



Φ Σ Κ

BIOLOGY MOCK EXAM

NESA Number

2020

HIGHER SCHOOL CERTIFICATE EXAMINATION

Biology

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- Write your NESA number where required

Total marks: 100

Section I – 20 marks (pages 2-10)

- Attempt Questions 1-20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 11-22)

- Attempt Questions 21-30
- Allow about 2 hours and 25 minutes for this section



Biology

Answer Sheet – Multiple Choice

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9
A B C D

If you think you have made a mistake, put a cross through the correct answer and fill in the new answer.

A B C D

If you change your mind and have cross out what you consider to be the correct answer, then indicate the correct answer by writing the word “correct” and drawing an arrow as follows.

A B C D
correct

- Start Here** →
- | | | | | | | | | | |
|-----|------------------------------------|------------------------------------|------------------------------------|------------------------------------|-----|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| 1. | A <input type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input checked="" type="radio"/> | 11. | A <input type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input checked="" type="radio"/> |
| 2. | A <input checked="" type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input type="radio"/> | 12. | A <input type="radio"/> | B <input checked="" type="radio"/> | C <input type="radio"/> | D <input type="radio"/> |
| 3. | A <input type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input checked="" type="radio"/> | 13. | A <input type="radio"/> | B <input type="radio"/> | C <input checked="" type="radio"/> | D <input type="radio"/> |
| 4. | A <input type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input checked="" type="radio"/> | 14. | A <input type="radio"/> | B <input type="radio"/> | C <input checked="" type="radio"/> | D <input type="radio"/> |
| 5. | A <input type="radio"/> | B <input checked="" type="radio"/> | C <input type="radio"/> | D <input type="radio"/> | 15. | A <input type="radio"/> | B <input checked="" type="radio"/> | C <input type="radio"/> | D <input type="radio"/> |
| 6. | A <input checked="" type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input type="radio"/> | 16. | A <input type="radio"/> | B <input type="radio"/> | C <input checked="" type="radio"/> | D <input type="radio"/> |
| 7. | A <input type="radio"/> | B <input checked="" type="radio"/> | C <input type="radio"/> | D <input type="radio"/> | 17. | A <input type="radio"/> | B <input type="radio"/> | C <input checked="" type="radio"/> | D <input type="radio"/> |
| 8. | A <input type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input checked="" type="radio"/> | 18. | A <input checked="" type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input type="radio"/> |
| 9. | A <input type="radio"/> | B <input type="radio"/> | C <input checked="" type="radio"/> | D <input type="radio"/> | 19. | A <input type="radio"/> | B <input type="radio"/> | C <input checked="" type="radio"/> | D <input type="radio"/> |
| 10. | A <input checked="" type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input type="radio"/> | 20. | A <input checked="" type="radio"/> | B <input type="radio"/> | C <input type="radio"/> | D <input type="radio"/> |

Section I

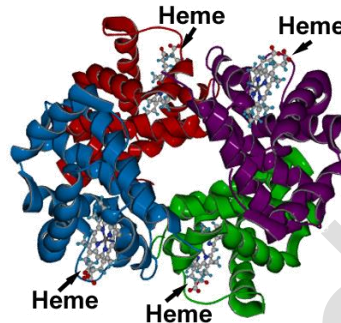
20 marks

Attempt Questions 1-20

Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1-20

- 1 The following diagram below represents a molecule of the protein haemoglobin.



Which level of protein structure is presented by this model?

- A. Primary
- B. Secondary
- C. Tertiary
- D. Quaternary

Explanation:

Quaternary structure shows how multiple polypeptides orient themselves in 3D space and interact with each other.

- 2 A genetic disorder is controlled by a gene on the Y chromosome. What is the probability a man with the condition will have an affected daughter?

- A. 0%
- B. 25%
- C. 25%
- D. 100%

Explanation:

Females have two X chromosomes and do NOT possess Y chromosomes. Therefore it is impossible for the man's daughter to be affected.

3 Which of the following is an example of the body's specific immune response?

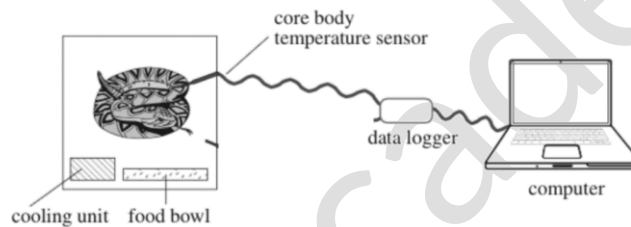
- A. The first line of defence (e.g. the skin)
- B. Inflammation
- C. Phagocytosis

D. Antibody production

Explanation:

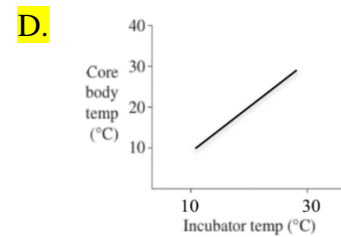
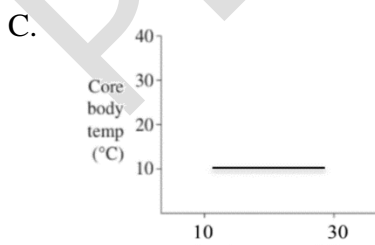
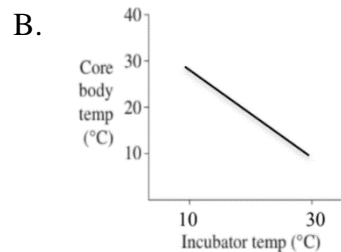
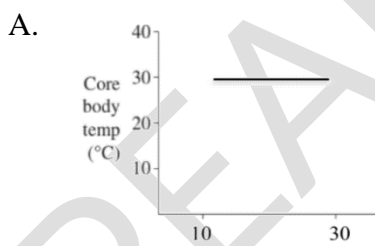
Antibodies are part of the 3rd line of defence and are produced in response to a specific antigen presenting molecule. The first three options fall into the first and second line of defence which are non-specific.

4 An experiment was set up to measure the changes in the core body temperature of a snake in response to changes in the temperature of the surrounding.



The cooling unit in the incubator housing the snake was used to reduce the temperature of the surrounding from 30°C to 10°C.

Which graph best predicts the change in core body temperature of the snake?



Explanation:

Snakes are endotherms. The body temperature of an endotherm will fluctuate with the environment's ambient temperature. As the incubator cools down from 30°C to 10°C, the core temperature of the snake will as well.

- 5 What was Pasteur's contribution to our understanding of infectious disease?
- He produced a set of postulates to identify the organism which causes a particular disease
 - He disproved the theory of spontaneous generation by showing that microbes could only come from pre-existing microbes
 - He invented the light microscope and improved milk packaging techniques
 - His experiment showed that disease causing microbes could spontaneously arise from rotten and decaying matter

Explanation:

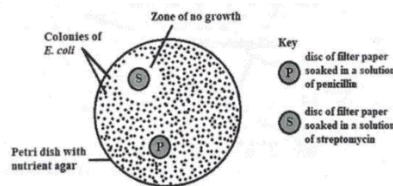
Louis Pasteur disproved the theory of spontaneous generation using his swan-necked flask experiment.

