Part A – 20 marks
Attempt Questions 1 – 20
Use the multiple-choice answer sheet.

1. Which of the following lists the five steps in the stimulus-response model in the correct order?

(A) receptor, stimulus, coordinating centre, effector, response

(B) receptor, stimulus, effector, coordinating centre, response

(C) stimulus, receptor, coordinating centre, effector, response

(D) stimulus, effector, coordinating centre, receptor, response

2. Viruses are

(A) unicellular.

(B) multicellular.

(C) smaller than bacteria.

(D) larger than protists.

3. The application of computers and statistics to manage and interpret large biological data sets is called

(A) bioinformatics.

(B) biochemistry.

(C) biotechnology.

(D) comparative genomics.

4. Which of the following is an example of the first line of defence?

(A) Production of antibodies

(B) Increase in blood flow to the infected area

(C) Tight junctions between epithelial cells

(D) The engulfing of pathogens by macrophages

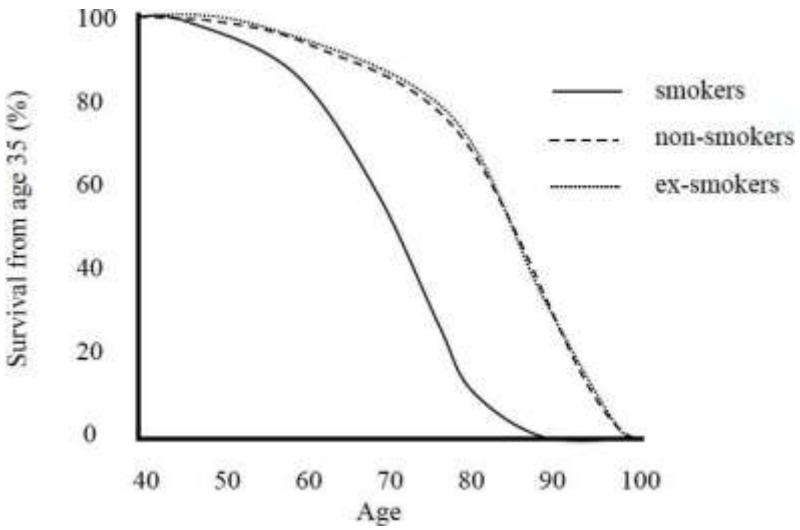
Questions 5 - 7 refer to the information below about the British Doctors' Study.

The British Doctors' Study was an epidemiological cohort study which started in 1951 and ran until 2001.

It set out to establish whether, as strongly suspected, there was a link between smoking and health outcomes. It was the first study to prove the link between smoking and lung cancer and was hugely influential in informing government moves to reduce smoking.

A very large number of male doctors were sent health surveys at regular intervals. These asked questions about any health issues they might have as well as about lifestyle factors such as alcohol consumption, diet and smoking habits.

The simplified graph below illustrates one of their findings.



5. What percentage of smokers survived to age 70?

(A) 35%

(B) 45%

(C) 55%

(D) 65%

6. Which one of the following statements about giving up smoking is best supported by this graph?

(A) If you give up smoking early enough, you have virtually the same life expectancy as a non-smoker.

(B) More people give up smoking before the age of 40 than do afterwards.

(C) It is smoking early in life which causes most of the damage to health.

(D) Giving up smoking gives you a better life expectancy than a smoker, but not as good as someone who has never smoked

7. What was the independent variable in this study?

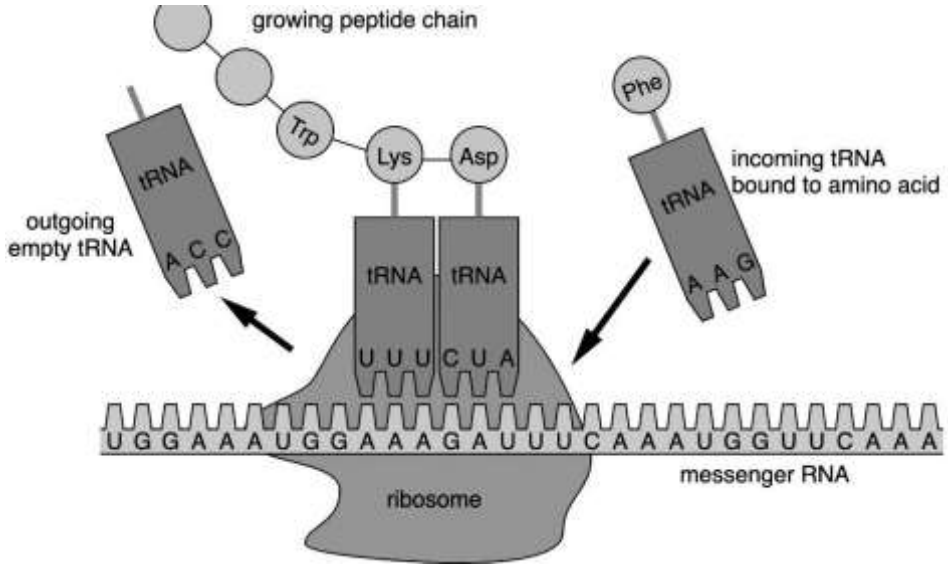
(A) age

(B) smoking habits

(C) gender

(D) cancer rate

8. Below is a diagram of a process during protein synthesis



Boumphreyfr vector conversion by Glrx, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons

Determine the DNA sequence that codes for the amino acid "Asp".

(A) C T A

(B) C U A

(C) G A T

(D) G A U

9. 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) co-dominance

(C) hybrid vigour

(D) polygenic expression

10. 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) 13

(B) 136

(C) 1 136

(D) 11 360

11. When considering the ethical implications of a biotechnology, ethicists would give most consideration to:

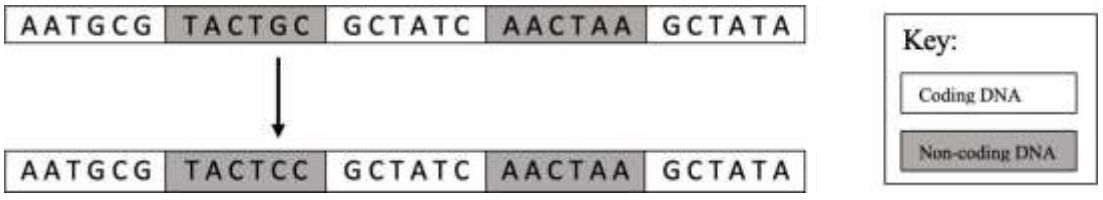
(A) the possible economic gains to be had from the biotechnology.

(B) the views of religious leaders.

(C) the views of scientists working in the field.

(D) the rights of people and organisms affected by the biotechnology.

12. The diagram below shows a point mutation occurring on a strand of DNA.



What is the most likely possible outcome of this point mutation on the phenotype of the individual?

(A) Change to phenotype as the mutation occurs on non-coding DNA.

(B) No change to phenotype as the mutation occurs on non-coding DNA.

(C) Change to phenotype as all mutations affect the phenotype, regardless of where they occur.

(D) No change to phenotype as point mutations do not affect the phenotype of the individual.

