



JAMES RUSE AGRICULTURAL HIGH SCHOOL

2021

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Biology

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen.
- Draw diagrams using pencil.
- NESA approved calculators may be used.
- Write your Student Number at the top of the response sheet on page 15

Total Marks – 100

Section I – Pages 2 – 13

20 marks

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

Section II – Page 16 – 46

80 marks

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

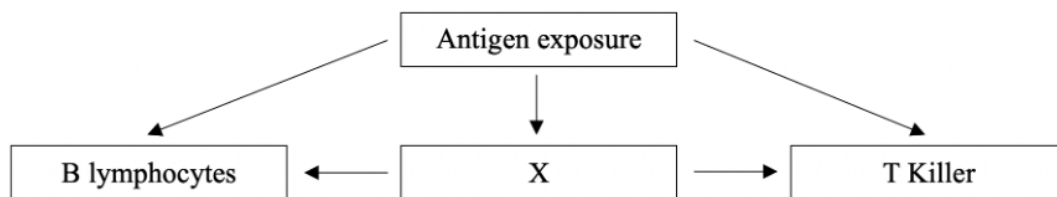
Section I

20 marks

Attempt Questions 1 – 20.

Enter your answers in the multiple choice quiz on Google Classroom.

- 1 Which of the following are both non-cellular pathogens?
- A. Bacteria and virus.
 - B. Prion and protozoa.
 - C. Protozoa and bacteria.
 - D. Virus and prion.
- 2 Mutations occurring in cells which do not go on to form gametes can be classified as:
- A. somatic mutations
 - B. germ line mutations
 - C. morphological mutations
 - D. oncogenes
- 3 In the diagram, X represents a cell with the function of secreting chemicals that stimulate the cloning of B and T lymphocytes.



What type of cell is X?

- A. T plasma cell
- B. T memory cell
- C. T suppressor cell
- D. T helper cell

- 4 The table below shows the water gained and lost by 2 species of mammals.

	mammal species A		mammal species B	
water gain	mL /day	% of total	mL /day	% of total
drinking	0	0	1500	60
eating	6	10	750	30
metabolism	54	90	250	10
water loss				
evaporation	43.9	73	900	36
urine	13.5	23	1500	60
third avenue of water loss	2.6	4	100	4

Which of the following statements is consistent with the given data?

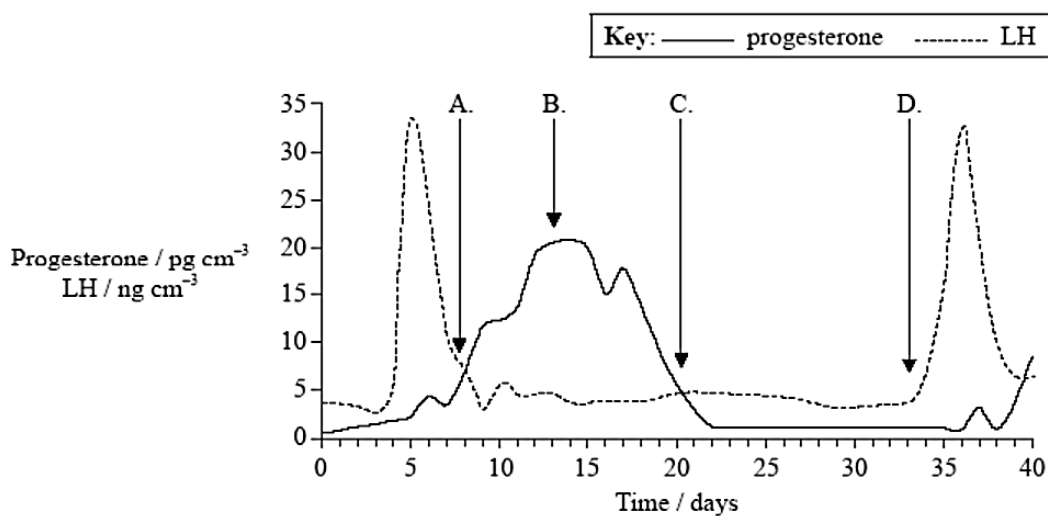
- A. The high proportion of water lost through evaporation in species A shows that species A is adapted to survive in a hot and dry climate
- B. The higher metabolic rate of species B compared to species A indicates that species B could be a desert animal.
- C. 0% water gain and 13.5 ml water loss through urine are indicators of mammal A being a hibernating animal.
- D. The overall water gain and loss is higher for mammal B than mammal A, indicating that mammal B has larger surface area.

- 5 In 2014, during an outbreak of Ebola virus disease (EVD) in West Africa thousands of local people and several healthcare workers died. Infections resulted from human-to-human transmission through contact with broken skin, mucus, bodily fluids, and secretions.

Which of the following measures could prevent future outbreaks of EVD?

- A. Administration of antibiotics
- B. Isolation of infected people
- C. Use of education programs
- D. Vaccination of infected people

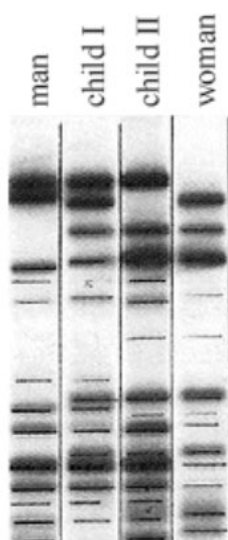
- 6 The hormones progesterone and luteinising hormone (LH) were measured in a woman's blood over 40 days as shown below:



When did her menstrual bleed start?

- A. Day 8
- B. Day 13
- C. Day 21
- D. Day 34

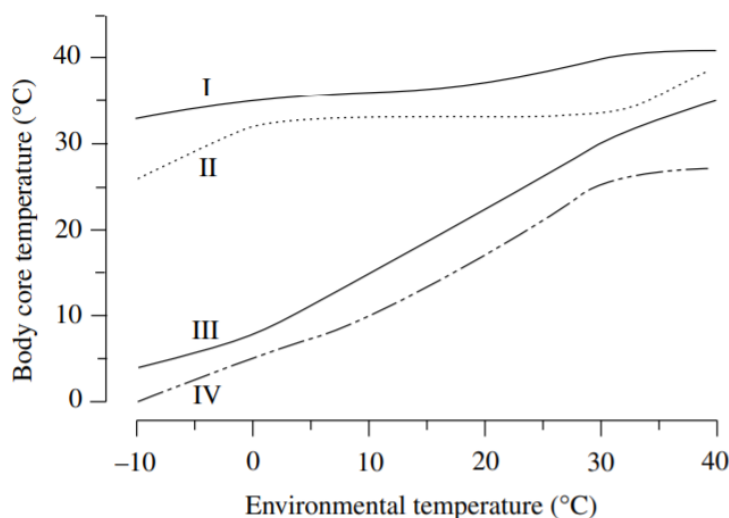
- 7 The following data show the results of a DNA profile of a family.



What conclusion can be made from the analysis of these DNA fragments?

- A. Both children are related to both parents.
- B. Child I is related to the man but child II is not.
- C. Both children are unrelated to either of the parents.
- D. Child II is related to the man but child I is not.

- 8 The graph below shows the relationship between body temperature and environmental temperature of 4 different organisms.



Which of the following statements is best supported by the data?

- A. Animals I and II are most likely mammals.
- B. Animal II is endothermic over the environmental temperature range of 0 to 30°C.
- C. Animal III maintains its body core temperature relatively constant by shivering when the environmental temperature falls below 37°C.
- D. Animal IV is most likely a mammal in polar region.

- 9 Duchenne muscular dystrophy is a genetic disorder, where the muscles waste away due to inadequate production of a protein called dystrophin. A group of researchers isolated the gene for dystrophin and inserted it into a plasmid extracted from a bacterium. A concentrated solution of these recombinant plasmids was then injected into the muscles of mice with a missense mutation in the gene for dystrophin.

Which of the following is the function of the injected plasmid in treating the disorder?

- A. To stimulate a humoral immune response to the bacteria in the treated mice.
- B. To deliver the dystrophin protein directly to the muscles of the treated mice.
- C. To act as a vector for the delivery of dystrophin genes to the muscle cells of the treated mice.
- D. To create a strain of genetically engineered bacteria that will cure Duchenne muscular dystrophy.

- 10 A pathology centre took blood samples from three patients. One patient was suspected of suffering from anaemia, which reduces the oxygen carrying capacity of the blood. Another patient was suffering from Human immunodeficiency virus (HIV) which attacks T cells. The third patient had a red, raised area following a puncture wound.

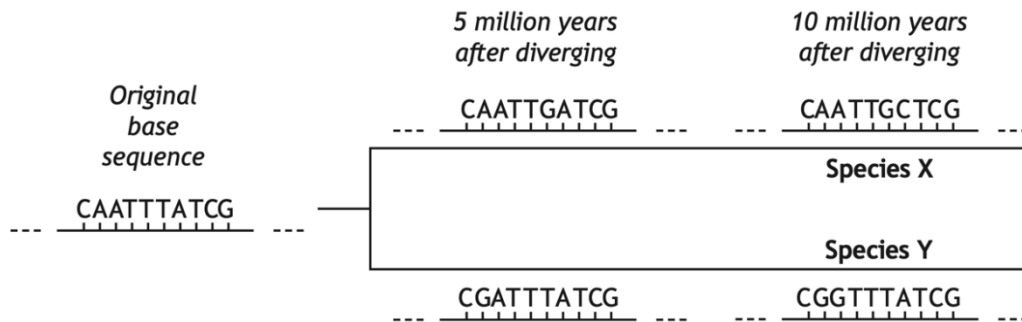
The table below shows the numbers of different types of blood cells found in blood samples taken from the three patients.

	Blood cells found in blood sample (cells/mm ³)			
<i>Type of blood cell</i>	<i>Reference range (95% healthy individuals)</i>	<i>Patient X</i>	<i>Patient Y</i>	<i>Patient Z</i>
Phagocyte	3000 – 8000	2689	9680	7370
Lymphocyte	800 – 5000	273	3741	2692
Erythrocyte	3000000 – 6000000	2873000	5243000	2148000

Which of the following correctly matches the patient to the condition?

