



Smith's Hill High School

Promoting excellence in a spirit of trust and co-operation

STUDENT NAME:

2024

Trial HSC Examination

Biology

General Instructions

Reading time – 5 minutes

Working time – 3 hours

Write using black pen

NESA-approved calculators may be used

Total Marks – 100

Section I - 20 marks

- Attempt Questions 1 – 20
- Allow about 35 minutes for this part

Section II - 80 marks

- Attempt Questions 21 – 36
- Allow about 2 hours and 25 minutes for this part

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Section I – 20 marks

Attempt Questions 1-20

Allow about 35 minutes for this part

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

1. After transcription, mRNA undergoes alteration before leaving the nucleus. The alteration is caused by:
 - A. removal of introns.
 - B. attachment to tRNA molecules.
 - C. removal of SNPs.
 - D. fusion with other transcribed mRNA molecules.

Questions 2 and 3 refer to the following information:

Several breeds of domestic dog exhibit a condition called merle, in which the coat has patches of coloured fur on a paler background of the same pigment. The mutant merle allele (M) causes the dilution of the fur pigment and exhibits incomplete dominance over the normal allele (N). The image on the right shows a heterozygote (MN) red merle dog, with patches of brown on a background of lighter-coloured fur.



(Image available under Creative Commons License: CC-BY-SA-2.0)

Apart from affecting coat colour, the merle allele is associated with hearing and vision problems. Dogs that are homozygous for the merle allele (double merles) often have abnormally small eyes and are at high risk of being deaf. For this reason, breeders avoid making crosses between two merle dogs.

2. If two merle dogs were crossed, what would be the probability of producing a double merle dog?
 - A. 25%
 - B. 50%
 - C. 75%
 - D. 100%
3. Which of the following is the best description of the term “incomplete dominance”?
 - A. All individuals in the population carry the recessive allele.
 - B. Only some heterozygotes express the dominant allele.
 - C. Both alleles are expressed in heterozygotes.
 - D. Both alleles are partially expressed in heterozygotes.

4. An analysis of the quantity of nuclear DNA in different cells of a domestic dog was carried out, with the following results. (1 Gb = 1 billion base pairs)

Cell	I	II	III
No. base pairs	2.5 Gb	5 Gb	15 Gb

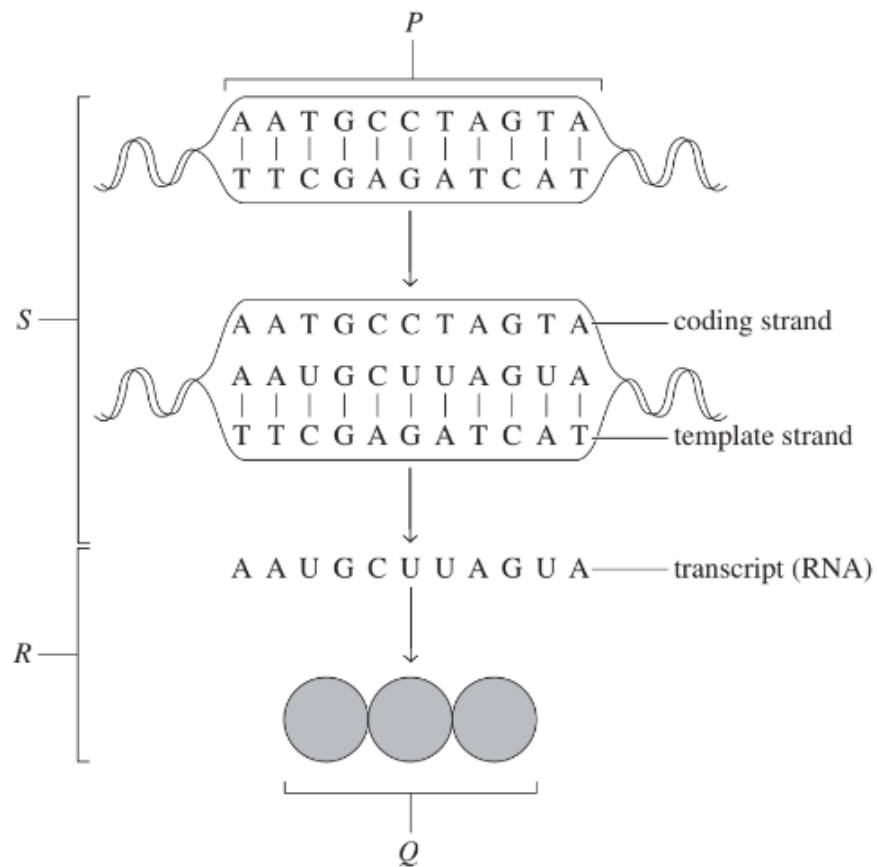
Which of the following gives a possible identification or location for each cell type?

	Cell I	Cell II	Cell III
A.	white blood cell	testis	liver cell
B.	ovary	red blood cell	liver tumour
C.	red blood cell	ovary	liver cell
D.	testis	muscle cell	liver tumour

5. Which row of the table correctly compares the processes of meiosis and mitosis?

	Meiosis	Mitosis
A.	produces diploid cells	produces haploid cells
B.	occurs in germ cells	occurs in somatic cells
C.	no genetic variation occurs	genetic variation increases
D.	the number of chromosomes doubles	the number of chromosomes remains the same

6. The diagram shows a simplified version of polypeptide synthesis involving nucleic acids.



Which row of the table correctly identifies the components of this process?

	P	Q	R	S
A.	DNA	polypeptide	translation	transcription
B.	DNA	polypeptide	transcription	translation
C.	polypeptide	RNA	translation	transcription
D.	DNA	RNA	transcription	translation

7. Birthmarks are genetic abnormalities that cause localised overproduction or underproduction of *melanin* – the protein that gives skin its colour. They result in a dark or light patch on the skin, usually unique to that individual.



Image: <https://www.flickr.com/photos/dreama/2252596109>

Which of the following best describes the genetics of birthmarks?

- A. Somatic mutations on the non-coding segments of the individual's DNA
 - B. Somatic mutations on the coding segments of the individual's DNA
 - C. Germline mutations on the non-coding segments of the individual's DNA
 - D. Germline mutations on the coding segments of the individual's DNA
8. Errors that occur during meiosis can cause chromosomal mutations. One category of chromosomal mutation is aneuploidy, which refers to cells having an abnormal number of chromosomes. Which of the following is a likely cause of aneuploidy?
- A. Chromosome duplication during Metaphase I of meiosis
 - B. Nondisjunction of chromosomes during Anaphase I of meiosis
 - C. Chromosome inversion during Prophase I of meiosis
 - D. All of the above.
9. The liger is a hybrid species produced by mating a male lion and a female tiger. Which genetic feature would most often allow for hybridisation to occur?
- A. Both parents have the same chromosomes.
 - B. Both parents have a different number of sets of chromosomes.
 - C. Both parents have the same number of chromosomes.
 - D. Both parents have a different number of chromosomes.

10. Which of the following statements best describes biotechnology?

- A. It always involves the manipulation of genes.
- B. It has been in existence for less than 100 years.
- C. It is only used in the production of food.
- D. It uses organisms and biological processes to make products that are used by humans.

