



Biology

Section I 20 marks

Questions 1-20 (1 mark each)

Question	Answer	Outcomes Assessed	Targeted Performance Bands
1	A	BIO12-14	2-3
2	D	BIO12-5, BIO12-12	2-3
3	B	BIO12-13	2-3
4	D	BIO12-14	3-4
5	A	BIO12-15	3-4
6	B	BIO12-13	3-4
7	A	BIO12-14	3-4
8	D	BIO12-12	3-4
9	C	BIO12-15	3-4
10	C	BIO12-6, BIO12-12	3-5
11	B	BIO12-15	3-5
12	A	BIO12-13	3-5
13	A	BIO12-15	3-5
14	C	BIO12-6, BIO12-12	3-6
15	B	BIO12-13	4-6
16	A	BIO12-14	4-6
17	B	BIO12-5, BIO12-15	4-6
18	C	BIO12-14	5-6
19	D	BIO12-12, BIO12-6	5-6
20	C	BIO12-12, BIO12-6	5-6

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Section II
80 marks

Question 21 (3 marks)

Outcomes Assessed: BIO12-14

Targeted Performance Bands: 2-3

Criteria	Marks
<ul style="list-style-type: none">Explains why a measles vaccine is the best control measureDemonstrates sound understanding of the adaptive immune systemReferences stimulus	3
<ul style="list-style-type: none">Describes why a vaccine might be most suitable to protect against infectionDemonstrates sound content understanding of the adaptive immune system	2
<ul style="list-style-type: none">Outlines some relevant information	1

Sample Answer:

Measles is a highly contagious infectious disease. Because it is so easily transmissible (living in airspace for up to 2 hours and living in the nose and throat of an infected person), it can easily pass from person to person by simply inhaling the pathogen after a sick person has left the room. A vaccine protects a person against a measles infection by priming the immune system with a particle, for example, a weakened measles pathogen, that stimulates the immune system to produce antibodies and memory cells. These memory cells can quickly produce antibodies that can respond to the actual measles pathogen so that a person will not become as sick as if the person had not had the vaccine. This preparation means that a person is protected against future exposures even if the sick person is spreading the virus.

weakened or attenuated

dead / weakened form of virus

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2 marks to show all correct information
 1 mark for logical sequence
 and arrows

Question 22 (5 marks)

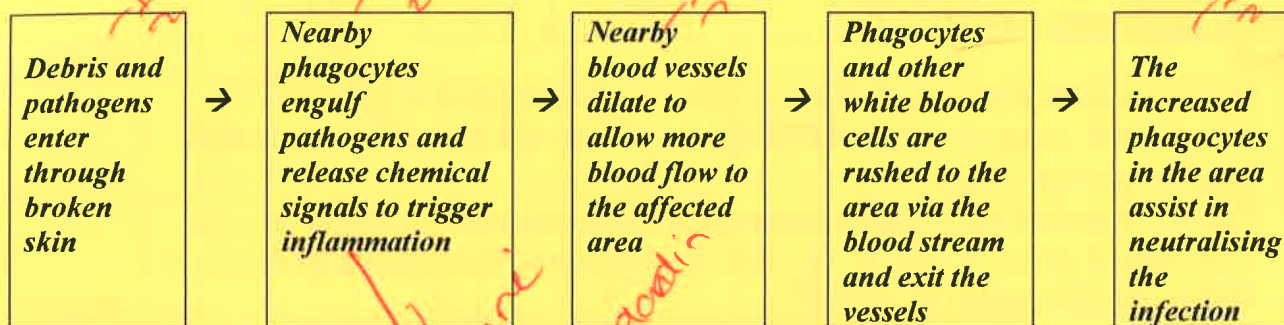
(a) (3 marks)

Outcomes Assessed: **BIO12-14**

Targeted Performance Bands: 2-3

Criteria	Marks
<ul style="list-style-type: none"> • Outlines all key features of the inflammation response • Communicates information correctly in the form of a flow chart, including the use of arrows 	3
<ul style="list-style-type: none"> • Outlines some key features of the inflammation response • Communicates information mostly correctly in the form of a flow chart 	2
<ul style="list-style-type: none"> • Identifies relevant information of the inflammation response OR <ul style="list-style-type: none"> • Communicates information correctly in the form of a flow chart for an immune response other than inflammation 	1

Sample Answer:



Question 22

(b) (2 marks)

Outcomes Assessed: **BIO12-14**

Targeted Performance Bands: 2-3

Criteria	Marks
<ul style="list-style-type: none"> • Justifies the use of antibiotics to treat the infection and • identifies specificity of antibiotics for bacterial infection 	2
<ul style="list-style-type: none"> • Identifies relevant information 	1

signals → 1 mark
 vasodilation → 1 mark
 engulf phagocytes → 1 mark

Sample Answer:

Antibiotics would be effective to treat the infection, however not in all situations. As antibiotics are specific to bacteria, it would help reduce the infection if it was bacterial. However, it would most likely not have any effect if the infections were not bacterial.