	<i>Condition</i>		
	<i>Anaemia</i>	<i>HIV</i>	<i>Infected Wound</i>
A.	Y	X	Z
B.	X	Z	Y
C.	Z	Y	X
D.	Z	X	Y

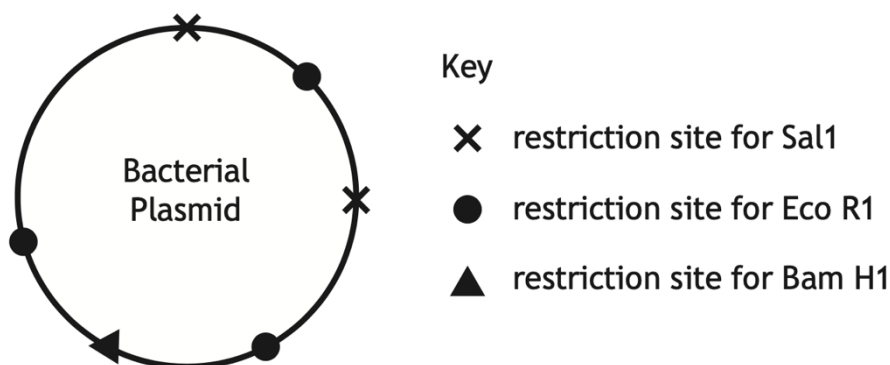
- 11 Over millions of years of evolution, mutations occur at a broadly constant rate within a gene. This allows genes to be used as molecular clocks. The diagram below shows how the base sequence in part of a gene changed as two evolutionary lineages diverged from an original base sequence.



Assuming this rate of mutation continued, by how many bases would this part of the gene differ in Species X compared with Species Y 20 million years after diverging from the original base sequence?

- A. 4
 - B. 8
 - C. 16
 - D. 20
- 12 Which of the following statements best explains why bacteria are used in gene cloning?
- A. Bacteria can replicate non-bacterial sequences of DNA in a short time.
 - B. Bacteria allow the entry of foreign DNA into their nuclei.
 - C. Bacteria replicate exponentially by undergoing mitotic divisions.
 - D. Bacteria contain restriction enzymes that randomly cut chromosomes into fragments of varying size.

- 13 The diagram shows a bacterial plasmid with restriction sites for three different restriction endonucleases, Sal I, Eco RI and Bam HI.



Which row in the table identifies the number of fragments produced if the plasmid was cut with the combinations of restriction endonucleases shown?

	Combination	
	<i>Sal I and Bam HI</i>	<i>Sal I and Eco RI</i>
A.	3	4
B.	3	5
C.	4	4
D.	4	5

- 14 Consider the following steps taking place in the cell cycle:

- I. Re-formation of nuclear membranes
- II. Pairing of homologous chromosomes
- III. DNA replication

Which of these take(s) place during either interphase or mitosis in animal cells?

- A. I only
- B. I and II only
- C. II and III only
- D. I and III only

- 15** Osmoregulation is the process by which water and salt (or solute) concentration in the blood achieves homeostasis using aldosterone and anti-diuretic hormones (ADH).

Aldosterone acts on sodium ions causing them to be actively reabsorbed back into the blood from the kidney. As a result, the blood in the capillaries surrounding the kidney's distal tubule will have a higher solute concentration.

An increase in solute concentration in the blood causes the pituitary gland to secrete ADH into the blood stream to increase their permeability of distal tubules to water. This increases the amount of water reabsorbed back into the blood from the kidney. The amount of ADH secreted will decrease when the solute concentration in the blood returns to normality establishing osmoregulation.

A dehydrated marathon runner consumed a concentrated salt sports drink to satisfy his thirst.

How does his body control the two hormones, ADH and aldosterone, to help to re-establish normal water balance?

- A. ADH is released and aldosterone is inhibited
- B. ADH is inhibited and aldosterone is released.
- C. Both ADH and aldosterone are released.
- D. Both ADH and aldosterone are inhibited.

- 16 Adrenocorticotrophic hormone (ACTH) is the hormone that stimulates cholesterol conversion to progesterone and testosterone. Progesterone is then converted to cortisol due to the action of an enzyme 21-hydroxylase. If the enzyme is defective, the synthesis of cortisol is reduced, and an excess of testosterone is produced. This results in a disorder called congenital adrenal hyperplasia (CAH).

To diagnose CAH disorder, an ACTH stimulation test is performed. Blood is measured for starting levels of testosterone. ACTH is then injected, and another blood sample is taken and analysed after 120 minutes.

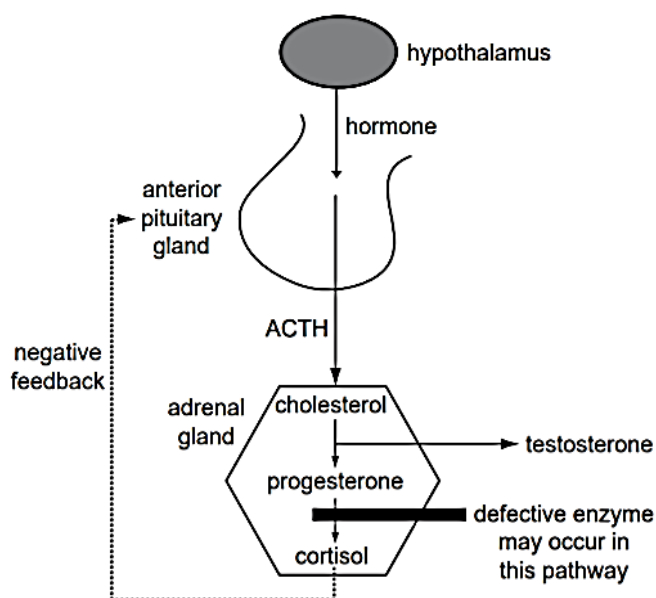
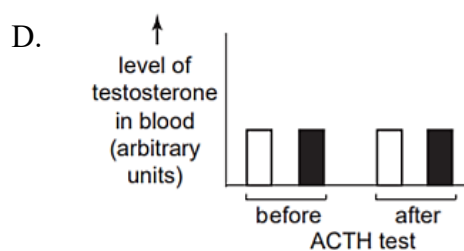
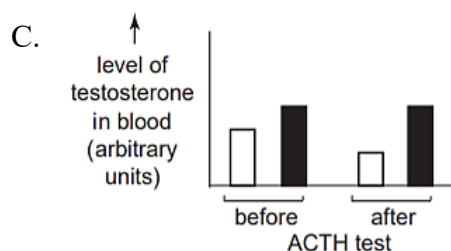
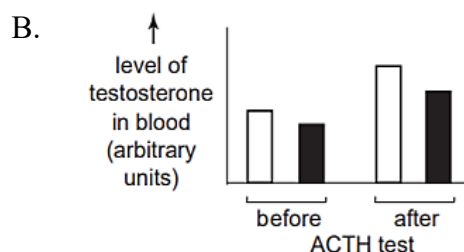
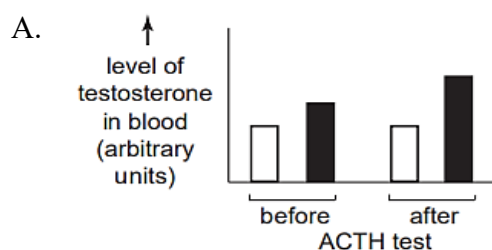


Figure 1: ACTH pathway



Figure 2: Graph Key

Using the given key which of the following graphs best depicts the changes in the level of testosterone in an ACTH stimulation test?



Use the following information to answer question 17 and 18.

A comet assay is a technique used to determine the amount of double-strand breakages in DNA (DNA damage) in cells. A cell is exposed to a mutagen that damages the DNA causing double-strand breaks. The nucleus of the cell is placed on a microscope slide coated with an agarose gel. An electric current is applied to the gel that causes DNA to move (electrophoresis), and the DNA is stained with a fluorescent dye. When viewed using a microscope, undamaged DNA from the nucleus appears as a round shape (the head), and the fragments of damaged DNA with double strand breaks extend out from the head (the tail). The length of the tail corresponds to the amount of the damage in the DNA.

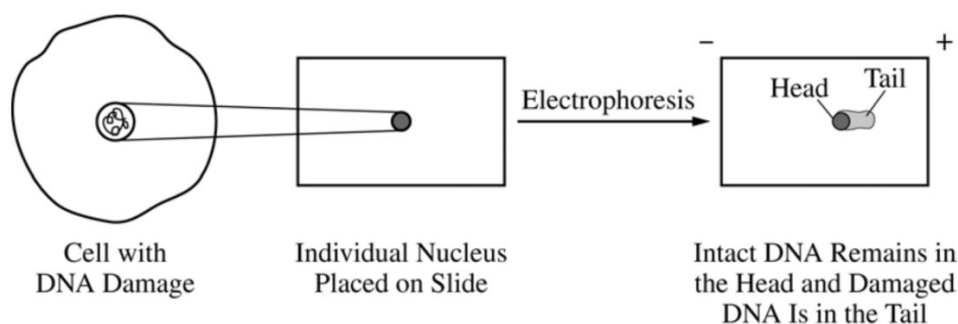


Figure 1: Comet Assay

- 17** The following events occur after DNA is subjected to radiation. The events are listed in no specific order.

W: Mutation
X: Change in cell activity
Y: Change in protein structure
Z: Change in polypeptide sequence

What is the correct sequence of steps?

- A. W, X, Y, Z
- B. Z, X, W, Y
- C. Z, Y, X, W
- D. W, Z, Y, X

- 18** In a separate experiment, cells are treated with a chemical mutagen that causes only nucleotide substitutions in DNA.

Which of the following is the most correct prediction for the result of a comet assay for this treatment?

- A. The tail will be longer than a cell with double-stranded breaks in DNA.
- B. The head will remain in place and the tail will move towards the negative terminal.
- C. The only visible part will be the head with no tail.
- D. There will be no visible head or tail.

Use the following information to answer question 19 and 20.

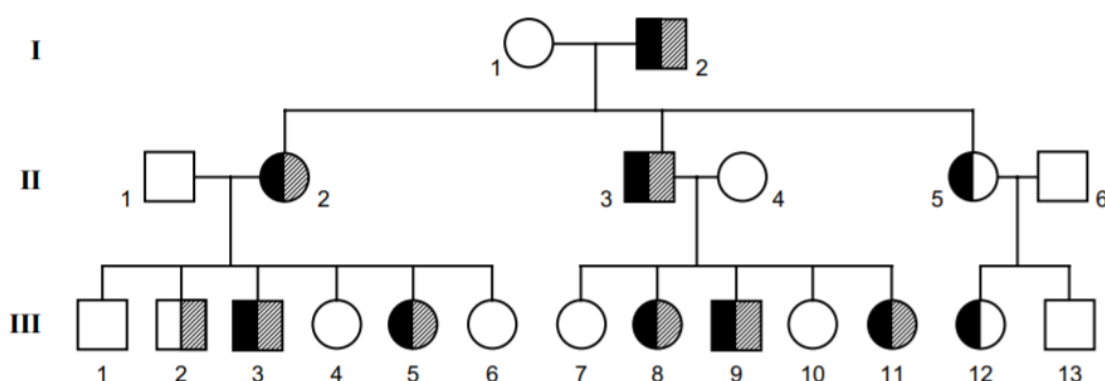
Two linked genes in humans have the following alleles.

