Neap:

Trial Examination 2016

VCE Biology Units 3&4

Written Examination

Question and Answer Booklet

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

Student's Name: _____

Teacher's Name: _____

Structure of Booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	40	40	40
B	11	11	70
			Total 110

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers.

Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

No calculator is allowed in this examination.

Materials supplied

Question and answer booklet of 30 pages.

Answer sheet for multiple-choice questions.

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page, and on the answer sheet for multiple-choice questions.

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 booklet.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2016 VCE Biology Units 3&4 Written Examination.

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SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

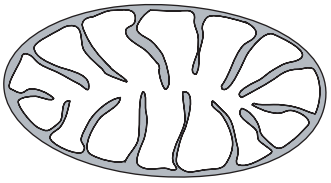
Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** for the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Question 1

An example of a carbohydrate is

A. glycerol.
B. glycogen.
C. glucagon.
D. guanine.

Question 2



The organelle above

A. produces carbon dioxide.
B. contains grana.
C. has a large surface area to absorb carbon dioxide.
D. is not present in plant cells.

Question 3

The organelle that is mainly involved in translation is the

A. nucleus.
B. Golgi apparatus.
C. chloroplast.
D. ribosome.

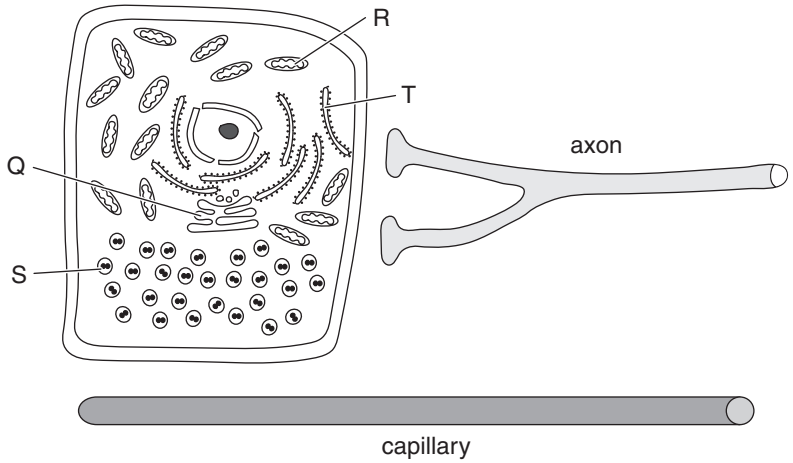
Question 4

Phospholipids are

A. polymers of nucleotides.
B. comprised of the elements C, H and O.
C. an integral component of cell membranes.
D. in a fixed position within a bilayer.

Use the following information to answer Questions 5 and 6.

The following diagram shows an endocrine cell that has a function of secreting a signalling molecule. The endocrine cell is in close contact with an axon that sends a message from the nervous system to stimulate a secretion very quickly. The endocrine cell is also in close contact with a capillary so the signalling molecule can be removed from the extracellular space. Structures Q, R, S and T are components of the endocrine cell that play a role in the functioning of the cell.



Question 5

The order of organelles directly involved from manufacture of the signalling molecule to its secretion is

A. R, S, T

B. T, Q, S

C. Q, R, S

D. S, T, Q

Question 6

The action of the signalling molecule, once secreted from the endocrine cell, would be to

A. activate an action potential in the axon.

B. move into the capillary and bind to target tissue elsewhere.

C. diffuse across the neuroglandular junction.

D. bind to receptors on the endocrine cell that stimulate the secretion.

Use the following information to answer Questions 7–9.

Catalase is an enzyme that speeds up the breakdown of hydrogen peroxide into water and oxygen gas. A properly controlled experiment was carried out where the change in mass of a series of hydrogen peroxide solutions was measured over a 5-minute period. The results are set out in the table below.

Hydrogen peroxide solution (%)	Rate of mass loss (g min^{-1})
12	1.4
10	1.4
8	1.4
6	1.2
4	0.8
2	0.3

Question 7

Which of the following would be a suitable hypothesis for this experiment?

A. If the mass loss increases then the hydrogen peroxide solution gets more concentrated.

B. The hydrogen peroxide solution affects the rate of mass loss.

C. As the percentage of hydrogen peroxide solution increases, the rate of mass loss increases.

D. As the hydrogen peroxide solution increases from 2 to 12%, the rate of mass loss will increase from 0.3 to 1.4 g min^{-1}.

Question 8

The dependent variable in this experiment is the

A. percentage of hydrogen peroxide.

B. concentration of catalase.

C. time of each experiment.

D. rate of mass loss in g min^{-1}.

Question 9

Which of the following would be a suitable explanation of the results?

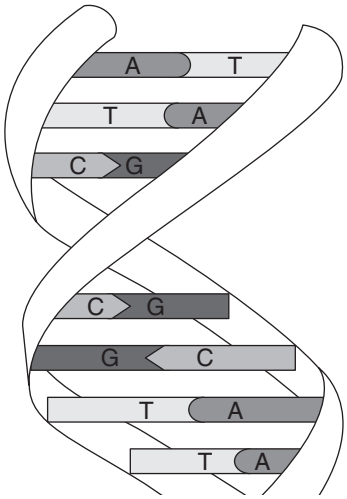
A. As the hydrogen peroxide percentage decreases, the catalase starts to denature.

B. As the hydrogen peroxide percentage increases, the catalase active sites are becoming saturated, which limits the rate of mass loss.

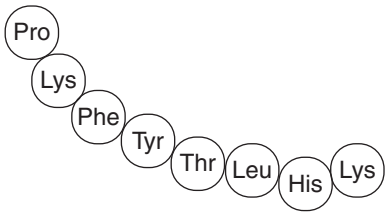
C. As the catalase percentage increases, the hydrogen peroxide limits the rate of mass loss.

D. No suitable explanation can be given because the results should have been left for longer so that valid conclusions about the effect of changing hydrogen peroxide percentage on catalase activity could be made.

Question 10



molecule A



molecule B

Which of the following correctly shows the functional link between molecule A and molecule B in the diagrams above?