- 6 Which of the following body systems is involved in detecting and responding to environmental changes?
- Nervous
 - Circulatory
 - Lymphatic
 - Excretory

Explanation:

The endocrine and nervous system are the two internal coordinating systems that work in conjunction to regulate homeostasis.

- 7 The following diagram shows the effects of the antibiotics, streptomycin and penicillin on the bacterium *Escherichia coli* (*E. coli*).



What can be inferred about the response of *E. coli* to the antibiotics?

- E. coli* is resistant to streptomycin only
- E. coli* is resistant to penicillin only
- E. coli* shows no resistance to either antibiotics
- E. coli* is resistant to both penicillin and streptomycin

Explanation:

Streptomycin has killed the bacteria around it, and thus, is effective against *E. coli*. Penicillin exhibits no effect on the bacteria

- 8 At the end of a marathon race a runner's body is dehydrated. How does the body control the two hormones, ADH and aldosterone, to help to re-establish normal water balance?
- A. ADH is released and aldosterone is released
 - B. ADH is inhibited and aldosterone is inhibited
 - C. Both ADH and aldosterone are inhibited
 - D. Both ADH and aldosterone are released

Explanation:

ADH increases water reabsorption by increasing the amount of aquaporins in the distal convoluted tubule and collecting duct. Aldosterone facilitates water reabsorption through osmosis by increasing sodium reabsorption.

- 9 A New Zealand research team inserted a single gene into an onion to reduce the activity of the enzyme that makes your eyes water, resulting in an onion that you can cut without crying. Which term best describes this team's process?
- A. Cloning
 - B. Artificial pollination
 - C. Genetic engineering
 - D. Artificial insemination

Explanation:

The scientists have introduced a gene of interest to modify the genome of the onion.

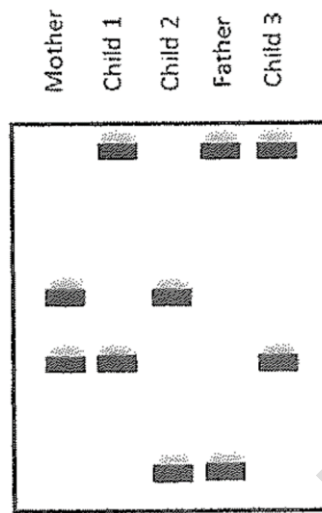
- 10 Reproduction ensures the continuity of species. Select the row that correctly represents the method and type of reproduction for the organism identified.

	<i>Organism</i>	<i>Method of Reproduction</i>	<i>Type of Reproduction</i>
A.	Yeast	Budding	Asexual
B.	Birds	External fertilisation	Asexual
C.	Bacteria	Binary fission	Sexual
D.	Ferns	Internal fertilisation	Sexual

Explanation:

Yeast reproduce via budding, a process involving mitosis to replicate the parent cell nucleus and is thus an asexual form of reproduction

- 11 Results from a DNA fingerprint analysis for a man and woman and their three children are shown in the diagram below.



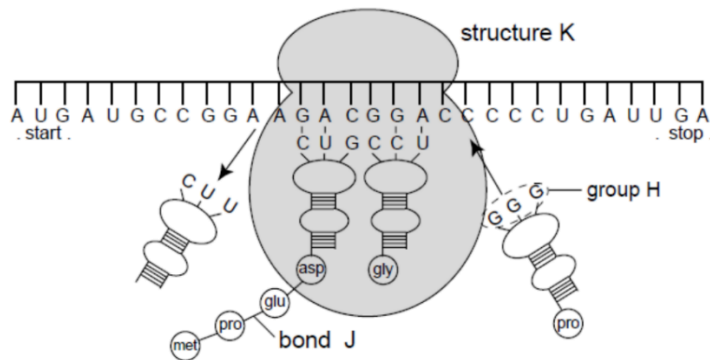
Which child, if any, is NOT the biological offspring of the father?

- A. Child 1
- B. Child 2
- C. Child 3
- D. All the children could be the biological offspring of the father.

Explanation:

All children have bands that match bands from both parents.

12 The diagram below is of a biological process involved in protein synthesis.



What is the correct identification of the process, structure K and group H?

	<i>Process</i>	<i>Structure K</i>	<i>Group H</i>
A.	Transcription	Chromosome	Anticodon
B.	Translation	Ribosome	Anticodon
C.	Transcription	Chromosome	Codon
D.	Translation	Ribosome	Codon

Explanation:

Translation happens in the cytoplasm and is carried out in the ribosome. The codon is carried on the mRNA molecule and the anticodon is carried on the tRNA, which enters the ribosome and forms complementary bonds with the mRNA.

13 Which of the following is a plant defence against pathogens?

- A. Pathogen-specific antibodies are produced
- B. Large spines prevent bacteria and fungi from gaining entry
- C. The production of antimicrobial proteins and enzymes
- D. Yellowing of leaves and stem and increased sap flow

Explanation:

Plant immune defences are purely innate and they do not produce antibodies. Large structural adaptations like spines will not prevent entry of bacteria and fungi (instead, plants have adaptations such as cell wall reinforcement which will prevent pathogen entry and spread). Yellowing of leaves and stem and increased sap flow does not contribute to plant immunity.

Plant antimicrobial peptides (AMPs) are a component of the barrier-defense system of plants.

- 14 Below is a picture seen through healthy eyes and the same picture seen through eyes affected by cataracts.



Normal Vision

Vision with Cataracts

In which part of the eye do cataracts form?

- A. The cornea
- B. The iris
- C. The lens
- D. The retina

Explanation:

A cataract is an opacification of the lens of the eye which leads to a decrease in vision. Cataracts often develop slowly and can affect one or both eyes. Symptoms may include faded colors, blurry or double vision, halos around light, trouble with bright lights, and trouble seeing at night. All other structures are usually unaffected.

- 15 After an organ transplant operation, why must patients take drugs that suppress the immune system?

- A. To strengthen the immune system and prevent infection of the transplanted organ
- B. To prevent the body from attacking the transplanted organ as if it were a pathogen
- C. To prevent the transplanted organ from rejecting its new body
- D. To strengthen the transplanted organ and hasten the healing process

Explanation:

Immunosuppressant drugs are used after an organ transplant to dampen the effect of the immune system and prevent the organ from being destroyed.

- 16 Coat colours of Andalusian fowls are an example of a trait determined by codominant alleles. Black, blue (a mixture of black and white) and white are the three phenotypes in Andalusian fowls.

When blue fowls are crossed with white fowls, what percentage of the F1 will be blue?

- A. 0%
- B. 25%
- C. 50%
- D. 75%

Explanation:

Alleles:



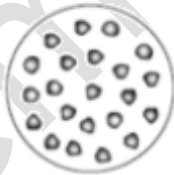
BB = Black

WW = White

BW = Blue

	B	W
W	BW	WW
W	BW	WW

- 17 Students performed an investigation to compare the effectiveness of two water treatments for purifying pond water.
- Three samples of pond water, A, B and C, were collected and each used to inoculate an agar plate. The plates were incubated at 25°C and examined three days later. The number of visible bacterial colonies on each plate was counted and the results tabulated.