Gene 1	Gene 2
A: secretor	B: production of protein X
a: non-secretor	b: no protein X produced

Information regarding these traits in a family was collected and the chromosome composition of each member for these two genes was established. It was found that, in all, there were four different chromosome compositions in the family. The four types are shown in the following table:

	Type 1	Type 2	Type 3	Type 4
Genotype				

The pedigree for the family is shown below



Codes for interpreting the pedigree

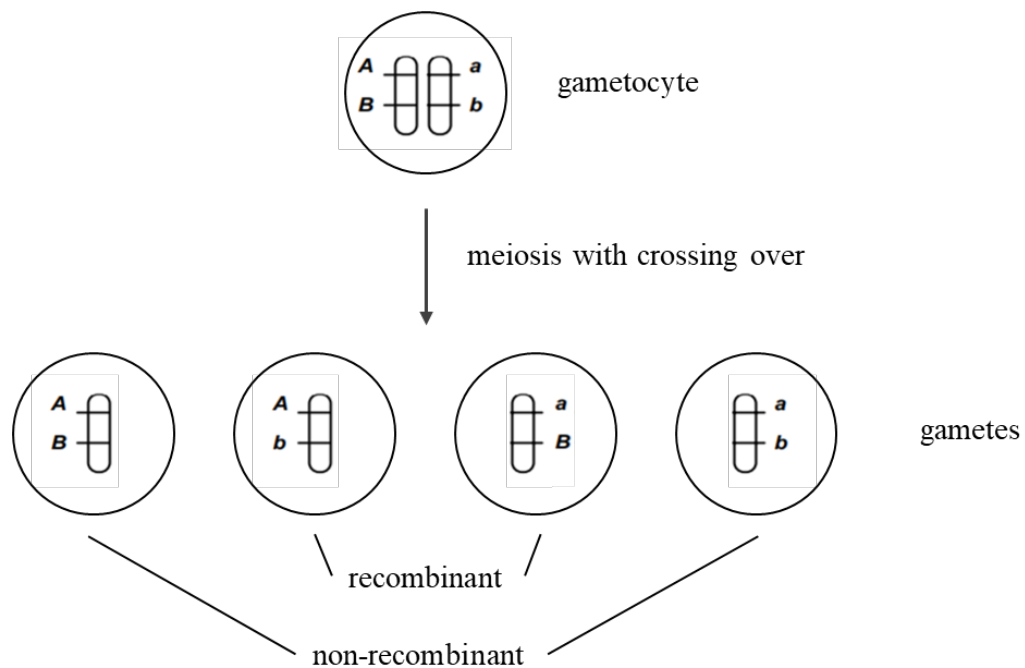
secretors and produce protein X 	non-secretors and produce protein X 	secretors and no protein X 	non-secretors and no protein X
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Questions 19 and 20 are on the following page

19 Which of the following is correct about the genotype of the identified individual?

- A. I-1 is type 1.
- B. II-2 is type 2.
- C. III-2 is type 3.
- D. III-12 is type 4.

20 The distance between the two genes on the chromosome can be estimated based on the percentage of recombinant gametes that are formed following crossing over between the two genes during meiosis.



Based on the pedigree presented above, which of the following is the best estimate of the percentage of gametes that are formed due to crossing over between the two genes?

- A. 14%
- B. 18%
- C. 27%
- D. 38%

There are no questions on this page

Section I

Multiple Choice Answer Sheet

Please enter your answers into the Quiz on Google Classroom

Section II – 80 marks

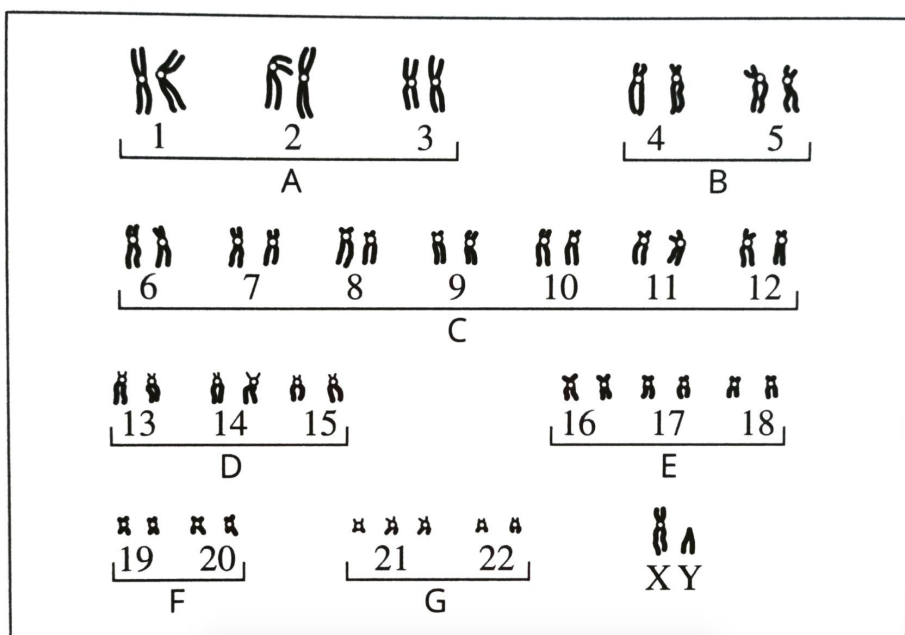
Attempt Questions 21 – 33

Allow about 2 hour and 25 minutes for this part.

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations

Question 21 (2 marks)

The figure below represents an individual's karyotype.



With reference to the above diagram, describe the information that can be obtained from a karyotype.

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Question 22 (5 Marks)

Safflower, *Carthamus tinctorius*, is a minor crop grown in Australia for the edible and industrial oil markets. Commercial safflower production occurs mainly in New South Wales, Victoria and South Australia. After oil is extracted from the seed, the remaining meal can be used as stockfeed. The first commercial GM (genetically modified) safflower was released in Australia in 2018. There are both supporters and critics for the use of this biotechnology.

- (a) Describe the benefits of ONE other named transgenic crop to agriculture. **2**

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- (b) Discuss ONE social or cultural issue which has influenced the use of a named GM crop. **3**

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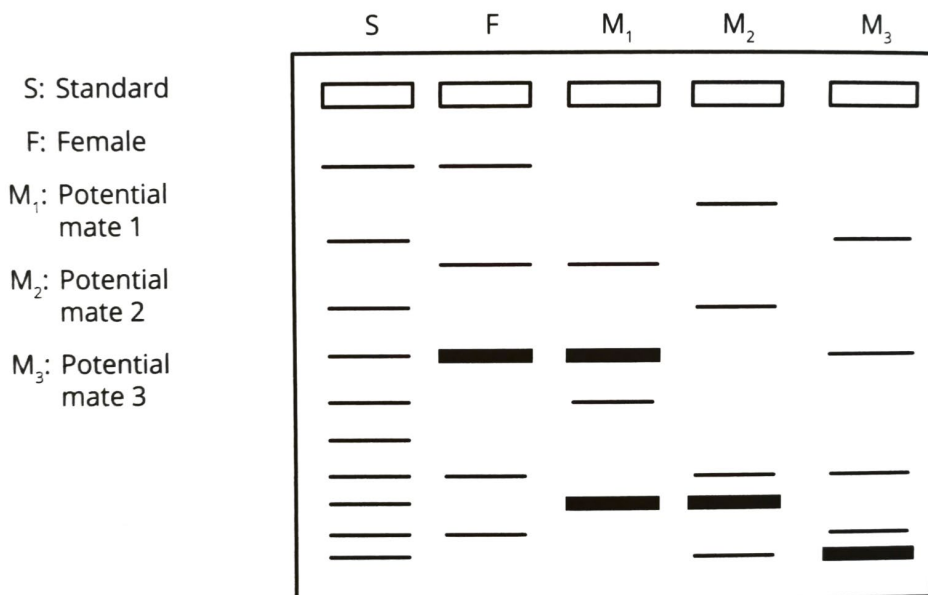
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Question 23 (4 Marks)

The Amur leopard, *Panthera pardus orientalis* are a subspecies of leopard only found in Russia and China. The Amur leopard has been listed as Critically Endangered with an estimated population of 100 individuals recorded in 2017. Breeding programs are used in zoological parks to help avoid extinction.

The gel electrophoresis shown below considers several DNA markers for a female Amur leopard and three potential mates from other zoos.



Justify the use of gel electrophoresis in selecting the pair of Amur leopards, from this captive population, that you would recommend for breeding. Support your answer with reference to the data. 4

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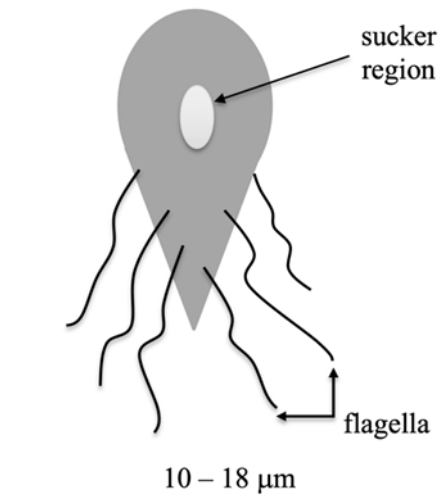
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Question 24 (3 Marks)

Giardiasis is the most common form of non-bacterial diarrhoea of people in Australia. The adult parasite, *Giardia lamblia*, responsible for the disease, is shown in the figure below. The adult is a single cell. Its ventral side is flattened and has a shallow depression used as a type of sucker. *Giardia* lives in the upper part of the intestine (duodenum) of an infected person where it rapidly multiplies. To pass from one human to another it encloses itself in a cyst that passes out in the faeces.



Describe ONE procedure that would be suitable for preventing the spread of *Giardia* and justify its use. 3

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Question 25 (3 marks)

Some types of leukocytes can change this shape to engulf foreign particles, for example bacteria. This process also includes the foreign particle being destroyed inside the cell.

(a) Name the process described above. **1**

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(b) The process above is a non-specific response to an antigen. Outline ONE physical change that occurs in a host's cell or tissue in response to a pathogen by the human immune system. **2**

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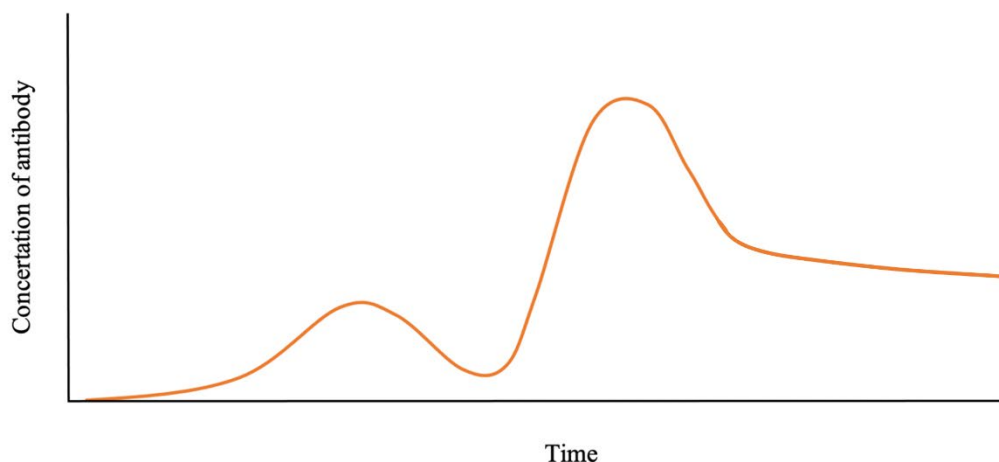
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Question 26 (5 Marks)

The graph below shows the change in antibody concentration over time after vaccination involving an initial and then second, or booster, dose.