A. transcription then replication

B. translation then transcription

C. replication then translation

D. transcription then translation

Question 11

A small amount of steroid hormone binds to a receptor and eventually leads to a sustained response.

Which of the following statements most accurately describes the action of this hormone?

A. The hormone would bind to extracellular receptors.

B. The response to this hormone would be to activate an enzyme.

C. The sustained response would be due to more steps in the signal transduction pathway.

D. The hormone would bind to intracellular receptors.

Question 12

Androstenone is a chemical that is found in high concentrations in the saliva of male pigs and, when inhaled by a female pig that is in heat, results in the female assuming the mating stance.

The type of signalling molecule that androstenone could be classified as would be

A. pheromone.

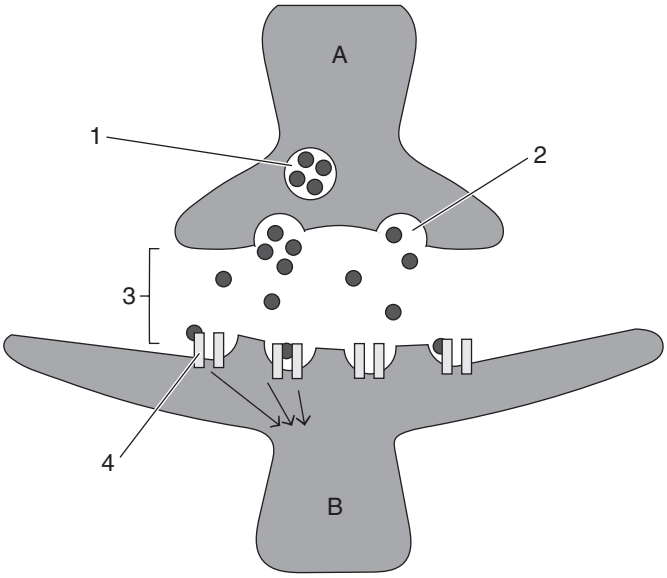
B. plant growth regulator.

C. neurotransmitter.

D. hormone.

Question 13

The diagram below illustrates how a nerve message passes from one nerve cell to another. A and B represent nerve cells and 1 to 4 represent important components of the nerve message.



Nerve cells A and B and components of the nerve message 1, 2, 3 and 4 are respectively

	A	B	1	2	3	4
A.	motor neuron	interneuron	vesicle	exocytosis	synapse	receptor
B.	sensory neuron	interneuron	vesicle	exocytosis	synapse	receptor
C.	interneuron	sensory neuron	vesicle	endocytosis	synapse	receptor
D.	sensory neuron	motor neuron	vesicle	exocytosis	synapse	detector

Question 14

The table below illustrates the effect of differing levels of auxin and cytokinin on undifferentiated plant tissue (a callus).

Level of plant growth regulator applied to callus	Effect on callus
auxin only	little growth of callus
equal amounts of auxin and cytokinin	callus grows well
more auxin than cytokinin	callus differentiates into root tissue
more cytokinin than auxin	callus differentiates into shoot tissue

A horticulturist wanted to propagate a large number of plants. She started with a very small callus and wanted to initially enlarge it, cut it into several portions and then grow each portion into shoot tissue.

The appropriate action to be taken would be to start with

A. auxin to promote callus growth and then add a large amount of cytokinin to promote shoot growth.

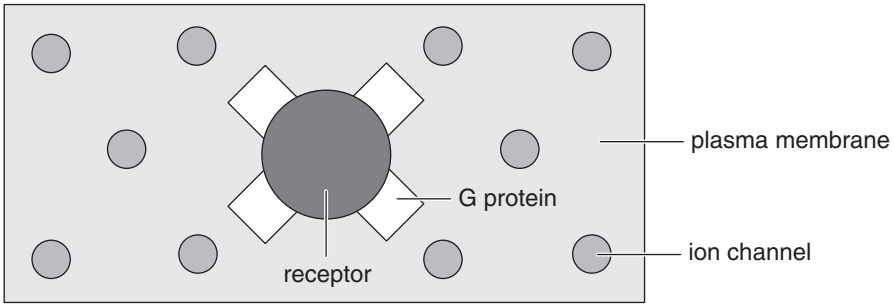
B. equal amounts of auxin and cytokinin to promote callus growth and then increase the level of auxin to promote shoot growth.

C. cytokinin to promote callus growth and then add a large amount of auxin to promote shoot growth.

D. equal amounts of auxin and cytokinin to promote callus growth and then increase the level of cytokinin to promote shoot growth.

Question 15

The diagram below shows the plasma membrane from the inside of a cell. Some membrane receptors activate G proteins. The change in conformation of the receptor leads to the detachment of the G proteins from the receptor, which leads to the response of opening ion channels (sometimes referred to as 'gated' channels). More than one gated channel can be opened by a single G protein.



This type of response is an example of

A. signal amplification.

B. homeostasis.

C. negative feedback.

D. positive feedback.

Question 16

The most appropriate example of a pathogenic organism being transmitted from host to host is

A. a prion disease being transmitted when uncooked brain was consumed.

B. the herpes simplex virus being transmitted via contact between two individuals.

C. the malarial plasmodium being transferred from person to person due to mosquito bites.

D. a dog with the rabies virus biting a human and transferring the disease to them.

Question 17

An example of a physical barrier that reduces the incidence of pathogens causing disease would be

A. the mucus lining the bronchioles in the lungs.

B. stomach acidity.

C. jasmonic acid being directed to a leaf after a herbivore has consumed part of it.

D. unbroken skin.

Question 18

HIV/AIDS has killed almost 40 million people since the first cases were reported in 1981. Once in the body, the virus attaches to CD4 receptor sites on the surface of T-helper cells. The T-helper cell is eventually destroyed by the virus, which then spreads to other T-helper cells until there are very few of them left in the body.

What effect would this have on the body's immune response?

