# Smith's Hill High School

*Promoting excellence in a spirit of trust and co-operation*

STUDENT NAME: ……

**2023**

**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 – 33
- Allow about 2 hours and 25 minutes for this part

**This paper MUST NOT be removed from the exam room**

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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

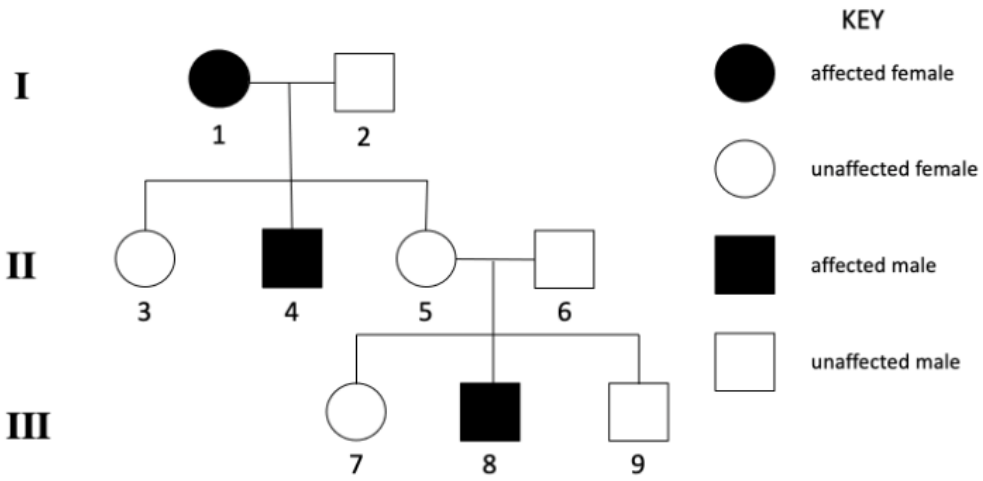
1. Giardia is a pathogen of the vertebrate gut and is transmitted in water. It possesses mitochondria but lacks a cell wall. Giardia is a:

    A. fungus.
    B. protozoan.
    C. bacterium.
    D. There is not enough information to distinguish between the above possibilities.

2. Which of the following lists only types of non-Mendelian inheritance?

    A. Multiple alleles, autosomal dominant, sex-linked recessive
    B. Multiple alleles, incomplete dominance, autosomal recessive
    C. Incomplete dominance, polygenic, codominance
    D. Incomplete dominance, codominance, autosomal dominant

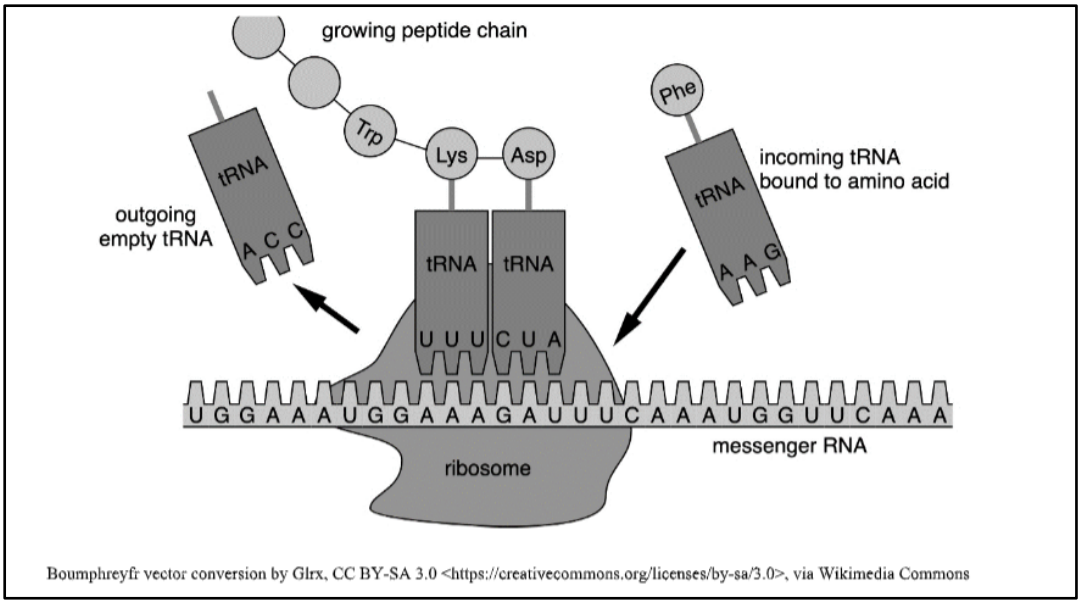
3. The following pedigree shows the inheritance of an autosomal trait over three generations in a human family.




Individuals 5 and 6 are planning to have another child. What is the probability that this child will inherit the trait?

    A. 75%
    B. 50%
    C. 33%
    D. 25%

4. Below is a diagram of a process during protein synthesis:




Determine the sequence of the section of DNA coding strand that codes for the amino acid 'Asp'

A. C T A
B. C U A
C. G A T
D. G A U

5. In the human ABO blood group system, the alleles for antigens A and B are both expressed in an individual carrying both alleles.

This is an example of:

A. incomplete dominance
B. polygenic expression
C. hybrid vigour
D. codominance

6. Some scientists were comparing a gene mutation found on human chromosome 13. They compared the base sequence of 113 600 people. The mutation can be seen below:

Normal base sequence: ATAGCTATC
Mutated base sequence: ATAGCTTTC

What is the minimum number of people that must have the mutated base sequence for it to be classified as a single nucleotide polymorphism (SNP)?

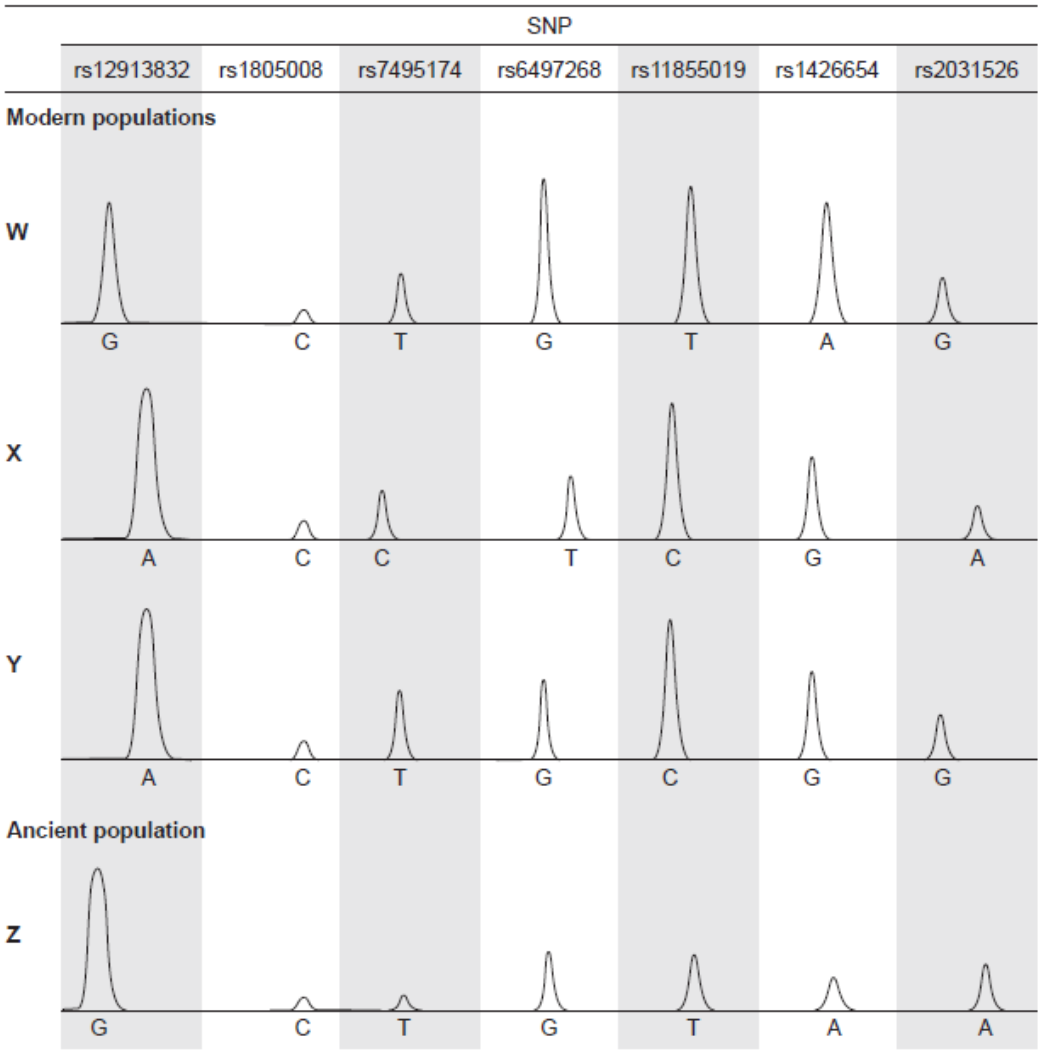
A. 11
B. 113
C. 1 136
D. 11 360

7. Which of the following statements relating to genetic change is CORRECT?

A. A frameshift mutation results from the cutting and splicing of sections of a chromosome.
B. A base substitution affects many genes in one chromosome.
C. All changes to base pair sequences in coding regions of DNA result in phenotypic change.
D. Mutations in non-coding DNA regions can result in phenotypic changes.

8. The diagram below shows electropherograms for DNA profiles of three modern human populations (W, X and Y) and one ancient human population (Z). The electropherograms show which nucleotide is present in each of seven single nucleotide polymorphisms (SNPs) for each population.

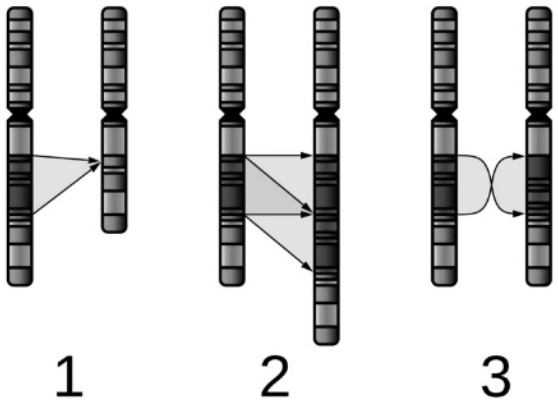
A SNP is a variation in a single nucleotide at a specific location in the genome. For example, the SNP rs12913832 has either guanine (G) or adenine (A).




Which one of the following statements is consistent with the information in the electropherograms?

A. The modern populations do not show enough similarity to the ancient population to indicate a close relationship.
B. Population X is the modern population that is most similar to population Z because only one nucleotide base is different.
C. Population W is older than population X and population Y.
D. Population X is more closely related to population Y than population Z is to population Y.