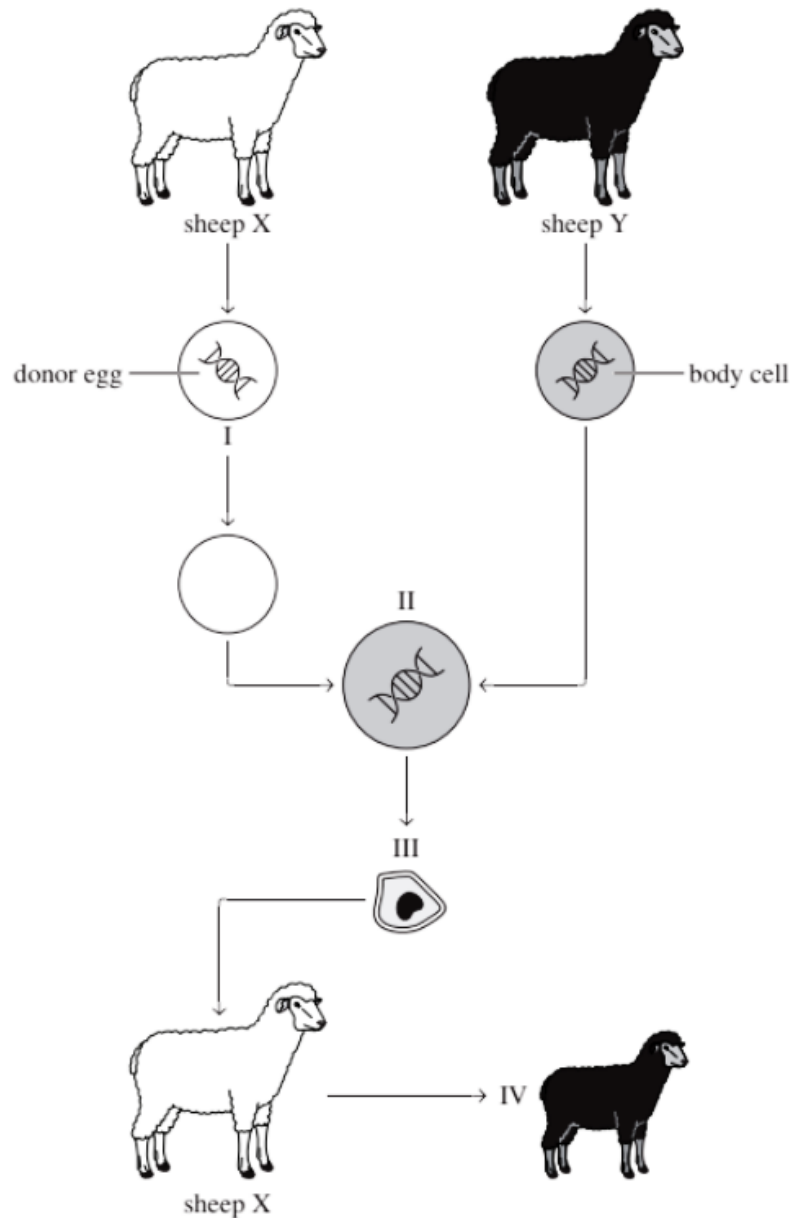
11. Non-coding DNA

- A. only codes for specific protein sequences.
- B. has not been found to have any functional roles.
- C. can impact an individual's phenotype.
- D. makes up approximately 1% of all DNA in an individual.

12. Which of the following procedures is most likely to *increase* the genetic diversity of the population?

- A. Artificial insemination
- B. Whole organism cloning
- C. Cross pollination
- D. Genetic drift

13. A simplified diagram of whole organism cloning is shown.



Which row of the table correctly identifies the components of this process?

	I	II	III	IV
A.	removal of DNA	fusion of cells	embryo forms	clone of sheep Y
B.	addition of DNA	removal of DNA	transfer to uterus	clone of sheep X
C.	mutation of DNA	fusion of cells	embryo forms	clone of sheep Y
D.	removal of DNA	mutation of DNA	embryo forms	clone of sheep X

14. Written below are four different scenarios relating to genetics and populations.

- P. The population of white rhinoceros in Africa is critically endangered due to hunting and habitat loss.
- Q. During the breeding season, buff-banded rail birds in the Philippines fly from one island to the next to breed.
- R. In Taronga Zoo's new tiger breeding program, tigers stay for periods of 3–6 months before being moved onto another zoo for breeding.
- S. The small population of pink iguanas on Wolf Island in the Galapagos Islands will not interbreed with other, genetically similar, groups of iguanas as it has developed a distinct "head bobbing" mating ritual.

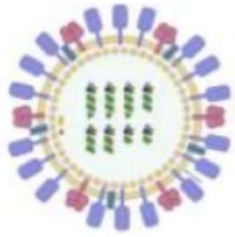
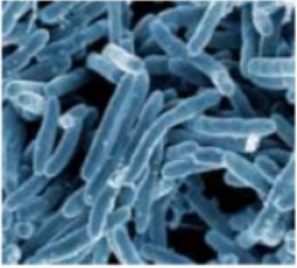
Which of the following classifies these scenarios correctly?

	P	Q	R	S
A.	Gene flow	Genetic drift	Genetic drift	Gene flow
B.	Genetic drift	Gene flow	Genetic drift	Gene flow
C.	Gene flow	Gene flow	Genetic drift	Genetic drift
D.	Genetic drift	Gene flow	Gene flow	Genetic drift

15. Microscopic examination and biochemical analysis of a potential pathogen were carried out. Which of the following pieces of evidence would establish that the pathogen is NOT a virus?

- A. The pathogen is surrounded by a lipid membrane.
- B. The pathogen possesses RNA.
- C. The pathogen can reproduce in nutrient medium.
- D. A, B and C.

16. The pathogens responsible for four different diseases are shown below.

	
Influenza (approx. 0.1 μ m)	Giardiasis (approx. 12 μ m)
	
Hydatid disease (approx. 30mm)	Tuberculosis (approx. 3 μ m)

(Images available under Creative Commons License: CC-BY-SA-4.0)

A newly-synthesised general antibiotic would most likely be effective against:

- A. Influenza
- B. Giardiasis
- C. Hydatid disease
- D. Tuberculosis

17. A student conducted an investigation based around Louis Pasteur's famous experiment. They set up five flasks with chicken broth, subjected them to the conditions outlined below, and left them for a week to allow for microbial growth.



Flask A
Unboiled, left unsealed



Flask B
Unboiled, then sealed



Flask C
Boiled, then sealed



Flask D
Boiled in swan-neck flask,
then swan-neck removed from flask



Flask E
Boiled & left in swan-neck flask

Which flasks would you expect to contain some microbial growth after the week?

- A. Flasks A and B only
- B. Flasks A, B and D only
- C. Flasks A, D and E only
- D. Flasks C and E only

18. The following is an extract from The Australian Commission on Safety and Quality in Health Care website

Standard precautions are basic infection prevention and control strategies that apply to everyone, regardless of their perceived or confirmed infectious status. Strategies include hand hygiene, personal protective equipment, cleaning, and appropriate handling and disposal of sharps. These are a first-line approach to infection prevention and control in health service organisations and are routinely applied as an essential strategy for minimising the spread of infections. Standard precautions minimise the risk of transmission of infectious agents from one person or place to another, even in high-risk situations, and render and maintain objects and areas as free as possible from infectious agents.

Transmission-based precautions are specific interventions to interrupt the mode of transmission of infectious agents. They are used to control infection risk with patients who are suspected or confirmed to be infected with agents transmitted by contact, droplet or airborne routes. Transmission-based precautions are recommended as extra work practices in situations when standard precautions alone may be insufficient to prevent transmission. Transmission-based precautions are also used during outbreaks to help contain the outbreak and prevent further infection. Transmission-based precautions should be tailored to the infectious agent involved and its mode of transmission – this may involve a combination of practices.

A patient is confirmed to have been infected with Mpox, caused by a viral pathogen, which is transmitted through physical contact.