A. Antibodies would not be made, thus disabling cell-mediated immunity.

B. Cytotoxic T cells would not be made, thus disabling humoral immunity.

C. There would be a reduction in the control of both the humoral and cell-mediated immune response.

D. Antibodies would be made but cytotoxic T cells would not be made against the virus.

Question 19

The cells of the immune system that are directly involved in an allergic response are

A. mast cells.

B. B cells.

C. T cells.

D. memory cells.

Question 20

Cancerous cells are usually recognised as self and this is why the immune system does not reject them. However this is not quite true, as some cancers express some proteins that are antigenic. This knowledge is providing immunologists with the hope of new treatments for cancer. Monoclonal antibodies are currently being manufactured that, when administered, are able to target certain types of cancer cells.

This is a form of

A. artificial active immunity.

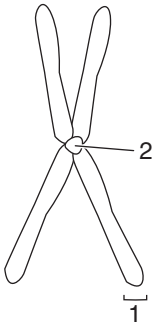
B. artificial passive immunity.

C. natural active immunity.

D. natural passive immunity.

Question 21

The diagram below shows a chromosome during the cell cycle.

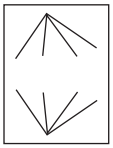
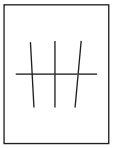
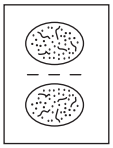
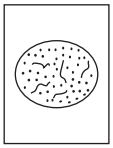


Structures 1 and 2 are respectively

	Structure 1	Structure 2
A.	centromere	chromatid
B.	chromatin	chromatid
C.	chromatid	centromere
D.	telomere	chromatin

Question 22

The following light micrographs from a garlic root tip were taken. The cells are representative of the different stages of the cell cycle.

Cell 1	Cell 2	Cell 3	Cell 4	Cell 5
				

The correct order of the cells from the start to the end of the cell cycle would be

A. 1, 2, 3, 4, 5

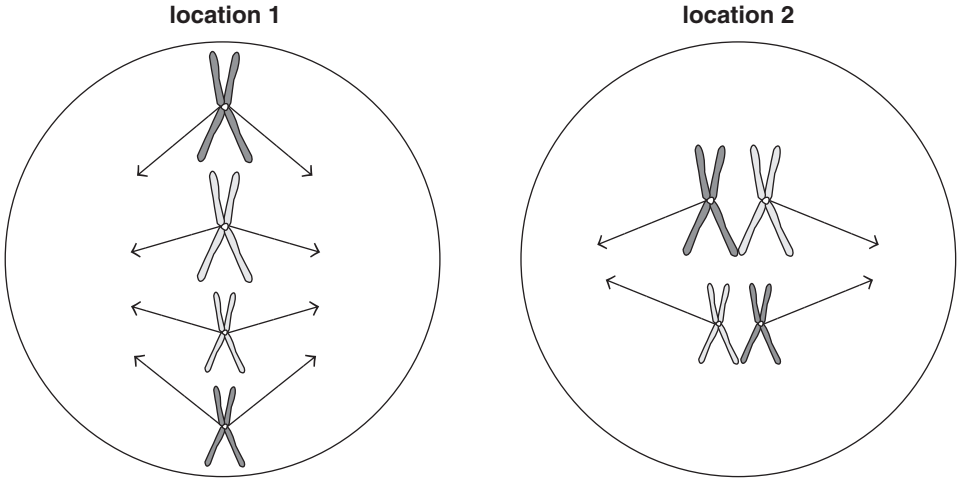
B. 5, 4, 3, 2, 1

C. 3, 2, 4, 1, 5

D. 5, 4, 2, 1, 3

Question 23

The diagram below shows dividing cells drawn from two different locations within a diploid organism.



It would be reasonable to conclude that the locations within the diploid organism of the dividing cells shown in diagrams 1 and 2 are respectively

	Location 1	Location 2
A.	testes	bone marrow
B.	ovary	testes
C.	bone marrow	skin
D.	skin	testes

Question 24

The table below shows the number of chromosomes in the somatic cells of three different primates.

Name of primate	Scientific name	Diploid number
human	*Homo sapiens*	46
chimpanzee	*Pan troglodytes*	48
monkey	*Macaca mulatta*	42

It could be concluded that all three organisms would have

A. a different number of autosomes.

B. a different number of sex chromosomes.

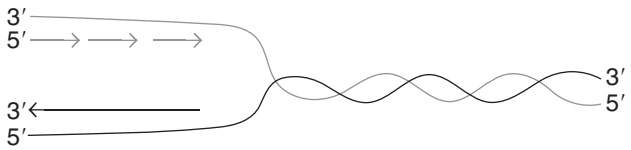
C. the same haploid number.

D. the same number of homologous chromosomes.

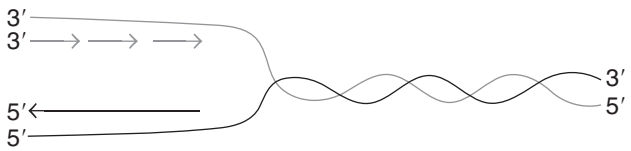
Question 25

Replication of DNA is best represented by

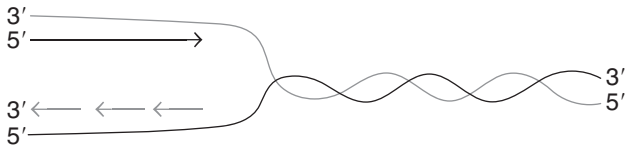
A.



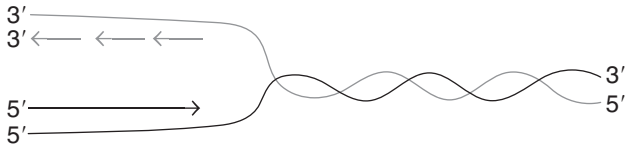
B.



C.



D.



Question 26

A dog breeder was unsure of the genetic status of one of their dogs with respect to colour of hair (gene A), length of hair (gene B) and colour tipping of the hair (gene C). These independently inherited traits displayed typical autosomal dominant and recessive patterns of inheritance. The breeder decided to perform a test cross to determine the genetic status of the dog.

The cross that would illustrate the dog under question was indeed of pure-breeding would be

A. AABBCC × aabbcc

B. AaBbCc × aabbcc

C. AaBbCc × AaBbCc

D. AABBCC × AABBCC

Question 27

A rare genetic disorder located along the mitochondrial DNA is displayed in a particular individual.