9. The image below shows three examples of chromosomal mutations.




Source:Richard Wheeler (Zephyris)Vector version: NikNaks, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons

Which option correctly identifies the type of mutation for example number 2?

A. Deletion
B. Duplication
C. Inversion
D. Translocation

10. Which of the following would lead to a decrease in genetic diversity in a population?

A. Migratory birds mating as they travel throughout their migration
B. Producing Bt cotton by introducing a transgenic gene into a regular cotton plant
C. Using one 'stud bull' to mate with a number of female cows
D. Bees pollinating a flowering plant, causing the plant to produce seeds

11. Farmers use artificial pollination or artificial insemination to improve the quality or yield of their products for sale.

Which of the following is a similarity between artificial pollination and artificial insemination?

A. Both techniques introduce DNA from one organism to produce new individuals with desirable traits.
B. Both techniques create exact copies of new individuals with desirable traits.
C. Both techniques select gametes from individuals with desirable traits to be passed to offspring.
D. Both techniques switch genes on or off to produce new individuals with desirable traits.

12. A genetics research company has developed a new biotechnology but is facing resistance from members of the community who believe the process is unacceptable under their religious beliefs.

    This would be an example of which of the following?

    A. A social implication
    B. A cultural influence
    C. An ethical implication
    D. An economic influence

13. Avian influenza (bird flu) is a highly infectious disease in agricultural birds such as chickens, turkeys and ducks. It is difficult to detect as many wild bird species can carry the virus but do not show symptoms.

    Symptoms of the disease include:

    - Sudden death
    - Ruffled feathers
    - Inability to walk, stand or move
    - Drop in egg production

    The disease is spread through animal to animal contact, bites and scratches, air, faeces, clothing, footwear, equipment such as cages, feed and water containers and vehicles, and contaminated meat/eggs.

Jost, Chris. "Controlling bird flu in Indonesia using participatory approaches".

    Which of the following strategies would NOT be helpful to prevent the spread of an Avian influenza outbreak?

    A. Use of antibiotics
    B. Cleaning of equipment
    C. Limiting contact between agricultural birds and wild birds
    D. Quarantine

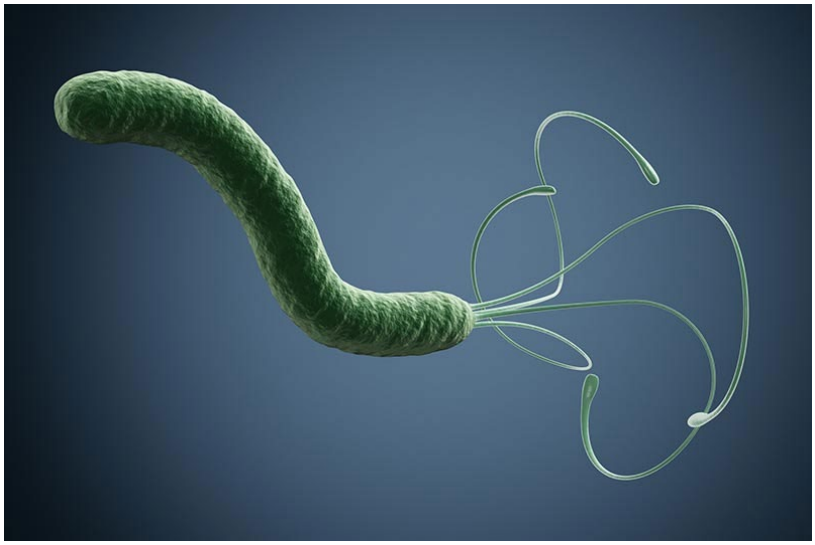
14. In the 19th century, Robert Koch developed a series of criteria to determine

    A. the rate of microbial growth.
    B. the microbial cause of an infectious disease.
    C. the ability of microbes to generate spontaneously.
    D. the most effective antibiotic treatment for a particular disease.

15. What is the role of the helper T-cell?

    A. Secrete proteins known as antibodies, which act to neutralise the extracellular pathogen
    B. Once activated, will release cytokines to activate the humoral and cell-mediated immune response
    C. Clone themselves and remain in the body to respond to future exposure from the same pathogen.
    D. Produce many copies of themselves, travel to the site of infection and release cytokines to destroy the infected cell.

16. *Helicobacter pylori* is a bacterial pathogen known to cause stomach infections and ulcers. It uses chemotaxis (movement along a concentration gradient) to move through the stomach's acidic mucus and bind to the less acidic epithelial cells underneath, helped by its flagella which allow it to move in a screw-like motion through the mucus lining. It also secretes *urease*, an enzyme that helps to neutralise the acid around it.

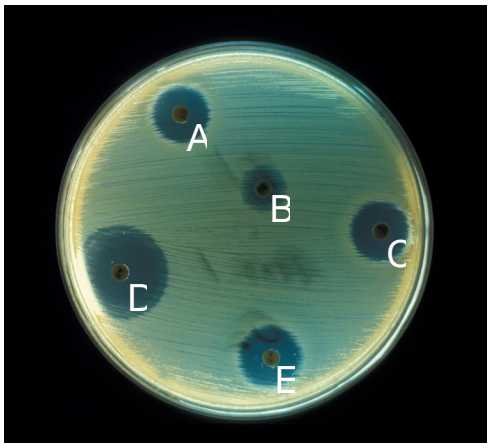


Source: Boston University (2017)

Flagella and urease production in *Helicobacter pylori* represent which of the following?

    A. Adaptations to create an acidic environment
    B. Adaptations to survive and move through its environment
    C. Physical and chemical changes that occur in host cells
    D. The host response to infection

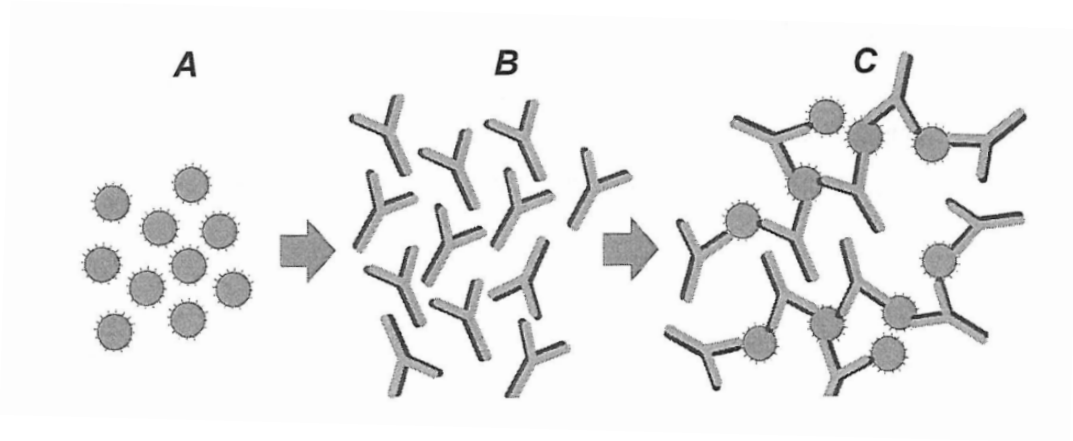
17. The following photograph shows the results of an experiment designed to compare the efficacy of different antibiotics against a particular strain of bacteria which had been evenly inoculated across the agar plate. The antibiotics present in each disc are labelled A to E.




What conclusion can be drawn from the photograph?

A. Antibiotic D is the most effective against that strain of bacteria.
B. Antibiotic B is the most effective against that strain of bacteria.
C. Antibiotic B is the most effective antibiotic.
D. Antibiotic D is a wide spectrum antibiotic.

18. The diagram below represents one aspect of the adaptive immune system response in humans.




Which of the following rows correctly identifies *A* and *B*?

| | *A* | *B* |
|---|---|---|
| A. | Phagocytes | Antigens |
| B. | Plasma cells | Antibodies |
| C. | Macrophages | Virus particles |
| D. | Antigens | Antibodies |

19. Which of the following best describes a negative feedback mechanism?

A. A system of homeostatic regulation in which an increase in one factor triggers a pathway that counteracts the increase
B. A system of homeostatic regulation in which factors oscillate around a set point
C. A system of homeostatic regulation in which the nervous system counteracts changes
D. A system of homeostatic regulation in which an increase in one factor triggers a pathway that leads to further increase in that factor

20. Which of the following rows correctly identifies the components of a thermoregulatory negative feedback loop?

| | *Stimulus* | *Control Centre* | *Response* |
|---|---|---|---|
| A. | Increased temperature | Hypothalamus | Vasodilation |
| B. | Decreased temperature | Hypothalamus | Vasodilation |
| C. | Decreased temperature | Hippocampus | Vasoconstriction |
| D. | Increased temperature | Pancreas | Vasoconstriction |

**Section II – 80 marks**
**Attempt Questions 21-33**
**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.

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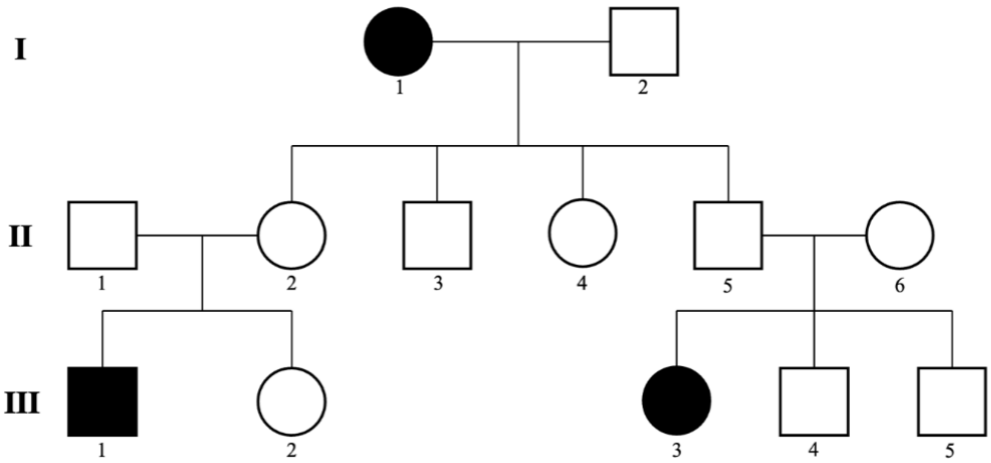
**Question 21** (4 marks)

Use the pedigree below to answer the following questions:




a) Identify the mode of inheritance. **1**

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b) Individual II-3 wants to conceive a child with an affected female. Show your working to calculate the phenotypic AND genotypic ratio of their potential offspring. **3**