Which of the following precautions would NOT be appropriate transmission-based precautions?

- A. Use of an impermeable apron or gown in addition to standard personal protective equipment (PPE)
- B. Use of gloves in addition to standard personal protective equipment (PPE) for all manual contact with patient and their surroundings
- C. Use of goggles or a face shield in addition to standard personal protective equipment (PPE)
- D. Moving the patient to a single room, or a shared room with patients who also have confirmed Mpox diagnoses.

19. Which of the following correctly identifies the role of hormones in regulating blood glucose levels?

	<i>Increases blood glucose levels</i>	<i>Decreases blood glucose levels</i>
A.	Glucagon	Insulin
B.	Parathyroid hormone	Calcitonin
C.	Insulin	Glucagon
D.	Vasopressin	Calcitonin

20. Which of the following correctly identifies the components of an endotherm response to cold?

	<i>Receptors</i>	<i>Control Centre</i>	<i>Effectors</i>
A.	Thermoreceptors	Hypothalamus	Sweat glands
B.	Thermoreceptors	Hypothalamus	Smooth muscle cells in blood vessel walls
C.	Photoreceptors	Hippocampus	Smooth muscle cells in blood vessel walls
D.	Thermoreceptor	Hippocampus	Skeletal muscles

Student name:

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Section II – 80 marks

Attempt Questions 21-36

Allow about 2 hours and 25 minutes for this part

Instructions

Write Student Name at the top of each page.

Answer the questions in the spaces provided.

These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Question 21 (2 marks)

Two major stages in the conception of mammals are fertilisation and implantation.

Outline what is meant by fertilisation and implantation.

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Question 22 (3 marks)

Draw a table that compares the forms in which DNA exists in eukaryotes and prokaryotes. Provide at least THREE characteristics for each type of organism.

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Question 23 (7 marks)

A Punnett square can be used to forecast the possible genotypes and phenotypes that two individuals may produce when crossed.

a) Outline the difference between the terms genotype and phenotype.

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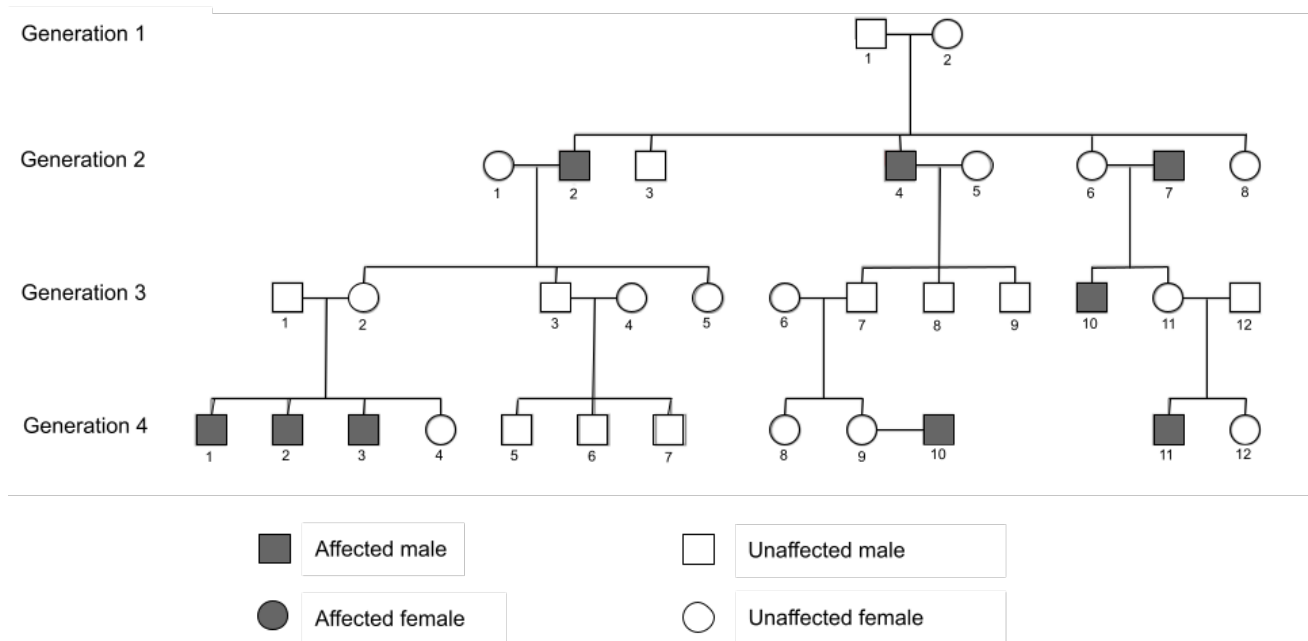
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The diagram below shows the pedigree for a family, tracing a particular condition.

It is known that Individual 1 in Generation 2 is homozygous.



Question 23 continues on the next page.

Question 23 continued.

- b) Identify the inheritance pattern of the trait shown in the diagram. Explain your answer. **3**

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- c) Individuals 9 and 10 in Generation 4 want to have children. Using standard notation, complete the Punnett square to calculate the probability of their children being affected by the condition. **2**

Probability

Question 24 (3 marks)

An investigation was carried out to measure the reproductive success rates for a range of vertebrate species. Data was collected and compiled into the following table.

Vertebrate species	Number of offspring produced	Number of offspring surviving to 6 months
<i>L</i>	8	7
<i>M</i>	97	8
<i>N</i>	311	14
<i>O</i>	1432	35

- a) Identify which species is likely to be terrestrial.

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- b) Explain the results obtained with reference to different modes of fertilisation.

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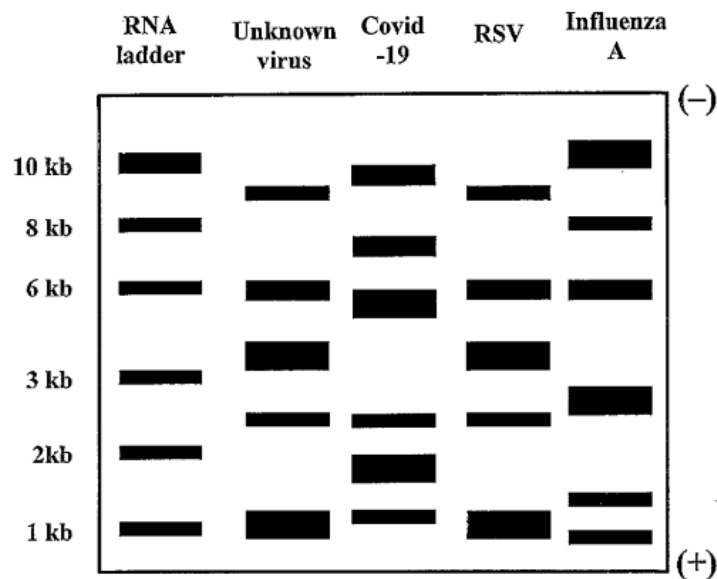
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Question 25 (5 marks)

A pathologist is seeking to identify the cause of a patient's respiratory infection. They obtain genetic samples of three common respiratory viruses and electrophorese these along with the virus sample from the patient. Their test produces the following results:



a) What virus does the patient have? Justify your response.

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b) Gel electrophoresis is an example of a technology that can be used in the study of genetic material.

Describe one method of examining the inheritance patterns in a population.

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Question 26 (12 marks)

Cancers are a group of diseases – usually non-infectious – caused by one or more mutations which lead to uncontrolled cell division. The dividing cells form tumours (lumps of tissues) that can interfere with organ function and may spread to different parts of the body if cells break off and enter the bloodstream or lymphatic system.

Researchers are in the process of trialling “cancer vaccines” using mRNA technology.