It would be true to say that the genetic disorder was inherited from the individual's

A. maternal grandmother.

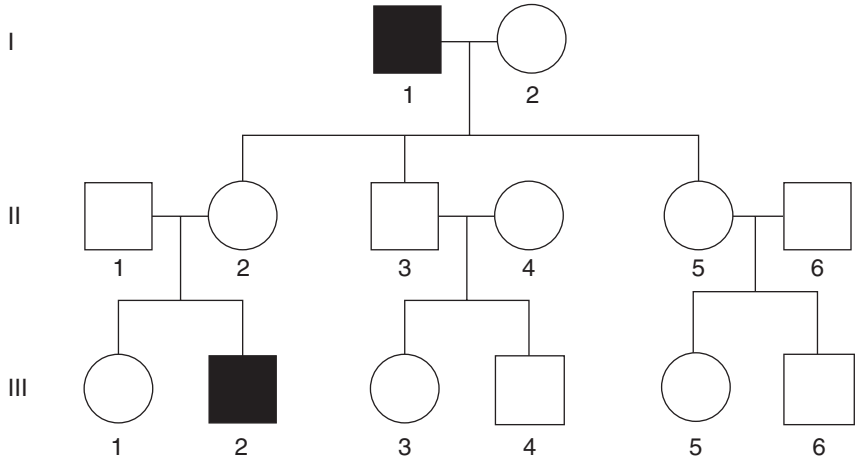
B. paternal grandmother.

C. maternal grandfather.

D. paternal grandfather.

Use the following information to answer Questions 28 and 29.

The pedigree below shows the inheritance of a sex-linked recessive trait. The alleles involved are symbolised with X^B and X^b.



Question 28

The chance that individual III-1 is a carrier would be

A. 66%

B. 50%

C. 0%

D. 100%

Question 29

The genotype of individual I-1 is

A. X^bY

B. X^BX^b

C. X^bX^b

D. X^BY

Question 30

The agouti gene in mice is an interesting example of genetic inheritance. The wild type allele (y) codes for yellow-and-black striped hair, which looks grey from far away. There is another allele of the agouti gene that causes the mice to have a light yellowish colour because the black stripes are missing from the hairs. This allele is dominant to the wild type allele (Y). A series of crosses between yellow individuals was carried out to see how closely the phenotypes of the offspring reflected the laws of probability. The results of these crosses are shown in the table below.

Cross number	Parent phenotype	Offspring phenotype
1	yellow × yellow	9 yellow : 4 wild type
2	yellow × yellow	8 yellow : 3 wild type
3	yellow × yellow	9 yellow : 5 wild type
4	yellow × yellow	10 yellow : 6 wild type

The best explanation for the data would be that

A. not all of the parents were heterozygous for colour.

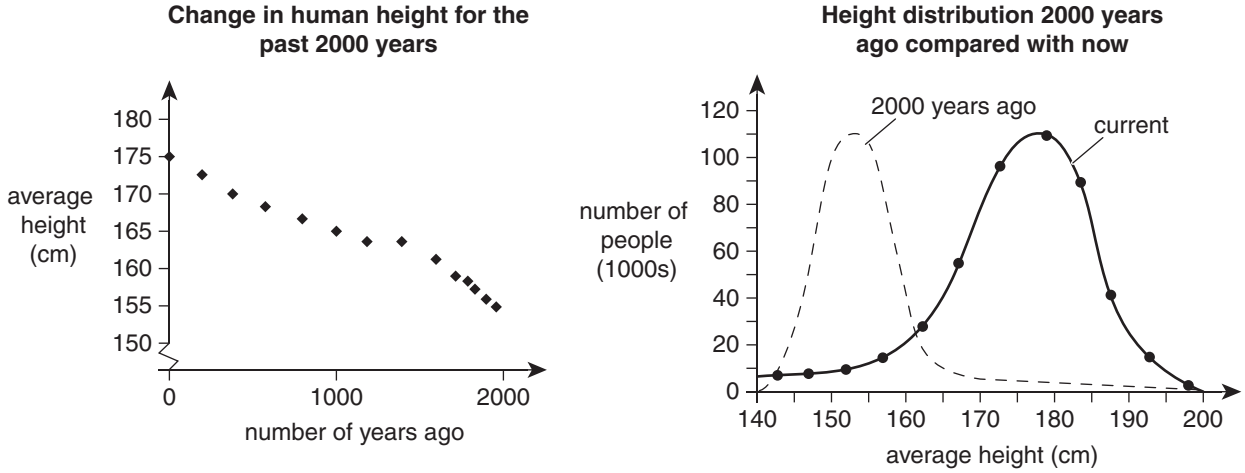
B. all of the yellow offspring would be heterozygous.

C. all of the wild type offspring would be heterozygous.

D. all of the yellow offspring would be homozygous.

Question 31

The graphs below show the average change in human height over the past 2000 years as well as the height distribution of the most recent group measured in 2016 compared to 2000 years ago.



When analysing both sets of data, these graphs illustrate that

A. human height is controlled by a single gene.

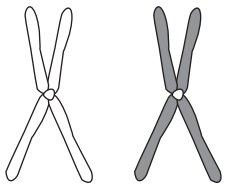
B. a greater understanding of genetics 200 years ago led to human height increasing.

C. the proportion of 'short' alleles in the gene pool 2000 years ago was much smaller than the present.

D. height phenotype is influenced by both the environment and genetics.

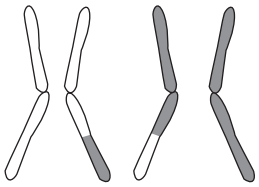
Question 32

Crossing over during meiosis is a way of providing more allelic variety in gametes. Crossing over is random and can occur a number of times between homologous chromosomes.

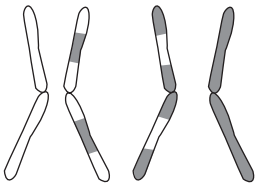


If one pair of homologous chromosomes from the diagram above were to undergo crossover in two places, then the resultant gametes could look like

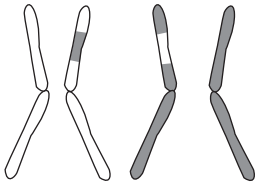
A.