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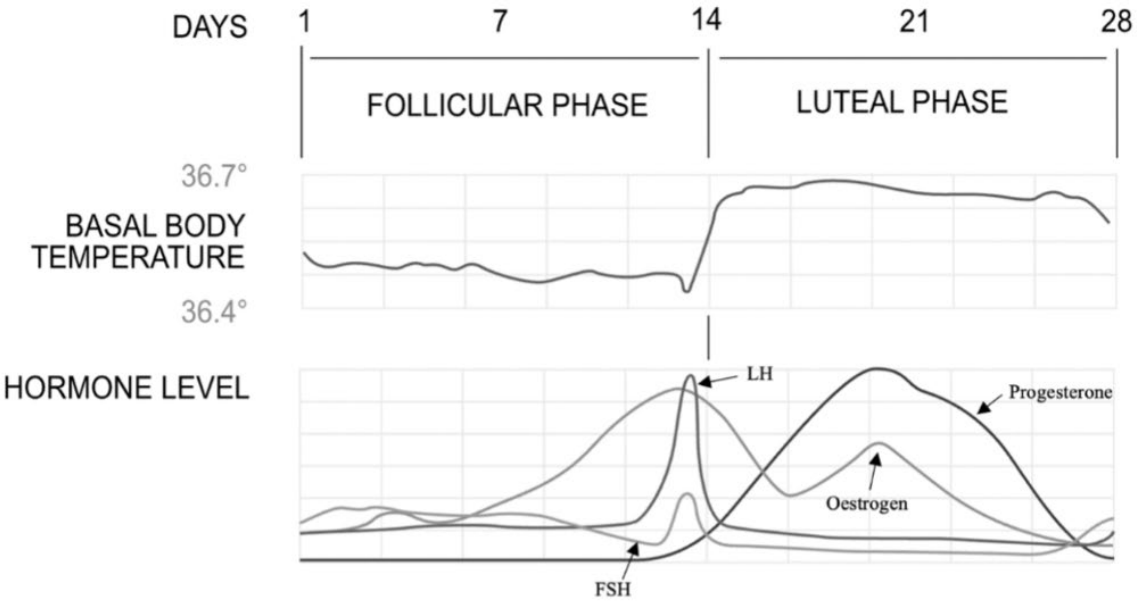
**Question 22** (6 marks)

Use the diagram below to answer the following questions:






a) Identify the day on which ovulation would most likely occur. **1**

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b) Outline the role of progesterone once an egg has been fertilised. **2**

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**Question 22 continues on the next page.**

**Question 22 continued.**

c) Hypopituitarism is a disorder in which the pituitary gland is unable to produce hormones such as FSH and LH.

Use the diagram and your understanding of female reproductive hormones to explain the impact this disorder would have on a woman's menstrual cycle and ability to conceive a child. **3**

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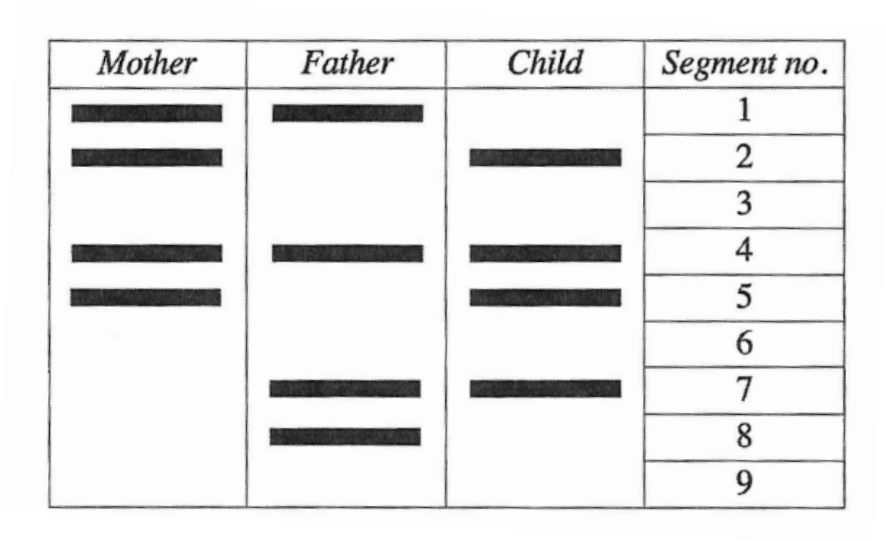
**Question 23** (5 marks)

A family had a child with *cystic fibrosis*, a heritable, autosomal recessive genetic disorder that results in the production of highly sticky mucus in both the lungs and digestive tract and can prove life-threatening. The father of the child is known to have a family history of cystic fibrosis, however, he does not have the condition. It was not known whether the mother had a family history of cystic fibrosis, but she does not have the condition.

The family requested a genetic test and the following DNA profile was obtained.




a) Identify which segment from the DNA profile contains the allele that is responsible for cystic fibrosis and provide a reason for your selection **2**

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b) Outline the process of DNA profiling. **3**

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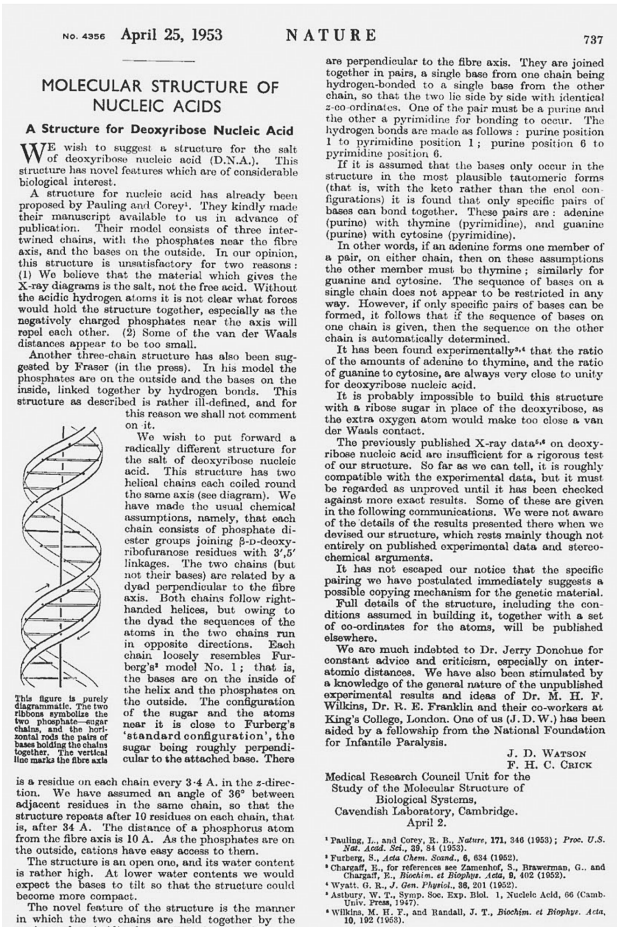
**Question 24** (6 marks)

The year 2023 marks the 70th anniversary of the publication of the Nature article in which James Watson and Francis Crick described the molecular structure of DNA.

Six years earlier, in 1947, J. Michael Creeth, of the University College Nottingham, published a paper in which he provided evidence for the presence of hydrogen bonding between purine and pyrimidine bases in DNA. This knowledge, now referred to as complementary base pairing, paved the way for the ultimate determination of the structure of the DNA double helix and is crucial to understanding nucleic acid function and current biotechnological processes based on DNA.



No. 4356 April 25, 1953 NATURE 737

## MOLECULAR STRUCTURE OF NUCLEIC ACIDS

### A Structure for Deoxyribose Nucleic Acid

WE wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

A structure for nucleic acid has already been proposed by Pauling and Corey[1]. They kindly made their manuscript available to us in advance of publication. Their model consists of three inter-twined chains, with the phosphates near the fibre axis, and the bases on the outside. In our opinion, this structure is unsatisfactory for two reasons: (1) We believe that the material which gives the X-ray diagrams is the salt, not the free acid. Without the acidic hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other. (2) Some of the van der Waals distances appear to be too small.

Another three-chain structure has also been suggested by Fraser (in the press). In his model the phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. This structure as described is rather ill-defined, and for this reason we shall not comment on it.



This figure is purely diagrammatic. The two ribbons symbolize the two phosphate–sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical line marks the fibre axis

We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate diester groups joining β-D-deoxyribofuranose residues with 3′,5′ linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite directions. Each chain loosely resembles Furberg's[2] model No. 1; that is, the bases are on the inside of the helix and the phosphates on the outside. The configuration of the sugar and the atoms near it is close to Furberg's 'standard configuration', the sugar being roughly perpendicular to the attached base. There is a residue on each chain every 3·4 A. in the z-direction. We have assumed an angle of 36° between adjacent residues in the same chain, so that the structure repeats after 10 residues on each chain, that is, after 34 A. The distance of a phosphorus atom from the fibre axis is 10 A. As the phosphates are on the outside, cations have easy access to them.

The structure is an open one, and its water content is rather high. At lower water contents we would expect the bases to tilt so that the structure could become more compact.

The novel feature of the structure is the manner in which the two chains are held together by the purine and pyrimidine bases. The planes of the bases are perpendicular to the fibre axis. They are joined together in pairs, a single base from one chain being hydrogen-bonded to a single base from the other chain, so that the two lie side by side with identical z-co-ordinates. One of the pair must be a purine and the other a pyrimidine for bonding to occur. The hydrogen bonds are made as follows: purine position 1 to pyrimidine position 1; purine position 6 to pyrimidine position 6.

If it is assumed that the bases only occur in the structure in the most plausible tautomeric forms (that is, with the keto rather than the enol configurations) it is found that only specific pairs of bases can bond together. These pairs are: adenine (purine) with thymine (pyrimidine), and guanine (purine) with cytosine (pyrimidine).

In other words, if an adenine forms one member of a pair, on either chain, then on these assumptions the other member must be thymine; similarly for guanine and cytosine. The sequence of bases on a single chain does not appear to be restricted in any way. However, if only specific pairs of bases can be formed, it follows that if the sequence of bases on one chain is given, then the sequence on the other chain is automatically determined.

It has been found experimentally[3,4] that the ratio of the amounts of adenine to thymine, and the ratio of guanine to cytosine, are always very close to unity for deoxyribose nucleic acid.

It is probably impossible to build this structure with a ribose sugar in place of the deoxyribose, as the extra oxygen atom would make too close a van der Waals contact.

The previously published X-ray data[5,6] on deoxyribose nucleic acid are insufficient for a rigorous test of our structure. So far as we can tell, it is roughly compatible with the experimental data, but it must be regarded as unproved until it has been checked against more exact results. Some of these are given in the following communications. We were not aware of the details of the results presented there when we devised our structure, which rests mainly though not entirely on published experimental data and stereochemical arguments.

It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.

Full details of the structure, including the conditions assumed in building it, together with a set of co-ordinates for the atoms, will be published elsewhere.

We are much indebted to Dr. Jerry Donohue for constant advice and criticism, especially on interatomic distances. We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M. H. F. Wilkins, Dr. R. E. Franklin and their co-workers at King's College, London. One of us (J. D. W.) has been aided by a fellowship from the National Foundation for Infantile Paralysis.

J. D. WATSON
F. H. C. CRICK

Medical Research Council Unit for the Study of the Molecular Structure of Biological Systems,
Cavendish Laboratory, Cambridge.
April 2.

