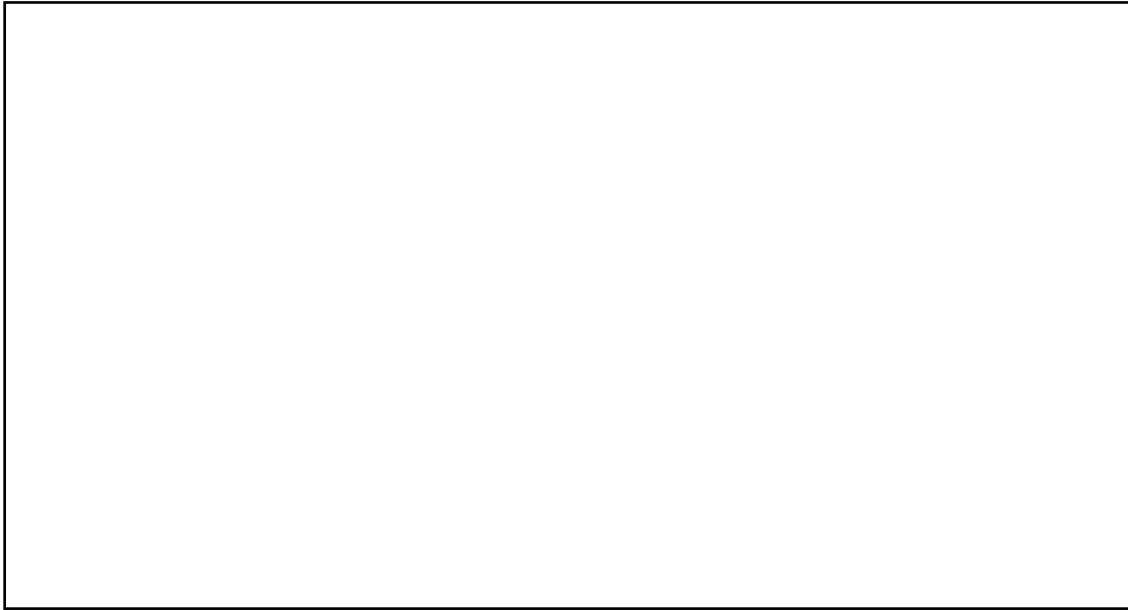
- c. The degree of relatedness between two species can also be determined using DNA hybridisation. Five DNA hybrid molecules were produced that combined mouse DNA with DNA from each of the other five species.

Which of the hybrid molecules would have the lowest melting point? Use the data to provide a reason to support your answer.

2 marks

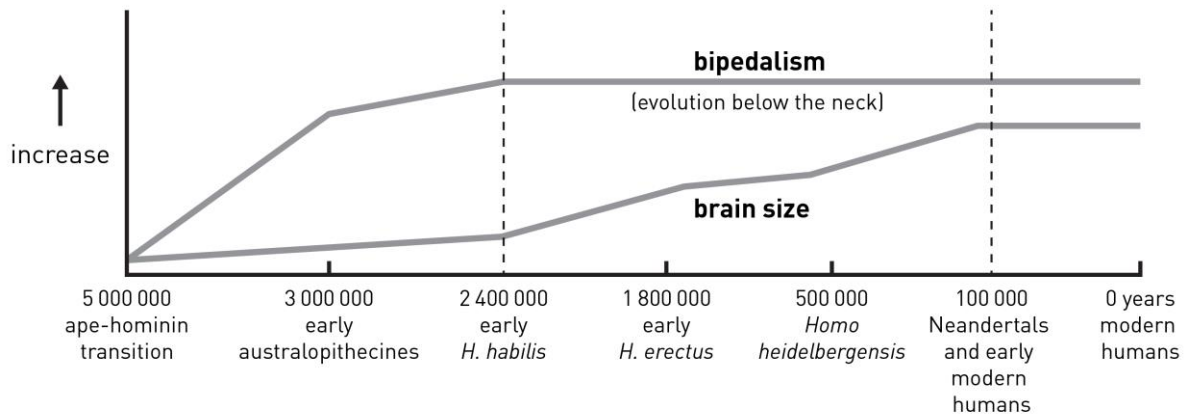
- d.** Use the data provided to assemble a cladogram in the box below that shows the degree of relatedness between humans and the other five species.