After a cancer patient has undergone cancer treatment – such as chemotherapy and radiation – to remove their cancerous tumours, the vaccines are designed to prevent more tumours developing by targeting any cancerous cells or tissues still found in the patient’s body fluids.

The vaccine is personalised for each patient. The medical team identifies a number of proteins that are found on the surface of the patient’s tumours and are unique to the cancerous cells. They then develop strands of mRNA that “code” for those proteins and incorporate them into the vaccine.

The patient is then given a series of treatments in which they are injected with copies of the strands of mRNA that code for the proteins found on the cancer cells.

- a) Explain what makes it possible for researchers to develop mRNA that codes for a newly discovered protein that is unique to a particular patient’s tumour.

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Question 26 continues on the next page.

Question 26 continued

- b) Distinguish between this approach and vaccines for infectious diseases. **3**

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- c) Explain how this approach might prevent the cancer from recurring in patients. **5**

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Question 27 (3 marks)

In recent times, large cruise ships have been referred to as “floating Petri dishes”, due to the risk of diseases spreading amongst the large number of passengers spending weeks in close proximity to each other.



(Image available under Creative Commons License: CC-BY-SA-4.0)

Imagine you are employed as the senior medical officer on a large cruise ship.

Outline and justify the techniques you would recommend to reduce the transmission of viral pathogens such as Covid-19, which causes respiratory disease, and norovirus, which causes food poisoning.

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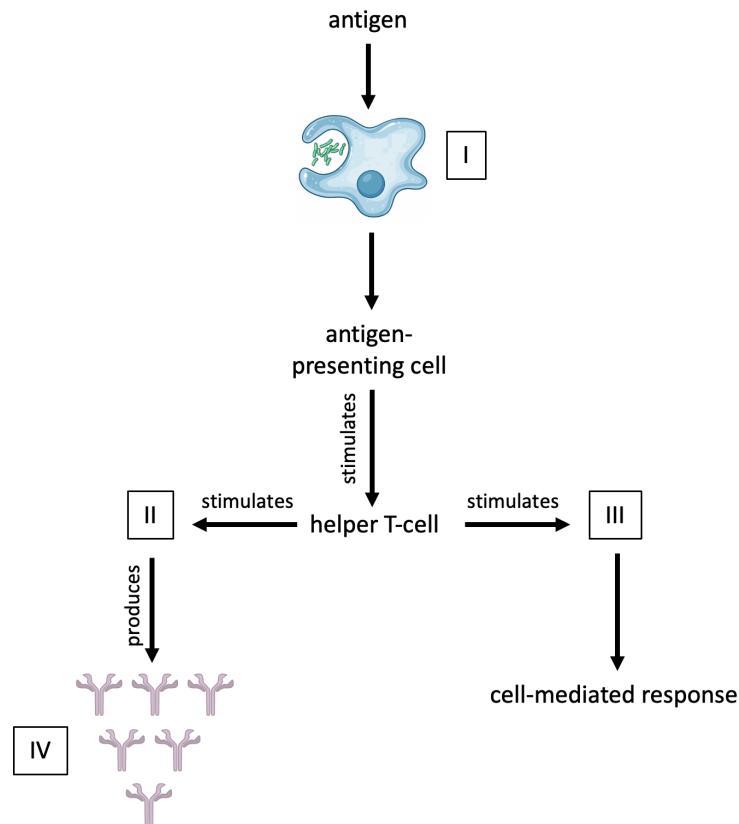
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Question 28 (4 marks)

The diagram below illustrates a part of the immune response to an antigen. Certain cell types and substances involved in the immune response are labelled I to IV.



a) Name the cell types I, II and III.

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I:

II:

III:

b) Explain what is meant by the term “cell-mediated response”.

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Question 29 (3 marks)

Several farmers noticed a disease affecting their apple crops. The fruit developed slowly and began to rot on the tree before ripening. The farmers approached academics at the local agricultural college for help in determining what was causing the problem.

The academics thought this would be a good assignment to set their post-graduate students.



Outline the steps the students should use to determine the cause of the disease.

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Question 30 (5 marks)

Many different pathogens have developed adaptations that allow them successful entry into, and transmission between, hosts.

a) Define pathogen.

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b) Identify TWO pathogens that affect humans. For each pathogen, describe ONE adaptation that makes it successful.

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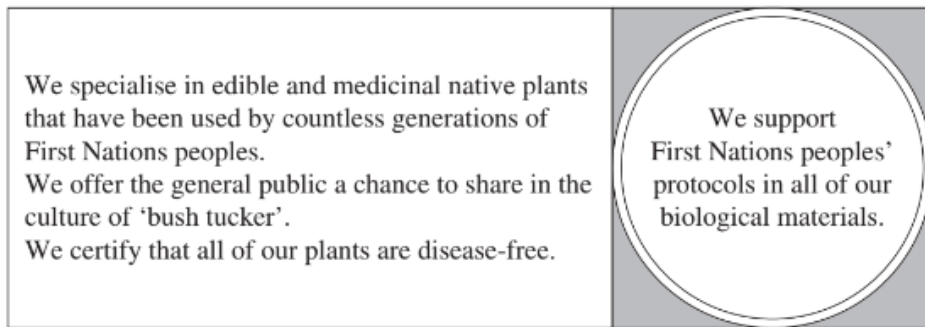
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Question 31 (3 marks)

Consider the following extract from the website of a plant nursery that specialises in edible and medicinal native plants.



Explain why it is important to recognise and protect the cultural and intellectual property of First Nations peoples.

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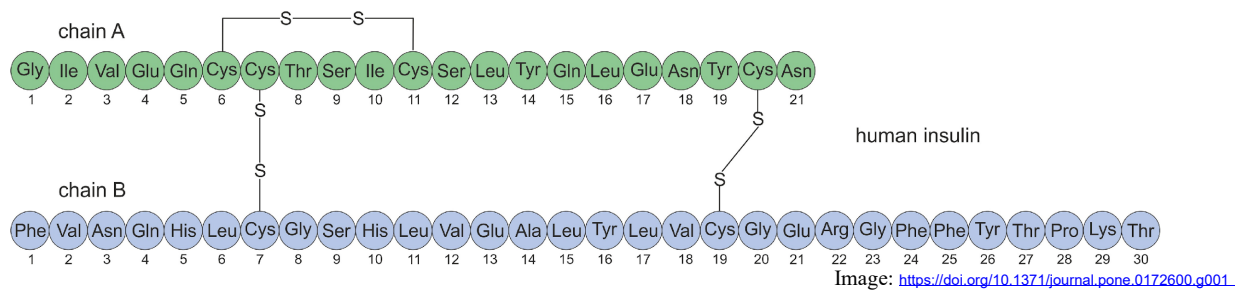
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Question 32 (9 marks)

In 1979, researchers at Genentech, USA, cloned the genes for the two polypeptide chains that make up insulin, using chemically-synthesised genes inserted into plasmids. The two polypeptides were purified and joined together to produce functional insulin.



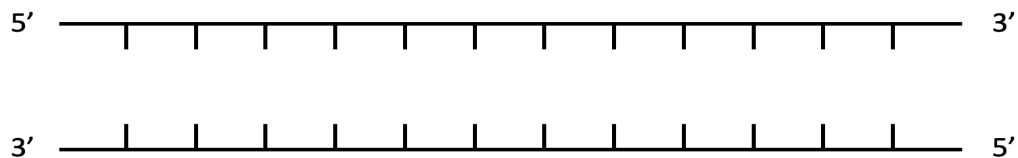
A more recent technique for making gene inserts for recombinant DNA applications uses complementary DNA (cDNA), which is synthesised from the mRNA that codes for the desired protein. The mRNA base sequence is copied to produce a single-stranded DNA molecule, using reverse transcriptase. The single-stranded DNA is then treated with DNA polymerase to form double-stranded DNA.