Identify the time at which the primary and secondary vaccinations were given and account for the features of the graph using your knowledge of primary and secondary immune response. Annotate the graph to support your answer. **5**

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Question 27 (4 Marks)

Sexual reproduction is a mechanism that has evolved to ensure the continuity of species. In animals several reproductive strategies ensure that reproduction occurs effectively in the environment they live in. Both internal and external fertilisation strategies are known to produce reproductive success.

“Internal fertilisation is more advantageous than external fertilisation in ensuring the continuity of a species”.

Assess the above statement.

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Question 28 (4 Marks)

Lead poisoning is a serious health problem. Too much lead can affect all organs, including the kidneys, causing “lead related nephrotoxicity”. In extreme cases nephrotoxicity causes polycystic kidney disease in which fluid-filled cysts grow in the kidney, interfering with the normal kidney tissue and limiting the kidney’s ability to filter the blood. The number of cysts builds up over time, enlarging the kidney and ultimately causing renal failure.

Evaluate the effectiveness of an identified technology that can assist with this type of disorder. In your answer include any specific limitations of the treatment or consequences for the patient’s diet and/or lifestyle associated with the use of this technology. **4**

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Question 29 (3 Marks)

The coiled-coil was one of the earliest tertiary protein structures described and first discovered in the two-stranded coiled-coil protein (CC) alpha-keratin. Coiled-coils consist of two or more alpha-helices winding around each other.

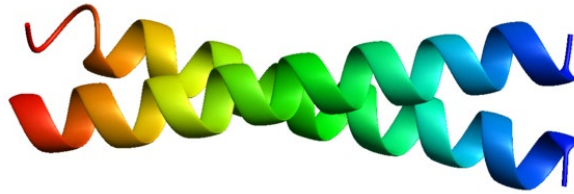


Figure 1: Coiled-coil

Such proteins are involved in a wide variety of structural and mechanical processes in cells. Long-CC (LCC) includes long coiled-coils with a minimum stretch of 70 amino acids in one coiled coil and a minimum stretch of 50 amino acids in the other.

A study was carried out to compare the presence of CC and LCC proteins in species from different kingdoms. The graph below represents the estimated percentages of CC proteins, LCC proteins and superlong CC per genome for 22 different species.

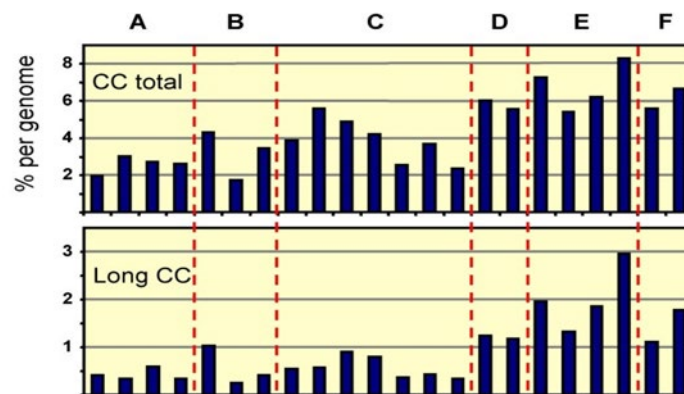


Figure 2: % coiled-coil proteins per genome for 22 species. A: Archaea; B: Gram positive bacteria; C: Gram negative bacteria; D: Fungi; E: Animals; F: Plants

Question 29 continues on the next page

“Animals are more closely related to plants than other kingdoms”.

Analyse the data provided and assess whether this statement is supported.

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End of Question 29

Question 30 (8 Marks)

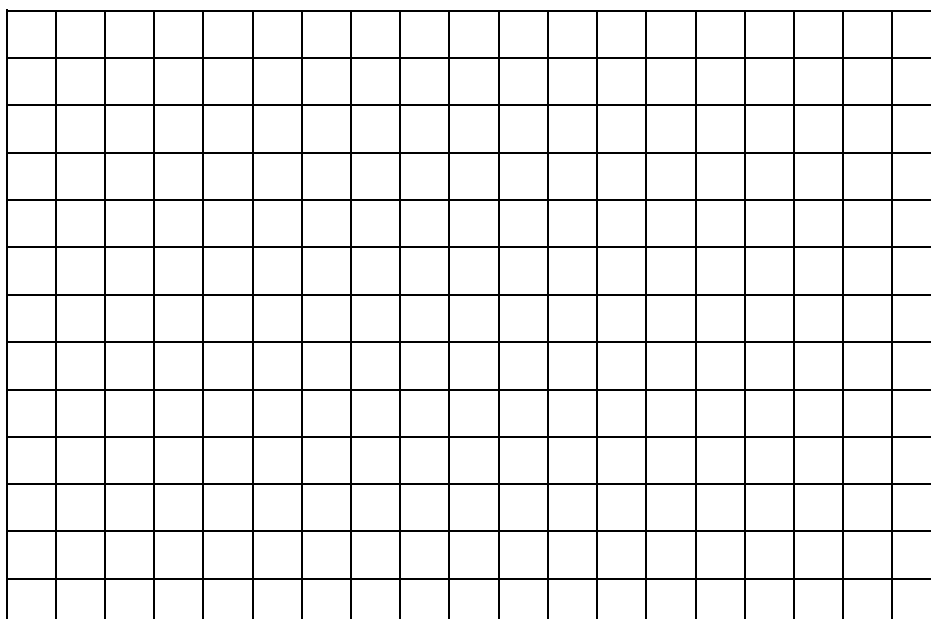
The data below examines the changes in allele frequencies at a single locus with two alleles B and b in two very large populations of rabbits due to natural selection. It is known that a variety of genetic traits affect the survivability of rabbits in the wild, as well as in breeding populations. One such trait is furless rabbits (naked bunnies). This trait was first discovered in England by W.E. Castle in 1933. The furless rabbit is rarely found in the wild because the cold English winters are a selective pressure against it.

The dominant allele for normal fur is represented by B and the recessive allele for no fur is represented by b.

Generation	Frequency of allele b	
	Population x	Population y
0	0.50	0.50
10	0.37	0.65
20	0.30	0.80
30	0.24	0.90
40	0.20	0.98
50	0.18	1.00
60	0.14	1.00
70	0.12	1.00
80	0.12	1.00
90	0.10	1.00
100	0.10	1.00

(a) Graph the frequencies of B and b as a function of generation.

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Question 30 continues on the next page

(b) Account for the shape of the graph. Support your answer with reference to the information provided. 2

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(c) In rabbits, an unlinked second gene controls the length of fur, if any. Long hair (L) is dominant over short hair (l).

A long-haired rabbit was crossed with a furless rabbit to produce many offspring, all of which have fur. One-quarter of the offspring are short-haired rabbits.

Deduce the genotypes of the two parent rabbits. Show working. 3

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End of Question 30

Question 31 (3 Marks)

Foetal alcohol spectrum disorders (FASDs) are one of the growing class of lifestyle caused disorders. FASDs are a group of conditions that can occur in a person whose mother drank alcohol during pregnancy. People with FAS have central nervous system (CNS) problems, minor facial feature abnormalities, and growth problems. People with FAS can have problems with learning, memory, attention span, communication, vision, or hearing. They might have a mix of these problems. People with FAS often have a hard time in school and trouble getting along with others.

The poster shown is an example of a poster from an educational program that targets FASD.



Explain the use of this educational program to society.

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Question 32 (12 marks)

Agrobacterium tumefaciens is a rod-shaped bacterium found in soil. Its flagella allow it to move through the soil in response to chemicals released by wounded plant cells. Once it enters its plant host, it injects a section of its DNA called the T-DNA which is derived from its Ti (tumour inducing) plasmid into its host causing the host to form undifferentiated (tumour) tissue termed a crown gall.

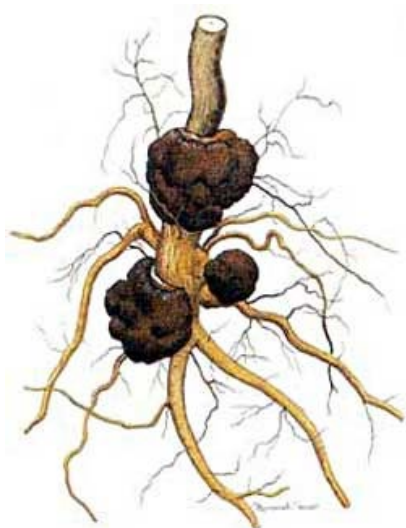


Figure 1: Crown gall

(a) Compare the forms in which DNA is found in agrobacterium and its host before infection. **2**

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(b) Explain how agrobacterium can operate as a mutagen. **2**