<i>Sample</i>	<i>A</i>	<i>B</i>	<i>C</i>
<i>Treatment</i>	5 grams of pool chlorine per litre of water	Boiling for one minute	No treatment
<i>Number of visible bacterial colonies</i>	0 	6 	22 

What is the dependent variable in this investigation?

- A. Treating the water by boiling or adding pool chlorine
- B. The use of a control sample
- C. The number of visible bacterial colonies
- D. The use of sterile agar plates for each sample

Explanation:

The dependent variable is the variable that is measured. In this case the number of visible bacterial colonies was measured

- 18 Which observation can be used to demonstrate Koch's contribution to understanding the cause of disease?
- A. The bacteria, *Helicobacter pylori*, are present in the stomach of all people diagnosed with stomach ulcers
 - B. Some mosquitoes carry a pathogen that is often fatal to people
 - C. A lack of vitamin C is found in all people suffering the nutritional disease scurvy
 - D. Polio vaccinations trigger an immune response

Explanation:

Option A reflects Koch's first postulate - the same microorganism must be present in every host with a certain disease.

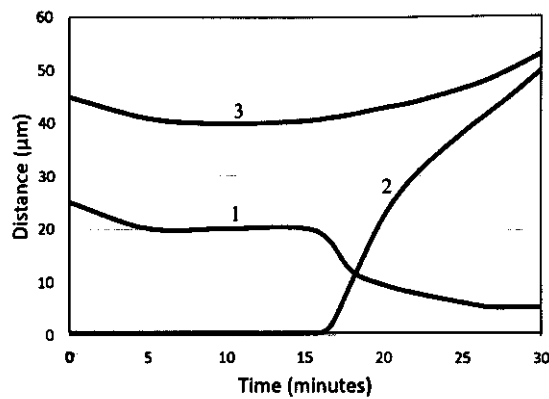
19 Which of the following correctly indicates a function of each hormone in the menstrual cycle?

	<i>LH</i>	<i>FSH</i>	<i>Progesterone</i>	<i>Oestrogen</i>
A.	Stops FSH being produced	Maintains the lining of the uterus during the middle of the menstrual cycle	Causes the mature egg to be released from the ovary	Prepares the uterus to receive a fertilised ovum
B.	Maintains the lining of the uterus during the middle of the menstrual cycle	Stimulates the pituitary gland to release LH	Causes an egg to mature in the ovary	Causes the mature egg to be released from the ovary
C.	Causes the mature egg to be released from the ovary	Causes an egg to mature in the ovary	Prepares the uterus to receive a fertilised ovum	Stimulates the pituitary gland to release LH
D.	Stimulates the ovaries to release oestrogen	Prepares the uterus to receive a fertilised ovum	Stops FSH being produced	Maintains the lining of the uterus during the middle of the menstrual cycle

Explanation:

FSH stimulates ovarian follicles, causing the egg to grow. Rise in oestrogen stops FSH production and stimulates an increase in LH production, which triggers ovulation. Progesterone maintains endometrial lining in preparation for implantation of a fertilised ovum.

- 20 The graph below shows three measurements obtained during mitosis in a cell. On the time scale, “0” marks the beginning of the time when chromosomes line up at the equator.



What measurements do the curves represent?

	<i>Distance between centromeres and centrioles</i>	<i>Distance between centromeres of sister chromatids</i>	<i>Distance between centrioles</i>
A.	1	2	3
B.	1	3	2
C.	3	1	2
D.	3	2	1

Explanation:

1 - Centrioles are at opposite cell poles and centromeres are at the centre. During spindle fibre contraction, the distance between the centrioles and centromeres decreases.

2 - Sister chromatids are attached to one another at the centromere at the beginning of metaphase. During anaphase, they are quickly pulled apart and thus, the distance between them increases rapidly.

3 - Throughout mitosis, centrioles remain at opposite poles of the cell.

Section II

80 marks

Attempt Questions 21-30

Allow about 2 hours and 25 minutes for this section

Question 21 (5 marks)

The photograph below shows a genetically modified AquAdvantage Salmon (top) compared to an Atlantic salmon of the same age.



The AquAdvantage Salmon is basically an Atlantic Salmon which has had a growth hormone from the Chinook Salmon and a gene promoter from the Ocean pout inserted into its genome. As a result of this, it grows to market size in 16 - 19 months, instead of 30 months needed by farmed Atlantic Salmon.

- (a) The AquAdvantage Salmon is an example of a transgenic species. Outline what this means.

1

Criteria	Mark
<ul style="list-style-type: none">• Outlines the definition of transgenic species in relation to the AquAdvantage salmon	1

A transgenic species is a species which contains genetic material from two or more species. The AquAdvantage Salmon is transgenic as it contains a growth hormone from the Chinook Salmon and a gene promoter from the Ocean pout.

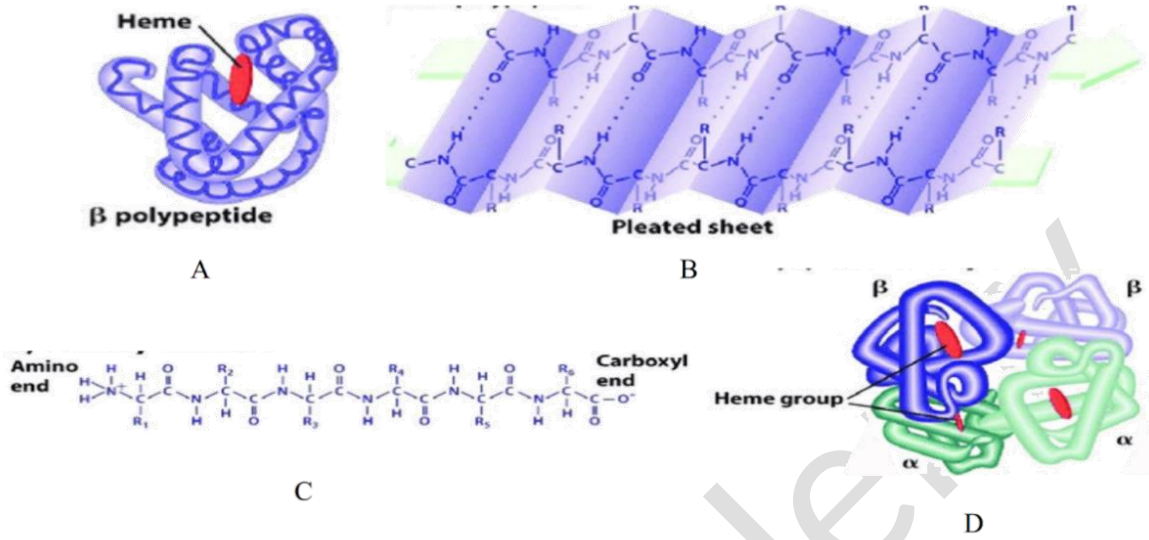
- (b) Discuss the potential impacts of this reproductive technology as applied to the AquAdvantage Salmon on society and the environment. **4**