- a) The following base sequence is found in part of the mRNA for insulin.

3' UCG GGA GGU CCU 5'

Use the template below to write the base sequence for the double-stranded cDNA that could be produced from this strand of mRNA.

2



Question 32 continues on the next page.

Question 32 continued.

- b) The human genome displays considerable variation in the genes coding for insulin. Different individuals may have different base sequences in their insulin genes yet they still produce the same insulin protein. Explain how this is possible. **4**

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- c) The conversion of single-stranded DNA to double-stranded DNA is also used in the process known as the polymerase chain reaction (PCR). Outline the steps in the Polymerase Chain Reaction. **3**

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Question 33 (6 marks)

“Humans have been able to manipulate the genetic composition of plants and livestock in many ways to the benefit of agriculture. Not all of these techniques involve genetic engineering.”

Use specific examples to justify this statement.

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Question 34 (3 marks)

Identify ONE type of mutagen and describe how it operates.

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Question 35 (4 marks)

One type of structural, non-coding DNA is centromeres. Centromeres consist of repeated sequences of bases known as alpha satellites. During cell division, structures called spindle fibres attach to this region of the cell to guide the movement of chromosomes.

Research has suggested that individuals with trisomy conditions tend to have greater variation in alpha satellites than individuals without those conditions. Explain why this might be the case. **4**

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Question 36 (8 marks)

Homeostasis of water balance in the human body involves a hormone called ADH (antidiuretic hormone).

ADH is released by the pituitary gland, which sits just below the hypothalamus in the brain. ADH is released in response to higher concentrations of solutes in the blood and causes the kidneys to reabsorb more water rather than releasing it in urine. When solutes reach a certain level in the blood plasma (above 295 mOsm/kg), it indicates that blood volume is becoming too low.

Osmoreceptors in the hypothalamus detect higher concentrations, triggering the pituitary gland to act. Simultaneously, the hypothalamus will trigger a sensation of thirst, causing a person to drink, which will help to increase blood plasma volume, bringing solute levels back to 295 mOsm/kg.

When solute concentrations drop too far below that level, the osmoreceptors in the hypothalamus detect that change. The hypothalamus then triggers the pituitary gland to release less ADH, causing the kidneys to release more water in urine.

Use the information provided and your understanding of similar processes to construct a diagram that shows the regulation of water balance using ADH.

8**End of Exam**

2024**TRIAL
EXAMINATION****Biology****Multiple Choice Answer Sheet****Colour in ONE choice only.**

1.	A	☐	B	☐	C	☐	D	☐
2.	A	☐	B	☐	C	☐	D	☐
3.	A	☐	B	☐	C	☐	D	☐
4.	A	☐	B	☐	C	☐	D	☐
5.	A	☐	B	☐	C	☐	D	☐
6.	A	☐	B	☐	C	☐	D	☐
7.	A	☐	B	☐	C	☐	D	☐
8.	A	☐	B	☐	C	☐	D	☐
9.	A	☐	B	☐	C	☐	D	☐
10.	A	☐	B	☐	C	☐	D	☐
11.	A	☐	B	☐	C	☐	D	☐
12.	A	☐	B	☐	C	☐	D	☐
13.	A	☐	B	☐	C	☐	D	☐
14.	A	☐	B	☐	C	☐	D	☐
15.	A	☐	B	☐	C	☐	D	☐
16.	A	☐	B	☐	C	☐	D	☐
17.	A	☐	B	☐	C	☐	D	☐
18.	A	☐	B	☐	C	☐	D	☐
19.	A	☐	B	☐	C	☐	D	☐
20.	A	☐	B	☐	C	☐	D	☐

BioTrial SHHS 2024 Marking Criteria

Section I

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	A	D	D	B	A	B	B	C	D	C	C	A	D	C	D	B	C	A	B

Section II:

Question 21

Criteria	Marks
● Outlines the meaning of fertilisation AND implantation	2
● Outlines the meaning of fertilisation OR implantation	1

Sample: Fertilisation occurs when a sperm (male sex cell) fuses with an ovum (female sex cell) to form a single-celled zygote. Implantation is the process in which the fertilised egg reaches the uterus and embeds itself in the lining of the uterus.

Markers notes:

- Don't use the term you are defining in your definition (For implantation needed some description of process - was marked generously as long as you referred to "into" the endometrium/uterine lining
- Zygote or equivalent needed for full meaning of fertilization
- Misconception: implantation is not the sperm entering the egg.

Question 22

a)

Criteria	Marks
• Draws an appropriate table. AND • Provides at least THREE appropriate comparisons	3
• Draws an appropriate table. • AND • Provides TWO appropriate comparisons	2
• Provides ONE appropriate comparison	1

Sample:

Question 22

<i>DNA of eukaryotes</i>	<i>DNA of prokaryotes</i>
double stranded	double stranded
large number of genes	small number of genes
linear	circular
located in the nucleus	attached to the plasma membrane

Note: Responses could also compare the size of DNA, presence/absence of introns, presence/absence of transposons, same base pairs and relative numbers of base pairs.

Markers notes:

- Tables - should have rows and headers and complete borders (was marked very generously)
- Think about how you would *compare* in a table - rows need to show equivalent information that is either similar or different for eukaryotes and prokaryotes
- Don't say "no protein" for prokaryotes, their single, looped chromosome is wound around a central protein
- Don't say "no chromosome" for prokaryotes as they have a single, looped chromosome
- Don't say "non-helical for" prokaryotes (it was marked correct in this instance as one of the resources we gave you said that), it is "semi-condensed" in comparison to eukaryotes (condensed in chromatin and super condensed in chromosomes), but still has a helical shape
- Use the term "non-chromosomal" to refer to DNA found in mitochondria, chloroplasts and plasmids

Question 23

a)

Criteria	Marks
• Outlines the difference between the terms genotype and phenotype .	2
• Defines either phenotype or genotype	1

Sample: A genotype is the sum of the genetic information of an individual, whereas a phenotype refers to the physical characteristics expressed in the individual.

Markers notes: avoid “expression” when describing genotype - it confuses the distinction.

b)

Criteria	Marks
• Uses correct reasoning to support interpretation of any reasonable inheritance pattern (consistent with reasoning)	3
• Uses some reasoning to identify any type of inheritance pattern and one of its features OR • Gives two points of reasoning without identifying a pattern	2
• Provides some relevant information	1

Sample: The type of inheritance pattern shown is Sex-linked recessive. It is clearly recessive as the condition skips one generation. If it were autosomal recessive, then individual 1 in Generation 2 known to be homozygous, would have to be homozygous for the dominant allele, and would therefore only have unaffected children with Individual 2 as they would have to be homozygous recessive. However two of their children have the condition. Sex-linkage is also consistent with the pattern of more males having the condition, no affected males having affected sons and affected females only having affected sons.

Markers notes: can't access full marks with incorrect statements such as “females cannot be affected by sex-linked inheritance”.