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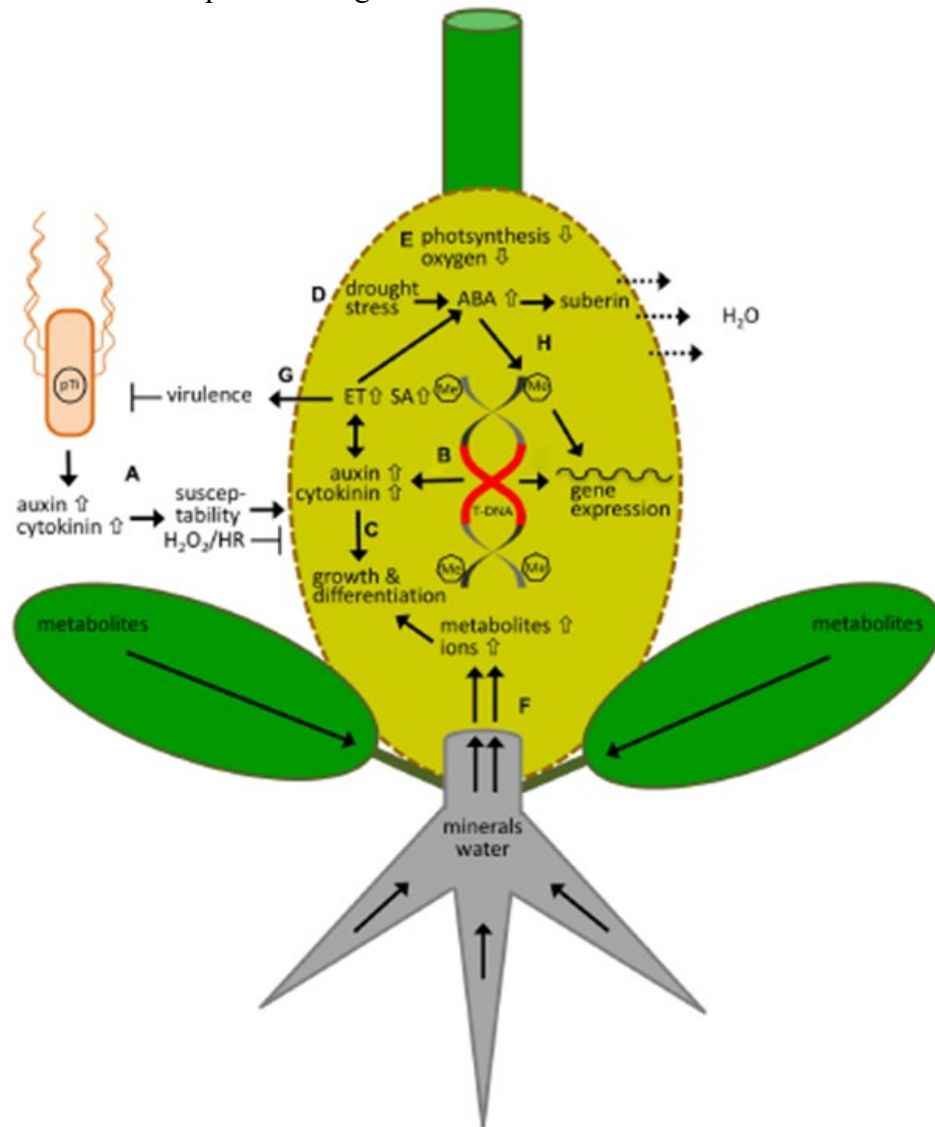
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Question 32 continues on the next page

The interaction between a plant and *Agrobacterium* is detailed below:



- (A) *Agrobacterium* cells produce the hormones cytokinin and auxin, which increase host susceptibility and inhibit H_2O_2 production and hypersensitive response (HR) upon infection.
- (B) After integration of the bacterial T-DNA into the plant genome, cytokinin and auxin are synthesized by T-DNA encoded enzymes and accumulate inside the tumour.
- (C) This causes massive changes in the gene expression pattern resulting in metabolomic and morphological adaptations that are necessary for tumour growth and differentiation.
- (D) Loss of water is minimized by an increase in the levels of the stress hormone ABA. Evaporation of water from the disrupted crown gall surface drives the flow of water and minerals into crown galls.
- (E) Because photosynthesis is downregulated, the O_2 levels are low, the tumour produces C and N compounds heterotrophically and gains energy mainly anaerobically by alcoholic fermentation.
- (F) The developing tumour becomes a metabolic sink for the host plant, which accumulates metabolites produced by source leaves and minerals taken up by the roots.
- (G) Auxin and cytokinin also cause an increase in ethylene (ET) which together with salicylic acid (SA) inhibits *agrobacterium* virulence.
- (H) ABA induces DNA methylation of the plant genome, regulating gene expression of drought-stress responsive genes. The oncogenes of the T-DNA remain unaffected by methylation of the plant genome.

Question 32 continues on the next page

(c) Outline ONE response of the plant to agrobacterium infection. **2**

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(d) Describe ONE adaptation that makes agrobacterium a successful pathogen of plants. **2**

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(e) Identify a mechanism by which the plant maintains homeostasis when infected by agrobacterium. **1**

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(f) “Regulation of genes affects the phenotype of the organism.”

Discuss this statement using the information provided. **3**

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End of Question 32

Question 33 (24 marks)

Rubella is an infectious disease caused by *Rubivirus rubella*. The disease is frequently mild, with a characteristic rash often appearing two weeks after exposure and lasting for three days. Other symptoms include fever, sore throat and fatigue, with joint pain common in adults. Up to half of infected cases are asymptomatic.

Rubella is usually spread from one person to the next through the air via coughs of people who are infected. People are infectious during the week before and after the appearance of the rash. Only humans are infected. Once recovered, people are immune to future infections.

In the early 1940s, Australian ophthalmologist Norman Gregg noticed a high incidence of congenital cataracts in babies whose mothers had suffered from rubella during pregnancy. It was then statistically shown that infection during early pregnancy may result in a miscarriage or a child born with congenital rubella syndrome (CRS). The main defects result almost exclusively from rubella infection occurring in the first 16 weeks of gestation and include deafness due to cochlea malformation, eye and cardiovascular defects and central nervous system damage leading to mental retardation.

Rubella is preventable with a single dose of the rubella vaccine being more than 95% effective. When rubella vaccination became feasible around 1971, both the United States and the United Kingdom embarked on vaccination programs. In the United States, the strategy was to vaccinate infants, so that eventually the reservoir in childhood would be abolished. In contrast, the United Kingdom decided on a program of vaccinating adolescent girls. Both strategies were partial successes, in that CRS incidence began to decrease.

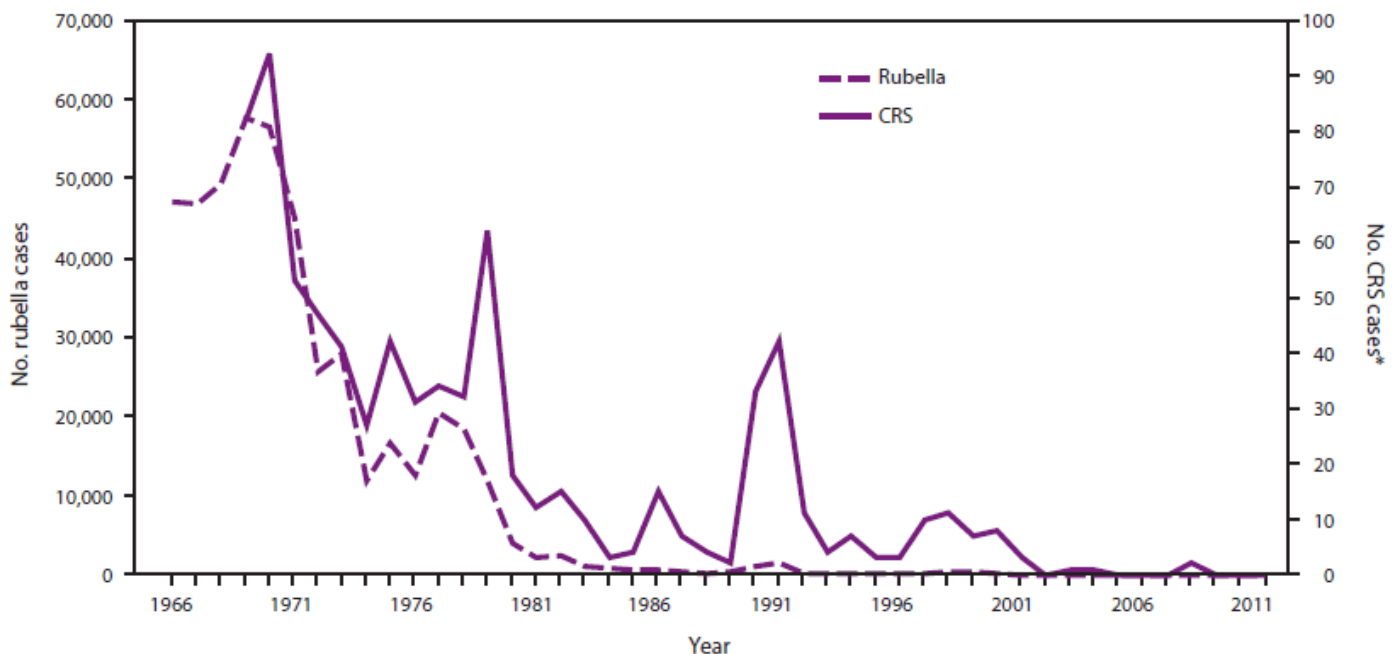


Figure 1: Number of Rubella and Congenital Rubella Syndrome Cases in the United States 1966-2011

Question 33 continues on the next page

(a) Describe the trends in the incidence of infectious rubella cases. 2

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(b) Use the evidence in the graph to justify the statement that the US program was only a partial success in reducing the rate of CRS. 2

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(c) Justify a hypothesis as to why the UK program was only a partial success in reducing the rate of CRS. 2

Hypothesis:.....

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Justification:.....

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Question 33 continues on the next page

(d) Today, most developed countries have a comprehensive immunization program and rubella has been eliminated in many areas of the world. However, in a number of developing countries rubella infections are common and significant number of babies are born with CRS.

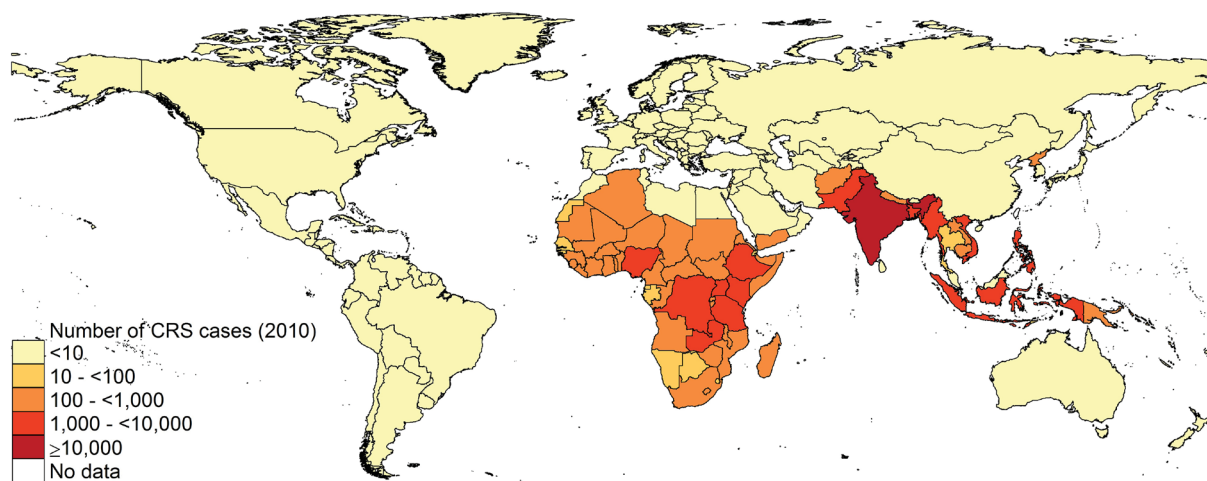


Figure 2: Estimates of the median number of CRS cases born by country in 2010

Explain how a named medical technology could be used to treat a symptom of CRS and propose a reason why this is not routinely done. 3

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(e) The mechanism for how CRS occurs is not clear, although it is known that the pathogen crosses the placenta and infects the embryo. It appears that the rate of mitosis in some embryonic tissues is decreased.