Criteria	Mark
<p>1 mark for each beneficial/detrimental impact on society/environment (up to FOUR) Must include both impacts on society and the environment to receive full marks</p>	
<ul style="list-style-type: none"> Provides a total of FOUR beneficial or detrimental impacts that transgenic species may have on society and the environment 	4
<ul style="list-style-type: none"> Provides a total of THREE beneficial or detrimental impacts that transgenic species may have on society and the environment 	3
<ul style="list-style-type: none"> Provides a total of TWO beneficial or detrimental impacts that transgenic species may have on society and the environment 	2
<ul style="list-style-type: none"> Provides a total of ONE beneficial or detrimental impact that transgenic species may have on society and the environment 	1

The application of transgenic technology to AquAdvantage Salmon may yield both negative and positive impacts on society and the environment. The AquAdvantage Salmon can mature significantly earlier than its wild counterpart, wherein it will grow to market size in 16 - 19 months, instead of the 30 months needed by farmed Atlantic Salmon. In terms of the impact on the environment, if these genetically modified salmon were to escape and enter the ocean, they would be able to outcompete wild fish populations for resources such as food and mating rights potentially leading to vast decreases in the wild population. Additionally, if their genes were to enter wild populations, it could cause extinction of natural gene variants due to natural selection, leading to a reduction in genetic diversity. However, due to their extremely fast maturation, AquAdvantage Salmon show large promise as a countermeasure to food shortages associated with a growing population and famine, reflecting a potentially positive impact on society. Furthermore, with larger supplies of AquAdvantage Salmon, there is also potential for a marked price decrease for salmon products making it more readily available as a source of nutrients to the general public.

Question 22 (10 marks)

The diagrams above show the four levels of protein structure.



(a) Complete the table below of correct protein structure at the level represented.

2

Criteria	Marks
<ul style="list-style-type: none"> Identifies 4 protein structures 	2
<ul style="list-style-type: none"> Identifies 2 or 3 protein structures 	1
<ul style="list-style-type: none"> Identifies 0 or 1 protein structures 	0

<i>Protein Diagram</i>	<i>Protein Structure at the Level Represented</i>
A	Tertiary
B	Secondary
C	Primary
D	Quaternary

(b) Explain how the structure of a named protein is related to its function.

4

Criteria	Marks
<ul style="list-style-type: none">Identifies a protein and states its functionMakes evident the relationship between the structure and function of the protein	4
<ul style="list-style-type: none">Identifies a protein and states its functionSketches in general terms the relationship between the structure and function	3
<ul style="list-style-type: none">Identifies a protein and states its function	2
<ul style="list-style-type: none">Identifies a protein	1

Haemoglobin is a protein which exists within RBCs and is responsible for carrying oxygen from the lungs to the tissues. It is composed of four haem sub-units and an iron ion. This makes it possible for haemoglobin to carry four oxygen molecules wherein each oxygen molecule attaches to an individual haem group.

When the concentration of oxygen within the blood stream is low, haemoglobin exhibits a lower affinity towards oxygen. Due to this reduction in affinity, haemoglobin will readily release oxygen onto human tissue, thereby allowing for cellular respiration to take place.

This ensures the body is able to circulate an adequate supply of oxygen to required tissues when faced with an oxygen dependent situation for example following intense exercise.

Haemoglobin displays a higher affinity towards oxygen when the oxygen concentration is high and hence will not release oxygen when not required.

- (c) The coding strand of some DNA is shown. It is part of a sequence that codes for a polypeptide. 4

A T C A G T C G T A C G A T C G C A T A

Contrast the effect of a frameshift mutation with the effect of a base substitution mutation on the polypeptide produced from this sequence.

Criteria	Marks
<ul style="list-style-type: none"> Demonstrates an understanding of both types of mutation using the sequence provided Contrasts the effect of each mutation on the polypeptide produced 	4
<ul style="list-style-type: none"> Demonstrates an understanding of both types of mutation using a specific sequence Refers to polypeptide produced 	3
<ul style="list-style-type: none"> Outlines both types of mutation <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> Demonstrates an understanding of one type of mutation and its effect on the polypeptide produced 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

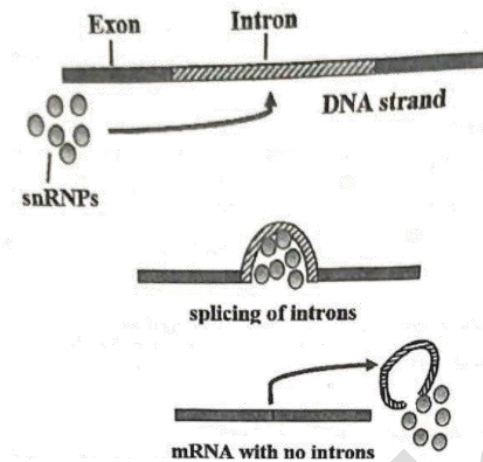
The codons are initially read as ATC, AGT, CGT, ACG, ATC, GCA.

A frameshift mutation could result in the removal or insertion of one or more bases. Consequently, this will alter all codons following the frameshift mutation and by extension, also alter the reading frame of the DNA strand. For example, if the second T base was deleted, this will result in the codon sequence now being read as ACA, GTC, GTA, CGA, TCG, CAT. This would result in all amino acids being incorrectly coded for, resulting in a different polypeptide.

In contrast, a base mutation replaces just one base in 1 codon. One amino acid may be coded incorrectly but the reading frame will not be altered in contrast to frameshift mutations. However, the rest of the amino acids in the polypeptide will remain correct. The mutation may also have no effect due to genetic redundancy, wherein several codon sequences can result in the same amino acid being coded for. In this case, the protein may be entirely unaffected.

Question 23 (6 marks)

The diagram below shows the process of how an intron is removed from a section of DNA to form a strand of mature mRNA.



3

(a) Outline the transcription phase of polypeptide synthesis.

Criteria	Marks
<ul style="list-style-type: none"> • Provides a detailed outline of the transcription phase of polypeptide synthesis. Includes: <ul style="list-style-type: none"> ○ Initiation <ul style="list-style-type: none"> ▪ RNA polymerase unwinds and unzips the DNA strand ○ Elongation <ul style="list-style-type: none"> ▪ RNA polymerase slides down template strand and attaches complementary ribonucleotides ○ Termination <ul style="list-style-type: none"> ▪ RNA polymerase encounters a STOP codon and mRNA is fully formed 	3
<ul style="list-style-type: none"> • Missing ONE of the above points 	2
<ul style="list-style-type: none"> • Missing TWO of the above points 	1

Genes are composed of STOP and START codons, promoter sequences which signal where transcription will begin, and introns and exons. Transcription occurs in three stages:

1. **Initiation**
RNA polymerase binds to the promoter sequence just before the gene of interest. The RNA polymerase-promoter complex partially unwinds and unzips the DNA strand.