Question 23 cont.

c)

Criteria	Marks
Correct use of a Punnett square and ratio	2
Provides ONE of the above	1

Sample: X^H = dominant allele, X^h = recessive allele (for condition)

	X^H	X^H
X^h	$X^H X^h$	$X^H X^h$
Y	$X^H Y$	$X^H Y$

Probability: 0%

Question 24

a)

Criteria	Marks
Identifies species L as terrestrial	1

Sample: L

b)

Criteria	Marks
Demonstrates an understanding of internal AND external fertilisation AND Effectively links this to the data provided	2
Demonstrates an understanding of internal AND external fertilisation OR Comments on the results using data from the table	1

Sample answer:

Internal fertilisation is the fusion of gametes inside the female body. External fertilisation - both the egg and sperm are released into a less stable, usually aquatic, external environment. Internal fertilisation produces fewer offspring than external fertilisation but fertilisation success, and survival, rates are higher than external fertilisation due to a stable internal environment. Species L has a low number of births, but a high reproductive success rate (88%) in comparison to species M, N and O with high number of births and low reproductive success rates (all <10%).

Marker feedback

Use data points, not just vague reference (marked generously in this instance, as its only a 2 marker, but it should be completely habitual by now)

Many students wrote way too much for a two-mark question.

Question 25

a)

Criteria	Marks
Correctly identifies the virus Gives data from the stimulus to justify the identification	2
ONE of the above	1

Sample: The patient has RSV, because the virus sample only matches the banding pattern of RSV - at 9kb, 6kb, 4kb, 2.5kb and 1kb, indicating that the two samples have the same length fragments of RNA and hence are likely from the same pathogen.

Marker feedback

- Marked generously
- Read the stimulus properly
- Full justification should say that it the unknown virus fragments only matches the one virus
- Gel electrophoresis doesn't show SNPS, and in the instance of viruses, wouldn't show alleles (they don't have pairs of chromosomes) - be careful of over-answering as it can add contradictions/misconceptions when you're careless.

b)

Criteria	Marks
Method includes - Technology matched to the correct data type (e.g. SNPs, sequence) - How the data discerns patterns/relationships (e.g. degree of similarity determines degree of relatedness)	3
Method includes - An appropriate technology or data type - How the data discerns patterns/relationships (e.g. degree of similarity determines degree of relatedness)	2
Example of what you might be looking for (e.g. comparing degree of similarity or predicting outcomes) Or Identification of technology or data type Or Definition of inheritance patterns	1

Sample: SNPs can be used to examine genetic diversity in populations, which can be helpful in conservation management of endangered species. For example, when studying Tasmanian Devils, cells can be sampled from the Devils and the DNA amplified (with PCR) and then a profile of known SNPs can be developed using microarrays. The more shared SNPs between individuals, the more closely related they are. Across a population this can help establish genetic diversity, which, through this technique, has been determined to be relatively low in Tasmanian Devils, highlighting the need to improve gene flow in conservation management.

Question 26

a)

Criteria	Marks
Cause and effect language Demonstrates extensive understanding of the role of mRNA in protein production including 4 of: - Identifying the process of polypeptide synthesis and translation - Steps in translation (including role of tRNA, codon and/or anticodon), or, extraction of tumor protein to analyse /tumor DNA to sequence - Link between amino acids and protein structure - Synthesis of mRNA	4
Cause and effect language Demonstrates thorough understanding of the role of mRNA in protein production including 3 of: - Identifying the process of polypeptide synthesis and translation - Steps in translation (including role of tRNA, codon and/or anticodon), or, extraction of tumor protein to analyse /tumor DNA to sequence - Link between amino acids and protein structure - Synthesis of mRNA	3
Demonstrates sound understanding of the role of mRNA in protein production including 2 of: - Identifying the process of polypeptide synthesis or translation - Steps in translation (including role of tRNA, codon and/or anticodon), or, extraction of tumor protein to analyse /tumor DNA to sequence - Link between amino acids and protein structure - Synthesis of mRNA Or Provides an outline of a process that derives the mRNA code by either working backwards from the structure of the protein or sequencing the DNA (without just re-stating the question)	2
Any relevant information	1

Sample: It is possible to develop mRNA for a newly discovered protein as all proteins are produced by the same process using the same underlying code. mRNA is a single-stranded nucleic acid that is usually produced during protein synthesis. Translation involves the ribosome "reading" the mRNA bases in groups of three called codons. Each codon that passes through the ribosome triggers the ribosome to place a particular amino acid into a chain (polypeptide). Once produced a polypeptide will usually spontaneously fold into a protein due to chemical interactions between the amino acids in the chain. Therefore, if researchers can study the polypeptide chain/s (primary structure/s) that form the basis of the protein (isolated from the tumor), they should be able to work out a sequence of mRNA that will produce the same sequence of amino acids as the protein. As long as it folds correctly into the protein, then the desired protein should be produced.

(could also suggest that researchers could sequence the DNA of the cancer as a starting point)

Markers notes:

- Be careful not to re-state the question, particularly if you're only providing a partial/brief answer.
- Include big picture (polypeptide synthesis/transcription)

b)

Criteria	Marks
Identifies 3 explicit differences between the cancer vaccinations and traditional vaccinations	3
Identifies 2 explicit differences between the cancer vaccinations and traditional vaccinations	2
Identifies 1 implied difference between the cancer vaccinations and traditional vaccinations	1

Sample: Traditional vaccines train the immune response to recognise a single antigen, whereas this one trains the immune system to recognise multiple antigens. Traditional vaccines are given prior to infection with a disease whereas this one is given after the disease has been treated. Traditional vaccines target pathogens, whereas this vaccine targets proteins produced by the patient's own body.

(could also include: Traditional vaccines use same vaccination for whole population, whereas this vaccine has to be personalised for an individual patient. Traditional vaccines use part/whole pathogen whereas this one uses a protein produced by the person's cells. Traditional vaccines prevent diseases from spreading through a population, whereas this one only prevents cancer within one individual)

Marker's notes:

- mRNA vs non-mRNA vaccine was paid up to 2 marks, however there have been mRNA vaccines used extensively and with a great deal of public fanfare for COVID.
- Remember to clearly, explicitly distinguish with words such as "whereas" and "however", or a table of differences.
- Remember that distinguish is different to "compare" - only differences are helpful with distinguish.

c)

Criteria	Marks
Cause and effect language Demonstrates extensive understanding of how mRNA vaccinations work to create an immune response to a specific antigen or series of antigens Relates the process of vaccination to protecting the patient from future occurrences of the cancer	5
Cause and effect language Demonstrates thorough understanding of how mRNA vaccinations work to create an immune response to a specific antigen or series of antigens Relates the process of vaccination to protecting the patient from future occurrences of the cancer	4
Demonstrates sound understanding of how mRNA vaccinations work to create an immune response to a specific antigen or series of antigens Relates the process of vaccination to protecting the patient from future occurrences of the cancer	3
Relates the process of provoking an immune response to immunological memory	2
Some relevant information (e.g. kills cancer cells)	1

Sample: Giving the patient a vaccine that contained mRNA for one or more proteins unique to the surface of the cancer cells would help the patient's immune system to target those cells or their parts using the adaptive immune system. In the same way that an mRNA vaccination for an infectious disease introduces the pathogen's antigen by providing the person's cells mRNA which the cells will translate into the pathogen's antigen, the patient's cells will produce many copies of the surface proteins following vaccination. If these proteins are treated as antigenic by the immune system, then macrophages should present them to naive T cells, stimulating them to become Helper T cells, which should then initiate a humoral response by interacting with naive B cells with an antibody specific to the antigen. Plasma B cells should then proliferate, producing more specific antibodies that will interfere with the antigen, preventing them from spreading the cancer. Simultaneously the Helper T cell will trigger the proliferation of Cytotoxic T cells specific to the antigen, which will recognise cancerous cells and destroy them by inducing apoptosis. If successful, this would also develop immunological memory, meaning that any future occurrences of the cancer would trigger an even stronger immune response, protecting the patient.