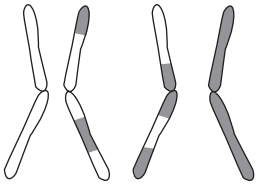
B.



C.



D.



Use the following information to answer Questions 33 and 34.

In a given population of 100 beetles, the frequency of each phenotype is illustrated in the table below.

Phenotype	Genotype	Frequency
brown beetles	bb	26%
green beetles	BB	30%
hazel beetles	Bb	44%

Question 33

The number of brown alleles in the population is

A. 96

B. 52

C. 44

D. 26

Question 34

If there was a selective advantage in the environment for the green beetles, the impact this would have on allele frequencies would be

A. an increase in the B allele and no change in the b allele.

B. a decrease in the B allele and an increase in the b allele.

C. no change in either the B or b allele.

D. an increase in the B allele and a decrease in the b allele.

Question 35

Burrowing bettongs are kangaroo-like marsupials that were once widespread across arid and semi-arid areas in the south, central and western parts of Australia. The three remaining subspecies are critically endangered and have gone through extensive separate breeding programs on a few islands off the coast of Western Australia.

When reintroducing them back to the mainland, cross-breeding between the three subspecies of burrowing bettongs would

A. be unsuccessful because they are not the same species.

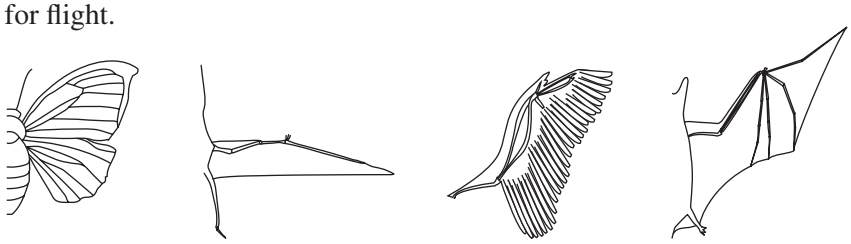
B. result in gene flow.

C. be the result of genetic drift.

D. be an example of the founder effect.

Question 36

The four organisms (moth, pterodactyl, bird, bat) in the diagram below have all independently developed adaptations suited for flight.



moth **pterodactyl** **bird** **bat**

What is the most appropriate way of describing the form of evolution involved in the evolution of flight in these four organisms?

A. divergent evolution due to their non-flying ancestors developing different features as a result of different environmental pressures

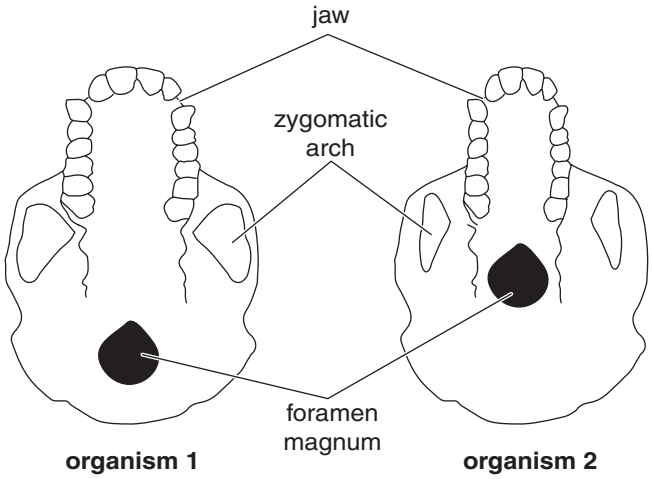
B. divergent evolution due to their non-flying ancestors developing similar features as a result of similar environmental pressures

C. convergent evolution due to their non-flying ancestors developing different features as a result of different environmental pressures

D. convergent evolution due to their non-flying ancestors developing similar features as a result of similar environmental pressures

Question 37

The diagram below shows two primate skulls (organism 1 and organism 2) viewed from underneath. Illustrated are the size of the jaw, the size of the zygomatic arches and the position of the foramen magnum.



Based on the information provided it would be reasonable to conclude that

A. organism 1 was vegetarian and bipedal, whereas organism 2 was a knuckle-walker.

B. organism 1 did a lot of chewing and was a knuckle-walker, whereas organism 2 did less chewing and was bipedal.

C. organism 1 did not do a lot of chewing and was a knuckle-walker, whereas organism 2 did a lot of chewing and was bipedal.

D. the parabolic jaw was indicative of a similar lifestyle.

Question 38

Listed below are a group of hominins.

1. *Homo neanderthalensis*
2. *Australopithecus afarensis*
3. *Homo erectus*
4. *Australopithecus africanus*
5. *Homo habilis*
6. *Homo sapiens*

The hominins from oldest to modern would be

A. 1, 2, 3, 4, 5, 6

B. 2, 4, 5, 6, 1, 3

C. 2, 4, 5, 3, 1, 6

D. 6, 5, 4, 3, 2, 1

Use the following information to answer Questions 39 and 40.

The Pyrenean ibex (*Capra pyrenaica pyrenaica*) was one of the four subspecies of the Spanish ibex, or Iberian wild goat. Pyrenean ibex were very abundant in the Pyrenees region of France and Spain throughout the Middle Ages, but as a result of hunting pressure, their numbers decreased rapidly in the 19th and 20th centuries. In the latter half of the 20th century, only a small population of Pyrenean ibex could be found. These were located in the Ordesa National Park in the Spanish Central Pyrenees. In January 2000 a female named Celia, the last natural Pyrenean ibex, was found dead.

Question 39

The extinction of the Pyrenean ibex

A. was due to natural causes.

B. was due primarily to human impact on their environment.

C. is not scientifically substantiated.

D. occurred well before Celia died.

Question 40

Scientists have attempted to clone the Pyrenean ibex using DNA from Celia that was harvested from her ear. The nuclei were extracted from the somatic cells obtained from Celia and placed into enucleated ova. The ova were then transferred into domestic goats as surrogates. Of the 285 embryos that went through this process, one clone was born alive, but only survived for ten minutes.