Explain how a reduced rate of mitosis could cause ONE identified symptom of CRS 2

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Question 33 continues on the next page

(f) An alternative hypothesis for the mechanism is that some of the symptoms of CRS are due to maternal infection causing malfunction of the mother's liver resulting in excessively high (toxic) levels of Vitamin A in the blood of both the mother and the developing embryo. Vitamin A is stored in the liver and is also found in the diet in cheese, dairy, liver and meat.

A group of unvaccinated pregnant women in a developing region has just been exposed to rubella virus.

Outline an epidemiological study that could be carried out ethically to test the Vitamin A hypothesis outlined above. **5**

Type of epidemiological study	Circle any appropriate words: descriptive, analytic, experimental, observational, prospective, retrospective, cohort, case-control, cross-sectional, case, longitudinal, clinical trial, blind, double-blind
Method of study	
What results would support the Vitamin A hypothesis	

Question 33 continues on the next page

In your response, refer to:

- 8

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End of Exam

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Section II extra writing space

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MARKING CRITERIA - 2021 Biology Trial

Section I – MCQ's

1	2	3	4	5	6	7	8	9	10
D	A	D	A/D	B	C	A	B	C	D

11	12	13	14	15	16	17	18	19	20
B	A	B	D	A	A	D	C	C	A

Question 20

In order to determine the number of crossings over, we look for offspring of individuals which are heterozygous for each trait (in this family, type 1) and individuals who are homozygous recessive (type 4). Those of type 1 have both dominant alleles on one chromosome (and therefore also both recessive alleles on the other chromosome).

Without crossing over, their gametes are either both dominant, or both recessive. Their offspring will be either type 1 or type 4 (as the other parent is homozygous recessive for both traits.)

For a type 1 individual, following crossing over between the two genes, the gametes will contain only one dominant allele (either A or B). Their offspring will be either type 2 or type 3.

There are three crossings of type 1 and type 4 individuals:

I1 and I2 have 3 children: 2 type 1 (no crossing over between genes) and 1 type 2 (crossing over between genes).

II1 and II2 have 6 children: 2 type 1 and 3 type 4 (no crossing over between the genes) and 1 type 3 (crossing over between the genes).

II3 and II4 have 5 children: 3 type 1 and 2 type 4 (no crossing over between the genes).

The children of II5 and II6 do not provide any information about crossing over between the two genes, as they are all homozygous recessive for the b allele.

Out of $(3+6+5) = 14$ children there are 2 which have formed following crossing over between the genes. $2/14 = 14\%$

Section II – Extended Responses

MODULE 6

Question 21 (2 marks)

Criteria	Mark
Explains that the gender and any chromosomal mutations/disorders can be determined	2
Some relevant information	1

Sample answer

A karyotype displays all the chromosomes, in pairs, for an individual, if there is a mutation this can be seen from insertions or deletions. Karyotypes also show the sex chromosomes and can be used to determine an individual's gender. This individual is a male, based on the X,Y chromosomes and they have a trisomy mutation at chromosome 21.

Comment

Most students answered correctly including.

No need to include details about the disorder/symptoms.

The question asks for a description of the karyotype not an explanation of the outcome/disorder.

You need to include specific information that can be determine about this individual.

Include gender.

Range 1-2

Avg. 1.50

Question 22 (5 Marks)

(a)

Criteria	Mark
- Provides a named example - Describes the benefits	2

One of the above.	1
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Sample answer

Bt cotton is a GM crop that is produced by the insertion of bacteria plasmid from *Bacillus thuringiensis*. This transgenic organism has the ability to produce a protein that is toxic to pests, which provides natural protection without the need for pesticides.

*if the answer has more than one example, only the first was marked.

Comment

Provide a named example

Range 1-2

Avg. 1.85

(b)

Criteria	Mark
- ONE named example provided - Clearly identifies an issue - Discuss points for and against	3
- Vaguely discusses issues and provide points for and/or against. OR - Only identifies several issues and provide points for and/or against.	2
Some relevant information	1

Sample Answer:

Herbicide-Resistant corn, such as Roundup Ready Corn, is modified to be tolerant to weedkiller containing glyphosate. There is social concern from people with a perception that weedkiller is harmful to the health of people and animals, which leads them to question the safety of GM corn

itself. There has been a large amount of research and evidence to support the safety of both GM corn and Roundup.

Comments:

Modified to produce beta carotene. Beta carotene is converted into Vitamin A when metabolised by the human body.

Clearly identify an issue.

Must discuss an issue (points for and against)

Avoid using an economic example as part of a social issue. The syllabus classifies economic influence of biotechnology separately. (Golden Rice was not used due to economic reasons vs. social/cultural)

- Other planned solutions for malnutrition as well as programs currently in place are cheaper and do not require GMOs, thereby making golden rice unnecessary.
- Golden rice produces too little beta-carotene to eradicate VAD

Range 0-3

Avg. 2.29

Question 23 (5 marks)

Criteria	Mark
• Demonstrates a clear understanding of gel electrophoresis. • Clear conclusion with breeding recommendation - Male 2 (M₂) • Explains how this would be useful in selecting mates for a breeding program to increase variation.	4
• Recommends Male 2 for breeding with support OR • Explains how gel electrophoresis would be useful in breeding program	3
• Identifies Male 2 for breeding • Identifies the role/process of gel electrophoresis	2
• Some relevant information	1

Sample Answer:

Gel electrophoresis is a technique used to separate DNA fragments according to their size. By comparing individuals in a population, the number of similarities and level of relatedness can be determined. This genotypic assay can be used to select mates with variation in the offspring. Male 2 (M₂) would be the best recommendation for the breeding program based on the greater number of variations as seen in the gel electrophoresis. M1 and M3 have more similarities with F which may leave the offspring susceptible to selection pressures.

Comments

Using gel electrophoresis, we can see how many different DNA fragments are present in a sample and how large they are relative to one another.

A DNA marker (also known as a size standard or a DNA ladder) is loaded into the first well of the gel. The fragments in the marker are of a known length so can be used to help approximate the size of the fragments in the samples.

Many selected the wrong mate but gave valid justification.

Not looking for variation from the marker but variation from F (female).

Question is a justification of us, you do not need an explanation of the use.

There is no connection in the stimulus between bands and desirable traits. Only variation.

Range 1-4

Avg. 2.81

Question 24 (3 marks)

Criteria	Mark
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• ONE Detailed procedure. • Explanation to support.	3
• Procedure outlined with some detail missing	2
• Some relevant information	1

Sample answer:

To pass from one human to another it encloses itself in a cyst that passes out in the faeces, these cysts contaminate the food or drink of other humans. Thoroughly washing hands with soap, water and drying them after using the toilet or before preparing food removes the pathogen and prevents contamination of food to stop transmission by the faecal-oral route.

Comments:

Remember if a question states 'ONE', then the answer should have ONE. (The first will be marked, any others will not. In the case of contradictions marks will be lost).

Be careful that your ONE procedure doesn't flow into others. Best would be hand washing after toilet use for this pathogen. (e.g. some people stated hand washing after or before food prep.)

'Hygiene and sanitation' could include a lot of things. – cleaning the toilet, hand washing, sanitising hard surfaces/door handles, brushing teeth, bathing.

Be distinct and clear.

Sewage water is not used for drinking/washing/cooking. Treatment and management of sewage water is appropriate for minimising the spread of diseases but not because we drink it.

Range 0-3

Avg. 2.67

Question 25 (3 Marks)

(a)

Criteria	Mark
Correctly identifies the process of phagocytosis	1

Sample answer:

Phagocytosis

Comments Everyone got this correct!

Range 1

Avg. 1

(b)

Criteria	Mark
Outline of a physical change	2
Identifies a physical change	1

Sample answer:

The second line of defence includes inflammation, which involves skin redness due to increased blood circulation to the site of infection.

Comments:

Only mark ONE, first one that appears.

Outline – general terms, main features

**Must be a physical change not chemical*

Cytokines are protein signalling involved in the process of inflammation, but they would be classified as chemical changes.

Cytokines are chemical signalling molecules

Histamine are chemical signalling molecules

Possible:

- Heat, either increased local temperature, such as a warm feeling around a localised infection, or a systemic fever
- Swelling of affected tissues.

Range 0-2

Avg. 1.5

Question 26 (5 Marks)

Criteria	Mark
• Clear distinction between primary and secondary response to a pathogen by the adaptive immune system • Correctly annotates relevant features on the graph (vaccinations, responses including increased rate and concentration in secondary response and antibody residual) • Annotations and description are linked	5
• As above, but minor errors or lacking detail • Annotates main features on the graph	4
• Provides relevant information about primary and secondary response AND • Annotates some features on the graph but incorrectly positioned or lacking detail	3
• Provides relevant information about primary and secondary response OR • Annotates some features on the graph but incorrectly positioned or brief	2
• Some relevant information provided	1

Sample answer:

When the adaptive immune system is exposed to a pathogen for the first time it triggers a primary response. The primary response to an infection involves the activation and secretion of antibodies from plasma cells and the differentiation of T cells. Differentiated memory cells remain but the number of effector cells decreases over time. Subsequent exposure, in this case through a second

dose of the vaccination, the secondary response is faster and stronger due to the memory cells that remain from the primary response with antigen specificity. This elicits a greater output of antibodies for a longer period of time.

Comments:

Many people didn't add enough aspects to the graph (even though they wrote about them in their response, the questions states annotate the graph to support your answer.

Read carefully. It says primary and secondary vaccinations were given but it doesn't say to annotate primary and secondary vaccinations. It says account for the features of the graph.

The antibody structure (or action) does not change between first and second exposure.

Many didn't talk about the larger residual conc. of antibodies from secondary exposure.

Some people wrote great explanations but didn't interact with the stimulus enough, this place you in a 3 mark section.

Range 2-5

Avg. 3.58

Q 27

Marking criteria	Marks
Provides an assessment of the statement with relation to agreement/disagreement . • Shows a thorough understanding of both internal fertilisation and external fertilisation in terms of ensuring the continuity of a species • Shows clear understanding of the advantages/disadvantages of internal fertilisation over external fertilization.	4
• Shows a sound understanding of both internal fertilisation and external fertilisation • Links both to ensuring the continuity of a species • Outlines benefits and/or weaknesses of internal and external fertilisation	3
Outlines features of both internal fertilisation and external fertilisation	2

OR Identifies some features of internal fertilisation and/or external fertilisation	
Provides some relevant information	1

Sample answer:

For the continuity of a species, each generation must successfully reproduce to produce sufficient numbers of the next generation. A critical number of embryos must survive to gestational maturity. This is less likely with external fertilisation. Organisms that reproduce by external reproduction spend a substantial amount of energy and resources in the production and release of very large numbers of sperm and eggs. This is because each sperm and egg and the resulting embryos have limited chances of survival, not being protected by the parent for example in the open ocean. Chances of successful fertilisation are low in such vast aquatic environments. Larger numbers ensure some will be fertilised. Internal fertilisation provides a smaller safer environment for release of gametes, fertilisation and maturation of the embryos. Chances of successful fertilisation are increased and embryos are protected from predators within the body of the parent. Even after birth/egg laying parental care assists survival of the offspring.