2. **Elongation**
The RNA polymerase separates from the RNA polymerase-promoter complex and slides down the template strand, attaching complementary ribonucleotides.

3. **Termination**
The RNA polymerase will encounter a STOP codon and a terminator sequence. The RNA polymerase will terminate, and the pre-messenger RNA molecule is formed in preparation for translation. The DNA strand used as the template is the antisense strand and the complementary strand is called the sense strand.

(b) Assess the significance of mutations to introns on evolutionary fitness.

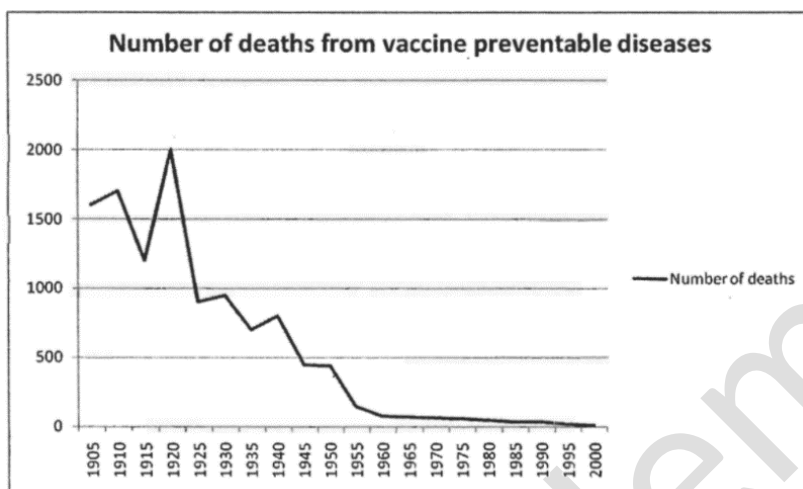
3

Criteria	Marks
<ul style="list-style-type: none"> • Explains the process of RNA splicing • Links this to introns not being expressed in the final polypeptide sequence • Provides a final judgement 	3
<ul style="list-style-type: none"> • Missing ONE of the above points 	2
<ul style="list-style-type: none"> • Missing TWO of the above points 	1

Prior to the process of translation, RNA splicing occurs. The pre-messenger RNA contains introns and exons. Exons are coding regions of DNA, whereas introns are non-coding regions and are spliced from the pre-mRNA complex. Due to this, mutations to intron segments of DNA are not expressed in the final protein. As such, intron mutations do not have deleterious impacts on the organisms and do not impact evolutionary fitness.

Question 24 (9 marks)

Refer to the graph and information below.



Diphtheria vaccine introduced to schools in 1920; Measles vaccine introduced 1932; Tetanus vaccine introduced 1939; Pertussis (whooping cough) vaccine introduced 1942; Polio vaccine introduced 1955 and used widely

(a) Outline the trend in the graph.

3

Criteria	Marks
<ul style="list-style-type: none"> • Outlines the trend in deaths prior to the introduction of vaccines AND • Outlines the trends in deaths following the introduction of vaccines • Refers to numerical data 	3
<ul style="list-style-type: none"> • Outlines the trend in deaths prior to the introduction of vaccines AND • Outlines the trends in deaths following the introduction of vaccines • Does not refer to numerical data 	2
<ul style="list-style-type: none"> • Outlines the trend in deaths prior to the introduction of vaccines OR • Outlines the trends in deaths following the introduction of vaccines 	1

From 1905 to 1920, there were a high number of deaths caused by vaccine preventable diseases, with the highest value being 2000 deaths in 1920. However, from 1920 to 1924, the number of deaths steeply decreased as the diphtheria vaccine was introduced. From this point onwards, the number of deaths also decreases following the introduction of each new vaccine. For instance, the number of deaths decreased from 800 to 490 between 1942 and 1947 following the pertussis vaccine. From 1955 and onwards, the number of deaths plateaus significantly as vaccine usage becomes widely used.

- (b) Describe how vaccinations are used to control the spread of disease and evaluate their effectiveness. **6**

Criteria	Marks
<ul style="list-style-type: none"> Provides a detailed description of how vaccinations function Provides at least THREE benefits and concerns associated with the use of vaccines (must have at least one of each) Provides a final assessment 	6
<ul style="list-style-type: none"> Provides a sound description of how vaccinations function Provides TWO benefits and concerns associated with the use of vaccines (must have at least one of each) Provides a final assessment <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> Provides a sound description of how vaccinations function Provides at least THREE benefits and concerns associated with the use of vaccines (must have at least one of each) Missing final assessment 	5
<ul style="list-style-type: none"> Provides a brief description of how vaccinations function Provides ONE benefits or concerns associated with the use of vaccines (must have at least one of each) Provides a final assessment <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> Provides a brief description of how vaccinations function Provides TWO benefits or concerns associated with the use of vaccines (must have at least one of each) Missing final judgement 	4
<ul style="list-style-type: none"> Provides an incomplete description of how vaccinations function Provides ONE benefit or concern associated with the use of vaccines Provides a final judgement 	3
<ul style="list-style-type: none"> Provides an partially correct of how vaccinations function Provides ONE benefit or concern associated with the use of vaccines Missing final judgement 	2
<ul style="list-style-type: none"> Provides some detail about how vaccinations function 	1

Vaccinations control the spread of disease through active acquired immunity (1). They contain dead pathogens, weakened pathogens or pathogens with modified toxins. Vaccines introduce modified forms of pathogens into an individual to trigger the primary immune response. The subsequent production of memory T cells and memory B cells effectively provides immunity to the disease in face of repeated exposure to the same pathogen (1). Vaccinations are administered over a number of years to produce enough lymphocytes to confer immunity to a particular disease. When the same antigen is identified, the memory cells will activate the production of cytotoxic T

cells and B cells much more rapidly. The B cells will produce a large amount of plasma cells, drastically increasing the antibody concentration in the body to fight off the infection. The pathogen is eliminated before symptoms are felt and hence, the vaccination prevents the host from spreading the disease (1).

By reducing the proportion of available carriers within the population, the spread of disease is reduced via the process of herd immunity. Herd immunity is achieved if a sufficiently high proportion of individuals are immune to the disease. This is crucial in protecting those who cannot be vaccinated such as the elderly, newborn babies and the immunocompromised (1). Vaccinations can also be distributed and applied in face of epidemics to control the spread of an already-present disease.

However, herd immunity is prone to the free rider problem, in which individuals choose not to vaccinate and are protected by the vaccinated community around them. Such cases lead to the collapse of herd immunity and increases the spread of disease (1). Further, memory cells deplete over time, increasing an individual's susceptibility to the disease. Booster shots must be administered over time to replenish the number of memory cells in the body and maintain immunity (1).