13. Certain diseases can be caused by the ingestion of food contaminated with a pathogen that is a misfolded protein. This type of pathogen is a:

(A) prion

(B) plasmid

(C) parasite

(D) virus

14. Babies born in Australia are tested after birth for phenylketonuria (PKU). Individuals with PKU cannot metabolise the amino acid phenylalanine but can remain healthy if they avoid eating high-protein foods. PKU is a(n):

(A) nutritional disease

(B) environmental disease

(C) infectious disease

(D) genetic disease

15. Scientists are investigating the mitochondrial genomes of different Aboriginal Australian populations. A purpose of these investigations is to reveal the pathways of migration of Aboriginal Australians who arrived from Sahul. Mitochondrial DNA can be used for this purpose because it

(A) contains genes that code for enzymes.

(B) is always the same in specific populations.

(C) is conserved through the maternal lineage.

(D) is more structurally stable than nuclear DNA

16. Which epigenic mechanism can repress gene expression?

(A) Methylation of DNA

(B) Acetylation of histones

(C) Transcription of non-coding RNAs

(D) Chromosomal recombination

Questions 17 - 18 refer to the following information

In the technique of genetic profiling, each DNA profile represents several loci (gene positions) on a pair of homologous chromosomes.
DNA profiles for three animals of the same species are shown below.

Locus	Allele	Animal 1	Animal 2	Animal 3
A	1	▬		
	2		▬	
	3		▬	
	4	▬		▬
	5			▬
B	1			
	2		▬	
	3	▬		
	4	▬	▬	▬
	5			▬
C	1			▬
	2			▬
	3	▬		
	4		▬	
	5			
D	1	▬		
	2		▬	
	3		▬	
	4			▬
	5	▬		
E	1			
	2	▬	▬	
	3			▬
	4		▬	▬
	5			

17. At how many loci is Animal 2 homozygous?

(A) 1

(B) 2

(C) 3

(D) 4

18. If Animal 1 mated with Animal 3 and produced a single offspring, the offspring

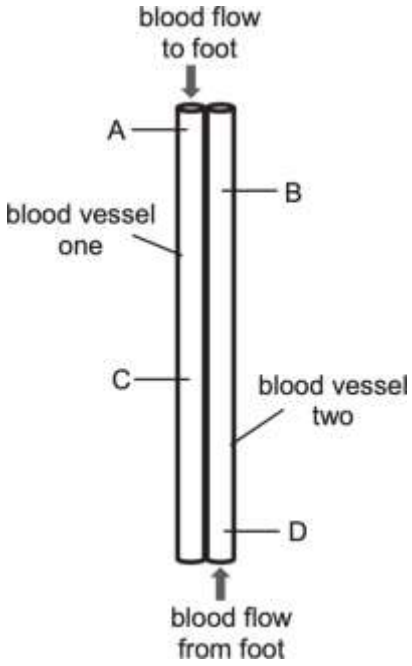
(A) Must be homozygous at locus A

(B) May be homozygous at locus D

(C) Could be either homozygous or heterozygous at locus C

(D) Must be heterozygous at locus E

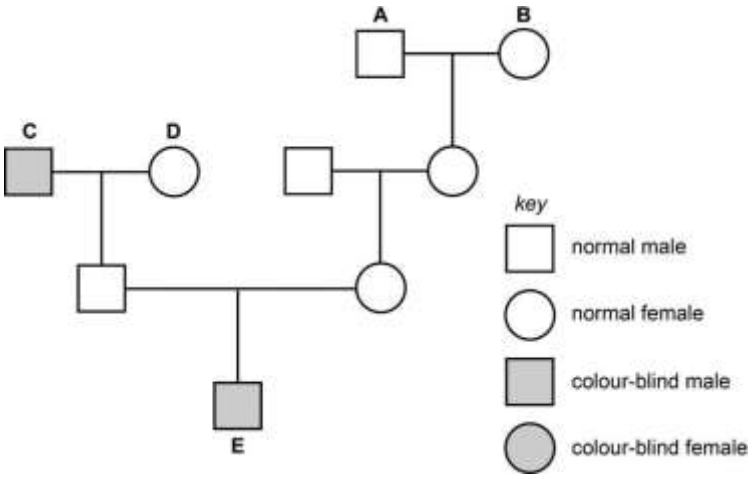
19. Birds that live in cold environments have a counter-current heat exchange system in their legs, which is shown in the diagram below.



The temperature of the blood is lowest at position

(A) A
(B) B
(C) C
(D) D

20. The diagram below shows a pedigree of a family carrying the sex-linked allele for red-green colour blindness.



From which member of his family did E inherit the allele for colour-blindness?

(A) A
(B) B
(C) C
(D) D

Part B

Answer the questions in the spaces provided.

Marks

Question 21 (6 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) Outline TWO plant adaptations for defence against pathogens. **2**

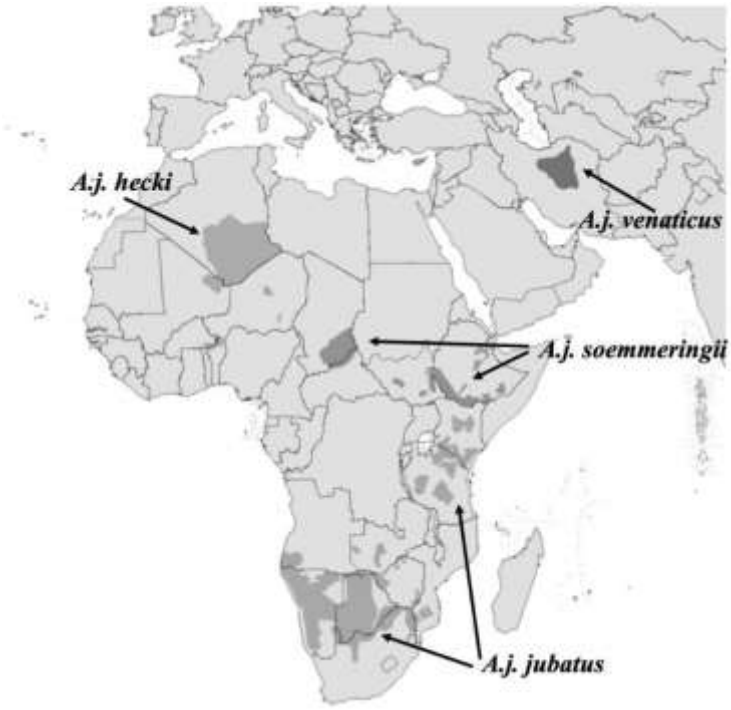
(b) Describe the steps a pathologist could use to test the hypothesis that the suspected bacterium is the cause of the disease. **4**

Question 22 (11 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.

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



Question 22 continues on page 11

Question 22 (continued) **Marks**

(a) Explain how gene flow and genetic drift could impact the future gene pool of the cheetah. **5**

(b) Describe how DNA profiling can be used to show genetic diversity within a population **3**

Marks

3

(c) Explain how information gained through DNA profiling of cheetah populations can hel direct efforts to conserve them.