If cloning technology such as this became more successful and could be used routinely to bring extinct organisms such as the Pyrenean ibex back to life, then the consequences of the technology could be

A. a new thriving population of Pyrenean ibex.

B. that once the first generation of Pyrenean ibex are founded, subsequent generations would display more genetic variety.

C. a population of genetically identical Pyrenean ibex.

D. data providing evidence of the impact that the environment has on the phenotype of the Pyrenean ibex.

END OF SECTION A

SECTION B – SHORT-ANSWER QUESTIONS

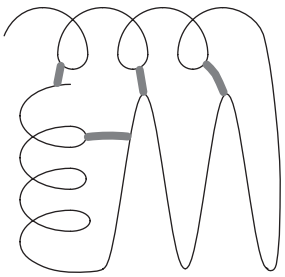
Instructions for Section B

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

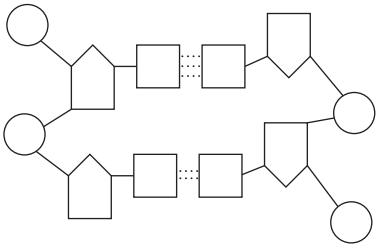
Question 1 (6 marks)

The diagrams below represent two important biomacromolecules (1 and 2).

biomacromolecule 1



biomacromolecule 2



a. **i.** Name biomacromolecule 1. 1 mark

_____

ii. Name biomacromolecule 2. 1 mark

_____

b. How many nucleotides are illustrated in the diagrams? 1 mark

_____

c. Label the α-helices observed on the diagrams above. 1 mark

d. List the elements that make up biomacromolecule 2. 1 mark

_____

e. What is the importance of the disulphide bonds illustrated? 1 mark

_____

_____

Question 2 (7 marks)

Mitochondria and chloroplasts can be isolated and purified using a variety of biochemical techniques, including homogenisation and differential centrifugation. Once isolated, the function of both organelles can be investigated more specifically. The isolated mitochondria and chloroplasts can be suspended in solutions containing a variety of chemicals so that the optimum environment for functioning can be determined. After their isolation, both mitochondria and chloroplasts are suspended not in water, but in a saline solution of a specific concentration.

a. If both organelles were suspended in water (rather than saline solution), explain how this would affect their structure. 1 mark

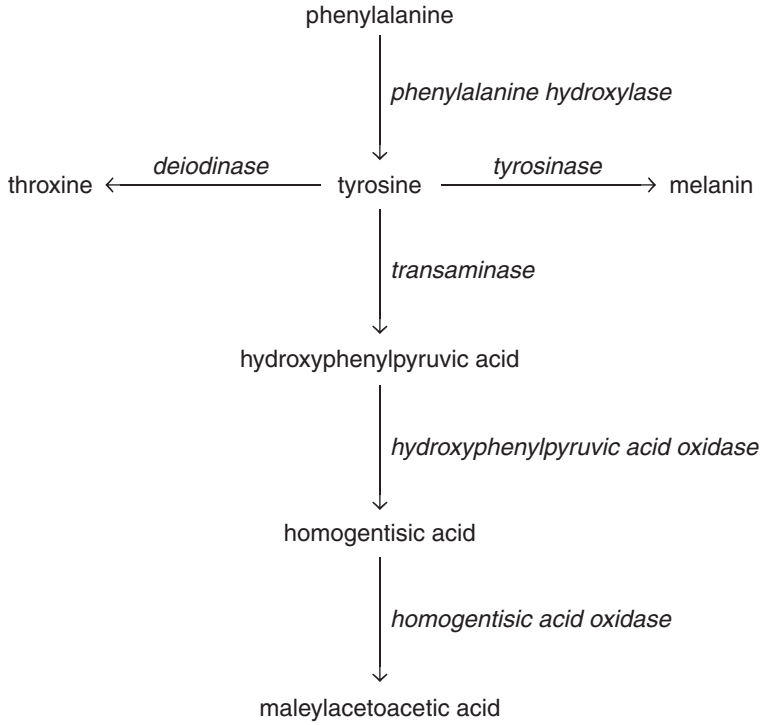
b. When provided with optimal conditions, state the inputs and outputs of single cultures of chloroplasts and single cultures of mitochondria. 4 marks

	Input(s)	**Output(s)**
Chloroplast		
Mitochondria		

c. Describe how electron transport assists both organelles to carry out their overall function. 2 marks

Question 3 (6 marks)

Phenylalanine is an essential amino acid and tyrosine is a non-essential amino acid. Both are part of an important biochemical pathway involved in the production of melanin (a skin pigment). Errors in metabolism within this biochemical pathway can lead to diseases such as phenylketonuria (PKU), albinism and alkaptonuria (AKU). The diagram below summarises the pathway.



a. What is the difference between an essential amino acid and a non-essential amino acid? 1 mark

b. Name the substrate and product of the reaction catalysed by tyrosinase. 1 mark

c. Describe the structural and functional differences between hydroxyphenylpyruvic acid oxidase and transaminase. 2 marks

d. PKU is a disease where the enzyme phenylalanine hydroxylase is not produced due to a genetic error.

i. Describe **one** effect the absence of phenylalanine hydroxylase would have on the metabolic pathway involving phenylalanine. 1 mark

ii. What measures could be taken to reduce the effect described in part **d. i.**? 1 mark

Question 4 (4 marks)

Threonine and theanine (like glutamine) are both amino acids and can both act as signalling molecules. When consumed as supplements they both have vastly different effects on the body. Threonine is important for healthy nerves, muscles and liver, whereas theanine produces calming, mood-enhancing effects in the brain.

a. Using your understanding of the structure of amino acids, explain why these two different amino acids can have such vastly different effects on the body. 2 marks

b. There is evidence that the presence of threonine around nerve cells stimulates axon growth, thus promoting healthy nerve cells.