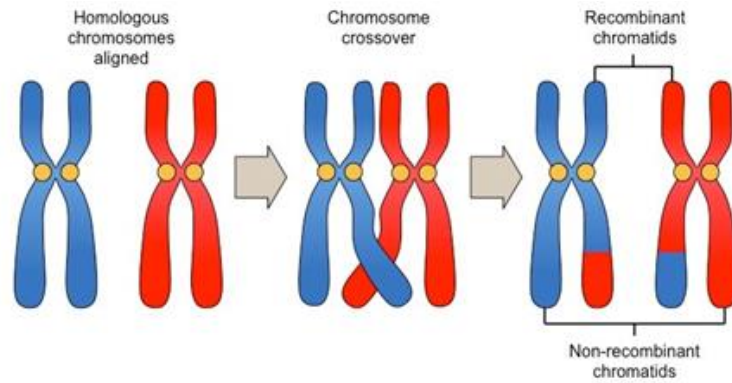
Hence, vaccination as a strategy to control the spread of disease is immensely effective if herd immunity is maintained and as such, the wider public should be well-educated and informed about its use (1).

Question 25 (7 marks)

(a) Draw a labelled diagram to explain how crossing over occurs in meiosis.

3

Criteria	Marks
<ul style="list-style-type: none"> • Correctly draws a labelled diagram of crossing over with the following features: <ul style="list-style-type: none"> ○ Homologous chromosomes aligned ○ Chromosome crossover with exchange of genetic information and formation of chiasma ○ Production of recombinant chromatids 	3
<ul style="list-style-type: none"> • Missing ONE of the described features 	2
<ul style="list-style-type: none"> • Missing TWO of the described features 	1



(b) Identify where crossing over occurs in meiosis.

1

Criteria	Marks
<ul style="list-style-type: none"> Correctly identifies which stage of meiosis crossing over occurs 	1

Crossing over occurs in Prophase I.

(c) Assess the importance of crossing over in contributing to genetic variation.

3

Criteria	Marks
<ul style="list-style-type: none"> Describes how crossing over contributes to genetic variation Explains the significance of genetic variation in survival and continuity of species and hence, the importance of crossing over 	3
<ul style="list-style-type: none"> Describes how crossing over contributes to genetic variation Sketches, in general terms, the importance of genetic variation in survival and continuity of species 	2
<ul style="list-style-type: none"> Describes how crossing over contributes to genetic variation 	1

Crossing over is the exchange of genetic material between homologous chromosomes which results in the formation of recombinant chromosomes with a unique pattern of genetic information, thereby contributing to genetic variation. Genetic variation is essential to the continuity of species as it allows the possibility for some individuals within a population to adapt to and survive in the changing environment. Because natural selection acts directly only on phenotypes, more genetic variation within a population usually enables more phenotypic variation. Phenotypic variation increase an organism's ability to survive and reproduce, which then ensures the survival of the allele in the population. Crossing over is a natural way in which variation is introduced into a population and is crucial to the evolutionary survival of species.

Question 26 (10 marks)

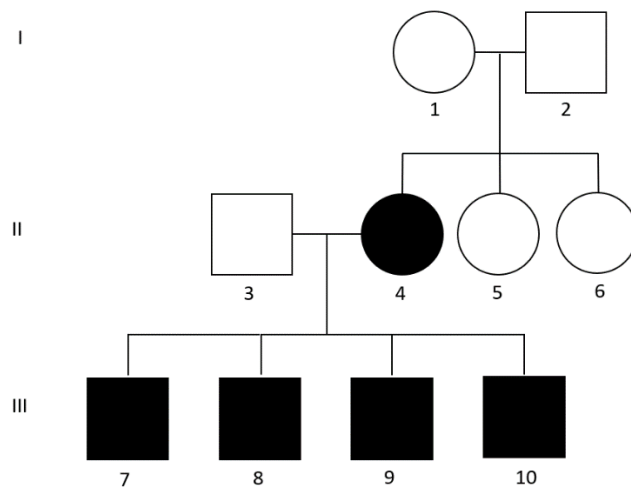
A non-infectious disease was observed in a mother and her four sons who live with her. She has no daughters. The father of these children does not have the disease and does not live with them. The woman's parents and her two sisters who live overseas do not have the disease.

A geneticist suspects that the disease is inherited.

(a) Draw the family pedigree for this disease.

3

Criteria	Marks
<ul style="list-style-type: none"> • Correctly constructs the family pedigree for the presenting disease with no features missing <ul style="list-style-type: none"> ○ Correct shape of pedigree ○ Generations and individuals are labelled ○ Key provided 	3
<ul style="list-style-type: none"> • Correctly constructs the family pedigree for the presenting disease with ONE feature missing 	2
<ul style="list-style-type: none"> • Correctly constructs the family pedigree for the presenting disease with TWO features missing 	1



- (b) Identify two points of evidence which indicates that the disease could be the result of a recessive allele and not be sex-linked. 2

Criteria	Marks
<ul style="list-style-type: none"> Provides TWO reasons as to why disease could be caused by a recessive allele as opposed to a sex-linked allele 	2
<ul style="list-style-type: none"> Provides ONE reason as to why disease could be caused by a recessive allele as opposed to a sex-linked allele 	1

The disease may be inherited by an autosomal recessive fashion if the woman's husband (II3) has a heterozygous genotype. If we suppose the dominant allele to be 'R' and the recessive to be 'r,' a Punnett square of the woman and her husband will look as follows:

	R	r
r	Rr	rr
r	Rr	rr

Therefore, it is possible for the woman's sons to be affected as the 'rr' genotype is present in the Punnett square.

Furthermore, the woman's parents must both be heterozygous, producing a Punnett square as follows:

	R	r
R	Rr	Rr
r	Rr	rr

This gives rise to the 'rr' genotype which belongs to the woman and 'Rr' genotypes which are carried by her unaffected sisters.

(c) Complete the following table for one non-infectious disease.

5

Criteria	Marks
• Provides correct information in FIVE cells	5
• Provides correct information in FOUR cells	4
• Provides correct information in THREE cells	3
• Provides correct information in TWO cells	2
• Provides correct information in ONE cell	1

<i>Name of disease</i>	Cystic fibrosis
<i>Type of non-infectious disease</i>	Genetic/hereditary
<i>Cause/Transmission</i>	Autosomal recessive mutation of the CFTR gene, resulting in non-functional/sub-optimal CFTR proteins, causing decreased movement of water into the extracellular environment and hence, dry, sticky mucus
<i>Symptoms</i>	<ul style="list-style-type: none"> • Very salty-tasting skin. • Persistent coughing, at times with phlegm. • Frequent lung infections including pneumonia or bronchitis. • Wheezing or shortness of breath. • Poor growth or weight gain in spite of a good appetite. • Frequent greasy, bulky stools or difficulty with bowel movements. • Male infertility.
<i>Treatment/prevention/control</i>	<ul style="list-style-type: none"> • Medications that target gene mutations • Antibiotics to treat and prevent lung infections • Mucus-thinning drugs • Bronchodilators • Anti-inflammatory medications • Vest therapy • Physiotherapy • Nutritional counselling

Question 27 (4 marks)

Spinifex is a grass common across central Australia where soils are nutrient-deficient. It frequently grows as a circular clump of stems and the diameter of the clump increases slowly each year. Initially the leaves are flat, and the roots are shallow. As the plant matures, the leaves curl inwards to form long thin tubes with the stomata on the inside, while the roots grow deep into the soil to obtain nutrients and water. Silicon granules make the stems tough.