Q 28.

Marking Criteria	Marks
• Evaluates how an identified technology functions to fulfil the normal function of the damaged organ • Includes the benefits and limitations of an identified technology with respect to functionality • Makes an informed judgement about the effectiveness of the technology	4
• Outlines the circumstances in which an appropriate technology would be used • Outlines how the technology functions to fulfil the normal function of the damaged organ • Identifies the benefits and limitations of the technology	3
• Outlines an appropriate technology • Identifies benefits and/or limitations of the technology	2
Provides some relevant information	1

Sample answer:

People with polycystic kidney disease will typically progress to a point where kidney failure has occurred, at which point dialysis is required or the patient will have to be given a transplant. Dialysis

technology works by taking over the normal function of the kidney, cleaning the patient's blood. There are two types of dialysis: hemodialysis and peritoneal dialysis.

Hemodialysis is where the blood is removed from the patient and passed through the dialysis machine which uses osmosis to remove excess fluid, salts, and toxins from the blood. Which is usually performed by kidneys. As hemodialysis works by passive transport to remove ions it cannot remove all toxins and does not effectively perform other functions like reabsorption and secretion

Unfortunately, dialysis cannot replace or manufacture these chemicals. These will need to be replaced in the body with medication.

Diet of low salt, phosphorous and high protein foods are to be consumed to reduce the waste.

Lifestyle limitations include expensive, time consuming, fresh use of dialysate etc. Whereas Kidney transplant comes with lifelong immunosuppressants with a risk of malignancy and hyper tension.

Without such technology people with kidney failure resulting from polycystic kidney disease would not survive.

Q 29.

Marking criteria	
Assess the data and makes a statement of agreement or disagreement Supports/ disproves the assessment using valid relevant numerical data for CC and Long CC from the graph Identifies limitations	3
Any TWO of the above	2
Any ONE of the above	1

Sample answer:

The percentage of CC total per genome lies between the range of 1-7.5 for animals whereas Archaea is from 1-2.5,

Gram negative bacteria is from 1-4 whereas plants have a closer relation of cc total with a range of 1-6. Similarly, Long CC also show a close relation between animals and plants with a range of 1.4-1.8 and plants with a range from 1.3-3. But the data is limited as only 2 species of plants and 4 species of animals were used to compare CC and Long CC whereas 4 species of animals, 7 of Gram negative and 3 of gram negative species were used for comparison.

Q 30.

Marking criteria	
Correct plot and joining of the curves Labelling of the axes Label of the curves/Key	3
Any Two of the above	2
Any ONE of the above	1

b.

Marking Criteria	
Accounts for the shape of the graph Reference of the information provided	2
Any ONE of the above OR Some relevant information	1

Sample answer: Population Y has stabilized at generation 50. Stabilization indicates that only allele b is found in the gene pool. This is potentially due to environmental pressure selecting for b allele.

whereas in population x frequency of allele b is going down as it is being selected against, possibly due to cold. It stops at 0.1. Where it is in heterozygous rabbits and masked by the dominant rabbits having fur.

c.

Marking Criteria	
deduction of the short haired rabbits, deduction of the B/b, deduction of L/l alleles genotypes of the parents	3
Any TWO of the above	2
ANY ONE of the above	1

	Bl	Bl	BL	BL
bL	BbL l	Bbl L	BbL L	BbL L
bL	BbL l	BbL l	BbL L	BbL L
bl	Bbll	Bbll	BbLl	BbLl
bl	Bbll	Bbll	BbLl	BbLl

Genotypes

BbLl X bbLl

Short haired : ¼

Long haired : 3/4

Q31.

Marking criteria	Marks
Explains at least 3 benefits / use of such educational program	3

- Explains at least 2 benefit/use of such educational program OR - Outlines benefits of such programs	2
Provides some relevant information	1

Sample answer:

The impact of FASD on a person is lifelong and targeted prevention is required for groups at risk. The purpose of the campaign is to raise awareness of the risks of drinking during pregnancy by sharing the following key messages:

1. Alcohol should be avoided during pregnancy (and whilst planning)
2. All members of the community are responsible in reducing the risk, including the partner, family, friends and health care professionals (
3. The campaign is targeting people that are pregnant (or trying to conceive) to understand the life long impacts of alcohol consumption and thus help to reduce the incidence of FASD by adapting healthy lifestyle. Health care professionals also use such programmes to educate the expectant mothers on the adverse physical and cognitive stress created on their children due to FASD. The aim of above programme is to increase the quality of life.

Question 32

(a)

Marking Criteria	Marks
Identifies similarities and differences in forms of DNA in bacteria and plant cells	2
Identifies similarity or difference in DNA forms	1
OR	
Identifies properties of DNA structure (beyond double-stranded helix)	

Similarities:

Bacterial DNA, bacterial plasmid DNA, plant chloroplast and plant mitochondrial DNA are circular. Bacterial and plant DNA are packaged with proteins.

Differences:

Most plant DNA is found as linear chromosomes, located in nucleus. Most bacterial DNA is found as a circular chromosome, with no nucleus.

Range: 0-2; Average: 0.7

Comments: Compare mean similarities and differences. Many students only provided differences. A number of students identified properties, but did not make it clear what the similarities and/or differences were i.e. gave one type of property for one and a different type

of property for the other. A number of students did not have a clear idea of what form of DNA meant, or did not have a clear idea of the form of DNA in plant cells and/or bacterial cells.

Some common misconceptions or poorly explained concepts included that DNA was single stranded in bacteria, or in plasmids (it is generally double stranded), the plasmid was the main component of DNA in bacteria, bacterial DNA was not packaged with protein, there is nuclear DNA in bacteria, the main bacterial chromosome is linear.

(b)

Marking Criteria	Marks
Uses cause and effect statement to explain how it acts as a mutagen	2
Identifies how it acts as a mutagen OR Identifies a process which changes cell expression OR Defines a mutagen	1

Agrobacterium inserts a piece of its own DNA (from a plasmid) into a plant chromosome. This is a change to the sequence of base pairs, is (semi) permanent for infected cells, i.e. a mutation. This can be seen by the change in expression of those cells as they form a tumour.

Range: 0-2; Average: 1.2

Comments: The verb in this question was explain, which is most easily answered with a cause and effect structure. A number of students did not link a cause and effect so were unable to access all the marks, in particular they did not show how the DNA was changed. In general, do not use stimulus from later in the question to answer an earlier part.

A couple of misconceptions included: different proteins produced causing the mutation (it is a result of the mutation), the tumour causes the mutation (the mutation causes rapid growth of undifferentiated tissue).

(c)

Marking Criteria	Marks
Outlines a successful response of the plant to agrobacterium infection	2
Identifies a successful response of the plant to agrobacterium infection OR Proposes possible response to infection (not H ₂ O ₂ /hypersensitive response)	1

Increased amount of auxin and cytokinin due to infection by agrobacterium causes an increase in ethylene. Ethylene and salicylic acid (produced by the plant) inhibit virulence factors of the agrobacterium, limiting infection.

Range: 0-2; Average: 0.7

Comments: the question asked about a response to infection, not a response in general. A number of students outlined a response to water loss, which was dealt with in a later question. If you find yourself giving the same answer to two questions, probably one of them is not correct. If you give more than one response when ONE is asked for, the first one is marked (even if a later one is a better answer. Some students gave the production of H_2O_2 when the stimulus specifically said that it was inhibited by the pathogen, please read carefully.

A couple of misconceptions/misunderstandings addressed: the agrobacterium infection resulting in the crown gall (tumour) causes the downregulation of photosynthesis and the gall becoming a metabolic sink, into which compounds are produced heterotrophically which feed the pathogen. This isn't a response of the plant, it is a detrimental consequence of infection.

(d)

Marking Criteria	Marks
Describes one adaptation of agrobacterium	2
Identifies one adaptation of agrobacterium OR Identifies a consequence of the adaptation	1

Agrobacterium has the ability to detect wounded cells (which are easier to enter) and move through the soil towards them using flagella.

Range: 0-2; average: 1.4

Comments: Describe means to provide features and characteristics. A number of students identified a process, rather than an adaptation. Don't refer to answers that have been given in other questions unless you are using a result that you have derived.

(e)

Marking Criteria	Marks
Identifies suitable mechanism	1

The hormone ABA is increased to reduce water loss and maintain internal water balance.

Range: 0-1; average: 0.9

Comments: this question was answered fairly well. A small number of students did not identify what quantity was being maintained.

(f)

Marking Criteria	Marks
Demonstrates understanding of gene regulation Discusses effect of gene expression on phenotype using information provided	3
Demonstrates understanding of gene regulation Identifies effect of gene expression on phenotype using information provided OR Identifies multiple effects of gene expression on phenotype using information provided OR Discusses effect on phenotype using information provided	2
Some relevant information	1

Gene regulation includes a range of mechanisms by which a cell increases or decreases the production of gene products. Infection by agrobacterium changes the expression of genes, resulting in a range of observable traits of the infected plant (the phenotype). One of the most obvious would be the production of the gall at the site of infection. Here, the agrobacterium has caused a change of gene expression of many genes, including the production of hormones auxin and cytokinin resulting in a change from specialised cells (e.g. parenchyma) to undifferentiated tissue. The downregulation of photosynthesis causing a low-oxygen environment and the production of C and N-containing products to feed the agrobacteria directs metabolites towards the tumour and away from the rest of the plant, stunting the growth of the plant.

Range: 0-3; average: 1.7

Comments: A good way to start this question is to provide some definitions of the terms used, in order to demonstrate an understanding. Discuss means to provide points for and/or against. Some students need to revise the concept of gene regulation (this is important when considering the effects of mutations in non-coding regions of DNA). A number of students did not link gene regulation to changes in phenotype (physical appearance).

Misconceptions/misunderstandings addressed: physiological response such as closing or opening of stomata is not considered a change in phenotype. Tumours are a large mass of undifferentiated cells.

Question 33

(a)

Marking Criteria	Marks
Describes trends in the graph	2
Identifies a trend in the graph	1

The graph shows a general decrease in the number of rubella cases from about 50 000 per year in 1966 to less than 5000 per year in 1980 and less than 1000 per year for most years

after that. There were a number of outbreaks in the late 1960s, mid-late 1970s and early 1990s, with each outbreak having a smaller number of cases than the previous outbreak.

Range: 1-2; Average: 1.4

Comments: Describe means to provide characteristics and features. The question asked for trends (plural). There was no need to explain. The question asked about infectious rubella, not CRS.