[1] Pauling, L., and Corey, R. B., *Nature*, **171**, 346 (1953); *Proc. U.S. Nat. Acad. Sci.*, **39**, 84 (1953).
[2] Furberg, S., *Acta Chem. Scand.*, **6**, 634 (1952).
[3] Chargaff, E., for references see Zamenhof, S., Brawerman, G., and Chargaff, E., *Biochim. et Biophys. Acta*, **9**, 402 (1952).
[4] Wyatt, G. R., *J. Gen. Physiol.*, **36**, 201 (1952).
[5] Astbury, W. T., Symp. Soc. Exp. Biol. 1, Nucleic Acid, 66 (Camb. Univ. Press, 1947).
[6] Wilkins, M. H. F., and Randall, J. T., *Biochim. et Biophys. Acta*, **10**, 192 (1953).

Describe the role of complementary base pairing in the process of polypeptide synthesis and discuss the importance of complementary base pairing in ONE of the following biotechnological processes:
PCR (polymerase chain reaction) OR CRISPR-Cas9 editing. **6**

**Writing space continues on the next page.**

**Question 24 continued.**

**Question 25** (4 marks)

Discuss how the processes of gamete formation and fertilisation contribute to variation in the offspring in humans. **4**

**Question 26** (2 marks)

Phenotypic expression of certain genotypes can also be affected by environmental factors.

Discuss an example of a trait in a named organism that is affected by both genes and environment. **2**

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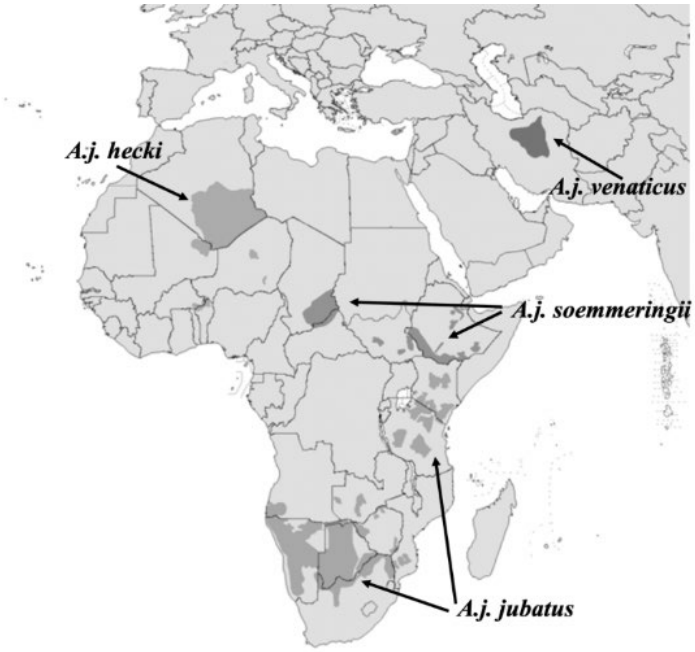
**Question 27** (7 marks)

The cheetah (*Acinonyx jubatus*) is a vulnerable species of large cat, known for being the fastest land animal. Since the 19th century, it is estimated that the cheetah population has declined from 100,000 to approximately 8,000 cheetahs.

The cheetah faces extinction due to climate change, hunting by humans and habitat destruction. They also have a low rate of reproductive success. Present-day cheetahs also have low genetic variability, increasing the rate of inbreeding among individuals.



The distribution of subspecies of the cheetah, as of 2015, can be seen in the image below:






The following could have a potential effect on the future gene pool of the cheetah:

- mutation
- gene flow
- genetic drift

Explain how each of the above could impact the gene pool of the cheetah. **7**

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**Question 27 writing space**

**Question 28** (3 marks)

Endangered species are under threat from many factors, including human-induced climate change, habitat destruction and hunting.

Outline an example of how population genetics data or genetic technologies are being used to assist in the conservation of a named endangered animal or plant species. **3**

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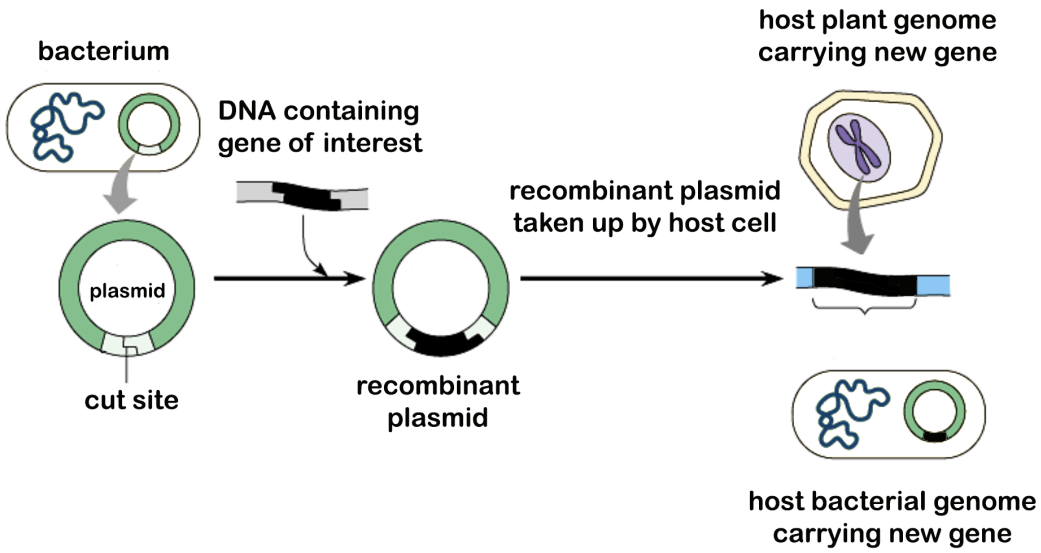
**Question 29** (10 marks)

The following diagram illustrates the general features of a technique used in biotechnology.




a) The above diagram shows some of the forms in which DNA occurs in prokaryotic and eukaryotic cells. Describe two differences between eukaryotic and prokaryotic forms of DNA. **2**

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b) Using examples, justify the application of the process illustrated above in agriculture and medicine. **8**

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**Question 29b writing space continued**

**Question 30** (7 marks)

A plant pathologist observed brown spots developing on the leaves of a lemon tree and wanted to determine the cause of the disease.

The pathologist suspected the tree was suffering from a bacterial disease, caused by infection with *Xanthomonas citri*.

a) Describe a method the pathologist could use to test the hypothesis that the suspected bacterium is the cause of the disease. **4**

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b) Explain the response of a named Australian plant to a named pathogen. **3**

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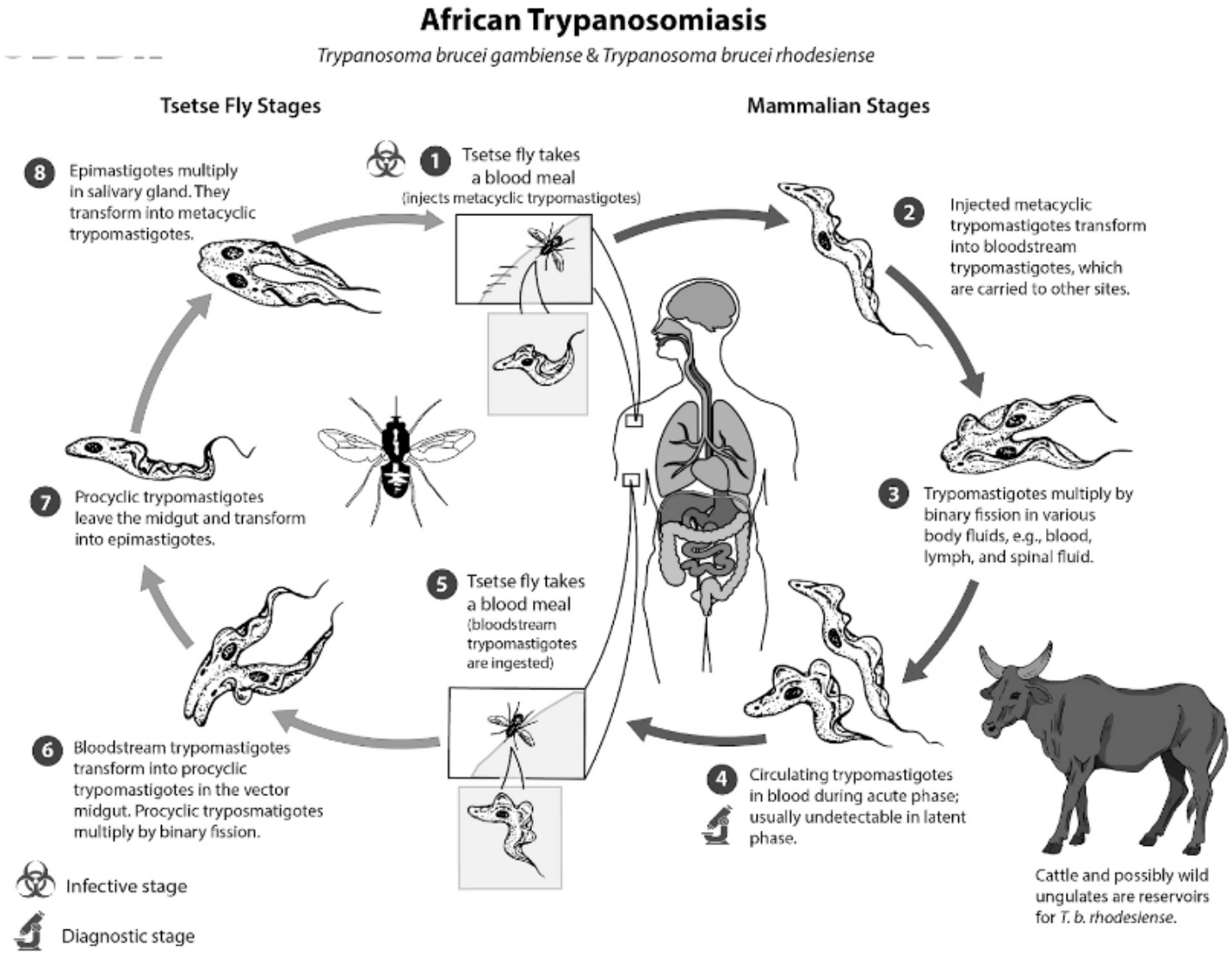
**Question 31** (9 marks)

Human African trypanosomiasis (HAT), commonly known as sleeping sickness, is a disease caused by the protozoan, *Trypanosoma brucei*, and is carried by the tsetse fly, *Glossina* sp. There are two trypanosome subspecies that affect humans: *T. brucei gambiense* and *T. brucei rhodesiense*.

A third subspecies, *T. brucei brucei*, only affects cattle. All humans possess a protein that protects them against infection with *T. brucei brucei*. The protein, called APO L1, causes the trypanosomes to break open before they can cause disease.