Explain how TWO of the adaptations outlined above allow Spinifex to survive in hot, dry conditions. **4**

Criteria	Marks
<ul style="list-style-type: none">Identifies TWO relevant adaptations and provides how each relates to the survival of Spinifex	4
<ul style="list-style-type: none">Identifies TWO adaptations and relates information about survival of Spinifex to ONE of these adaptations	3
<ul style="list-style-type: none">Identified TWO adaptations <p style="text-align: center;">OR</p> <ul style="list-style-type: none">Identifies an adaptation and related it to information about survival of Spinifex <p style="text-align: center;">OR</p> <ul style="list-style-type: none">Provides two pieces of information about survival of Spinifex in a hot dry environment	2
<ul style="list-style-type: none">Names on adaptation <p style="text-align: center;">OR</p> <ul style="list-style-type: none">Provides some information about survival of Spinifex	1

The curling of leaves in Spinifex plants helps the plant maintain homeostasis. This decreases the surface area and number of stomata exposed to the sun, thereby decreasing water loss via transpiration. The Spinifex also has deep roots to maximise water gain. The roots allow the plant to gain access to deep water reserves, thus allowing the plant to survive in arid conditions.

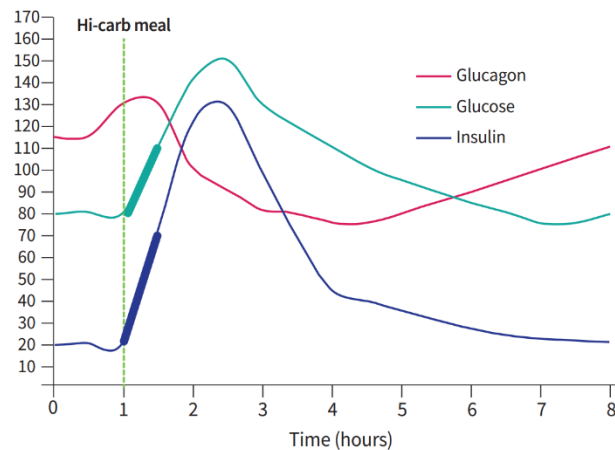
Question 28 (16 marks)

The graph below provides information about the homeostasis of blood glucose levels after a high carbohydrate meal.

- (a) Explain what happens to glucose, insulin, and glucagon levels after a high carbohydrate meal.

6

Criteria	Marks
<ul style="list-style-type: none">• Describes trends in measurements of glucagon, glucose, and insulin• Provides an explanation for the observed measurements of glucagon, glucose, and insulin	6
<ul style="list-style-type: none">• Describes trends in measurements of glucagon, glucose, and insulin• Provides an explanation for the observed measurements of two of three of either glucagon, glucose, or insulin <p style="text-align: center;">OR</p> <ul style="list-style-type: none">• Describes trends in measurements of two of three of glucagon, glucose, or insulin• Provides an explanation for the observed measurements glucagon, glucose, and insulin	5
<ul style="list-style-type: none">• Describes trends in measurements of two of three of glucagon, glucose, or insulin• Provides an explanation for the observed measurements of two of three of either glucagon, glucose, or insulin	4
<ul style="list-style-type: none">• Describes trends in measurements of two of three of glucagon, glucose, or insulin• Provides an explanation for the observed measurements of one of three of either glucagon, glucose, or insulin <p style="text-align: center;">OR</p> <ul style="list-style-type: none">• Describes trends in measurements of one of three of glucagon, glucose, or insulin• Provides an explanation for the observed measurements of two of three of either glucagon, glucose, or insulin	3
<ul style="list-style-type: none">• Describes trends in measurements of one of three of glucagon, glucose, or insulin• Provides an explanation for the observed measurements of one of three of either glucagon, glucose, or insulin <p style="text-align: center;">OR</p> <ul style="list-style-type: none">• Describes trends in measurements of two of three of glucagon, glucose, or insulin	2
<ul style="list-style-type: none">• Describes trends in measurements of one of three of glucagon, glucose, or insulin	1



Following a high-carbohydrate meal, levels of blood glucose increase as it is digested and absorbed into the bloodstream. This rise in glucose is detected by pancreatic beta-cells which produce insulin in response to reduce the levels of blood glucose. This results in an increase in levels of insulin in the blood. The increase in insulin causes a resultant reduction in blood glucose, which then results in a decrease in insulin as it is no longer needed.

Glucagon levels are initially high prior to a high-carbohydrate meal as no glucose is being actively absorbed. This is detected by the pancreatic alpha-cells and glucagon functions to maintain a normal level of glucose in the blood. Following a high-carbohydrate meal, glucagon is no longer needed and gradually declines when the levels of blood glucose begin to peak (at the 1.5 - 2 hour mark). As glucose levels drop due to the action of insulin, pancreatic alpha-cells begin producing more glucagon, which results in the gradual increase of glucose at the 7.5 hour mark.

- (b) Type 2 diabetes is a progressive condition in which the body becomes resistant to the normal effects of insulin and/or gradually loses the capacity to produce enough insulin in the pancreas. Tubules in the kidney contain sodium-glucose co-transporters 2 (SGLT2) which reabsorb glucose into the blood. **4**

Explain the role of SGLT2 inhibitors in the treatment of Type 2 diabetes.

Criteria	Marks
<ul style="list-style-type: none"> Describe and explain the expected level of blood glucose in people with type 2 diabetes Explain the role of an SGLT2 inhibitor Explain how SGLT2 inhibitors help in controlling blood glucose levels in people with type 2 diabetes 	4
<ul style="list-style-type: none"> Describe and explain the expected level of blood glucose in people with type 2 diabetes Explain the role of an SGLT2 inhibitor 	3
<ul style="list-style-type: none"> Describe and explain the expected level of blood glucose in people with type 2 diabetes 	2
<ul style="list-style-type: none"> States the expected level of blood glucose in people with type 2 diabetes 	1

People with unmanaged type 2 diabetes will have elevated levels of blood glucose (1). As their bodies cannot produce insulin or their cells are resistant to insulin which is required to reduce glucose levels in the blood, glucose cannot be effectively moved into cells and hence remains in the bloodstream (1). An SGLT2 inhibitor will prevent glucose from being reabsorbed into the bloodstream. Glucose will remain in the kidney tubules, and will be eventually excreted in the urine (1). This will result in a reduction in blood glucose and bring levels close to normal in a person with type 2 diabetes (1).

- (c) Diabetic nephropathy is a common complication of Type 1 and Type 2 diabetes. Over time, poorly controlled diabetes can cause damage to blood vessel clusters in your kidneys that filter waste from your blood. This can lead to prolonged kidney damage which may lead to chronic kidney disease. 6

Assess the impact of one method of management or treatment of kidney disease.