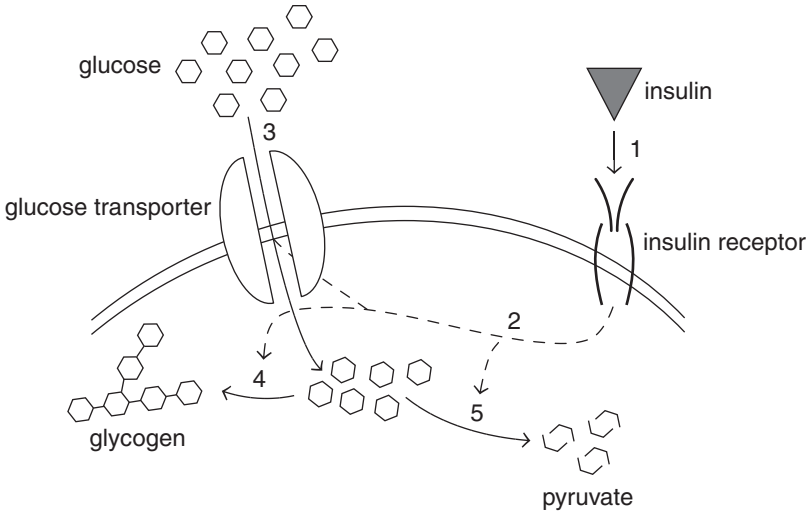
How could more axons lead to a healthier nervous system? 1 mark

c. Theanine is a competitive inhibitor with the postsynaptic glutamate receptors in stress neurons. Glutamate is a neurotransmitter that is associated with the stress response, and so theanine is thought to have a calming effect on the brain.

What does it mean to say that theanine is a competitive inhibitor with glutamate? 1 mark

Question 5 (4 marks)

The diagram below represents a fat cell response to the signalling molecule insulin. On the diagram, 1 represents signal reception; 2 represents signal transduction; and 3 to 5 are the various responses.



a. Describe the interaction between insulin and the insulin receptor (1). 1 mark

b. Explain how the same signal transduction pathway (2) can bring about different responses (3 to 5). 1 mark

c. Complete the table below showing how the various responses specifically lead to lowered blood glucose levels. 2 marks

Response	How response specifically lowers the blood glucose levels
3	
5	

Question 6 (10 marks)

"Each year globally, about 14 million people learn they have cancer, and 8 million people die from the disease. Research suggests that one-third of cancer deaths can be prevented, but sometimes services and technologies are not widely available, especially in low- and middle-income countries."

Source: Reproduced from Union for International Cancer Control (UICC), *Centers for Disease Control and Prevention (CDC): World Cancer Day Feature*. Accessed 22 February 2016. http://www.worldcancerday.org/centers-disease-control-and-prevention-cdc-world-cancer-day-feature

a. **i.** Why do cancer cells not activate the immune system in the same fashion as a pathogenic disease-causing organism? 1 mark

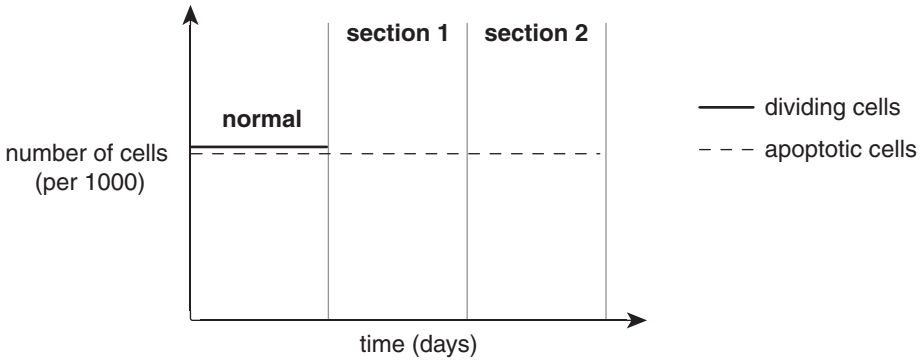
ii. A humoral response is usually stimulated when the body is exposed to a pathogen.
Name **one** cell involved in the humoral response and describe its role. 2 marks

The human body has various mechanisms that keep the body healthy. These include cell replacement, programmed cell death and homeostasis.

b. **i.** Describe **two** events that occur during interphase that prepare a cell for division (cell replacement). 2 marks

ii. Describe how a natural killer (NK) cell can play a role in programmed cell death. 2 marks

In a fully developed human body, the rate of cell replacement is equal to the rate of cell death, which is a normal condition for the body to be in. When the rate of cell division is greater than the rate of cell death in a particular part of the body, cancer can result. The graph below represents the number of dividing cells and apoptotic cells in a part of the body prior to being exposed to conditions known to be carcinogenic (section 1) and then to chemotherapy medication (section 2).



c. **i.** Complete the graph in **section 1** showing how carcinogens can affect the numbers of dividing cells. 1 mark

ii. Chemotherapy is a medical procedure that is targeted to kill all dividing cells, including the cancerous ones.

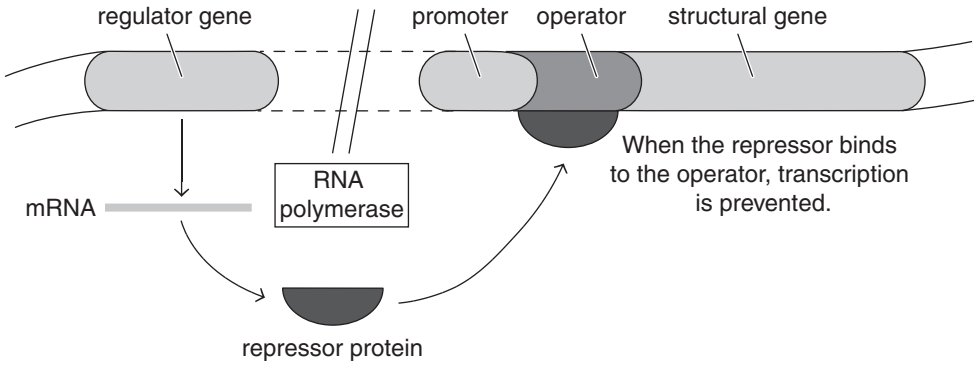
Complete the graph in **section 2** showing the effect of chemotherapy on the numbers of dividing cells. 1 mark

d. One side effect of chemotherapy medication is hair loss. One method published late in 2015 that is being used with some success is the use of cold caps, which are worn on the head while the chemotherapy drugs are being added into the body. The cold cap causes blood vessels to vasoconstrict, reducing the blood flow to the hair follicles in the head.