Markers notes:

- Extensive includes: coherent, full pathway for either primary and/or secondary response in the context of the scenario, including action or specificity of antibodies or cytotoxic T cells
- Thorough includes: partial pathway for either primary and/or secondary response in the context of the scenario
- Sound includes: identification of some important cell types involved and identification of production of either antibodies or cytotoxic T cells
- Answers from any part of the question (a, b or c) were used towards marks in other parts if necessary
- Make it clear you have used an extra writing booklet
- Read through all parts of multiple part questions before you begin to answer any one part as it will support your interpretation of the questions.

Question 27

Criteria	Marks
Outlines and justifies at least three appropriate techniques to reduce the transmission of viruses, with at least one technique relating to each type of virus	3
Outlines and justifies at least two reasonable techniques to reduce the transmission of viruses in general	2
Outlines and justifies at least one techniques to reduce the transmission of viruses	1

Answers could include:

To prevent transmission of a respiratory virus (to a maximum of 2 marks):

- Require passengers to wear face masks in communal areas during outbreaks to avoid transmission of airborne viruses that are sneezed or coughed out.
- Encourage passengers to wash their hands with soap and water or hand sanitiser regularly to prevent viral pathogens spreading from one person to another.
- Ensure regular cleaning of air conditioning units to prevent the spread of airborne respiratory viruses.

To prevent transmission of a food-borne virus (to a maximum of 2 marks):

- Require staff in food preparation areas to wash their hands regularly, particularly after using the bathroom, and to wear clean disposable gloves when handling food.
- Allow only staff, and not passengers, to handle food-serving utensils at buffets.
- Discard all uneaten food after every food service.
- Remove shared snacks (chips, nuts etc) from communal areas.

Markers notes:

If the technique was explicitly aimed at both and justified for both it was accepted for both.

All the usual food handling techniques were paid for norovirus, but remember that a virus can't replicate outside of a cell so those techniques will only work to minimise survival of viruses on food (not tht you were given this in the stimulus, but norovirus, for example, is very resilient, so putting food in the fridge may not kill it, but cooking food at high temperatures would - however, any food that may have been exposed to norovirus would be thrown out immediately).

Question 28

a)

Criteria	Marks
• Correctly names all three cell types	1

Sample Answer

I: macrophage (or phagocyte / white blood cell)

II: B lymphocyte (or B cell)

III: T lymphocyte (or T cell / killer T cell)

Markers notes: paid any B cell for II and any T cell for III.

b)

Criteria	Marks
Correctly explains the meaning of the term “cell-mediated response”, including reference to a specific action	3
Correctly explains the meaning of the term “cell-mediated response”	2
Identifies a component or action of the cell-mediated response	1

Sample Answer: The “cell-mediated response” refers to the action of Killer T-cells that bind to host cells that have been infected by a pathogen. They secrete chemicals that bind to and perforate the host cell’s membrane, causing the cell to burst and preventing the pathogen from reproducing.

Question 29

Criteria	Marks
Outlines the steps students should use to determine the cause of the disease, including four of Koch’s postulates	3
Outlines the steps students should use to determine the cause of the disease including three of Koch’s postulates	2
Outlines one of Koch’s postulates or identifies that using Koch’s postulates would be appropriate without outlining any of them.	1

Sample Answer

The students should carry out the following steps, according to Koch’s postulates:

1. Determine that all infected apples contain the suspected pathogen.
2. Isolate the suspected pathogen from a diseased apple and grow it in pure culture.
3. Infect healthy apples with the cultured pathogen and determine that they develop the same symptoms as the original diseased apples.
4. Isolate the pathogen from apples that were infected in Step 3, grow it in pure culture and determine that it is identical to the pathogen in the first culture.

Question 30

a)

Criteria	Marks
● Defines pathogen	1

Sample: Pathogens are infectious agents that can cause disease when they enter a host.

Marker feedback:

- Pathogens are agents that cause disease (even better, infectious disease)
- Not “invaders”
- I paid “organisms” that cause disease... but not “cells” (as that excludes viruses)
- They’re not just something that triggers an immune response - that would include antigenic substances such as pollen, or mRNA vaccinations, neither of which are pathogens

b)

Criteria	Marks
● Identifies TWO pathogens. AND ● Describes ONE appropriate adaptation for EACH of the pathogens identified	4
● Identifies TWO pathogens or types of pathogens. AND ● Describes ONE appropriate adaptation for ONE of the pathogens identified	3
● Identifies ONE type of pathogen or two diseases. AND ● Describes ONE appropriate adaptation for the pathogen identified	2
● Provides some relevant information	1

Sample:

- Viruses such as hepatitis and human immunodeficiency virus (HIV) can survive in body fluids which allows them to be passed on through sexual contact.
- Malaria (*Plasmodium malariae*) is a parasitic protozoan that has adapted to live in both mosquitos and humans. When a mosquito bites a human, the pathogen bypasses the barrier of skin and enters into the bloodstream.
- Some bacteria, such as *E. coli* (*Escherichia coli*), contain flagella (tiny hair-like structures) that enable them to move in fluids such as blood.

Markers notes:

Distinguish between pathogens and the disease they cause (even if you are only able to say the bacterium that causes Cholera, it’s better than just saying Cholera)

Prion was accepted as specific type, given the only names relate to disease names (e.g. Kuru)

Adaptations need to improve chances of survival to reproduce - so describe it in relation to increased survival/transmission or entry

Question 31

Criteria	Marks
Provides two reasons to recognise and protect First Nations' peoples' cultural and intellectual property using cause and effect language	3
Provides one reason to recognise and protect First Nations' peoples' cultural and intellectual property using cause and effect language	2
Provides some relevant information (such as an example)	1

Sample: The potential healing properties of bush medicines were first discovered by First Nations peoples on their lands, and this knowledge has been passed down through generations. This knowledge deserves to be recognised and First Nations people should receive compensation for their work. The traditional knowledge of First Nations peoples must be safeguarded to ensure that Indigenous cultural heritage is maintained.

Marker's notes:

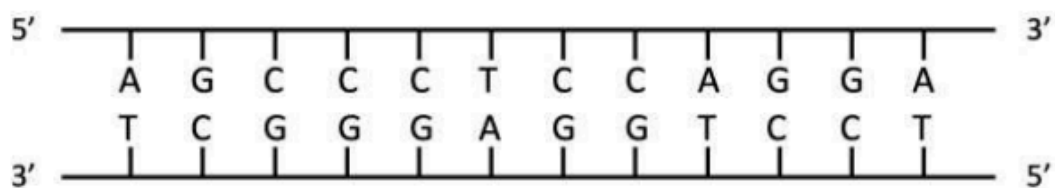
Very few people mentioned that financial compensation for expertise and work is an important reason to recognise cultural and intellectual property

Question 32

a)

Criteria	Marks
Provides the correct base sequence on double-stranded cDNA consistent with DNA structure and orientation	2
Provides the correct base sequence on double-stranded cDNA	1

Sample Answer



Markers notes:

DNA structure has a backbone with bases on the inside

DNA does not have U as a base.

Question 32 continued

b)

Criteria	Marks
Explains how difference in gene coding for insulin can produce the same protein, including explaining the redundancy of the genetic code and the likelihood that differences could occur in non-coding regions of the genes	4
Explains how difference in gene coding for insulin can produce the same protein, with reference to the redundancy of the genetic code or the likelihood that differences could occur in non-coding regions of the genes	3
Outlines how difference in gene coding for insulin can produce the same protein, with reference to the redundancy of the genetic code or the likelihood that differences could occur in non-coding regions of the genes	2
Provides some relevant information	1

Sample: There is some redundancy in the genetic code, so if there differences in the base sequence for the insulin gene occurred in the third base of the codons for certain amino acids, they would still code for the correct amino acid on the polypeptides that make up insulin. Therefore, despite the difference the protein would be identical. Similarly, if the differences occurred in the non-coding regions of the genes that were removed from the mRNA during mRNA processing, they would not be involved in translation and thus would not influence the the amino acid sequence and thus structure of the protein.