2 marks



Question 8 (6 marks)

Initially, it was believed that brain size evolved before bipedalism. However, as shown in the graph below, it is now believed that bipedalism occurred substantially earlier than the increase in brain size in *Homo* genus species.



Source: Dennis O'Neil

- a.** Discuss how the structural changes associated with bipedalism may have contributed to technological changes that led to the dietary changes that are believed to have influenced the evolution of a larger brain in hominins.

2 marks

- b.** Discuss **one** way in which the cognitive changes in hominins contributed to cultural evolution.

1 mark

In 1961, several hominin fossils were found in north-west Africa. These included several skulls, a jaw bone and fragments from arms, legs and hips. Initially, this finding was controversial because the exact location of the finding was not recorded.

- c. Explain why knowing the location of the finding was essential to be able to use the potassium to argon absolute dating technique to ascertain the age of the fossils.

1 mark

- d. Name two attributes of the skulls that could be used to prove that they were from *Homo sapiens* rather than from *Homo erectus*.

2 marks

Question 9 (10 marks)

A researcher wishes to clone a specific gene. This is achieved using restriction enzymes, bacteria and laboratory plasmids. The laboratory plasmids contain multiple restriction sites, as well as a gene for ampicillin resistance.

The cloning process is accomplished using restriction enzymes to cut around the gene of interest, which is then inserted into a laboratory plasmid. Bacteria are then exposed to the recombinant plasmid.

The diagram below identifies some common restriction enzymes, their associated recognition site and the shape of the cut site they produce.

Enzyme	Recognition sequence	Cut site
EcoRI	5' GAATTA 3' CTTAAG	5' G AATTC 3' 3' CTTAA G 5'
BamHI	5' GGATCC 3' CCTAGG	5' G GATCC 3' 3' CCTAG G 5'
HindIII	5' AAGCTT 3' TTCGAA	5' A AGCTT 3' 3' TTCGA A 5'
Sau3A	5' GATC 3' CTAG	5' GA TC 3' 3' CT AG 5'
Pov11	5' CAGCTG 3' GTCGAC	5' CAG CTG 3' 3' GTC GAC 5'
Alu1	5' AGCT 3' TCGA	5' AG CT 3' 3' TC GA 5'

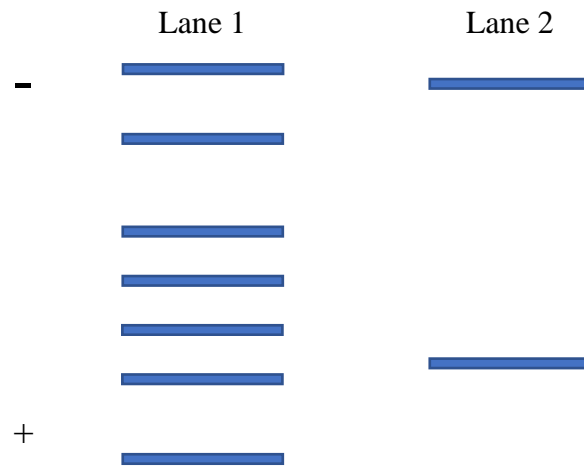
- a. Use the information supplied to choose an appropriate restriction enzyme to use. Provide a reason to support your answer.

2 marks

- b. Should the same type of restriction enzyme be used to cut around the gene of interest and to cut the plasmid open? Provide a reason to support your answer.

1 mark

The plasmid being used is 12 kb in size and the gene of interest is 3 kb in size. The researcher needs to be able to isolate the recombinant plasmid and does so using gel electrophoresis. The diagram below represents the appearance of the electrophoresis gel with the plasmid sample shown in lane 2.



- c. What did the researcher place into lane 1? Explain the purpose of the substance used in lane 1.

2 marks

- d. Identify which of the fragments in lane 2 represents the recombinant plasmid. Provide a reason to support your answer.

2 marks

After exposing the bacteria to the recombinant plasmid, the researcher then spread the bacteria evenly over a Petri dish that contains ampicillin in the agar. The even spread of bacteria produces a lawn culture. The researcher then checks the Petri dish 24 hours later and finds that there are only a few isolated colonies, as shown in the diagrams below.



Source: Copyright © 2018 The American Phytopathological Society, Adapted, by permission, from Activity 4: Transformation of *E. coli* using green fluorescent protein, Classroom Activities in Plant Biotechnology, APS Education Center

- e. Explain why the researcher included ampicillin in the agar and why the inclusion of ampicillin in the agar affected the bacteria in the manner shown.