The life cycle of the two subspecies that affect humans is illustrated in the figure below.




**Lifecycle of *T. brucei gambi*ense and *T. brucei rhodesiense*[5]**

**Question 31 continues on the next page**

a) The figure above illustrates proliferation by binary fission at various stages in the life cycle of the trypanosome. Indeed, until recently, there was little evidence of sexual reproduction in the life cycle of trypanosomes.

Discuss the benefits to the trypanosome of carrying out asexual reproduction in the human host. **2**

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b) In recent studies, scientists have identified proteins associated with meiosis in trypanosomes and it is believed that the sexual phase occurs in the salivary glands of the tsetse fly. The discovery of hybrid trypanosomes in humans and haploid trypanosomes in tsetse flies provided further evidence of sexual reproduction in trypanosomes.

While these discoveries supported the idea that trypanosomes have a sexual phase, they have caused concern among epidemiologists over the potential for trypanosomes to develop drug resistance.

Why would these recent discoveries cause this concern among epidemiologists? **2**

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**Question 31 continues on the next page**

c) Describe TWO strategies, other than administration of drugs or vaccines, that could be implemented to help control the spread of human African trypanosomiasis. **2**

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d) In an analysis of current strategies for the eradication of human African trypanosomiasis, Babokhov and co-workers wrote:

> "The biggest obstacle in the fight against HAT is that there is still no effective vaccine against both human pathogenic subspecies. Creating any sort of vaccine against trypanosomes is difficult due to antigenic variation. The constant changes of the VSG [variant surface glycoprotein] coat allow the parasite to evade immune defences."

Justify this statement, using your knowledge of vaccine function. **3**

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**Question 32** (9 marks)

Alpha-gal is a sugar molecule found in most mammals and mammalian products such as beef, pork, lamb, cow's milk products and gelatine. It is not found in primate mammals, including humans.

Alpha-gal syndrome (AGS) is a condition where an affected person will have a serious, life-threatening allergic reaction to food products containing alpha-gal sugar. The syndrome is triggered when a tick (a macroparasite) bites a mammal that produces the alpha-gal sugar and then bites a human. An example of the tick can be seen in the image below.

a) Evidence suggests that after a human is bitten by such a tick, an immune response is triggered. This is because antibodies specific to the alpha-gal sugar are found in the blood of the affected person.

Describe the processes involved in the production of antibodies to the alpha-gal sugar. **5**

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**Question 32 continues on the next page.**

**Question 32 continued.**

b) Scientists have found that alpha-gal is unable to be passed from human to human. Is alpha-gal syndrome an infectious or non-infectious disease?

Justify your answer. **4**

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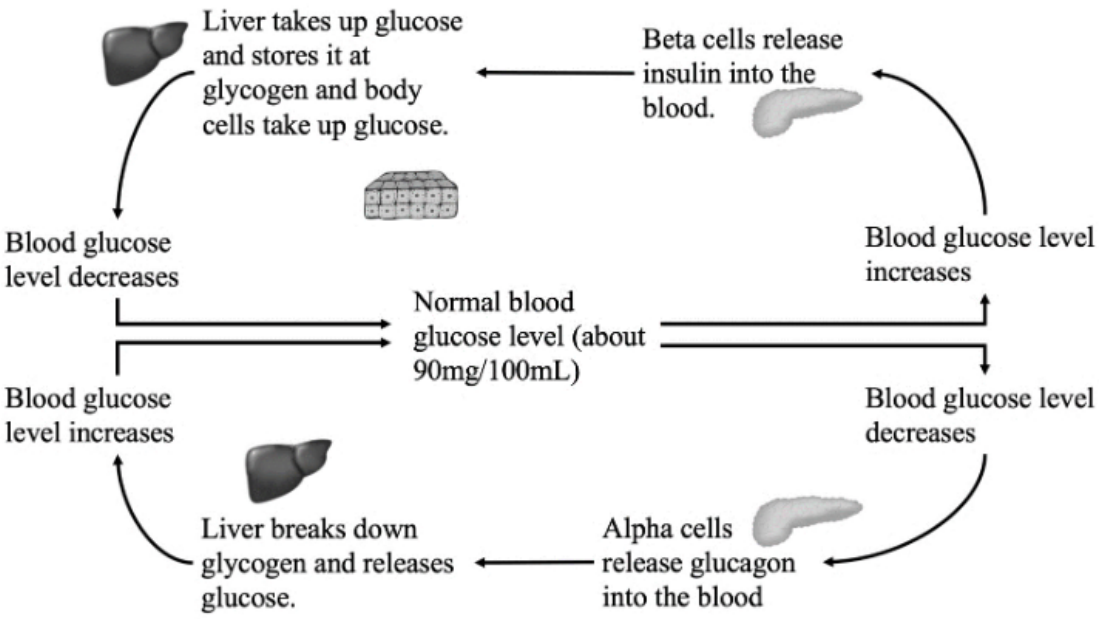
**Question 33** (8 marks)

Type 1 diabetes is a condition in which the pancreas produces little or no insulin. The diagram below shows the negative feedback loop of glucose control in a person without Type 1 Diabetes.




a) With reference to the feedback loop above, explain why a person with Type 1 Diabetes must inject insulin when they eat. **4**

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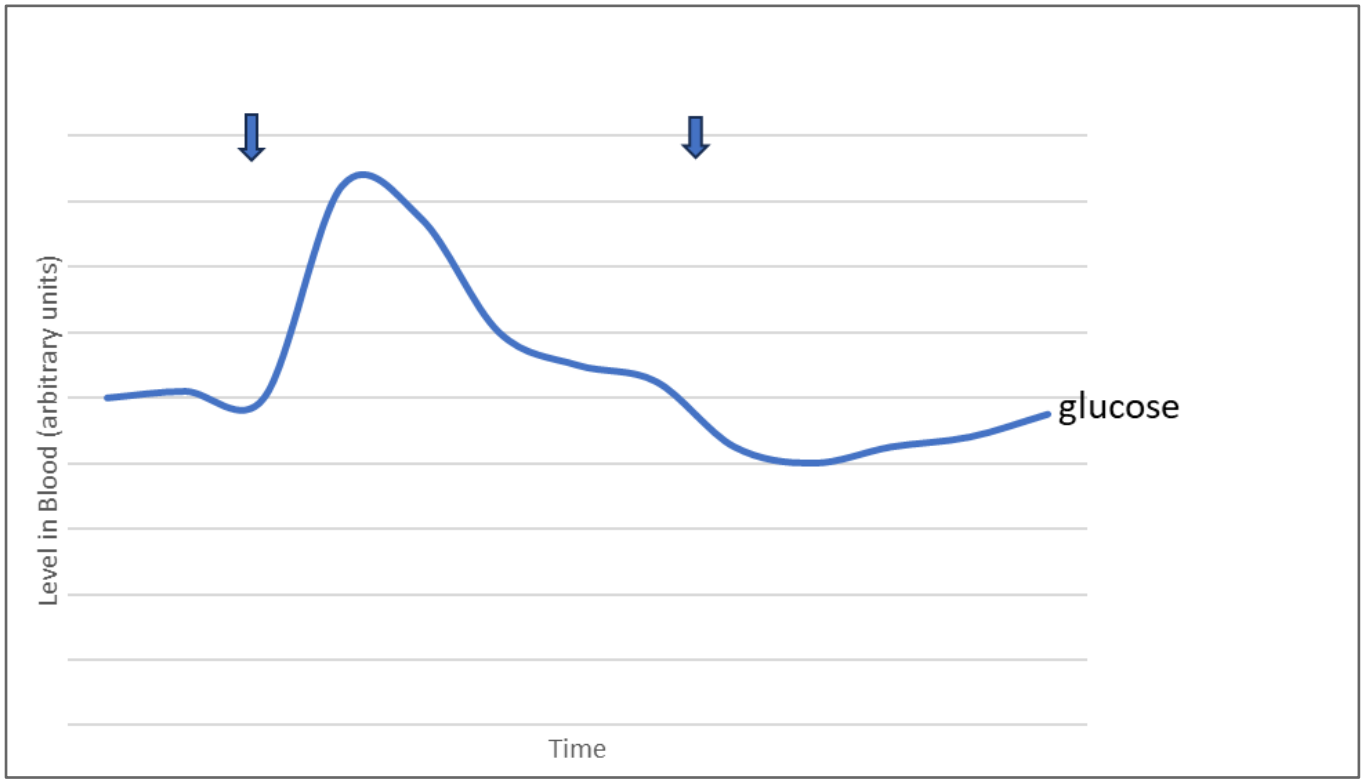
**Question 33 continues on the next page**

**Question 33 continued.**

b) The graph below shows the levels of glucose in the blood of a healthy individual over time. Arrows indicate events that would influence the levels of blood glucose.

i) Add labels to the arrows indicating when the individual ate and exercised. **1**

ii) Add one labelled line to the graph to indicate how levels of insulin would change over the same period. Add another labelled line to the graph to indicate how levels of glucagon would change over the same period. Note the vertical scale is arbitrary. **3**




**End of Exam**

**Student Name: ……**

# 2023

**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 2023 Marking Criteria

**Section I**

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

**Section II:**

Q 21

Identify the mode of inheritance.

| Criteria | Mark |
|---|---|
| • Student correctly identifies the mode of inheritance as autosomal recessive. | 1 |

**Sample answer**

*Autosomal recessive.*

**Question 29 (b)**

Individual II-3 wants to conceive a child with an affected female. Show your working to calculate the phenotypic AND genotypic ratio of their potential offspring.

| Criteria | Marks |
|---|---|
| • Student correctly identifies that person II-3 is *heterozygous*.<br>• Student correctly identifies that the phenotypic AND genotypic ratio of their potential offspring.<br>• Student shows their working. | 3 |
| • Student shows working to identify the genotypic and phenotypic ratio of a cross with some errors. | 2 |
| • Student provides some relevant information. | 1 |

| Criteria | Marks |
|---|---|
| • Student correctly identifies that person II-3 is *heterozygous*<br>• Student correctly identifies that the phenotype | |
| | |

**Sample answer**

*Based on the information provided, person II-3 must be heterozygous (Rr) as their mother (I-1) is affected (hh) but their father (I-2) is unaffected. As none of the people in generation II are affected, it is most likely that their father was homozygous dominant (HH), resulting in all heterozygous offspring.*

*If person II-3 (Hh) has a child with an affected female (hh) the genotypic and phenotypic ratio will be as follows:*

*Genotypic ratio:*
*50% heterozygous*
*50% homozygous recessive*

*Phenotypic ratio:*
*50% unaffected carriers*
*50% affected*

| *X* | *H* | *h* |
|---|---|---|
| *h* | *Hh* | *hh* |
| *h* | *Hh* | *hh* |

Markers note: many students did not include a key and some didn't follow conventions (capital letter for dominant allele, lower case for recessive, clear distinction between the two in terms of letter choice and dominant always placed first in genotype)
"Homozygous" is not enough information, "homozygous recessive" or "homozygous dominant"
Explicitly distinguish between phenotype and genotype when you present the results to ensure that you demonstrate knowledge of key terms.