Question 23 (3 marks)

Compare the processes of DNA replication and Polymerase chain reaction (PCR). **3**

……

……

Marks

Question 24 (4 marks)

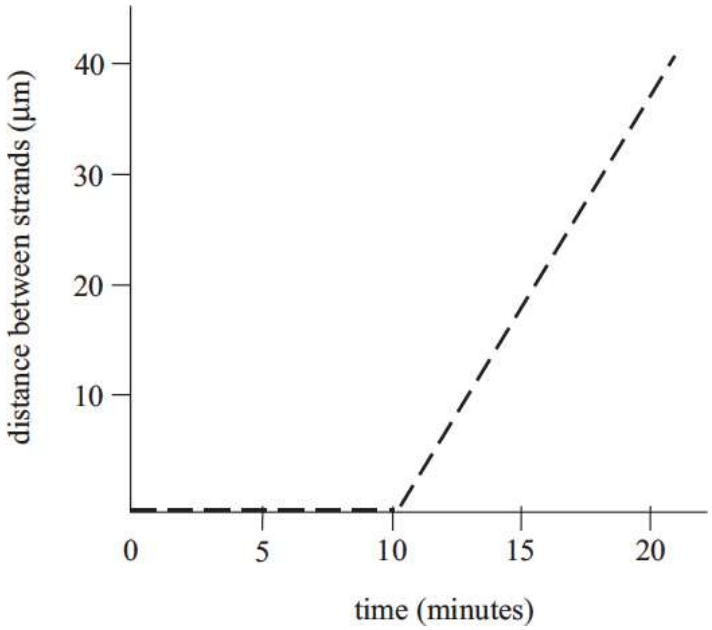
Influenza is an infectious respiratory disease. In humans, it can be caused by the influenza A or influenza B viruses **4**

Natural killer cells and cytotoxic T cells both play an important part in the human immune response to the virus causing influenza.

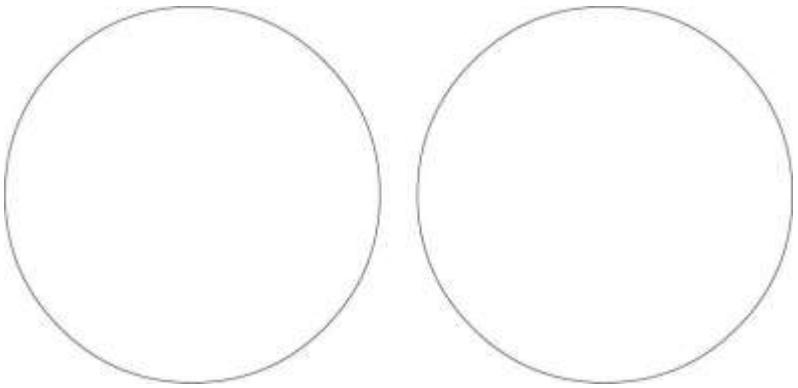
Compare the roles played by each of these two types of cells in the immune response to the influenza virus.

Question 25 (3 marks) **Marks**

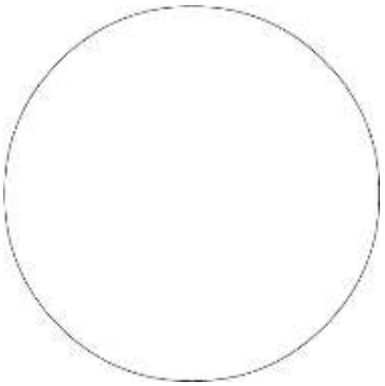
The following graph, which shows the distance between the sister chromatids of a replicated chromosome during a mitotic cell division:



Draw diagrams to show the arrangement of the chromosomes at 10 minutes, 15minutes and at 20 minutes in a diploid cell containing four chromosomes. **3**



Pattern at 10min. Pattern at 15 min



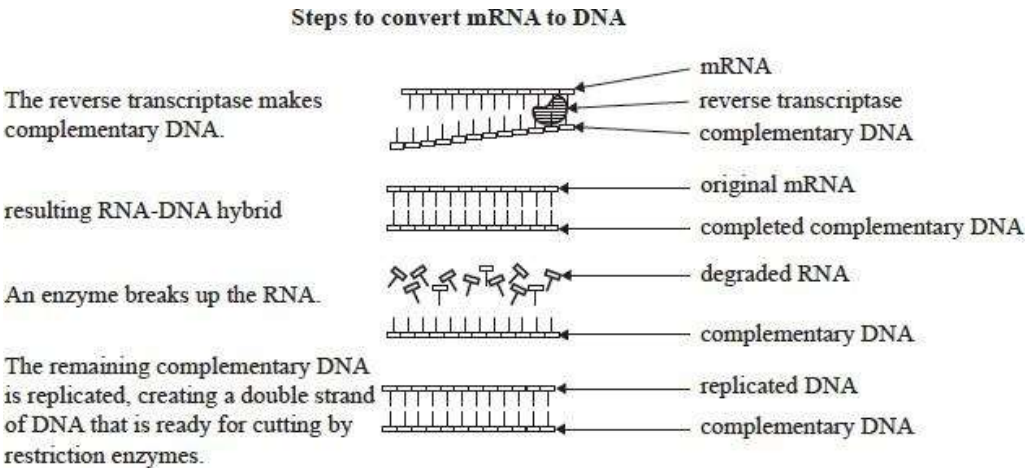
Pattern at 20min

Question 26 (5 marks) **Marks**

Artificial insulin has revolutionized the treatment of diabetes, providing an effective means of managing blood glucose levels.

Before restriction enzymes cut the insulin gene. Mature mRNA coding for insulin must first be converted to DNA.

The process by which this occurs is called reverse transcription.



With reference to differences between eukaryotic and procaryotic DNA, explain why reverse transcription is necessary for the production of artificial insulin. **5**

Question 27 (6 marks) **Marks**

E-cigarette operate by vaporising a nicotine containing liquid into an aerosol, which is then inhaled by the user.

Since their first introduction to broad global markets in 2007, use has become increasingly common, particularly among youth.

They were initially introduced as an alternative to traditional tobacco smoking, with the idea that it could potentially be less harmful due to the absence of tar and combustion products found in tobacco smoke. However, concerns have arisen about the safety and health risks associated with vaping.

Describe and justify an epidemiological study that could be carried out to investigate whether vaping using e-cigarettes causes lung disease. **6**

Question 28 (6 marks) **Marks**

Foot-and-mouth disease, a contagious viral disease for cattle, sheep, goats and pigs, resurfaced in Indonesia in May 2022 after the country had been declared free of it for over 30 years. What makes FMD virus so remarkable is its environmental resistance. It can persist on many inanimate objects, such as equipment used with livestock, people's clothing and shoes, on the tyres of vehicles and in livestock transport.

It can also persist in livestock feed and livestock products, such as meat and hides. There is no cure for FMD.