2 marks

- f. Before working with the bacteria, the researcher sprayed the bench and other surfaces with 70% ethanol.

Explain why they carried out this action.

1 mark

CONTINUES OVER PAGE

Question 10 (4 marks)

The Galapagos Islands are an archipelago approximately 1000 kilometres off the west coast of South America. The largest of the islands, Isabela Island, has a wet climate and a substantial amount of ground vegetation. The other smaller islands have a drier climate with little ground vegetation and a few woody cacti.



The Galapagos Islands are best known for their range of unique animals, including the herbivorous giant tortoise. Giant tortoises originated on Isabela Island and have a dome-shaped carapace (shell). The descendants of the giant tortoises that colonised the other islands developed a saddleback shell (which has a higher carapace), a longer neck and longer legs than the tortoises with the domed carapace.



Domed tortoise

Source: Michael Field, 2005
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<https://creativecommons.org/licenses/by-sa/3.0/deed.en>



Saddleback tortoise

Source: Mike Weston, 2006
CC BY-SA 2.5 license

<http://creativecommons.org/licenses/by/2.5>

- a.** Despite the differences in their appearance, the domed and saddleback tortoises are still members of the same species. Provide one piece of information that can be used to prove this statement.

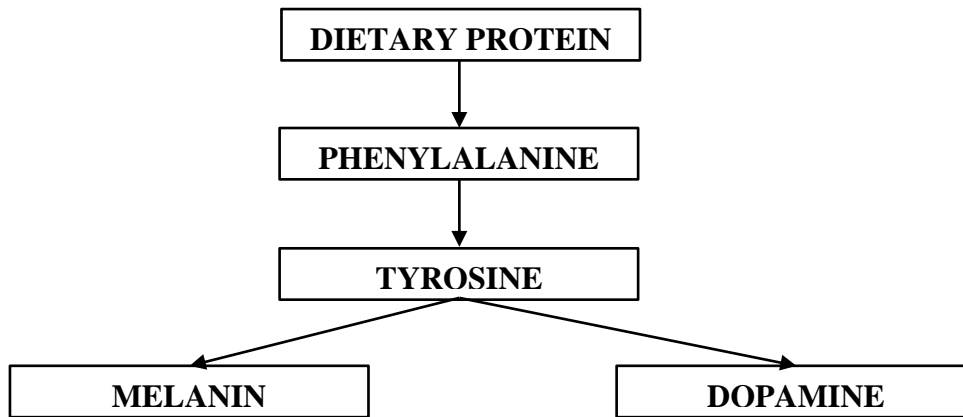
1 mark

- b.** Referring to the theory of natural selection, explain how the descendants of the tortoises that migrated away from Isabela Island developed higher carapaces and longer legs than the tortoises that remained on Isabela Island.

3 marks

Question 11 (6 marks)

Phenylketonuria is a genetic condition that is caused by an inability to convert the amino acid phenylalanine into tyrosine. Symptoms of phenylketonuria include seizures, delayed development and intellectual disability. An overview of the metabolic pathway involving phenylalanine and tyrosine is shown below.



- a.** The diagram above shows an arrow between phenylalanine and tyrosine. This represents a missing chemical.
- Which type of chemical would be responsible for converting phenylalanine to tyrosine?

1 mark

- b.** Genetic screening for phenylketonuria is performed on all newborn babies in Australia.
- Explain why it is important that genetic screening for this condition is carried out as soon as possible.

1 mark

- c.** There are many genetic conditions that, unlike phenylketonuria, are not screened for in newborns. Genetic screening remains a contentious issue for some.
- Give an ethical or social issue associated with carrying out genetic screening on newborn babies.

1 mark

- d.** The phenylketonuria screening test is called the Guthrie heel prick test and involves a blood sample being taken from the newborn baby.

Explain how the blood sample of a baby with phenylketonuria would differ from that of an unaffected individual.

1 mark

- e.** Albinism is another genetic condition and is caused by the inability to convert tyrosine into the pigment melanin. Individuals with albinism have white hair, white skin and red eyes.

Use the information provided to explain why individuals with phenylketonuria tend to have light-coloured skin, hair and eyes, but do not have albinism.

2 marks

END OF QUESTION AND ANSWER BOOK