Q22
a)

Identify the day on which ovulation would most likely occur.

| Criteria | Mark |
|---|---|
| • Student correctly identifies day 14. | 1 |

**Sample answer**

*Day 13 could be accepted as the diagram could be interpreted in this way.*

b)

Outline the role of progesterone once an egg has been fertilised.

| Criteria | Marks |
|---|---|
| • Student correctly outlines the role of progesterone once an egg has been fertilised. | 2 |
| • Student provides some relevant information. | 1 |

**Sample answer**

*Once the egg has been fertilised on Day 14, progesterone is released by the corpus luteum. Its role is to help maintain the endometrium for the fertilised egg to be implanted shortly after fertilisation. Once implantation occurs, progesterone maintains the pregnancy by maintaining the endometrium inside the uterus.*

c) Hypopituitarism is a disorder in which the pituitary gland is unable to produce hormones such as FSH and LH.

Use the diagram and your own understanding of female reproductive hormones to explain the impact this disorder would have on a woman's menstrual cycle and her ability to conceive a child.

| Criteria | Marks |
|---|---|
| Explains impact with reference to diagram and role of FSH and/or LH in terms of either stimulation of follicle production or interaction with other hormones. | 3 |
| Explains impact with reference to role of FSH and/or LH in terms of stimulation of follicle production and/or interaction with other hormones | 2 |
| Provides some relevant information | 1 |

Sample answer (note: if LH and FSH are treated holistically it would be reasonable)
FSH and LH are released by the pituitary gland and FSH stimulates the development of follicles in the ovary from which eggs are released. At low levels both hormones also stimulate the release of oestrogen, which can be seen in days 27 to 4 on the graph, leading to further development of the follicle. Therefore, if a woman had hypopituitarism, causing a lack of these hormones, she would be infertile due to an inability to trigger the development of the follicle and then to ovulate.

Markers note: this was marked generously with regards to reference to the diagram, be explicit in your wording.
Statements such as “will impact the person’s fertility” are meaningless unless you state the direction of impact (i.e. is it increasing or decreasing?). This is a common problem in responses in general.
Be specific. Don’t just say “FSH is critically important”, state why… “FSH is a hormone that stimulates the development of follicles from which ova are released”... that then links more strongly to your reasoning about how it affects fertility.

Q23a

| **Criteria** | |
|---|---|
| • Correctly identifies that segment 4 contains the cystic fibrosis allele AND provides a reason in reference to a recessive inheritance pattern | **2** |
| • Correctly identifies that segment 4 contains the cystic fibrosis allele | **1** |

*Sample answer*:

The DNA segment that contains the cystic fibrosis allele must be common to both the parents and the child, which is only true for segment 4. This is a recessive condition and will only be expressed in a homozygous recessive match-up, which indicates that the mother must also have a family history.

Markers notes: if appropriate justification and wording is made, child missing an allele that both parents have is also a reasonable interpretation, which makes segment 1 a reasonable answer.

Justifications need to provide complete reasoning, i.e. not only that the segment chosen meets the criteria, but also that no other segments do.

Q23b

Outline the process of DNA profiling.

| Criteria | Marks |
|---|---|
| • Student outlines and correctly orders multiple steps in the process of DNA profiling. | 3 |
| • Student identifies some steps in the process of DNA profiling. | 2 |
| • Student provides some relevant information. | 1 |

Sample answer

DNA profiling makes use of fragments of DNA known as short tandem repeats (STRs). STRs are non-coding regions of DNA and the number of repeats is unique to each individual person. The basic steps are as follows:

1. DNA is isolated and STRs are separated. They undergo polymerase chain reaction to increase the amount of DNA in the sample.
2. The sample then undergoes gel electrophoresis where fragments are separated by length. Short fragments will travel further in the gel than longer fragments.
3. The pattern created in the gel can then be used to compare STRs between individuals. The more similar the pattern, the more closely related the individuals are.

Q 24

Describe the role of complementary base pairing in the process of polypeptide synthesis and discuss the importance of complementary base pairing in ONE of the following biotechnological processes:

PCR (polymerase chain reaction) OR CRISPR-Cas9 editing.

| Criteria | Marks |
|---|---|
| • Correctly describes complementary base pairing, A-T, G-C<br>• Demonstrates a thorough understanding of the role of base pairing in polypeptide synthesis, including reference to synthesis of mRNA from DNA and the binding of mRNA to tRNA<br>• Demonstrates a thorough understanding of the importance of complementary | 6 |

| | |
|---|---|
| base pairing in one biotechnology, including:<br>○ A description of the technology<br>○ An accurate outline of the process involved in the technology, highlighting the role of complementary base pairing | |
| ● Correctly describes complementary base pairing, may include A-T, C-G<br>● Demonstrates a sound understanding of the role of base pairing in polypeptide synthesis, including reference to synthesis of mRNA from DNA and the binding of mRNA to tRNA<br>● Demonstrates a sound or thorough understanding of the importance of complementary base pairing in one biotechnology | 4-5 |
| ● Some description of complementary base pairing<br>● Demonstrates some understanding of the role of base pairing in polypeptide synthesis<br>OR<br>● Demonstrates some understanding of the importance of complementary base pairing in one biotechnology | 2-3 |
| ● Provides some relevant information | |

Sample Answer

Complementary base pairing involves the exact binding of thymine with adenine and cytosine with guanine. Its role is crucial in ensuring exact copying of nucleotide strands.

During protein synthesis, complementary RNA nucleotides must bind with the correct base in the DNA to produce a complementary nucleotide sequence on the mRNA. This mRNA leaves the nucleus and attaches to a ribosome, where tRNA molecules with complementary anticodons attach to the mRNA codons and bring the correct amino acids into line so that a polypeptide can be made. The complementary base pairing of nucleotides ensures that the genetic code in the DNA is correctly transcribed and translated to produce the correct amino acid sequence in the resulting polypeptide. Any error in the amino acid sequence could potentially cause a Mutation.

PCR is used to make multiple, exact copies of DNA. It is used to increase (amplify) the amount of DNA from a small sample so that there is enough to analyse in applications such as DNA profiling. The DNA to be copied is heated to separate the two strands and DNA primers, free nucleotides and DNA polymerase are added. The DNA primer binds to the starting sequence on the single strands of DNA by

complementary base pairing. The DNA polymerase then attaches free nucleotides to the exposed bases on the single strands. Complementary base pairing ensures that the primer binds to the DNA and the correct bases bind to the single strands throughout the process so that exact copies of the DNA are produced. The process is repeated many times to amplify the DNA.
In CRISPR technology, complementary base pairing allows for very accurate editing of DNA. The DNA to be edited is targeted by a guide RNA attached to a Cas9 enzyme. The guide RNA must have a base sequence complementary to the specific sequence on the target DNA. Complementary base pairing ensures that the enzyme is brought into the exact position to cut the DNA at the desired location. The process is derived from bacteria that use it to remove viral genes that have been inserted into their genome. It is used in biotechnology to insert genes from one species into another to produce recombinant DNA and has the potential to allow healthy genes to be inserted into the genome of patients suffering from genetic diseases, such as cystic fibrosis.

Markers notes:so many students didn't make clear what complementary base pairing actually is- A-T/C-G. MAny did not make that the focus of the question, instead got lost in the mechanics of processes. Refer to the outline of the general process, focusing in what is key in the question: importance of CBP. Why do these bases NEED to be complimentary?? What are they actually carrying around - the GENETIC CODE - it needs to be an EXACT replica of te DNA!

Q25

| Criteria | Marks |
|---|---|
| • Identifies meiosis as the process that produces gametes<br>• Demonstrates a thorough understanding of how meiosis contributes to variation in gametes, including crossing over and independent assortment of alleles<br>• Demonstrates a thorough understanding of how random fertilisation contributes to variation in offspring | 4 |
| • Identifies meiosis as the process that produces gametes<br>• Demonstrates some understanding of how meiosis contributes to variation in gametes, including crossing over and/or independent assortment of alleles<br>• Demonstrates some understanding of how random fertilisation contributes to variation in offspring | 3 |
| • Identifies meiosis as the process that produces gametes<br>• Demonstrates some understanding of how meiosis or random fertilisation contribute to variation in gametes | 2 |
| • Provides some relevant information | 1 |

***Sample Answer***

Gametes are formed by the process of meiosis in the sex organs of males and females. One parent cell undergoes two divisions to produce gametes with half the original number of chromosomes.

Homologous chromosomes pair during late prophase and metaphase and segregate into gametes independently of each other so there will be a mixture of paternal and maternal chromosomes in the gametes. Crossing over occurs so individual chromosomes then carry a mixture of maternal and paternal alleles. Independent assortment and crossing over mean the gametes will have a mixture of paternal and maternal alleles, creating variation. When fertilisation occurs, male and female gametes combine randomly and this further contributes to variation in the resultant offspring.

Markers notes:Essential to ALWAYS talk about the THREE processes in meiosis that contribute to genetic variation: crossing over AND describe it; random segregation AND independent assortment. Don't get caught up in the semantics of these last 2, they are always confused, but describe that the chromosomes are randomly separated and the alleles are independently assorted from one another into the gametes.AND fertilisation is the mixing of 2 different gametes

Q26

| Criteria | Marks |
|---|---|
| • Clearly describes an example of a trait in a named plant or animal that is affected by environment | 2 |
| • Provides some relevant information | 1 |

***Sample Answer***

Himalayan rabbits have white fur on their bodies with darker fur on their extremities. The gene for dark pigment is temperature-dependent and is only expressed in regions of the body that are cooler than core body temperature, such as the nose, ears and feet.

*Other examples include: fur colour in Siamese cats; flower colour in hydrangeas, dependent on soil pH; queen bee development by royal jelly; plant height affected by availability of nutrients and space (creating bonsai).*

Also accepted: height and skin in humans (though named organism is “human” or “Homo sapiens” not “person”)

Markers notes: quite a few students confused environmental influence on phenotype with environmental selection pressures, which is a misinterpretation of the question.

Q27

| Criteria | Marks |
|---|---|
| • Student demonstrates extensive understanding of two of the following processes: mutation, genetic drift and gene flow<br>• Student thoroughly explains how these processes could impact the future gene pool of the cheetah<br>• Student uses the stimulus to support all explanations provided | 7 |
| • Student demonstrates thorough understanding of two of the following processes: mutation, genetic drift and gene flow<br>• Student provides some explanation of how these processes could impact the future gene pool of the cheetah | 6 |
| • Student demonstrates a sound understanding of two of the following processes: mutation, genetic drift and gene flow<br>• Student provides some explanation of how these processes could impact the gene pool of the cheetah | 4-5 |
| • Student demonstrates some understanding of: mutation and/or genetic drift and/or gene flow<br>AND/OR<br>• Student provides some explanation of changes in genes within a population and their subsequent impact on future cheetah populations | 2-3 |
| • Student provides some relevant information | 1 |

Markers notes: definitions are required to show thorough knowledge

If all three terms were used, then marking was based on a balance across all three terms or the two terms that were written about most confidently depending on which would maximise marks.