Describe how the use of the cold cap would impact on hair loss in patients who are undergoing chemotherapy. 1 mark

Question 7 (6 marks)

In eukaryotic cells, many genes are inactive and need to be activated to be expressed. This is a way of ensuring cellular specificity. Certain signals are required to activate genes. The diagram below shows a simplistic view of gene regulation at the transcriptional level.



a. Why is it better for genes to be regulated at the transcriptional level? 1 mark

The following events occur in a particular sequence and show how a particular gene can be inactive:

1. The active repressor binds to the operator, blocking the expression of the structural genes.
2. The structural gene is off.
3. The regulator gene is transcribed, producing mRNA.
4. RNA polymerase is unable to bind to the promoter as the repressor is bound to the operator.
5. Regulator mRNA translates into an active repressor protein.

b. Correctly order the events 1 to 5. 1 mark

c. To switch the structural genes on, the repressor needs to be removed from the operator.
Describe how the repressor could be removed from the operator. 1 mark

d. Once transcription occurs there is further processing of the formed pre-mRNA.
Discuss the importance of the removal of introns to the production of mRNA. 1 mark

e. Describe the events of translation that lead to a specific structural protein. 2 marks

Question 8 (6 marks)

Two genes of significance with respect to human blood types are the ABO and rhesus genes. The ABO gene is located on chromosome 9 and the rhesus gene is located on chromosome 1. The table below illustrates the different alleles and the symbols used for each.

Gene	Allele	Notation
ABO	A	I^A
	B	I^B
	O	i
rhesus	positive	R
	negative	r

a. What is the relationship between the A, B and O alleles? 1 mark

b. **i.** What is the genotype of an individual who is AB negative? 1 mark

ii. Draw the chromosomal arrangement in prophase I of an AB negative individual in the space provided below. 2 marks

c. Two people decide to have a family. One person has a blood type of B positive and the other has a genotype of A negative.

Explain whether is it possible for these parents to conceive a child that is O negative. 2 marks

Question 9 (8 marks)

The polymerase chain reaction (PCR) is a powerful technology that enables specific sections of DNA to be amplified into sufficient quantities for further studies. The cuvette that goes into the PCR machine contains sample DNA, nucleotides, primers and *taq* polymerase.

a. Describe the importance of the primers and *taq* polymerase to the PCR process. 2 marks

Once a sample is subjected to PCR, further studies may be conducted of the amplified section of DNA. One application is the diagnosis of genetic diseases such as sickle-cell anaemia. The gene causing the disease has two alleles (roughly the same size) and once the sample DNA has been subjected to PCR, restriction enzymes are used to cut the DNA once along the sickle allele, which liberates two unequally sized fragments (the non-sickle allele is not cut by the restriction enzyme). Gel electrophoresis can then be used to determine the genetic status of individuals.

b. Why would a restriction enzyme cut the sickle allele once but not the normal allele? 1 mark

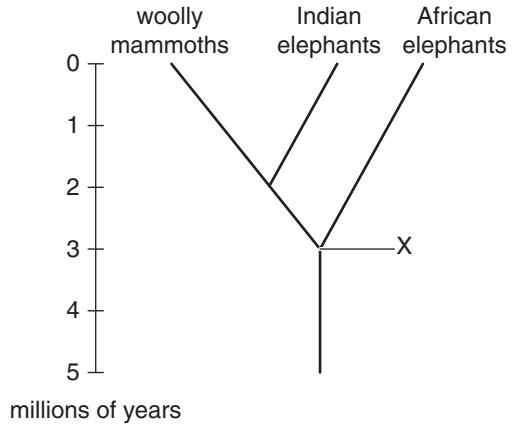
c. Draw a labelled diagram of the gel pattern of an individual that is heterozygous for the sickle-cell trait in the space below. 2 marks

d. People who are heterozygous for sickle-cell anaemia are at a selective advantage in an environment where malaria is endemic, such as Africa. In these areas, the number of individuals who are heterozygous is significantly higher than in areas where malaria is not endemic.

Is the prevalence of the sickle-cell anaemia allele in areas where malaria is endemic an example of natural selection in action? Explain. 3 marks

Question 10 (7 marks)

There is a large amount of evidence in support of the evolution of the elephant. The elephant family includes the extinct woolly mammoth, as well as the Indian and African elephants. It is hypothesised that the ancestral stock from which these three groups diverged began in Africa about 50 to 60 million years ago. The common ancestor was a mammal about the size of a current-day pig. The cladogram below shows the relationship between the African and Indian elephants, as well as the recently extinct woolly mammoth (extinct about 10 000 years ago).



a. Describe the events occurring at point X on the cladogram that led to the elephants diverging into two linages. 3 marks

b. What evidence from mitochondrial DNA studies would support the cladogram in the format it is currently in? 2 marks

c. How could carbon dating be useful in determining the age of the frozen remains of the more recent woolly mammoth fossilised tissue? 2 marks

Question 11 (6 marks)

A new species of hominin was discovered in a South African cave and was introduced to the world as *Homo naledi* in 2015. More than 1500 fossils were found scattered on the floor of the cave and belong to at least 15 individuals, making it one of the biggest hominin finds in history.

a. Define the term 'hominin'. 1 mark

Based on the fossil evidence, it was concluded that *Homo naledi* was bipedal, of low intelligence and lived about two million years ago. However, absolute dating has not yet been completed.

b. Discuss **two** problems the researchers face in determining the absolute age of the *Homo naledi* fossils. 2 marks

c. Explain the fossil evidence needed to make conclusions about

i. bipedalism. 1 mark

ii. intelligence. 1 mark

d. The cave system the fossils were located in suggested that *Homo naledi* intentionally deposited bodies of their dead in a remote and largely inaccessible cave chamber.

Why would this practice be regarded as a form of cultural evolution? 1 mark

END OF QUESTION AND ANSWER BOOKLET