(b)

Marking Criteria	Marks
Justifies statement using evidence from graph	2
Some relevant information	1

The number of cases of CRS decreased from a high of 90+ in 1970 to almost none in the 2000s, which is a successful outcome. There were still a significant number of CRS cases following rubella outbreaks during this time, significantly although the rate of rubella dropped by a factor of 30 from 1970 to 1991, the number of CRS cases in 1991 only reduced by a factor of 2 from 1970, indicating that a significant number of developing embryos were affected despite 20 years of vaccination program.

Range: 0-2; average: 1.7

Comments: Justify means to support argument or conclusion, and you were asked to do this using evidence from the graph. There was no need to explain. Some students missed that the CRS axis was on the right.

(c)

Marking Criteria	Marks
Proposes relevant hypothesis Justifies hypothesis using evidence	2
Proposes relevant hypothesis OR Justify incorrect hypothesis using evidence	1

Hypothesis: unvaccinated males acted as a reservoir for rubella infection of unimmunized pregnant females.

Justification: Not all females would have been immunized (a small percentage would not develop antibodies) and some would not have been vaccinated (e.g. those who came as adults from a country without a rubella vaccine program). They would be susceptible to rubella infection and their unborn children at risk of developing CRS. As the males were

unvaccinated, it is likely that outbreaks would have continued in the community, exposing these females.

Range: 0-2; Average: 1.2

Comments: The hypothesis for this question needed to be specific to the UK (not the US), and as the graph data was from the US, it could not be used to support the hypothesis. A mechanism based on your knowledge was needed as evidence to support your hypothesis.

Misconceptions addressed: CRS is not infectious, rubella is (although babies born with CRS are infectious for a while, this is not relevant to the question). It makes no sense to state that CRS is asymptomatic, if there are no symptoms, there is no CRS. Children born with CRS don't generally recover. If the mother is immune to rubella, the baby will not develop CRS (the point of the vaccine). Mutations to the rubella virus isn't a problem, otherwise infection wouldn't give lifelong immunity. (This doesn't generalise to all viruses, mutations in other viruses may be a problem for immunity. Immunity to rubella vaccine may wane if the immune response is not sufficiently strong, but no student addressed this).

(d)

Marking Criteria	Marks
Uses cause and effect statement to link medical technology to birth defect Proposes suitable reason for medical technology not being used routinely	3
Uses cause and effect statement to link medical technology to birth defect OR Identifies suitable medical technology to treat identifies birth defect Proposes suitable reason for medical technology not being used routinely	2
Identifies suitable medical technology to treat identifies birth defect OR Justifies suitable reason for medical technology not being used routinely	1

As many children with CRS are born with a malformed cochlea, a cochlear implant could be used to replace the function of the cochlea. This would use a microphone to collect and process sounds outside the ear, and then send them to the implant which stimulates the auditory nerve, bypassing the malformed ear and partially correcting deafness. This is unlikely to be used routinely as nowadays children with CRS are almost exclusively born in developing countries which can't afford to vaccinate against rubella, let alone perform expensive surgery.

Range: 0-3; Average: 1.7

Comments: Explain means cause and effect, and in order to answer the question properly you needed to show how the correctly named technology would replace the specific non-functioning parts of the body.

Misconceptions addressed: CRS is congenital (they are born with it, not acquired which comes later in life). It is not a genetic disease (there are no more damaged alleles or chromosomes than would normally be expected from a child without CRS). The main ear defect is a malformed cochlea, which requires a cochlear implant (which transmits an electrical signal to the brain via the auditory nerve), not a hearing aid or bone conduction implant. The main eye defect is cataracts, which could be treated with lens replacement, not laser surgery. The question did not ask about a medicine, or about treating rubella.

(e)

Marking criteria	Marks
Uses cause and effect statement linking reduced mitosis to symptom	2
Provides some relevant information about embryonic development	1

Mitosis is an important process in the developing embryo as it allows an increase in the number of cells as the embryo grows. Embryonic development occurs in stages, and if cell division is reduced during a particular stage, the tissues/organs which should form during that stage will not form correctly. This could account for a malformed cochlea if mitosis is reduced in the ear as it forms.

Range: 0-2; average: 1.3

Comments: Mitosis is a type of nuclear division (often described as cell division at the HSC level), which is important for growth in embryos, not much repair happens in embryos. If it is slowed, some developmental stages will be missed, meaning a lack of appropriate cells in some tissues and organs will be malformed. This is not a genetic condition (although some genetic conditions can also result in malformed organs or tissues)

(f)

Marking criteria	Marks
Type of study correctly identified Patients <16 weeks only included Valid investigation Details suitable method of study Details analysis of results	5
4 of the above (one less well)	4
3 of the above (two less well)	3
2 of the above (less well)	2
Some relevant information	1

Type of epidemiological study	Circle any appropriate words: descriptive, <u>analytic</u> , experimental, observational, <u>prospective</u> , retrospective, <u>cohort</u> , case-control, cross-sectional, case, longitudinal, clinical trial, blind, double-blind
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Method of study	1. Pregnancy of subjects dated using appropriate technology and those > 16 weeks excluded from study 2. Remaining subjects tested for rubella infection/antibodies and interviewed about possible symptoms of rubella. Those without signs or symptoms excluded from study. 3. Remaining subjects randomly allocated to two groups. The control group maintained their normal diet. The experimental group were placed on a low-Vitamin A diet, but sufficient to meet the need to the woman and developing child. 4. Blood levels of Vitamin A monitored regularly for all subjects 5. After birth, children examined for CRS symptoms such as cataracts, deafness, heart and CNS defects
What results would support the Vitamin A hypothesis	Higher levels of Vitamin A in blood correlated with higher rate of birth defects

Range: 1-4; average: 2.7

Comments: most students who attempted this question went some way to designing a study, but had difficulty describing the study (unclear how much of this you are expected to know for the HSC). Some students also designed studies correlating rubella and CRS, which is fairly well established. A large number of students thought that if there was a control group, then the study was a case control, which is not true, and also quite hard to do for this particular situation. Nothing was said about the number of women in the study, but it is unlikely to be large.

So, to help you decide what type of study it is:

1. *Descriptive: time, place, person, no control vs Analytic which has control*
2. *Observational follows exposure and disease status vs Experimental follows effects of controlled exposure*
3. *Types of observational:*
 - a. *Cohort: records exposure status then follows disease development, comparing unexposed to exposed. Longitudinal, repeated observations of the same variable. Can be prospective where participants are enrolled at the beginning of the study and then followed over time, or retrospective where the participants exposure and outcomes are recorded.*
 - b. *Case-control: a group with the disease and a group without the disease are formed and previous exposures and compared*
 - c. *Cross-sectional: sample of people enrolled and exposures and health outcomes are measured simultaneously*
 - d. *Case: intensive study about an individual or group in real-world context*
4. *Example of experimental is a clinical trial with a controlled process for exposure which tracks over time to determine effects of exposure*
5. *Unblinded (all parties know information), Blinded: information which may influence the participants is withheld until experiment is complete (or longer), Double-blinded:*

two parties (generally participants and researchers/health professionals) are blinded to information.

(g)

Marking criteria	Marks
Demonstrates thorough understanding of validity Correctly analyses own study Correctly analyses named epidemiological study Correctly analyses first-hand investigation Correctly analyses second-hand investigation Evaluates statement	8
Demonstrates good understanding of validity Correctly analyses own study Correctly analyses named epidemiological study Correctly analyses first-hand investigation Correctly analyses second-hand investigation Evaluates statement	7
Demonstrates good understanding of validity Correctly analyses three investigations or four investigations with some omissions	6
Demonstrates sound understanding of validity Analyses three investigations with some errors OR Demonstrates thorough understanding of validity	5
Demonstrates sound understanding of validity Analyses two investigations OR Demonstrates good understanding of validity	4
Demonstrates some understanding of validity Outlines validity of one investigation OR Demonstrates sound understanding of validity	3
Demonstrates some understanding of validity OR Outlines validity of one investigation	2
Provides some relevant information which defines validity	1

Validity in a scientific investigation is extremely important as it describes whether the results of an investigation really do measure the concept being tested. In a firsthand investigation it includes whether the hypothesis is tested over a suitable range with appropriate equipment, if variables are controlled, if an experimental control is used when appropriate and if the method is suitable for testing the independent and dependent variables. For an epidemiological study, these address the issue of internal validity, which deal with bias, confounding effects and chance, while external validity addresses the ability to generalise the findings to a wider population. In a second-hand investigation it includes whether the information refers to the hypothesis being investigated, the data was gathered using an

appropriate method and measuring devices, the findings are up to date as well as the nature of the article in terms of the credentials of the author, possible bias of the article and the nature of the publishing site (although this has been brought into controversy recently with a number of papers withdrawn from high impact journals).

In the epidemiological study proposed, only unvaccinated pregnant women <16 weeks gestation with signs or symptoms of rubella infection were included. There was a control group, and randomly allocating patients to each group reduced any possible bias. There was no other medical care provided, which controls that variable. Blood levels of vitamin A and birth defects were measured using an appropriate technology as the independent and dependent variables. This gives this investigation a level of internal validity, but external validity would be less relevant as the results do not need to be extended to males, non-pregnant females. However, it may not extend to pregnancies in other ethnic groups.

In the British Doctor's Study, a prospective longitudinal cohort study, internal validity was ensured by following a large number of doctors (which reduced bias) and collecting accurate data regularly on the number of cigarettes smoked daily, health status and causes of death. As the doctors had to be registered in order to practice medicine, there was an unusually high level of follow-up in a study of this type. As this was not an experimental study, there is no need to have an experimental control. External validity could be questioned as younger subjects and females were excluded from the study due to lower numbers of health issues and subjects respectively. However, the results from this study have had significant impacts on public health policy around the world.

In order to investigate the presence of microbes in water samples, validity was ensured by firstly testing different water samples (e.g. tap water, dam water and bottled water) for the presence of bacteria and fungi using appropriate procedures by inoculating agar plates, incubating them, counting the number and size of the colonies using a mm grid and identifying them by comparing them to reference images. Sterile processes such as running the inoculating loop through a flame were carried out to ensure that only the microbes in the water were tested. An experimental control was included with no water sample was performed, and variables such as composition of agar, temperature and length of incubation were controlled.

When investigating the response of an Australian plant to a named pathogen, the validity of this second hand investigation was ensured by checking the source and content of the article studied. The information was published in a reputable peer-reviewed journal (Function Plant Biology), was recent (2017), written by a professor of Biology who had published in the area for more than 25 years and did not appear to be biased. As the plant investigated was an Australian native plant, and a number of immune responses such as H₂O₂ production, lignification and callose formation were described, it addressed the aim of the investigation.

There are many aspects of an investigation which contribute to its validity, and it is important that they are all assessed to ensure that the investigation has addressed what it set out to address in order for the findings to be useful and relevant.

Range: 1-8, average 3.7

Comments: Some students did not demonstrate their understanding of validity in their own investigations, particularly in their own second hand investigation.