For thorough and above, knowledge had to be accurate, avoid contradictions and consistent throughout at least the two terms counted towards the mark.

Definitions were treated as interchangeable between terms to allow for maximum marks in the instance where definitions were not provided for all terms discussed. The same goes for depth of engagement with stimulus material.

**Common misconception:** inbreeding increases the rate of mutation. It increases the expression of recessive alleles (mutations that are often harmful), but does not make more mutations occur.

**Extensive vs thorough:** linking very confidently to the stimulus material (seeing opportunities to relate ideas such as climate change to geographic isolation or disasters that might cause genetic drift) and showing depth of understanding of concepts (distinguishing between

germline and somatic mutations, referring to alleles and allele frequencies accurately throughout, identifying causes of the processes, linking inbreeding to expression of alleles rather than increased number of mutations.

**Sample answer**

*The cheetah is a vulnerable species of large cat, that since the 19th century has seriously declined in population, from approximately 100,000 to 8,000 cheetahs. In the present day, they face many challenges such as low reproductive success, hunting, and climate change. Currently, cheetahs also have low genetic variability.*

*Mutation within the cheetah population could have a few possible effects on the future gene pool. Mutation is the random change in the genetic sequence. They can be random or can be caused by a mutagen such as UV radiation or chemical exposure. Random change in the genetic sequence can increase the genetic variability between the cheetah populations. If the mutation is helpful, it will be passed on to offspring, increasing the genetic differences between the subspecies in Africa and the Middle East. However, mutation can have harmful effects, and if the genetic mutation that occurs doesn't increase the survivability of the cheetah then it will not be a favourable trait and therefore will not eventually increase the genetic variation of the cheetah population.*

*Gene flow is the movement of genetic material from one population to another. It relies on the separation of populations. The map above shows there are four subspecies of cheetah, and whilst some cheetah subspecies live close enough for gene flow to occur, others do not. The rate of gene flow between the A.j. soemmeringii subspecies and the A.j.jubatus subspecies may be quite high, as these subspecies are more widespread, and also close enough to one another that members of each subspecies could mate. This gene flow increases genetic variability and limits the chance of inbreeding, this will have a positive impact on the cheetah population in the future as increasing genetic variability increases the likelihood of survival. However, the populations of A.j. hecki and A.j. venaticus are quite isolated, so gene flow with these populations may be limited. This could eventually cause speciation, where these populations become so different genetically to other cheetah species that they are unable to mate. This further reduces the population size and genetic variability, further increasing the chance of inbreeding, which increases the likelihood of offspring having genetic traits that are unfavourable to survival.*

*Genetic drift is the change in frequency of alleles due to chance. The population of the cheetah has dramatically decreased in the 19th century, from 100,000 to 8,000. This could be classified as a bottleneck event. As a result, the remaining cheetah left to reproduce have lower genetic variability as there is low population size. In future, if the cheetah population is to increase, this low genetic variation will remain within the population. There is higher risk of inbreeding and lower chance of beneficial alleles being present within the population. Further to this, if the populations of A.j. hecki and A.j. venaticus remain isolated, the founder effect may occur. The founder effect occurs when a small group from an original population is geographically isolated from the original population. Due to its small size, there is low genetic variation and therefore increased risk of inbreeding.*

Q28

| Criteria | Marks |
|---|---|
| • Clearly outlines an example of how population genetics data or genetics technologies are used in conservation of a named endangered animal or plant species | 3 |
| • Outlines an example of how population genetics data or genetics technologies are used in conservation | 2 |
| • Provides some relevant information | 1 |

***Sample Answer***

DNA profiling is being used to identify and trace the origin of elephant ivory, enabling authorities to identify areas where poaching is occurring and to prosecute wildlife poachers and traffickers.

*Other examples include:*

*Genome sequencing is employed to monitor the genetic variation in wild populations of the endangered northern quoll and to select specific individuals to use in captive breeding programs.*

*Scientists have harvested eggs from the last two remaining females of the critically-endangered northern white rhinoceros in the hopes that whole animal cloning can be used to bring the species back from the brink of extinction.*

*Study of genome markers in koala populations have shown that NSW and Queensland populations retain significant levels of genetic diversity. Ensuring this diversity is maintained will accompany conservation measures to protect koalas and their habitat.*

*The genome of the koala has been sequenced. Immune-system genes are being studied in the hopes of developing a vaccine against chlamydia, which is a major threat to koala survival.*

Common issue was speaking too broadly about data types and technologies or referencing only the reproductive aspects of technologies such as IVF or cloning, without relating it to genetics.

Another occasional problem was students referencing future technologies as if they were present day technologies - given the wording of the question this type of answer was not accepted unless it was made clear that the technology was not yet established for that species, but has potential.
Another occasional problem was students using examples that related to non-endangered species, or including inaccurate statistics in their responses.

Q29

| Criteria | Marks |
|---|---|
| • Describes TWO differences between eukaryotic and prokaryotic DNA | 2 |
| • Describes ONE difference between eukaryotic and prokaryotic DNA<br>OR<br>• ONE difference described correctly for each of eukaryotic and prokaryotic DNA | 1 |

**Prokaryotic DNA:**

- Is found freely in the cytoplasm (within a region called the nucleoid)
- Is naked (i.e. not bound with proteins and therefore doesn't form chromatin)
- Genomes are compact (contain little repetitive DNA and no introns)
- Contains extra-chromosomal plasmids
- Is circular in shape

**Eukaryotic DNA:**

- Is contained within a nucleus
- Is bound to histone proteins
- Genomes contain large amounts of non-coding and repetitive DNA (including introns)
- Do not contain plasmids (but organelles such as the mitochondria may contain their own chromosomes)
- Are linear in shape

Prokaryotes have a single circular chromosome composed of double-stranded DNA, whereas eukaryotes have multiple, linear chromosomes composed of chromatin surrounded by a nuclear membrane
A cell's DNA, packaged as a double-stranded DNA molecule, is called its genome. In prokaryotes, the genome is composed of a single, double-stranded DNA molecule in the form of a loop or circle. The region in the cell containing this genetic material is called a nucleoid. Some prokaryotes also have smaller loops of DNA called plasmids
NOTE: many students have confused single stranded DNA in prokaryotes- they are also double stranded. Viruses can be single stranded DNA or RNA, BUT prokaryotic DNA is double stranded

Question 29b

| Criteria | Marks |
|---|---|
| ● Demonstrates a thorough understanding of how recombinant DNA/plasmids are used in both agriculture and medicine<br>● Provides reasoned justification thoroughly supported through at least TWO examples, one for medicine AND one for agriculture<br>● Both given examples are thoroughly explained as transgenic organisms | 8 |
| ● Demonstrates a thorough understanding of how recombinant DNA/plasmids are used in both agriculture and medicine<br>● Provides reasoned justification thoroughly supported through at least TWO examples, one for medicine AND one for agriculture<br>● Example/s are explained/ described as transgenic organisms | 7 |
| ● Demonstrates an understanding of how recombinant DNA/plasmids are used in both agriculture and medicine<br>● Provides some reasoned justification supported through at least TWO examples, one for medicine AND one for agriculture<br>● Both given examples are described as transgenic organisms | 6 |
| ● Demonstrates an understanding of how recombinant DNA/plasmids are used in agriculture AND/OR medicine<br>● Provides some reason and/or justification supported through one example, one for medicine AND/OR one for agriculture<br>● One given example is thoroughly explained as transgenic organisms OR both are described | 4-5 |
| ● A relevant example/s identified/described<br>● A reason given for its use | 2-3 |
| ● Any relevant information | 1 |

***Sample Answer***

**Agriculture**

The illustrated process is used to create transgenic organisms that can express genes from other species. In agriculture, this is used to produce crop plants with desired characteristics to improve yields and efficiency. Recombinant plasmids from *Agrobacterium* are used in the production of BT cotton. The inserted gene is from a bacterium that produces a toxin that kills caterpillars. The BT cotton produces the toxin in its own cells and is thus resistant to leaf-eating caterpillars, reducing the need to use pesticides on the crop.

Genes that give herbicide resistance have been inserted into soybeans and corn so the crops can be treated with herbicide to kill weeds, leaving the crop unaffected. These crops make agriculture more economical and reduce environmental impact as fewer applications of herbicide are necessary for weed control.

Transgenic cows contain genes for improved meat production, milk quality and yield. Transgenic sheep have genes inserted to improve wool quality and yield. These technologies increase the productivity of farmers and can potentially ensure future food security.

**Medicine**

Pharmaceutical products have been produced by recombinant DNA technology. Insulin extracted from cow tissues was originally used to treat patients with diabetes but this occasionally caused allergic reactions. Transgenic bacteria, containing the human gene for insulin, have provided a cheaper and plentiful supply of human insulin for diabetes patients.

Transgenic animals have had genes inserted for the production of pharmaceutical products, *e.g.* human blood-clotting factor produced in the milk of transgenic sheep and spider silk protein from transgenic goats, which can be used to make artificial ligaments and tendons.

Recombinant DNA techniques have improved vaccine production. Genes that code for specific antigens have been introduced into yeast cells, which multiply rapidly to produce large quantities of the antigen for making the vaccine.

*Other examples include:*

***Agriculture***

- *Camel chymosin has been produced using recombinant plasmids in yeast to provide a ready supply of enzyme for cheese-making. It is difficult and time-consuming to make cheese from camel milk using currently-available cultures, so a ready supply of chymosin has the potential to increase efficiency and yields.*
- *As soils in Australia are becoming more saline, researchers are trialling transgenic plants that have a gene inserted to increase the exclusion of sodium ions from plant cells. It is hoped that this will improve the salt tolerance of crops.*
- *Genes that increase heat tolerance have been inserted into crop plants in the hopes that they will survive higher temperatures resulting from climate change.*
- *Recombinant DNA technology has been used to produce rice that contains a large concentration of Vitamin A (golden rice). It is hoped this will assist in curbing Vitamin A deficiency, which often leads to childhood blindness, in areas where rice is the staple diet. While development has been slow, due to regulatory delays and varying results from trials, a variety that contains a gene from sweet corn has recently become the first variety to be planted and harvested commercially, in the Philippines.*

***Medicine***

- *Gene therapy, e.g. recombinant plasmids have been used to carry healthy genes into the lung tissue of cystic fibrosis sufferers.*
- *Transgenic lactic acid bacteria that secrete a human protein and can be ingested are being trialled as a treatment for Crohn's disease.*
- *Transgenic animals are being used in medical research, e.g. mice that contain a human gene associated with motor neurone disease are being studied to investigate potential treatments for the disease.*
- *The genome of insect vectors can be modified as a method for control of vector-borne diseases, e.g. male Aedes aegypti mosquitoes have been engineered to transmit a gene to their offspring causing the offspring to die before becoming sexually mature. Trials in Brazil showed a 95% decrease in mosquito populations following the sustained release of the genetically-engineered males.*

Q30 a)

| Criteria | Marks |
|---|---|
| • Clearly outlines a method using Koch's postulates, including four steps | 4 |
| • Outlines a method using Koch's postulates, including three steps | 3 |
| • Outlines a method using Koch's postulates, including two steps | 2 |
| • Provides some relevant information | 1 |

***Sample Answer***

- Isolate the suspected pathogen from the diseased area of the leaf.
- Grow the suspected pathogen in pure culture.
- Infect disease-free leaves with the suspected pathogen from the culture. The infected leaves should show the same symptoms as the original diseased leaves.
- Isolate the suspected pathogen from the infected leaves and grow it in culture. It should be identical to the pathogen in the first culture.