(a) Outline the possible effects of FMD being spread to Australia. **3**

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(b) Outline a strategy that could prevent the spread of FMD to Australia. **3**

Question 29 (6 marks) **Marks**

(a) Describe TWO mechanisms in plants that allow water balance to be maintained **3**

(b) se an example to outline the role of the nervous system in maintaining homeostasis.U **3**

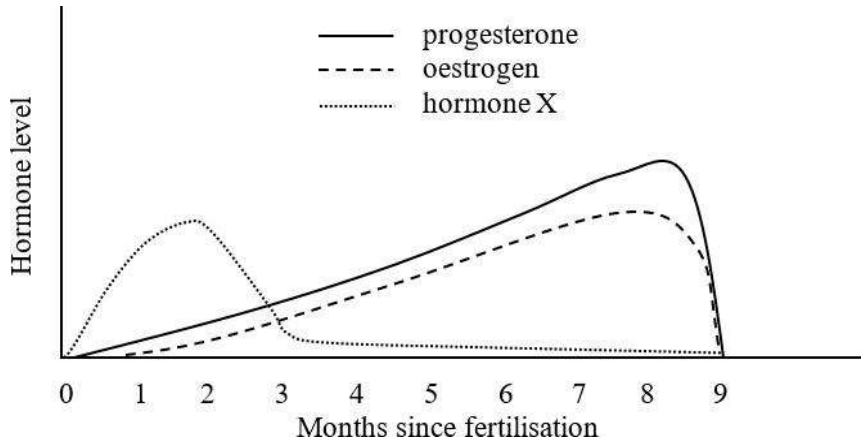
Question 30 (4 Marks) **Marks**

Construct a flow chart below in the space provided, outlining the steps involved in whole organism cloning

4

Question 31 (4 marks) **Marks**

The graph below shows how the levels of three hormones change during pregnancy.



(a) Identify hormone X **1**

(b) How does the source of progesterone change as pregnancy progresses? **2**

(c) Outline ONE role of oestrogen during pregnancy. **1**

Question 32 (5 marks) **Marks**

Assess the potential of gene therapy in the treatment of a named disease.

5

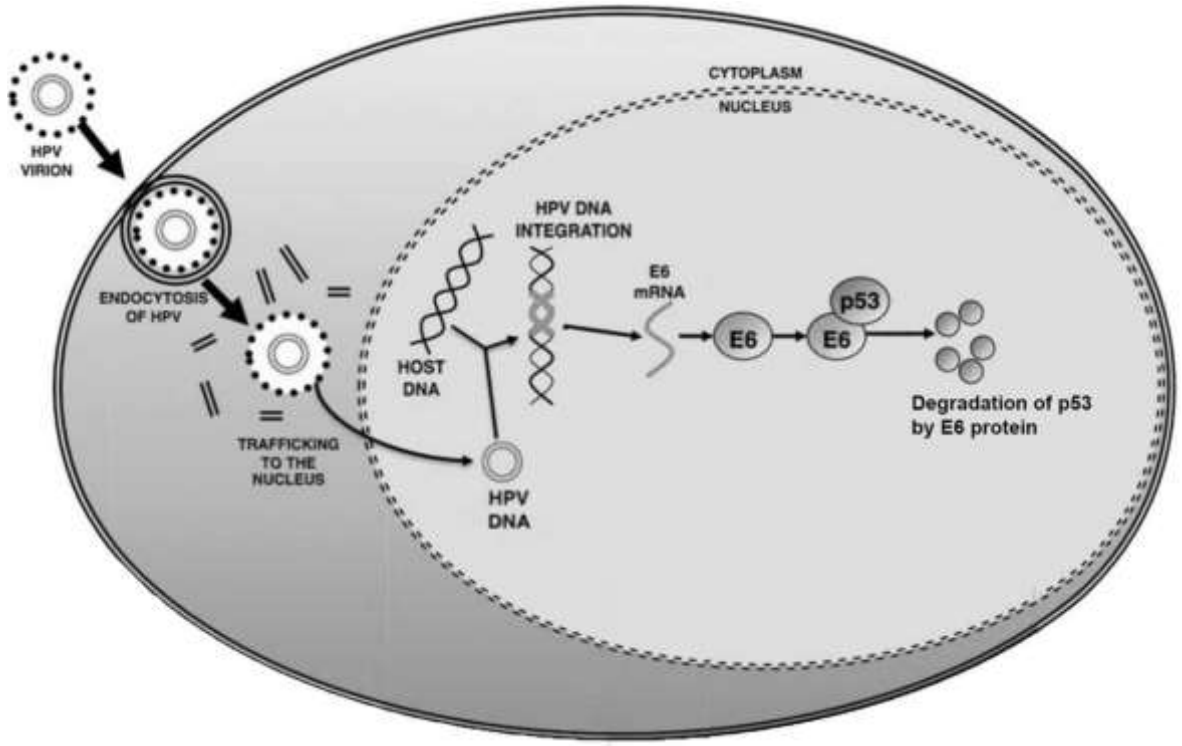
Question 33 (17 marks)

Human papillomavirus (HPV) is a group of viruses that infect the skin and mucous membranes of humans. HPV viruses are classified into different serotypes based on the DNA sequences of their viral genomes. Each HPV type is identified by a specific number (e.g., HPV-16, HPV-18, etc.).

HPV types can cause changes in the cells of the cervix, leading to the development of precancerous lesions. If these lesions are left untreated, they may progress to invasive cervical cancer.

HPV binds to the surface of epithelial cells and gain entry via endocytosis.

Once inside the cell it introduces its viral DNA into the cells nucleus. It uses the hosts cell's machinery to produce a viral E6 protein.



Schematic of HPV infection of a epithelial cell

Adapted from Human Papillomavirus and Oropharynx Cancer: Biology, Detection and Clinical Implications

Question 33 continues on page 25

Question 33 (continued)

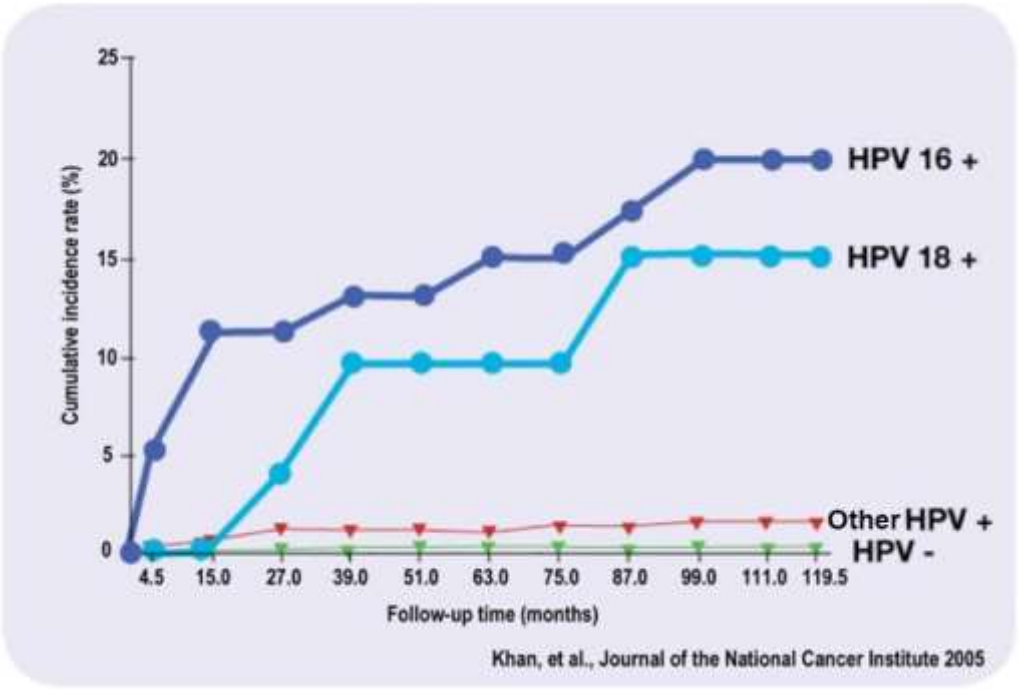
Marks 6

(a) With reference to protein synthesis, explain how infection of high risk HPV strains can lead to cervical cancer.

……

Question 33 continues on page 26

The graph below shows the ten year cumulative incidence rate of cervical precancer by different HPV serotypes. Patients were tested for HPV at the beginning of the 10 year period.



(b) Analyse the trends shown in the data. **4**

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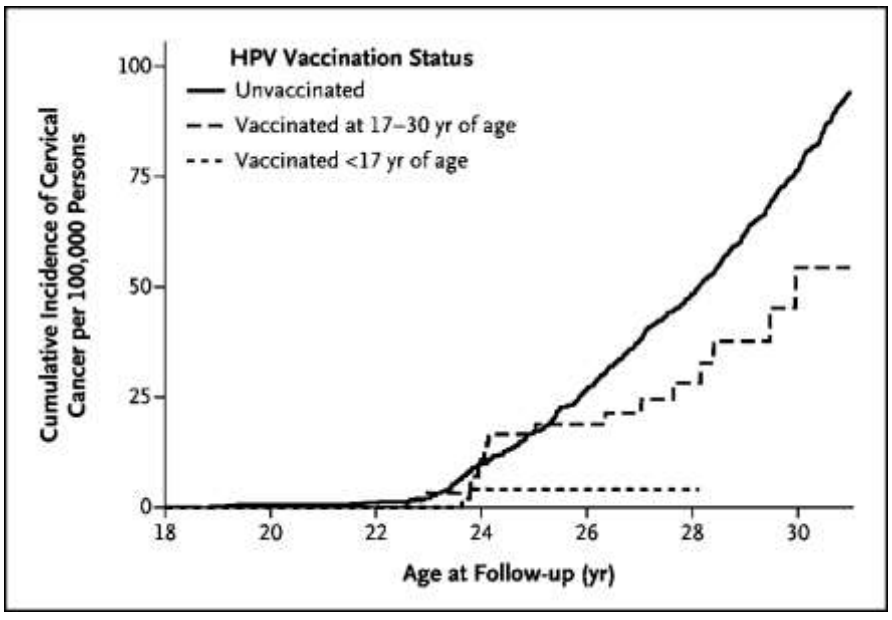
Question 33 continues on page 27

4

(c) A vaccine has been developed to protect against infection with HPV. Describe how giving this vaccine leads to the production of antibodies against HPV.

The graph below shows the cumulative Incidence of Invasive Cervical Cancer According to HPV Vaccination Status



Question 33 continues on page 28

(d) Account for the differences in incidence of cervical cancer among the 3 cohorts. **3**

END OF EXAM

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HSC Biology Trial 2023 – marking criteria

Section A

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

QUESTION 21(A) – Plant adaptation against pathogens

Criteria	Marks
• Clearly outlines at least two plant adaptations for defence against pathogens	**2**
• Clearly outlines one plant adaptation for defence against pathogens Or Identifies two adaptations/ outlines very briefly two adapations	**1**

Sample Answer

Plants deposit cell wall material around pathogens to seal them off from the surrounding tissue.

Plants such as eucalypyts store oils in their leaves, which act as chemical defences against fungal and bacterial pathogens.

Note – Cannot just state release chemicals, must be more specific.

QUESTION 21(B) – Koch's Postulates

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.

QUESTION 22(A) – Gene flow and genetic drift

Criteria	Marks

• Student demonstrates a thorough understanding of the processes of gene flow and genetic drift. • Student soundly explains how these processes could impact the future gene pool of the cheetah. • Student makes reference to the stimulus in their answer.	5
• Student demonstrates a sound understanding of the processes of gene flow and genetic drift. • Student provides some detailed explanation as to how these processes could impact the future gene pool of the cheetah.	4
• Student demonstrates some understanding of gene flow and genetic drift. AND • Student provides some explanation of changes in genes within a population and their subsequent impact on future cheetah populations.	3
• Student demonstrates some understanding of gene flow and genetic drift. AND • Student provides some brief explanation of changes in genes within a population and their subsequent impact on future cheetah populations.	2
• Student provides some relevant understanding og gene flow and genetic drift with no reference to the cheetahs.	1

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.

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.

QUESTION 22(B) – DNA Profiling

Marking Criteria	Marks
• Description of what genetic profiling is. • Definition of genetic diversity (or clearly implied) • Description of how genetic profiling can be used to show genetic diversity	**3**
• 2 of the above	**2**
• 1 of the above.	**1**

Genetic profiling typically looks at the number of short tandem repeats (STR) in particular sections of DNA. An individual and their close relatives will have characteristic patterns of STRs at certain loci.
Genetic diversity in a population is an expression of the extent to which different individuals within it carry different alleles.
By profiling a large number of individuals in a population a measure can be made of the degree of genetic diversity in that population. If the profiles obtained show a high degree of similarity, then individuals can be assumed to be closely related and the population to have low genetic diversity. If there is a wide range of profiles then it can be assumed that genetic diversity is high.

QUESTION 22(C) – DNA Profiling and conservation

Marking Criteria	Marks
• DNA profiling as a way to measure diversity stated • Importance of genetic diversity to conservation efforts explained • Information related to a conservation issue with cheetahs (method used)	**3**
• 2 of the above	**2**
• 1 of the above	**1**

Genetic diversity is a critical factor in determining whether or not a population of organisms can survive. DNA profiling can give an indication of the diversity within a population. A highly diverse population is better able to survive climate change or disease, as genetic diversity should ensure variation in the ability of individuals to resist or survive the disease.
Small populations in fragmented habitats are likely to experience a drop in genetic diversity through genetic drift.
Conservation authorities can use profiling to measure genetic diversity, and having identified populations with low diversity can take steps to move individuals from other populations to increase that diversity.

QUSTION 23 – DNA Replication VS PCR

Criteria	Marks
Describes 2 similarities and 1 difference between DNA Replication and PCR (vice versa)	3
Outlines 1similarity and 1 difference between DNA Replication and PCR	2
Outlines 1 similarity OR 1 difference between DNA Replication and PCR	1

QUESTION 24 – Immune Cells

Criteria	Marks
Describes similarities and differences between Natural Killer cells and cytotoxic T cells	4
Outlines similarities and differences between Natural Killer cells and cytotoxic T cells	3
Describes similarities OR differences between Natural Killer cells and cytotoxic T cells	2
Outlines similarities OR differences between Natural Killer cells and cytotoxic T cells	1

Suggested answer:

Natural killer cells are part of the innate/second line of defence. They do not require antigen presentation to be activated. They act early in the immune response / rapid response. NK cells respond quickly to infections, providing an immediate defense during the early stages of viral invasion, before the adaptive immune response fully takes effect. They are non-specific. By eliminating infected cells early in the infection, NK cells help limit viral replication and prevent the spread of the virus to neighboring cells.

Cytotoxic T cells are part of the adaptive/3rd line of defence. They act later in the immune response. They are specific/targeted to the pathogen. Their antigen receptors bind specifically with the antigen displayed on the infected cell.

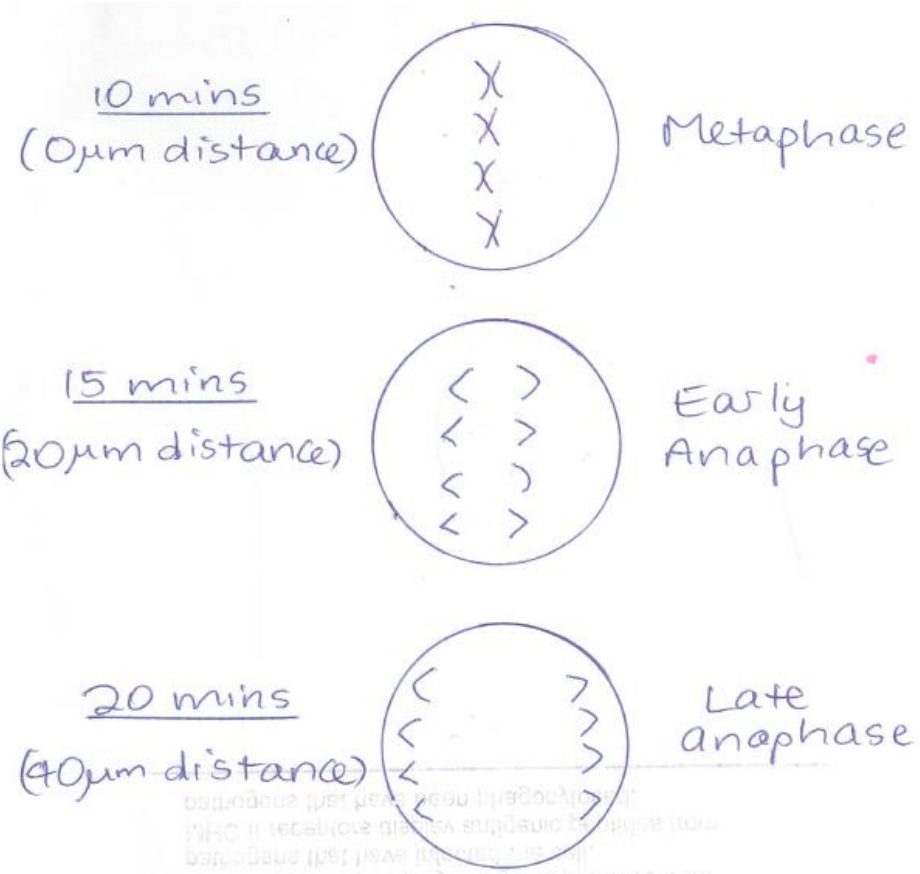
Both cells recognise virally infected cells displaying antigen on their MHC-I marker, resulting in cell death or apoptosis.
Both release granules containing perforin and granzymes. These substances create pores in the target cell's membrane, leading to cell death.

QUESTION 25 – Mitosis

Criteria	Marks
• Cells represented with the correct number of chromosomes. • Sister chromatids should be appropriately connected/ aligned, reflecting the cell division process. • Distance should be proportional to the data provided in the graph.	3

Deduct 1 mark for any point above missing

Suggested answer:



QUESTION 26 – Eukaryotic and Prokaryotic DNA

Criteria	Marks
• Explain the differences between eukaryotic and prokaryotic DNA in terms of introns and exons. • Identify human insulin gene is located in eukaryotic DNA and therefore contains introns • describes the synthesis of artificial insulin involves plasmids from prokaryotic cells. • Identify that bacteria, being prokaryotes, lack the machinery to process and remove introns from pre-mRNA. • Therefore mature mRNA, which has already had the introns removed, are used as a template to create DNA with introns already removed	5

Deduct 1 mark for any missing point

Suggested Answer:

Eukaryotic DNA contains both protein-coding regions called exons and non-coding regions called introns. Before a eukaryotic gene is expressed, the introns are removed through a process called splicing, and the exons are joined together.

On the other hand, prokaryotic DNA is found in prokaryotes, such as bacteria. Unlike eukaryotic DNA, prokaryotic DNA does not contain introns and does not undergo splicing.

To produce artificial insulin in bacteria, scientists typically insert the human insulin gene into a plasmid, which is a small, circular DNA molecule that can replicate independently within the bacterial cell. However, since bacteria lack the splicing machinery present in eukaryotic cells, they cannot properly process the human insulin gene with its introns intact.

QUESTION 27 – Epidemiology

Criteria	**Mark**
• Identifies correct hypothesis • Describes a valid study as cohort study, incorporating the following: large sample size, control group, some control of other variables, some statistical analysis and interpretation of data	6
• Identifies correct hypothesis • Describes 4 features of a valid study	4-5
• Identifies correct hypothesis • Outlines 3-4 features of a valid study	3-4
• Identifies correct hypothesis AND a feature of a valid study OR • Describes 2 features of a valid study	2-3
• Some relevant information	1

Sample Answer:

Hypothesis: Smoking e-cigarettes causes lung disease in the long term.
One method would be to set up a cohort study. Find a large group of smokers (about 10, 000 people) and a similar size group of non-smokers. Ensure that both groups have similar gender and age composition, and that both start the study with a similar distribution of general health conditions.
Follow each group over 20 – 30 years and record the incidence of development of lung disease. At the end of the study calculate the percentage of smokers who develop a lung disease and compare it to the percentage of non-smokers who develop a lung disease.

QUESTION 28(A) FOOT AND MOUTH

Criteria	**Marks**
Provides a detailed outline of the potential effects of FMD being spread to Australia. Including direct effects on agricultural production and indirect effects on other sectors such as the economic sector	3
Provides an outline of the potential effects of FMD being spread to Australia.	2

Including include direct on agricultural production OR indirect effects on other sectors such as the economic sector	
Provides some relevant information	1

Suggested answer:

Foot-and-mouth disease (FMD) would have an effect on animal welfare. FMD can cause painful lesions on the feet and mouth of infected animals, leading to reduced feed intake, lameness, and suffering.

FMD has no cure. If the disease enters Australia, methods of preventing its spread, such as destroying infecting animals, would be very expensive and disruptive to the livestock industry. There would be a reduction in meat and dairy production.
Australia is a major exporter of livestock and animal products. If FMD were to spread, it could lead to a ban on these exports from infected regions, causing significant economic losses to the agricultural industry. This would affect farmers, processors, exporters, and related industries.

Even after the outbreak is contained, it might take time for Australia to regain the trust of trading partners and re-establish market access for its livestock products.

Marker's comment:
FMD is <u>not</u> transmitted to humans in infected meat. It only infects cloven-hoofed animals (those with divided hooves). ie. Cattle, sheep, goats, pigs. Students perhaps confusing FMD with hand, foot and mouth disease which does affect humans.

QUESTION 28(B) FOOT AND MOUTH

Criteria	Marks
Outlines in detail a strategy that may be used to prevent the spread of FMD	3
Outlines a strategy that may be used to prevent the spread of FMD	2
Provides some relevant information	1

<u>Suggested answer:</u>

- Awareness campaigns of FMD
- Restrict import of animal products from Indonesia that may carry FMD
- Stronger clearance requirements for travelers entering Australia
- Increased screening of goods entering Australia, such as animal hides, meat and dairy products, clothing, farming equipment, frozen, chilled and freeze-dried foods that are of high risk origin
- Increased disease surveillance in North Australia's Top End (ie. WA, NT, Northern QLD)

QUESTION 29 (A)

Marking Criteria	Marks
• Describes in detail 2 mechanisms that allow water balance to be maintained	**3**
• Briefly describes 2 mechanisms that allow water balance to be maintained	**2**
• Outlines 1 mechanism	**1**

Suggested answer:

Control of water movement in plants occurs via 2 main mechanisms:
1. Water moving into plants at root hairs:

- Plants can change the osmotic rate by altering dissolved solute concentration in root hairs. ie. Increased solute concentration = increased water uptake by osmosis

2. Water moving out of plant from leaf stomata:

- Plants can change their transpiration rate by altering turgor of stomatal guard cells
- Decreased plant water levels stimulate release of stress hormone, abscisic acid, which initiates stomata to close
- When the plant has sufficient water, the guard cells become turgid. This causes cells to bend and open, allowing transpiration to commence once more.

Other factors/adaptations in plants may also assist in facilitating this balance of WATER INPUT <-> WATER OUTPUT

- Eg. Sunken stomata, reduced leaf size

QUESTION 29 (B)

Criteria	Marks
• Identifies the main features of a role of the nervous system using an example • Includes concepts of detection and response	3
• Identifies a role of the nervous system using an example	2
• Makes a correct statement about the nervous system OR • States an example	1

Suggested answer:

2 stages in homeostatsis include:

1. detecting change
2. counteracting the change

Hypothalamus is an important control centre in the brain
It receives information of stimuli from the internal and external environment via receptors, analyses it, and send instructions to effectors to carry out a response that counteracts the effects of the stimuli. This process is called negative feedback.

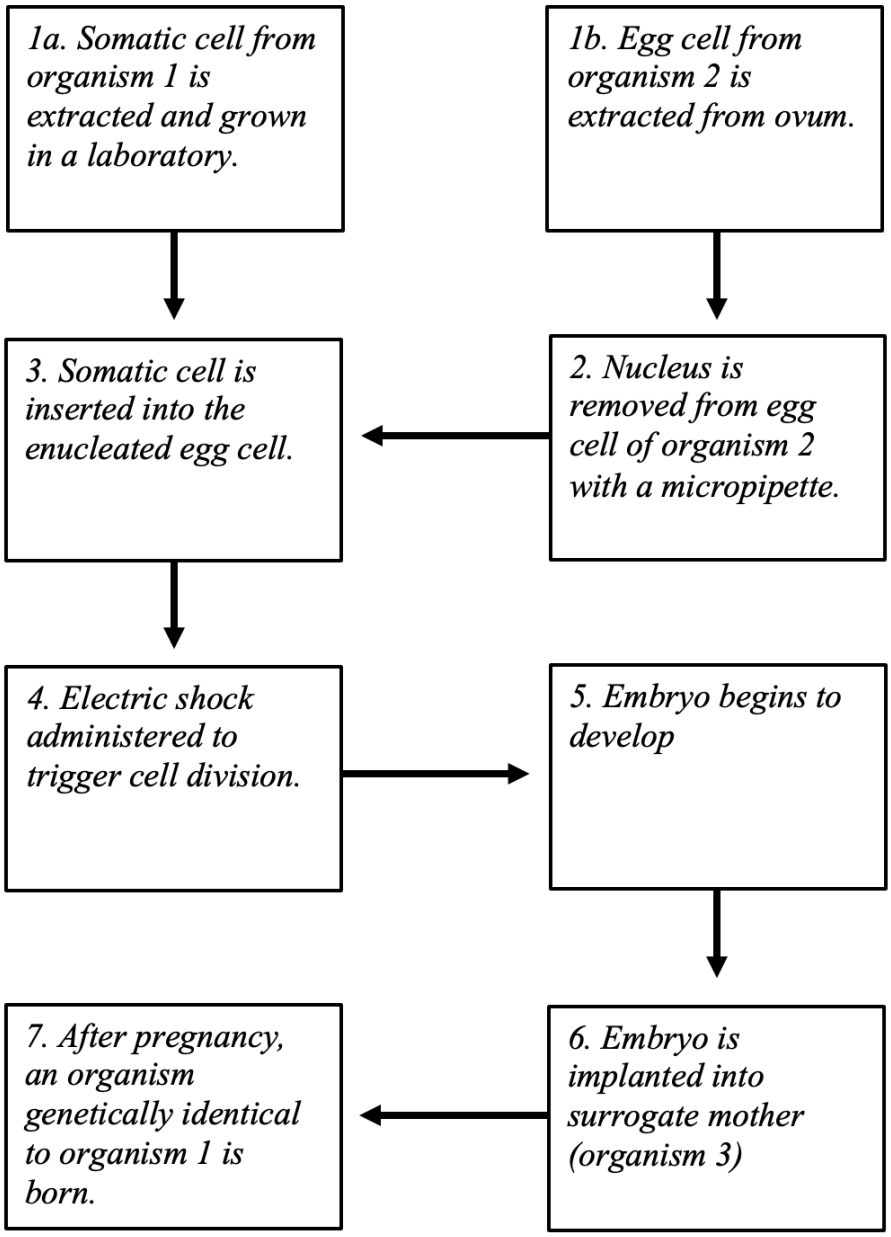
Eg. Temperature regulation

Thermoreceptors in the hypothalamus within brain and thermoreceptors in skin detect changes in temperature
Too hot: Messages sent to effectors to cool body down. Eg. Vasodilation : Blood vessels widen, usually near surface of skin, with increase in blood flow to expel heat from the body
Too cold: Messages sent to effectors to warm body up. Eg. Vasocontriction : Blood vessels narrow and contain heat to core of the body to stay warm. Erector muscles in skin contract to raise hairs up to produce an insulating layer of air to warm body. Rapid muscle contractions to induce shivering to generate heat to warm body.

QUESTION 30 – Cloning

Criteria	Marks
• Student uses a flow chart including multiple steps and arrows to thoroughly outline the correct order of all steps involved in whole organism cloning. • Process outlined includes isolation of Donor nucleus' cell, Enucleated egg cell stimulation for division and implantation into surrogate mother. • Link made between offspring and donor nucleus.	4
• Student uses a flow chart including multiple steps and arrows to soundly outline most of the steps involved in whole organism cloning.	3
• Student uses some aspects of a flow chart to provide some steps involved in whole organism cloning.	2
• Student provides some relevant information.	1

Sample answer


1a. Somatic cell from organism 1 is extracted and grown in a laboratory.
1b. Egg cell from organism 2 is extracted from ovum.
3. Somatic cell is inserted into the enucleated egg cell.
2. Nucleus is removed from egg cell of organism 2 with a micropipette.
4. Electric shock administered to trigger cell division.
5. Embryo begins to develop
7. After pregnancy, an organism genetically identical to organism 1 is born.
6. Embryo is implanted into surrogate mother (organism 3)

QUESTION 31(A) – pregnancy hormones

Marking Criteria	Marks
• Correct answer	**1**

HCG (human chorionic gonadotrophin)

QUESTION 31(B) – pregnancy hormones

Marking Criteria	Marks
• Early source identified • Later source identified	**2**
• One source identified	**1**

Progesterone is initially produced by the corpus luteum, but as the placenta develops, at approx the end of the first trimester, it takes over as the source of progesterone.

QUESTION 31(C) – pregnancy hormones

Marking Criteria	Marks
• One role outlined	**1**

Oestrogen prepares the uterine wall for implantation and stimulates development of blood vessels.

QUESTION 32 – gene therapy

Marking Guidelines	Marks
• Brief outline of named disease that potentially could be treated with gene therapy • Details of the technological process outlined • + pros of gene therapy • − cons of gene therapy Judgement of its potential	**4-5** **(if lacking detail 4)**
• 3 of the above or 4 less well done	**3**
• 2 of the above or 3 less well done	**2**
• Some information about the process	**1**

One example of gene therapy is as a treatment for cystic fibrosis. Sufferers lack a gene which makes an enzyme which plays a role in the transfer of materials across membranes. As a result they get a build up of mucus in the lungs. This technology uses an adenovirus vector to carry the gene to the cells lining the lungs. They are then able to make the necessary enzyme and the main symptom is relieved. Problems with the immune response against the vector, and little success with other vectors mean that this particular application has currently had limited impact. In the future, however, as techniques improve there is great potential in techniques of this sort to treat a range of genetic caused diseases.

QUESTION 33 (A) – Protein synthesis & cancer

Marking Criteria	Marks

• Link made between viral DNA gene inserted into host's genome and protein produced, by explaining in detail
  o Transcription
  o Translation
• Describes the effects of viral protein synthesis on host cellular processes, such as cell cycle regulation, apoptosis, and DNA repair
• AND links to how this can lead to uncontrolled cell proliferation.
	6

• Link made between viral DNA and protein produced, through description of:
  o Transcription
  o Translation
• Outlines how the viral protein will disrupt cell cycle control mechanisms by outlining functions of p53 tumour suppressor gene and
• link to uncontrolled cell proliferation
	5

• Brief description of transcription and translation in relation to producing viral protein • Outline effects of destruction of p53 gene	**4**
• Brief description of transcription and translation • Outline an effect of destruction of p53 gene OR • Describes the effects of viral protein synthesis on host cellular processes, such as cell cycle regulation, apoptosis, and DNA repair. AND links to how this can lead to uncontrolled cell proliferation.	**3**
• Brief reference to transcription and translation • Identify a role of p53 gene OR • Outline effects of destruction of p53 gene	**2**
• Some relevant information	**1**

High-risk HPV strains, such as HPV-16 and HPV-18, are responsible for most cases of cervical cancer. When these viruses infect cervical epithelial cells, they integrate their DNA into the host cell's genome. This leads to the expression a viral oncoproteins, E6.
The viral gene will use the hosts RNA polymerase to produce E6 mRNA. RNA polymerase adds complementary free RNA nucleotides (adenine, uracil, cytosine, and guanine) to the growing RNA strand.
This mRNA molecule is converted into a sequence of amino acids to build an E6 protein.
Ribosomes bind and move along the mRNA. Transfer RNAs (tRNAs) bring amino acids to the ribosome based on the codons in the mRNA.
Amino acids are added to the growing polypeptide chain through peptide bond formation. This continues until a stop codon is reached.
The newly synthesized polypeptide undergoes folding to adopt its functional three-dimensional structure of the E6 protein.

Once synthesised, the E6 oncoprotein targets a cellular protein called p53. P53 is a tumor suppressor protein that plays a critical role in regulating the cell cycle, DNA repair, and apoptosis (programmed cell death) in response to DNA damage.
P53 tumour suppressor gene
Cell cycle regulation – monitors the cell cycle, the process by which cells replicate and divide. If DNA damage is detected, p53 can halt the cell cycle at various checkpoints, giving the cell time to repair the damage before proceeding with division.
Apoptosis – If DNA damage is too severe to be repaired, p53 can trigger apoptosis, a process in which the cell undergoes programmed cell death. This eliminates cells with irreparable damage and prevents them from becoming cancerous.
DNA Repair – p53 can also stimulate the repair of damaged DNA by activating certain genes involved in DNA repair mechanisms. This helps maintain the integrity of the genome and reduces the likelihood of mutations that `could lead to cancer.
By promoting the degradation of p53, E6 prevents the cell from effectively responding to DNA damage, increasing the risk of uncontrolled cell division leading to cancer.

QUESTION 33 (B) – Incidence data

Marking Criteria	Marks
• Refers to data to correctly describe the trend for the 4 groups • Compares incidence rates for the different serotypes • Draws implications from the trends	**4**
• Refers to data to correctly describe the overall trend for 2 groups • Draws implications from the trends	**3**
• Correctly describe the trend for 2 groups • Or • Brief outline of 4 •	**2**
• Briefly outlines a trend • Or • Identifies an implication	**1**

HPV 16 and HPV 18 have a higher risk of developing cervical precancer when compared to all other HPV types and definitely in comparison to women who are HPV negative.

HPV 16+ showed the largest increase in cumulative incidence % in the first 15 months, increasing from 0 to ~11%. HPV18+ showed a significant increase between 15 and 39 months increasing from 0 to 10%. HPV 16+ continued to increase to 20% from 39 months. HPV 18+ cumulative incidence remained constant from 39 to 75 months. After this it increased 15%.

Other strains of HPV had a significantly lower incidence rate of ~1% from 27 months onwards.

If patients tested negative to HPV the incidence rate throughout the study was less than zero.

QUESTION 33 (C) – Vaccine

Marking Criteria	Marks
• vaccine contains HPV antigen • displayed on APCs by MHC • Specific helper T cell (detects antigen and) stimulates specific B cell • B cell divides/forms clones and differentiates in plasma cells and memory cells • plasma cell produces antibody	**4**
• 4 of above	**3**
• 3 of above	**2**
• 2 of above	**1**

QUESTION 33 (D) – Incidence data

Marking Criteria	Marks
• describes the differences in trend between 3 groups • Outline reasons for differences between the groups	**3**
• Outlines differences between the groups • State a reason for differences	**2**
• Some relevant information	**1**

Cumulative incidence is zero before 21 years of age. HPV is sexually transmitted so few women at that age are sexually active and if so, have not had as many sexual encounters to contract HPV.

Unvaccinated cohorts had the highest cumulative incident rates of cervical cancer among the 3 cohorts. They have not received the vaccine therefore lack immunity against the HPV virus. The virus can infect cells and consequently trigger uncontrolled cell proliferation.

Individuals vaccinated between 17-30 years old have a lower incidence rate of cervical cancer compared to unvaccinated cohort. However, their incidence rate is still significantly higher than those vaccinated before 17 years. Individuals vaccinated between 17-30 might have already been exposed to HPV before receiving the vaccine.

The vaccine is most effective when administered before exposure to HPV, as it helps prevent new infections and progression to precancerous lesions.

While the vaccine can still provide some protection and reduce the risk of new infections with the vaccine-targeted HPV strains, it may not be as effective in preventing the development of precancerous lesions if exposure has already occurred.

Individuals who were vaccinated before 17 years has the lowest cumulative incidence of cervical cancer. Vaccinating individuals under 17 years of age is particularly beneficial because it occurs before many people are likely to be exposed to HPV through sexual activity. Being vaccinated earlier is beneficial as it proves immunity to HPV earlier resulting in being less likely infected by HPV.