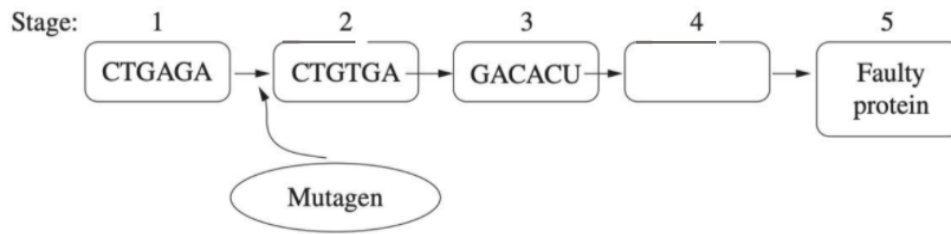
Criteria	Marks
1 mark per advantage/disadvantage (as long as there are both) (up to FOUR) 1 mark for an assessment on the impact of one method of management of kidney disease	
<ul style="list-style-type: none"> • Provides FOUR advantages AND disadvantages of one method of management of kidney disease • Provides an assessment on the impact of one method of management of kidney disease 	6
<ul style="list-style-type: none"> • Provides FOUR advantages AND disadvantages of one method of management of kidney disease 	5
<ul style="list-style-type: none"> • Provides THREE advantages AND disadvantages of one method of management of kidney disease 	4
<ul style="list-style-type: none"> • Provides TWO advantages or disadvantages of one method of management of kidney disease 	3
<ul style="list-style-type: none"> • Provides ONE advantage or disadvantage of one method of management of kidney disease 	2
<ul style="list-style-type: none"> • Identifies ONE method of management of kidney disease 	1

One method of management of kidney disease is haemodialysis, which involves blood being pumped through a dialysis machine to remove waste products and excess fluids. This happens through an artificial membrane and wastes undergo diffusion into a fluid known as a dialysate. Haemodialysis is flexible and can be conducted at a treatment centre or at home. It also provides an effective management method when kidney transplants are not readily available. However, it is time-consuming, and patients have to undergo dialysis 3 times a week, with each session lasting up to 4-5 hours. There are also dietary and fluid restrictions that need to be considered and it is difficult to completely remove all waste products from the bloodstream as no there is no active transport being utilised. Furthermore, patients have to undergo surgery to form an arteriovenous fistula in which blood is taken from and returned to following dialysis. In conclusion, haemodialysis is an effective and readily available management method in comparison to transplantation and can be easily conducted from home which can save time. However, since dialysis has to be done regularly, patients must organise their lives around their treatment regimen, which can be stressful for both themselves and their family.

Other treatment/management can include peritoneal dialysis and kidney transplantation.

Question 29 (5 marks)

The flowchart illustrates the effect of a point mutation on an organism.



(a) Identify the process that occurs at stage 4.

Criteria	Marks
<ul style="list-style-type: none"> Identifies the correct process 	1

At stage 4, the mutated mRNA sequence is translated by a ribosome

(b) Using the above data, draw a flowchart showing how the mutation has resulted in a faulty protein.

Criteria	Marks
<ul style="list-style-type: none"> Outlines at least FOUR steps that occur within the sequence Refers to information in the above diagram (e.g. A-->T) 	4
<ul style="list-style-type: none"> Outlines at least THREE steps that occur within the sequence 	3
<ul style="list-style-type: none"> Outlines at least TWO steps that occur within the sequence 	2
<ul style="list-style-type: none"> Outlines at least ONE steps that occur within the sequence 	1

From stage 1 to 2, the base sequence of the gene is altered A-->T



From stage 2 to 3, the DNA sequence is transcribed, producing an incorrect mRNA strand



At stage 4, the codon containing the point mutation encodes for incorrect amino acid during translation



Incorrect/dysfunctional/different polypeptide chain is produced



The polypeptide chain folds to produce a protein with impaired function

Question 30 (8 marks)

4

- (a) Outline the normal third-line defence to a pathogen the body has previously not encountered.

Criteria	Marks
<ul style="list-style-type: none">• Outlines the FOUR key processes:<ul style="list-style-type: none">○ Antigen-presentation○ Clonal selection and activity of cytotoxic T/plasma cells○ Formation of memory cells○ Ceasing of immune response once pathogen has been cleared from the body using suppressor T-cells	4
<ul style="list-style-type: none">• Outlines THREE of the above processes	3
<ul style="list-style-type: none">• Outlines TWO of the above processes	2
<ul style="list-style-type: none">• Outlines ONE of the above processes	1

The third-line response is initiated upon antigen presentation. This occurs when macrophages, dendritic cells or B cells engulf a foreign antigen and present it on MHC-II molecules in their cell membranes. Once the antigen is recognised by a helper T-cell, clonal selection is initiated and the helper T-cell stimulates the cell division of the appropriate immune cell designed to fight off the detected antigen. If the antigen is intracellular, cytotoxic T-cells will bind to and lyse the infected cell using lytic enzymes. If the antigen is extracellular (e.g. in lymphatic fluid or blood), plasma cells are produced, which make antibodies that bind to and neutralise the antigen. During primary exposure to the antigen, the body lacks memory cells, which are generated during the third-line response. Once the antigen has been cleared, suppressor T-cells signal for cessation of the third-line response.

- (b) Our immune system functions to protect our bodies from pathogens. In certain cases, however, serious disorders can arise from over-activity of the immune system. **4**

Discuss this statement using specific examples.

Criteria	Marks
<ul style="list-style-type: none"> • Describes TWO stimuli in which the immune system may inappropriately react to • Discusses the statement using TWO examples of different disease types 	4
<ul style="list-style-type: none"> • Describes TWO stimuli in which the immune system may overreact to • Discusses the statement using ONE disease example <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • Describes ONE stimulus in which the immune system may inappropriately react to • Discusses the statement using TWO examples of different disease types 	3
<ul style="list-style-type: none"> • Describes TWO stimuli in which the immune system may overreact to <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • Discusses the statement using TWO examples of different disease types <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • Describes ONE stimulus in which the immune system may inappropriately react to • Discusses the statement using ONE disease example 	2
<ul style="list-style-type: none"> • Discusses the statement using ONE disease example <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • Describes ONE stimulus in which the immune system may inappropriately react to 	1

The immune system may respond inappropriately to non-noxious stimuli, causing harmful over-activity of the immune system. Allergic diseases (hypersensitivity) occur when the body responds to harmless environmental stimuli such as dust, pollen, foods, medications or stinging insects. This can result in mild allergic inflammatory responses such as hay fever but can be as serious as life-threatening anaphylactic shock, where the body's blood pressure drops and airways constrict, impeding normal breathing and vascular function. The body can also respond inappropriately to self-antigen, causing autoimmune conditions. These include Type 1 diabetes and coeliac disease, where the pancreatic beta-cells and intestinal cells are attacked by the body's own immune system respectively. This has significant impacts on the lifestyle of patients, impairing essential metabolic processes from occurring and often resulting in patients having to be on lifetime medications and management strategies.