Markers notes:

Idea of codons and placement of amino acids required for explain.

c)

Criteria	Marks
Provides three main steps (denaturation, annealing and extension) in PCR with some use of terminology	3
Provides two main steps (denaturation, annealing and extension) in PCR with limited use of terminology	2
Provides some relevant information	1

Sample: DNA sample is mixed with primer, polymerase and nucleotides then heated to separate it into single strands. The solution is cooled to allow the primer to attach. Polymerase binds the complementary nucleotides to the exposed bases forming double-stranded DNA. The DNA is then heated again and the steps repeated until enough DNA is produced.

Marker's notes:

Many students confused this with DNA replication

Never miss an opportunity to mention complementary base pairing - its fundamental to so many processes, including this one

Often students confused annealing and extension (Annealing involves attachment of primer, extension is building the second strand)

Question 33

Criteria	Marks
• Demonstrates a thorough understanding of the distinction between genetic manipulation and genetic engineering • Provides at least two named examples of genetic manipulation including at least one example of genetic engineering and at least one example of genetic manipulation that preceded genetic engineering	6
• Demonstrates a sound understanding of the distinction between genetic manipulation and genetic engineering • Provides at least one named and one specific example of genetic manipulation including at least one example of genetic engineering and at least one example of genetic manipulation that preceded genetic engineering	5
• Demonstrates a sound understanding of the distinction between genetic manipulation and genetic engineering • Provides at least two specific examples of genetic manipulation including at least one example of genetic engineering and at least one example of genetic manipulation that preceded genetic engineering OR provides one specific example of either genetic engineering or a prior manipulation and a definition for the other form of genetic manipulation	4
• Demonstrates some understanding of the distinction between genetic manipulation and genetic engineering • Provides an example of genetic manipulation	2-3
• Provides some relevant information	1

Feedback: a strange question as you are justifying a statement that has been decided for you. Even though the marking criteria didn't require it, some students sensibly included an opening statement that said the statement was justified to ensure they had that verb covered.

Read carefully, this is really a distinguish question - as you can't address the second statement effectively without that distinction.

Most students focused on the last sentence of the stimulus quote out of context of the first, ignoring the "in many ways" and "plants and livestock" parts of the first sentence, and as a consequence, many didn't include an example for genetic engineering (some didn't even mention it). A six mark question is a big question. Don't be vague: which is more convincing – "to make cows bigger" or "to increase muscle mass, for example, in Belgian Blue cattle"?

Choose sensible processes to discuss - it's much easier to link selective breeding to manipulation of genetic material than artificial insemination or artificial pollination which are really extensions of selective breeding, so you have to outline selective breeding as part of your outline of them anyway.

Thorough = outline including clear distinction and appropriate, correct use of terminology

Sound = outline, or clear distinction, or appropriate terminology

2 marks = implied distinction, 3 marks = genetic engineering needs to be identified

Named = Variety name (Belgian Blue or Bt Cotton)

Specific = species name (cattle or cotton) and trait explicitly described

Sample Answer

Genetic manipulation includes selective breeding of crop plants and animals, which has been used for many centuries, and, more recently, whole animal cloning. Animals and plants with desirable traits were chosen to breed so that desirable traits, such as resistance to drought or disease, would be carried into subsequent generations. An example is the crossing of varieties of grains to produce high-yielding and disease-resistant wheat. Whole animal cloning is achieved by inserting a somatic cell nucleus from an individual with desirable traits into an enucleated ovum and transplanting the ovum into a surrogate mother.

Genetic engineering relates specifically to the manipulation of DNA, in which genes are transferred from one species to another to create a transgenic organism or cell line. Examples of genetic engineering include the use of recombinant DNA technology in producing "Pharm" animals, which produce human proteins in milk, and the production of Golden Rice, which has the gene for Vitamin A production inserted. Golden Rice was developed for use in parts of the world where rice is a major part of the diet and Vitamin A deficiency is common.

Question 34

Criteria	Marks
Identifies ONE type of mutagen. AND Provides a detailed description includes a definition of mutagen	3
- Identifies ONE type of mutagen. AND - Provides a description that refers to cell mutation	2
Identifies ONE type of mutagen	1

Sample

Electromagnetic radiation (EMR) is a type of mutagen. A mutagen is an agent which causes a sudden change in the genome of a cell. EMR is a mutagen that comes in various forms, including ultraviolet (UV) waves, X-rays and gamma rays. High frequency EMR can cause double-stranded breaks which the cell cannot accurately repair. When cells divide, DNA replication multiplies these errors.

Note: Responses may refer to chemical or naturally occurring mutagens.

Markers notes: a detailed description includes how it causes a problem that is then left unrepaired or is replicated, or multiple pathways of mutagenesis

Question 35

Criteria	Marks
Provides a detailed explanation of the cause of a trisomy condition, including: - Nondisjunction during meiosis - Consequence of fertilisation Explains how nondisjunction would be more likely due to variation in the alpha satellites Uses appropriate terminology throughout	4
Provides an explanation of the cause of a trisomy condition, including: - Nondisjunction during meiosis, or - Consequence of fertilisation Explains how nondisjunction would be more likely due to variation in the alpha satellites Uses appropriate terminology throughout	3
Provides an outline of the cause of a trisomy condition, including: - Nondisjunction during meiosis, or - Consequence of fertilisation Links nondisjunction to variation in the alpha satellites Uses some appropriate terminology OR Provides an accurate definition of trisomy and coherent reasoning that links the condition to more variation in alpha satellites	2
Defines trisomy or provides a cause for trisomy	1

Sample:

A trisomy is a condition in which someone's somatic cells has $2n+1$ chromosomes. It is caused by mistakes in separation of chromosomes during meiosis (nondisjunction), which leads to a gamete with $n+1$ chromosomes. Fertilisation with a normal gamete (n) then leads to a zygote with $2n+1$ chromosomes. As the spindle fibres responsible for separating chromosomes during meiosis attach to alpha satellites on the centromeres, variations in the alpha satellites would hinder the connection between spindle fibres and the centromeres. This would lead to mistakes in chromosome separation and therefore mistakes in chromosome numbers in gametes, which would explain the correlation between alpha satellite variation and trisomy conditions.

Markers notes

- Need a definition of trisomy for cause to be explained in detail
- For the outline, the definition of trisomy could be somewhat vague if the rest of the answer showed good reasoning and cause and effect language. Alternatively, the definition needed to be good if the reasoning was poor, but coherent (for example, coherent, but circular reasoning). The concept of nondisjunction without the terminology was also acceptable at this level and for one mark.

Question 36

Criteria	Marks
Negative feedback loop with two sides and: - Two paths on one side (or annotations to that effect) - Data points included - Stimuluses - Receptors - Control Centres - Effectors - Responses	8
Negative feedback loop with two sides and 5-6 of: - Two paths on one side (or annotations to that effect) - Data points included - Stimuluses - Receptors - Control Centres - Effectors - Responses	6-7
Coherent diagram with 3-4 of: - Two sides - Two paths on one side (or annotations to that effect) - Data points included - Stimulus - Receptor - Control Centre - Effector - Response	4-5
Coherent diagram with only one side, or Attempted two-sided diagram	3
One to two pieces of relevant information	1-2

Sample response:

