CSSA

2022

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

DO NOT REMOVE PAPER FROM EXAMINATION ROOM

Centre Number

Student Number

Biology

Morning Session
Wednesday, 10 August 2022

General Instructions:

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Use the Multiple-Choice Answer Sheet provided
- Draw diagrams using pencil
- NESA-approved calculators may be used
- Write your Centre Number and Student Number on the top of this page

Total marks: 100

Section I – 20 marks (pages 2 – 12)

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

Section II – 80 marks (pages 13 – 31)

- Attempt Questions 21 – 33
- Allow about 2 hours and 25 minutes for this section

Section I
20 marks

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

Use the Multiple-Choice Answer Sheet for Questions 1 – 20.

1 An unknown bacterial disease began to spread in one ward of a local hospital. Patients who contracted the bacteria experienced respiratory symptoms including coughing and sneezing. After a few days, several patients and staff in the ward experienced symptoms, however no other cases were identified in any other part of the hospital.

What is the most likely cause of transmission of this disease?

A. Inhalation of infected droplets

B. Contamination of water supply

C. Vector transmission via mosquitos in the hospital

D. Poor food preparation practices in the hospital cafeterias

2 Many plants are not able to self-fertilise to produce offspring. Which statement is NOT an example of a plant adaptation that prevents self-fertilisation?

A. Chemical substances within the plant can cause the pollen of that plant to fail to grow on a stigma of the same flower that produced it.

B. Some plants shed the pollen before the stigmas on the same plant are able to be fertilised.

C. Holly plants produce either male or female flowers.

D. A plant contains flowers that have both stamens and stigmas.

3 Below is an original DNA sequence and a mutation.

	DNA sequence
Original DNA sequence	ATG AAT TTA CGC GAT
Mutation	ATG AAT ATT ACG CGA

Which type of mutagen is likely to have caused this mutation?

A. Bacterial

B. Chemical

C. Chromosomal

D. Electromagnetic radiation

4 Ultra-High Temperature (UHT) treated milk is a type of milk that is processed at high temperatures (135°C) before being packaged. This type of milk does not need to be refrigerated before opening and has a longer shelf life than conventional milk.

Which of the following correctly explains why UHT milk is less likely to cause disease than conventional milk when not refrigerated?

A. UHT milk is sealed after treatment, therefore pathogens are unable to get into the packaging.

B. Sugars in UHT milk are destroyed by the high temperature, therefore causing less food intolerance.

C. Dairy cows utilised for UHT milk undergo antibiotic treatment to reduce the presence of bacteria in milk.

D. Pathogens in UHT milk are destroyed by the high temperatures, therefore there are no pathogens present in the milk until it is opened.

5 Which of the following shows the most correct function for the neuron type?

	Neuron	Function
A.	**Motor**	Conduct nerve impulses from the central nervous system to effectors
B.	**Sensory**	Conduct nerve impulses from the central nervous system to effectors
C.	**Motor**	Conduct nerve impulses from receptors to the central nervous system
D.	**Sensory**	Conduct nerve impulses from neurons to other neurons within the central nervous system

6 Sickle cell anaemia results from a point mutation of one nucleotide in the gene for the haemoglobin-beta chain. The tables show the sickle cell point mutation compared to the normal haemoglobin-beta chain.

Normal Haemoglobin-beta chain								
DNA bases	ATG	GTG	CAC	CTG	ACT	CCT	GAG	GAG
Amino Acid sequence	START	VAL	HIS	LEU	THR	PRO	GLU	GLU

Sickle cell Haemoglobin-beta chain								
DNA bases	ATG	GTG	CAC	CTG	ACT	GTG	GTG	GAG
Amino Acid sequence	START	VAL	HIS	LEU	THR	PRO	VAL	GLU

Which point mutation is represented by the sickle cell anaemia?

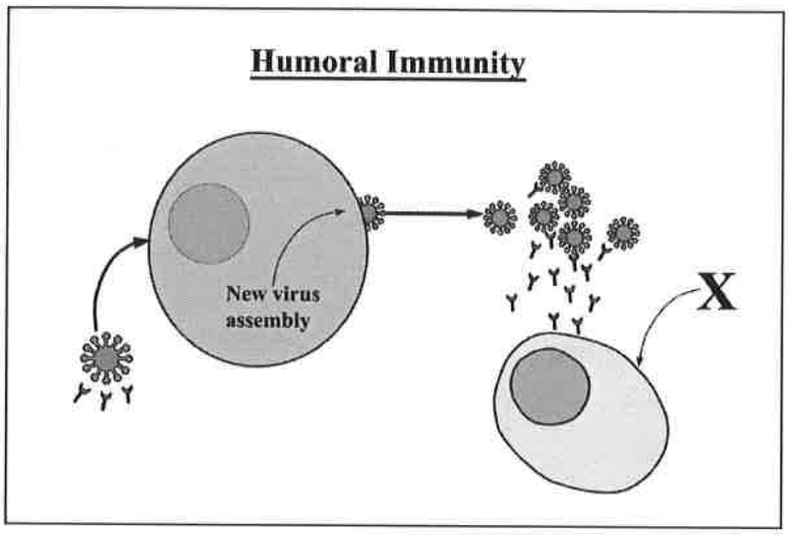
A. Frameshift insertion

B. Missense mutation

C. Nonsense mutation

D. Silent mutation

7 A student sketched the following diagram of the cells involved in the immune response.



What is the cell type indicated by X.

A. Host B-cell

B. Host T-cell

C. Virus antigen

D. Virus pathogen

8 Single nucleotide polymorphism (SNPs) refers to the presence of more than one allele of a gene in a population. This allele must be present in more than 1% of the population to distinguish it from a mutation.

There are at least ten million SNPs in the human genome and it is estimated that about 60,000 of them are found within regions of DNA that code for proteins.

What is the most likely reason SNPs are studied, given they occur infrequently?

A. To identify the role of mutation in protein synthesis

B. To identify the link between alleles and proteins

C. To identify the link between genes and alleles

D. To identify genetic markers for disease

9 Countercurrent exchange occurs in the mouths of gray whales (*Eschrichtius robustus*). The diagrams below show the arrangement of the periarterial venous retia (veins) and the artery in the tongue of a gray whale calf.

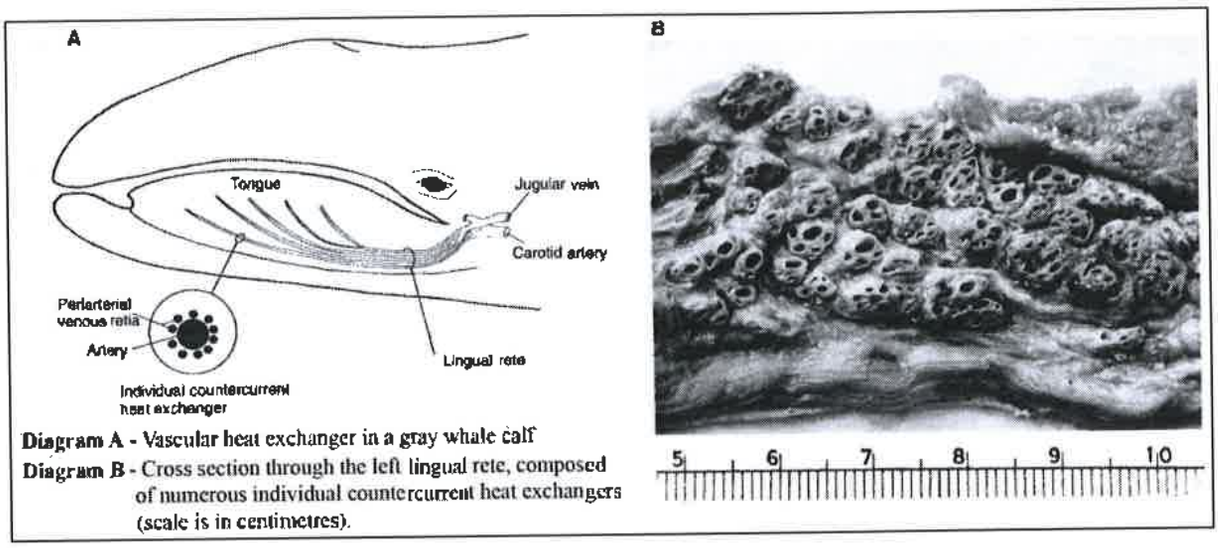


Diagram A - Vascular heat exchanger in a gray whale calf
Diagram B - Cross section through the left lingual rete, composed of numerous individual countercurrent heat exchangers (scale is in centimetres).

Which of the following correctly identifies the mechanism of countercurrent heat exchange in a gray whale calf?

A. Carotid artery → heats blood in jugular vein → cools tongue

B. Jugular vein → heats blood in periartial venous retia (veins) → heats tongue

C. Carotid artery → heats blood in artery surrounded by periarterial venous retia (veins) → cools tongue

D. Carotid artery → heats blood in artery surrounded by periarterial venous retia (veins) → heats tongue

10 Sickle cell anaemia is a disease in which the haemoglobin protein is produced incorrectly and the red blood cells have a sickle shape.

A person who is homozygous recessive for the sickle cell trait will have red blood cells that all have the incorrect haemoglobin.

A person who is homozygous dominant will have normal red blood cells. A person who is heterozygous for the sickle cell trait will have some misshapen cells and some normal cells.

What is the probability that a heterozygous father and a homozygous recessive mother will have a child that has both normal and misshapen red blood cells?

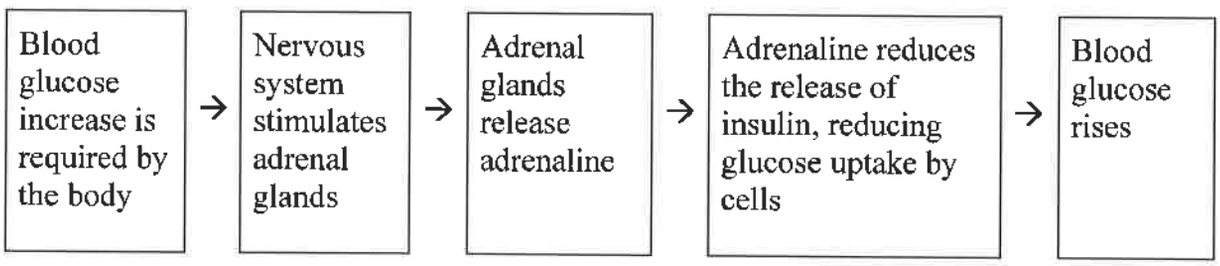
A. 0

B. $\frac{1}{4}$

C. $\frac{1}{2}$

D. $\frac{3}{4}$

11 The effect of the hormone adrenaline on blood glucose levels in humans is shown below.



Patients suffering from anaphylaxis are treated using adrenaline hormone.

What side effects might a patient experience after being treated with adrenaline?

A. Higher blood glucose levels, higher insulin levels

B. Higher blood glucose levels, lower insulin levels

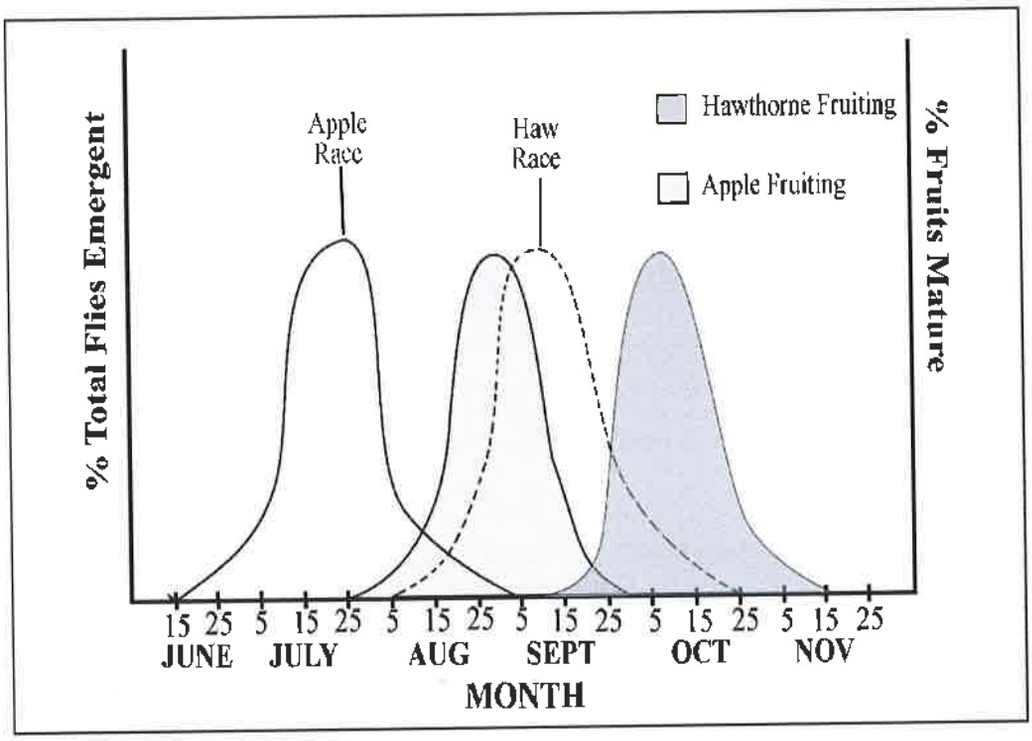
C. Lower blood glucose levels, higher insulin levels

D. Lower blood glucose levels, lower insulin levels

12 Hawthorn trees grow throughout North America and produce a small fruit which is eaten by a small fly maggot.

In 1864, apple growers discovered an unknown maggot feeding on apples. Over time, hawthorn and apple maggot flies have progressively become more distinct. Maggot flies tend to mate with their own kind. There is no geographic isolation between hawthorn and apple maggot flies.

Timing of Host Fruit Ripening



Different ripening of host fruit leads to temporal separation of apple and hawthorn flies

'Apple race' is used to identify the maggot flies that reproduce on apples. 'Haw race' is used to identify the maggot flies that reproduce on hawthorn fruit.

Which statement best describes the most suitable conclusion?

A. Preference for fruit type acts as a strong barrier to gene flow between the two types of maggot flies.

B. Preference for fruit type acts as a weak barrier to gene flow between the two types of maggot flies.

C. Preference for fruit type acts as a strong barrier to genetic drift between the two types of maggot flies.

D. Preference for fruit type acts as a weak barrier to genetic drift between the two types of maggot flies.

13 Which statement is an example of secretion in the nephron?

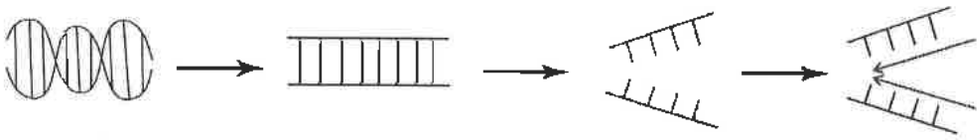
A. Urea moving into the descending loop of Henle

B. Urine moving into and collecting in the calyx of the kidney

C. Amino acids moved by active transport to the blood stream from the convoluted tubule

D. Proteins remaining in the glomerular blood vessels as blood passes through the Bowman's capsule

14 A student drew a diagram of the main steps of DNA replication. Which step or steps has the student INACCURATELY drawn.



Step 1: DNA unwinds Step 2: DNA unzips Step 3: DNA is replicated

A. Step 1

B. Step 2

C. Step 3

D. Steps 1 and 3

15 *Proteus syndrome* is a rare disorder resulting from a mutation in the AKT1 gene. The AKT1 gene regulates cell growth and division of bone, skin and other tissues. Organs and tissues affected by the AKT1 mutation grow out of proportion to the rest of the body.

Individuals affected with *Proteus syndrome* can be mosaic, having some cells that have normal AKT1 genes and some cells that have abnormal AKT1 genes.

What mutation is the most likely cause of *Proteus syndrome*?

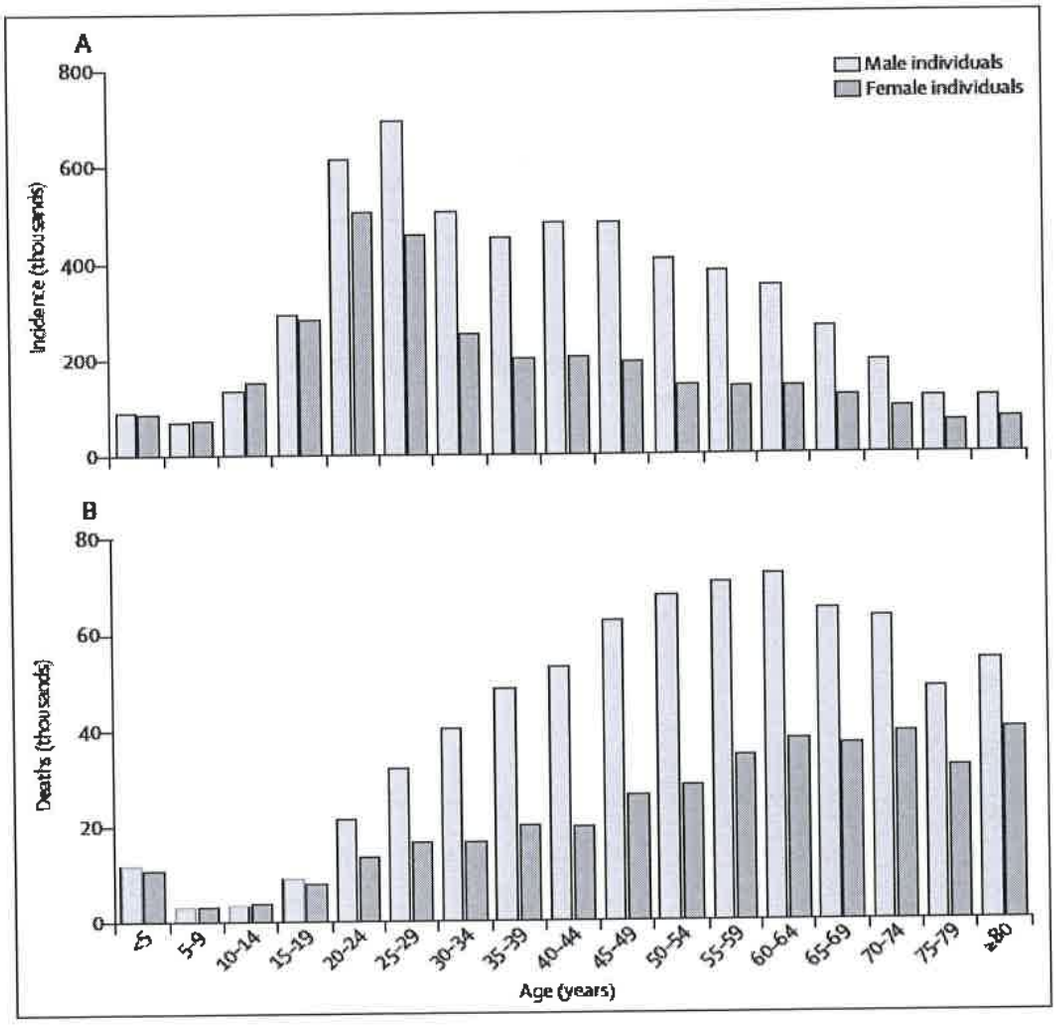
A. Mutation in a sperm or an egg

B. Somatic mutation after the zygote is formed

C. Germline mutation of the primary follicle in the ovary

D. Mutation of a single cell in the bone, skin or other tissue

16 The graphs below show the average global incidence and mortality of the disease tuberculosis in 2015.



What conclusion can be drawn from this data?

A. Being male is a risk factor for contracting tuberculosis.

B. The likelihood of dying from tuberculosis continually increases with age.

C. Males of all age groups are more likely to contract tuberculosis than females.

D. Males diagnosed with the disease are twice as likely to die from the disease than females.

17 Thermoregulation in humans is designed to maintain core internal temperature. A key part of this process are the thermoreceptors in the skin.

Which statement below correctly describes this process?

A. Thermoreceptors and effector cells receive stimuli which are sent to neurons.

B. Thermoreceptors receive stimuli which are sent to neurons and then on to effector cells.

C. Effector cells receive stimuli which are sent to the neurons and then on to the thermoreceptors.

D. Neurons receive stimuli which are sent to the effector cells and then on to the thermoreceptors.

18 A farmer noticed a number of his sheep were dying due to what seemed to be an infectious disease. The sheep would present with neurological symptoms before eventually dying. The affected sheep all ate meat products containing brain tissue before exhibiting symptoms. Antibiotic treatment and heat treatment of the meat did not reduce the spread of the disease.

What was the most likely cause of the disease in the sheep?

A. Bacterium

B. Fungi

C. Prion

D. Virus

19 Analyse the following tRNA strand segment.

tRNA	UAC	AUA	UAG	AGC
DNA				

Which table correctly shows the DNA sequence for the tRNA strand?

A.

tRNA	UAC	AUA	UAG	AGC
DNA	TAG	UAU	TUC	UCG

B.

tRNA	UAC	AUA	UAG	AGC
DNA	ATG	TAT	ATC	TGC

C.

tRNA	UAC	AUA	UAG	AGC
DNA	AUG	UAU	AUC	UCG

D.

tRNA	UAC	AUA	UAG	AGC
DNA	TAC	ATA	TAG	AGC

20 Colour vision deficiency in humans is a sex-linked characteristic. A red-green colour deficient woman and a man with normal vision are receiving genetic counselling concerning the woman's pregnancy.

Which statement best describes the genetic counselling advice that would be given to this couple regarding red-green colour deficiency?

A. 100% chance that a female offspring will have red-green colour vision deficiency

B. 25% chance that a female offspring will have red-green colour vision deficiency

C. 100% chance that a male offspring will have red-green colour vision deficiency

D. 25% chance that a female offspring will be a carrier of red-green colour vision deficiency

Section II
80 marks

Attempt Questions 21 – 34
Allow about 2 hours and 25 minutes for this section

- 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.
- Extra writing space is provided at the end of this paper. If you use this space, clearly indicate which question you are answering.

Question 21 (3 marks)

Measles is one of the most contagious diseases known. Measles is so contagious that if one person has it, up to 90% of the people close to that person who are not immune will also become infected. **3**

The measles virus can live for up to 2 hours in an airspace after an infected person leaves an area and then lives in the nose and throat mucus of an infected person. It can spread to others through coughing and sneezing.

Explain why a vaccine might be the best control measure to prevent the spread of measles

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Question 22 (5 marks)

Whilst working on a construction site, a worker cut her skin on equipment. After 1 hour, the worker noticed that the site of her injury had become red, hot and swollen.

(a) Construct a flow chart in the area below to demonstrate the immune response that is described above. **3**

(b) After 1 week, the worker went to see a doctor as the injury had still not subsided. **2**

Upon visual inspection, the doctor told her that antibiotics would be the most ideal treatment for the injury.

Justify the effectiveness of antibiotics in treating this injury.

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Question 23 (11 marks)

(a) Bt cotton is a genetically modified cotton that has had a gene inserted from *Bacillus thuringiensis* bacteria.

A student wanted to investigate the effect Bt cotton had on soil biodiversity when grown in farms across Australia. The student conducted thorough research and found studies that showed that the roots of the Bt cotton plant did release the Bt toxin into the surrounding soil. The student designed an investigation which could be used to test the effect Bt cotton plants have on soil biodiversity. That is, the number and type of bacteria and fungi that reside in the soil.

(i) Complete the table below for the investigation above. **2**

Independent variable	
Dependent variable	
The control	

(ii) Describe a method that the student can use in his investigation to ensure the experimental design is valid. **4**

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Question 23 continues on page 16

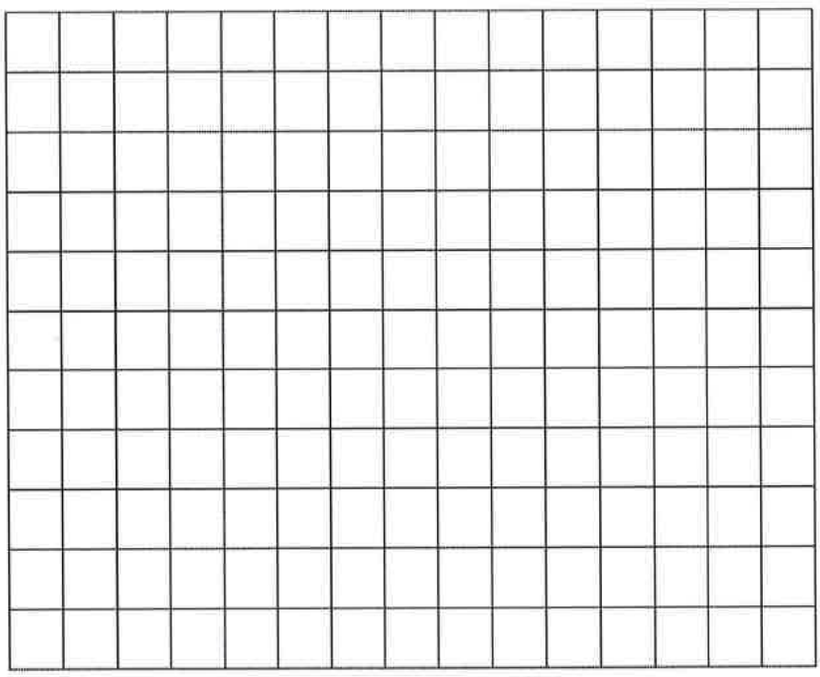
Question 23 (continued)

(b) A different genetically modified organism used in agriculture is Bt corn.

The Bt corn plant is resistant to many types of insect pest, due to certain genes utilised from the *Bacillus thuringiensis* bacteria. Below is a table demonstrating the use of Bt corn across farms, as well as the use of pesticide on these farms from 1998 –2006.

Year	**Average use of Bt corn per hectare (%)**	**Average insecticide use (g/ha)**
2000	18	150
2002	24	110
2004	33	103
2006	40	50

(i) Construct an appropriate graph on the grid below, using information from the table above. **4**



(ii) Estimate the average use of Bt corn per hectare (%) in 2005 and demonstrate this on the graph above. **1**

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Question 24 (6 marks)

A university student studied the percentage of various bases of four different species to determine base composition. The student's initial results are shown in the table below.

Species	% Thymine	% Cytosine
1	12	38
2	18	25
3	35	15
4	28	9

(a) Describe how complementary nucleotides are paired in DNA. **2**

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(b) Assess the accuracy of the data collected. **4**

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Question 25 (4 marks)

A pure-bred red bull was crossed with a pure-bred white cow. **4**

The frequency data of the F_2 generation of colours of offspring is shown in the table below.

F_2 generation offspring

Phenotype (Genotype)	Observed (%)
Red (C^RC^R)	25
Roan (C^RC^W)	50
White (C^WC^W)	25

Justify whether or not this data demonstrates Mendelian inheritance.

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Question 26 (4 marks)

A doctor reported examining hundreds of students with gastrointestinal illness. They reported symptoms of abdominal pain and watery diarrhoea of several days duration. **4**

Faecal specimens were collected from selected ill students, tested and determined to be positive for Cryptosporidium, a protozoal parasite that is spread by the faecal-oral route. This means that it is shed in the stool of a host and enters the mouth of the next host by poor hygiene practices and contaminated water.

The incubation period for cryptosporidiosis is 2–10 days, with an average of approximately 7 days.

The investigation was widened to the local hospital's emergency department. The age of sick patients ranged from under 12 months (1 year) to 76 years. The majority of patients lived within the town's city limits. Cases were widely distributed around the city.

Water was suspected as a possible source of the outbreak due to the wide geographic distribution of cases within the city limits and the occurrence among all age groups.

Describe TWO studies or investigations you could undertake to confirm the hypothesis that the public water supply was the source of the cryptosporidiosis outbreak?

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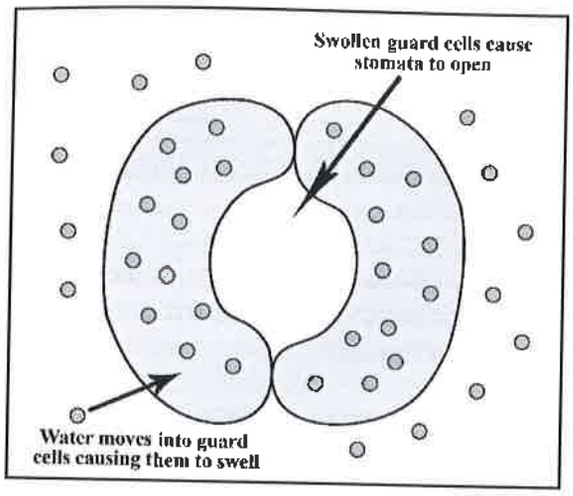
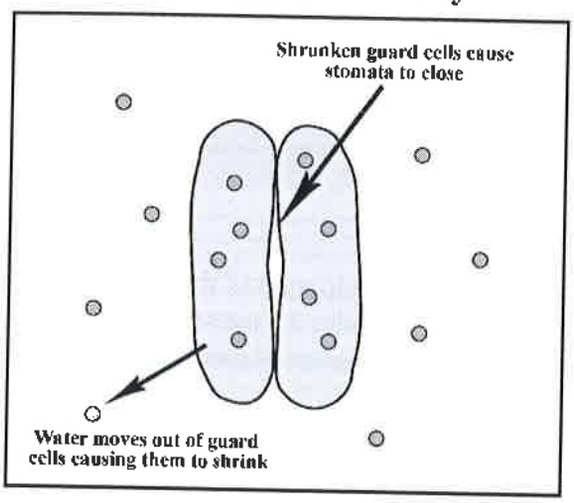
Question 27 (4 marks)

The diagrams below demonstrate how leafy plants maintain water levels through their stomata. 4

High Water Availability



Low Water Availability



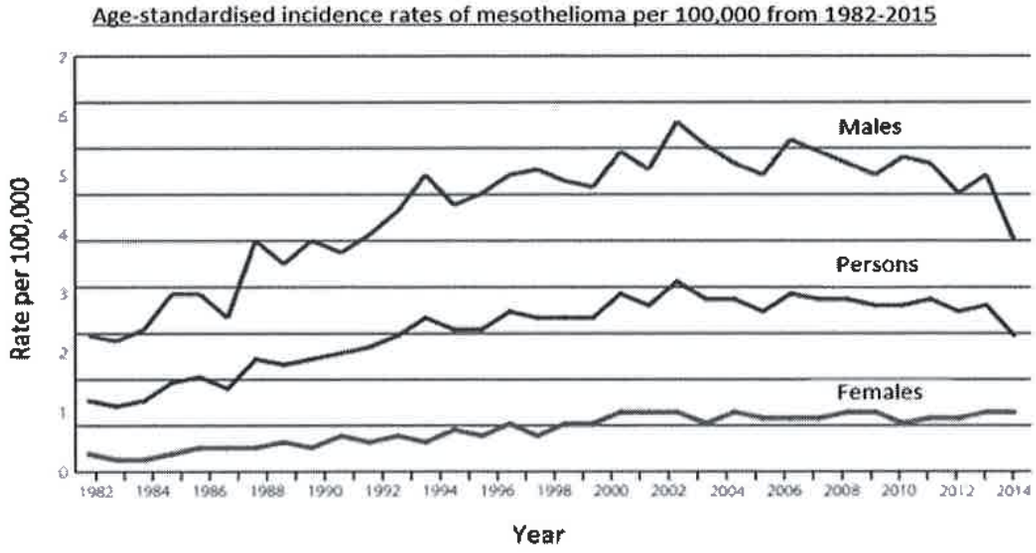
Using the information provided and your own knowledge of transpiration, construct a negative feedback loop demonstrating how leafy plants respond to changes in water availability.

Question 28 (7 marks)

Mesothelioma is a disease caused by inhaled asbestos fibres, usually affecting the lungs.

> "Australia has one of the highest rates of mesothelioma and other asbestos-related diseases (ARDs) in the world due to the country's past heavy use of asbestos. Despite having adopted a total ban on the importation and use of all forms of asbestos since 31 December 2003, Australia continues to deal with a substantial asbestos legacy. It has been projected that there will be approximately 19,400 new cases of mesothelioma diagnosed in Australia before the end of the century."
>
> "The National Asbestos Profile (NAP) collates a range of existing information and research data that reflect the significant impact of asbestos in Australia. It also highlights the control measures in place to reduce the current and future risks."

The graph below shows the incidence of mesothelioma in Australia per 100,000 from 1982 – 2015.



(a) Describe the trend in the incidence rate of mesothelioma and suggest a hypothesis to account for the difference in the trends between males and females. **3**

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Question 28 continues on page 22

Question 28 (continued)

(b) Explain the benefits of engaging in an epidemiological study of mesothelioma and its impact in determining possible directions for public health. 4

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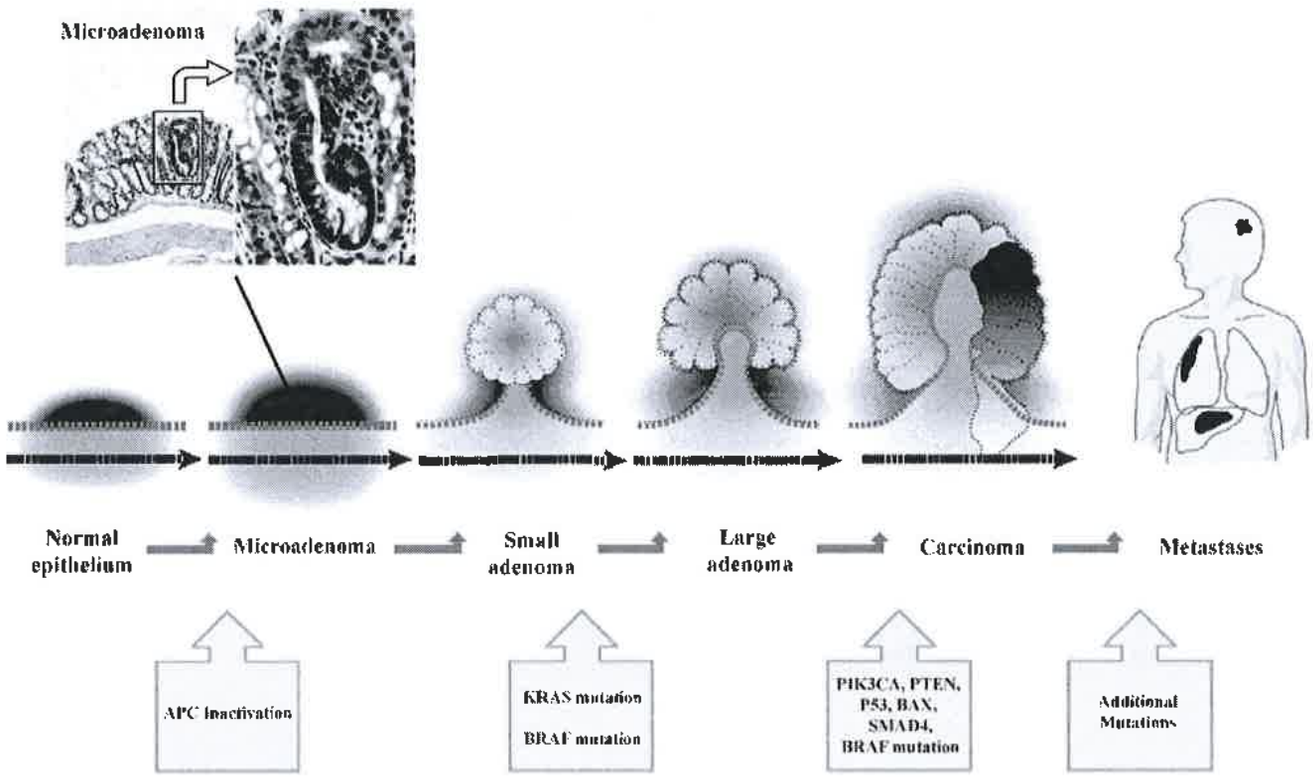
Question 29 (8 marks)

The diagram below illustrates how colon carcinoma develops from normal bowel epithelium. The table below identifies some genetic mutations that can be associated with colorectal (bowel) cancer.

Sequence of Genetic Changes Associated with Adenoma-Carcinoma



Genetic Mutations Associated with Colorectal Cancer

Mutation type	Genes	Comments
Oncogenes	KRAS	Mutations found in about 40% of cancers
	BRAF	BRAFV600E mutation found in 5-10% of cancers
	PIK3CA	Mutations found in 15-25% of cancers
Tumor suppressor	P53	Loss or mutation in up to 55% of cancers
	SMAD4	Frequency of mutations 10-15% of cancers
	APC	Inactivated in 85% of sporadic cancers
	PTEN	Frequency of inactivating mutations about 10% but loss of PTEN protein expression evident in 15-20% of cancers

Question 30 continues on page 24

Question 29 (continued)

(a) Using a specific example, explain how lifestyle choices can increase the risk of developing colorectal (bowel) cancer. **2**

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(b) What are oncogenes and how do they cause colorectal (bowel) cancer? **2**

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(c) Screening for bowel cancer provides the greatest opportunity of diagnosing early abnormal tissue growth in the bowel. **4**

Using the information provided on page 23, assess the benefits of regular bowel cancer screening for people over the age of 50.

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Question 30 (6 marks)

African sleeping sickness is a tropical disease caused by a parasite and spread by the tsetse fly in sub-Saharan Africa. The parasite is a eukaryotic unicellular organism without a cell wall. Infections begin with mild to moderate symptoms like fever and body aches before the patient experiences serious neurological issues that include sleep disturbances.

(a) Identify the type of pathogen that causes African sleeping sickness and describe a process by which it reproduces. **3**

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(b) Explain TWO main features of the innate immune response that causes the symptoms to develop in an infected individual. **3**

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Question 31 (8 marks)

The market for therapeutic antibody drugs has experienced significant growth as newly developed drugs have been approved for treating various human diseases, including many cancers, autoimmune, metabolic and infectious diseases. The U.S. Food and Drug Administration (U.S. FDA) is the governing body that approves the use of newly developed drugs for medical use in the United States of America.

The table below shows the U.S. FDA-approved monoclonal antibody treatments from 1997 to 2018.

Year	Number of New Drugs Approved
1997	1
2002	2
2004	3
2009	4
2014	6
2017	11
2018	12

Analyse how an understanding of biology has led to the development of named current and future biotechnologies in medicine.

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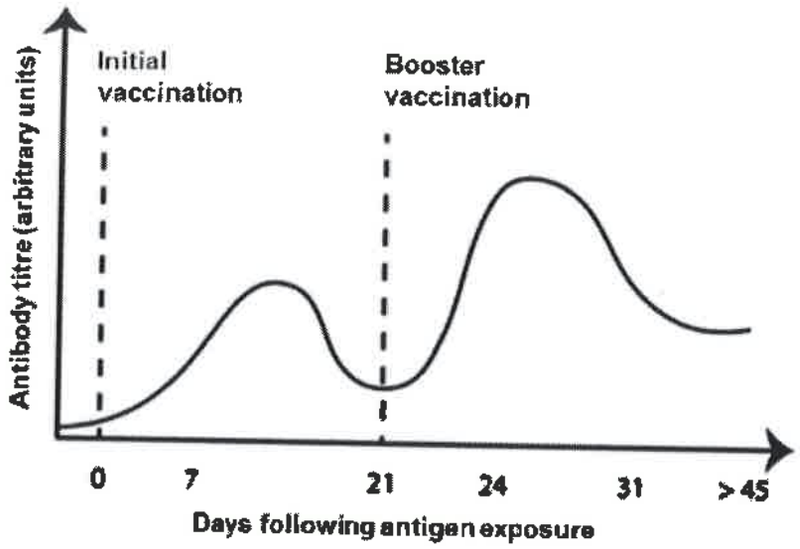
Question 31 continues on page 27

Question 31 (continued)

Question 32 (5 marks)

Below is a graph showing the antibody concentration in a person following their initial vaccination and their booster vaccination over time. 5



The federal government wanted to use this graph in their public health campaign to encourage members of the public to receive their booster vaccination. Discuss whether this would be an effective strategy using your knowledge of the adaptive immune response.

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Question 32 continues on page 29

Question 32 (continued)

Question 33 (9 marks)

DNA Metabarcoding is a new technique used to capture and identify DNA from unknown species around a farm. It is used to identify the variety of organisms present in the sampling area. The approach involves collecting airborne samples, swirling the trapped air through a liquid-filled tube and trapping any DNA fragments from species present. 9

The genetic material in cells that is shed by organisms into their environment is known as environment DNA (eDNA). The eDNA information that is collected is compared to a reference database of known insect DNA and any new migrant insects or pests could then be identified.

Describe the DNA techniques that may be used in *DNA metabarcoding* and justify how the population's genetic information could be used to help farmers to maintain biodiversity and minimise pesticide use on the farm.

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Question 33 continues on page 31

Question 33 (continued)

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End of Examination

EXAMINERS

George Lavidis (Convenor)	Christian Brothers' High School, Lewisham
Kathryn Bennett	St. Patrick's Marist College, Dundas
Stephanie Bohane	Casimir Catholic College, Marrickville
Patrick Ortiz	Good Samaritan Catholic College, Hinchinbrook
Melissa Shannon	St. Patricks College, Strathfield