NOTE: Must be clear that the isolated bacteria is grown in a culture (agar is ok), but not just 'petri dish' - what's in the petri dish?
Many students were missing the last step…. reisolate/culture & compare to original culture to ensure it's the same
Use specific terms: 'isolate'; 'pure culture'

Q30 b)

| Criteria | Marks |
|---|---|
| • Names an Australian plant<br>• Names a pathogen that triggers a response in that plant<br>• Explains the plants response to that pathogen | 3 |
| • Names an Australian plant<br>• Names a pathogen or disease associated with a response in that plant<br>• Describes the plants response or symptoms to that pathogen<br>Or<br>• Explains a response to a named pathogen of a non-Australian plant | 2 |
| TWO of:<br>• Names a plant<br>• Names a pathogen or disease that affects that plant | 1 |

| | |
|---|---|
| • Describes a plant response to a pathogen<br>OR<br>• Explains a plant response to a broad group of pathogens | |

Markers notes:
Common problems:

- Using non-Australian examples
- Naming disease rather than pathogen
- Naming general defenses rather than responses - which needed to be explained, not just described.

It was clear that many examples were coming from textbooks that have not provided a clear-cut example to help answer questions relating to this outcome. A couple of the common Year 12 textbooks go into ideas such as oxidative burst, hypersensitive response and RNA silencing without giving you an example of a named Australian species, with a named pathogen that it is impacted by and to which it has a particular response. The reason we explicitly teach *P. cinnamomi* infecting Australian eucalypts and causing Jarrah dieback is that it addresses the dot point and the response is relatively easy to remember and understand. And just a reminder that the pathogen group that *P. cinnamomi* belongs to is the oomycetes.

Sample answer
*P. cinnamomi* is a pathogen that infects Australian eucalypts causing Jarrah dieback. In response to the pathogen, the plant increases production of lignin, which provides added protection to the plant cell walls. This limits the spread of the pathogen from cell to cell within the infected area.

31 a)

| Criteria | Marks |
|---|---|
| • Demonstrates a clear understanding of the benefits of asexual reproduction in a human parasite | 2 |
| • Provides some relevant information | 1 |

***Sample Answer***

The environment inside the human host would be quite stable so trypanosomes that survive in the bloodstream would pass on their favourable characteristics to their offspring through asexual reproduction. Asexual reproduction also allows for rapid replication, which would increase the chances of the tsetse fly taking up the parasite during a blood meal.

Markers notes: note the wording of the question. It is asking for benefits. Given that it is only a two mark question, as long as you included one benefit and a clear understanding of a limitation, you received two marks; however, that was a generous approach to take. If it asks for benefits, give two benefits.

b)

| Criteria | Marks |
|---|---|
| • Identifies that sexual reproduction would result in variation in offspring<br>• Relates this variation to the potential for drug resistance to develop | 2 |
| • Provides some relevant information | 1 |

***Sample Answer***

Sexual reproduction and the production of hybrid trypanosomes would result in increased variation in the population. Any mutation that confers drug resistance could be passed to many other individuals during the sexual phase in the salivary glands of the tsetse fly and these drug-resistant trypanosomes could then be passed to many human hosts. Selective pressure imposed by administration of the drug would favour drug-resistant trypanosomes and they would increase in frequency in subsequent populations.

**Sample answer**

Sexual reproduction results in offspring with variation. If any of this variation confers resistance to drugs on offspring, there is the potential for drug resistance to increase and for the eventual emergence of an entirely drug resistant population of these pathogens.

Markers notes: a simple response for this was perfectly appropriate, but it needed to be an accurate one. Many of you answered it as if it were asking about bacteria, in which variation arises through mutation. In most sexually reproducing organisms, mutation rates are actually lower. That may or may not be the case for this group, but there would certainly be no assumption that mutation rates would increase as sexual reproduction occurs. As long as answers also related sexual reproduction to variation through sexual means, then marks were not lost for this inaccuracy; however if it was the only explanation provided, full marks could not be awarded.

c)

| Criteria | Marks |
|---|---|
| • Demonstrates an understanding of vector control and provides at least two ways by which tsetse fly populations could be reduced | 2 |
| • Provides some relevant information | 1 |

***Sample Answer***

One way to control the spread of a vector-borne disease is to reduce the population of the vector. A program to eradicate the tsetse fly could include spraying breeding areas to kill the flies or introducing sterile males into populations so that reproduction of the flies would be reduced.

Markers notes: responses needed to relate to the transmission of this particular pathogen by referring to control of vector populations or inhibiting vector biting in some manner. Quarantine was only accepted if the response included the notion that it could somehow minimise vector transmission.
Quite a few students introduced the idea of mosquito vectors when the stimulus made it clear that tsetse flies are the vectors in this instance.

d)

| Criteria | Marks |
|---|---|
| • Justifies the statement, demonstrating a thorough understanding of vaccine function, including specificity of antigen-antibody binding | 3 |
| • Justifies the statement, demonstrating some understanding of vaccine function, including specificity of antigen-antibody binding | 2 |
| • Provides some relevant information | 1 |

***Sample Answer***
A vaccine can be produced using an antigen from the pathogen. When the vaccine is administered, the patient's immune system produces B cells, which secrete antibodies, and T cells, which kill infected host cells. The immune cells and antibodies are specific to the antigen in the vaccine. If the person is exposed to the pathogen, the antibodies will only bind to the antigens on the pathogen if they are still the same as the antigen used in the vaccine. If the antigens on the pathogen have changed, then the vaccine will no longer protect an individual from developing the disease.

Markers notes: a thorough understanding of vaccine function needs to include how the vaccine introduces the antigen (e.g. using an attenuated pathogen or mRNA)
Again, be careful of vagueness - don't refer to "disease" when you mean "pathogen", don't confuse B and T cells or only say B cells when you mean plasma B cells
Use terminology - antigens.

Q 32 a)

Describe the processes involved in the production of antibodies to the alpha-gal sugar.

| Criteria | Marks |
|---|---|
| • Student extensively describes the processes involved in the production of antibodies to the alpha-gal sugar. | 5 |
| • Student thoroughly describes the processes involved in the production of antibodies to the alpha-gal sugar. | 4 |
| • Student soundly outlines the processes involved in the production of antibodies. | 3 |
| • Student provides some steps involved in the adaptive immune response. | 2 |
| • Student provides some relevant information. | 1 |

**Sample answer**

*When the alpha-gal sugar is released into the blood, it triggers an immune response. Once the sugar is in the bloodstream it would encounter antigen-presenting cells (APCs) such as macrophages or neutrophils. These cells would then engulf the sugar molecule and present this to the helper T-cell in the lymph node. The helper T-cell then triggers a naïve B-cell to differentiate into plasma B-cells and memory B-cells. The plasma B-cells then start to produce antibodies that can work against the alpha-gal sugar. When the person eats meat containing the alpha-gal sugar, the memory B-cells are triggered and more plasma B-cells will be made, triggering an allergy-like reaction.*

Markers note:
For extensive: antigen presenting cell presents sugar → helper T cell stimulates → naive B cell to differentiate and proliferate into → plasma B cells → produce antibodies (also needs to be clearly and consistently primary exposure)
For thorough: as above but could be missing one step (still needs to include plasma B cells)
For sound: as above, but missing two steps.

Q32 b)

Scientists have found that alpha-gal is unable to be passed from human to human.

Is alpha-gal syndrome an infectious or non-infectious disease? Justify your answer.

| Criteria | Marks |
|---|---|
| • Student provides a judgement that the disease is non-infectious.<br>• Student provides thorough reasons for the disease being non-infectious. | 4 |
| • Student provides a judgement about the disease being infectious or non-infectious.<br>• Student provides sound reasoning for their choice. | 3 |
| • Student provides some points about non-infectious diseases. | 2 |
| • Student provides some relevant information. | 1 |

**Sample answer**

*Alpha-gal syndrome is non-infectious. It is not caused by a pathogenic agent as it is caused by a sugar molecule. It is unable to be passed from an infected organism to another infected organism. The tick acts as a vector that transmits a sugar molecule that is naturally found in the non-primate mammal's tissue into a human.*

Note: correct definition for either infectious or non-infectious disease required to complete reasoning. Some points about infectious disease also accepted for 2 marks.

Q33 a)

With reference to the feedback loop above, explain why a person with Type 1 Diabetes must inject insulin when they eat.

| Criteria | Marks |
|---|---|
| • Student thoroughly explains the relationship between a person with Type 1 Diabetes and their need to inject insulin.<br>• Student references the feedback loop throughout their response. | 4 |
| • Student soundly explains the relationship between a person with Type 1 Diabetes and their need to inject insulin.<br>• Student attempts to make links to the feedback loop provided. | 3 |
| • Student makes an attempt to outline the importance of insulin to a person with Type 1 diabetes.<br>• Student does not reference the feedback loop. | 2 |
| • Student provides some relevant information. | 1 |

**Sample answer**

*Type 1 Diabetes is a disease where someone produces little or no insulin. Normal blood glucose level is approximately 90mg/100mL and insulin is an important hormone in maintaining this level during and after consumption of foods, in particular glucose. When a person with Type 1 Diabetes consumes glucose, their blood glucose level will rise. As the pancreas is unable to produce insulin, a person with Type 1 Diabetes will need to inject the insulin so that the liver can take up the glucose and store it as glycogen. This then causes blood glucose levels to decrease back to normal blood glucose levels.*

NOTE: Poorly answered. Students are not being specific and instead using very vague statements: anything to do with a negative feedback loop, language that must be used: '*return levels back to normal BGL which is 90mg/100mL'.* Can't just say 'decrease glucose levels' …to what? Does it continue to decrease? KEY:insulin is a vital hormone that ensures blood glucose levels are maintained AND it brings the BGL back to a steady state

Q33 b

i)

| Criteria | Marks |
|---|---|
| Clear, correct labels added | 1 |

ii)

| Criteria | Marks |
|---|---|
| Both lines added and labeled<br>Both lines rise and fall in the appropriate places | 3 |
| One line added and labeled<br>Line rises and falls in the appropriate places | 2 |
| One line added and labeled<br>Line either rises or falls in one appropriate place | 1 |