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Question 23 (11 marks)

(a) (i) (2 marks)

Outcomes Assessed: BIO12-5, BIO12-12

Targeted Performance Bands: 2-4

Criteria	Marks
• All part of the table correctly completed	2
• One or two parts of the table completed	1

*Reliability
Validity
Accuracy
logical source /
logical method*

Sample Answer:

Independent variable: presence or absence of Bt corn grown in the soil

Dependent variable: soil biodiversity i.e. the number and type of bacteria and fungi

The control: an agar plate that has not been exposed to soil

(a) (ii) (4 marks)

Outcomes Assessed: BIO12-2, BIO12-13

Targeted Performance Bands: 2-4

Criteria	Marks
• Explains a method that the student can use in his investigation to ensure the experimental design is valid by referring to reliability and accuracy of the design, variables and the control	4
• Explains a method that the student can use in his investigation to ensure the experimental design is valid by referring to reliability and/or accuracy of the design, variables and/or the control	3
• Explains an incomplete method that the student can use in his investigation (working towards a valid experimental design)	2
• Provides some relevant information	1

logical idea

Sample Answer:

The student should collect at least 10 soil samples from fields on the farm where Bt corn is not grown. They would also collect at least ten soil samples from the fields where Bt corn is grown. The student would then use 2 grams of soil from each sample and place it in 2 ml of water. The four drops of the water sample would be placed on individual agar plates and grown in an incubator at 35C for 3 days. The student would then count the type and number of microbes growing on each plate to compare it with the control plate. The control plate was an agar plate that was sealed without being exposed to the water sample from the two soil types.

*1 - IDV (sample from both field)
1 - Reliab → sample size from each farm
1 - accuracy - DV - cont, use of agar
1 - validity → keep, have + IDV + DV
control plate mentioned*

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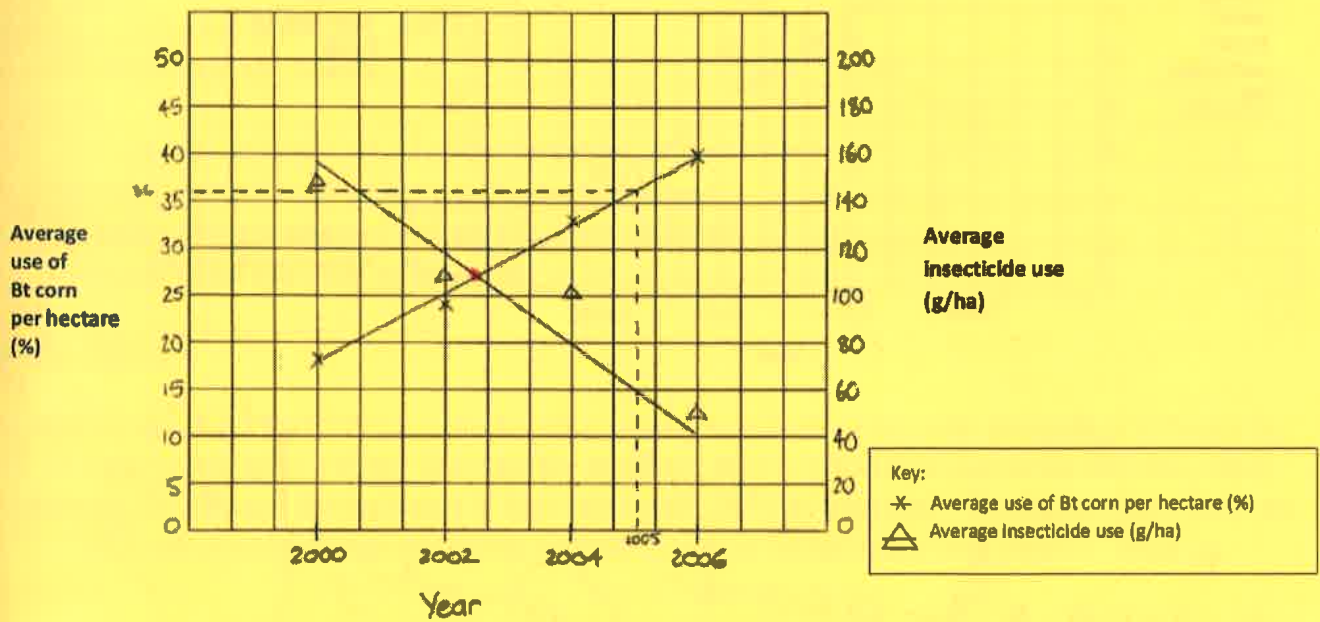
(b) (i) (4 marks)

Outcomes Assessed: BIO 12-4, BIO12-13

Targeted Performance Bands: 3-5

Criteria	Marks
<ul style="list-style-type: none"> Correctly and accurately graphs the data provided, including: <ul style="list-style-type: none"> All axes correctly scaled All data points correctly plotted Two lines-of-best-fit Key provided 	4
<ul style="list-style-type: none"> Mostly correctly and accurately graphs the data provided, including: <ul style="list-style-type: none"> Three of the above 	3
<ul style="list-style-type: none"> Graphs the data provided, including: <ul style="list-style-type: none"> Two of the above 	2
<ul style="list-style-type: none"> Attempts to graph the data provided 	1

Sample Answer:



35 - 37.5%

38.1%

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(b) (ii) (1 marks)

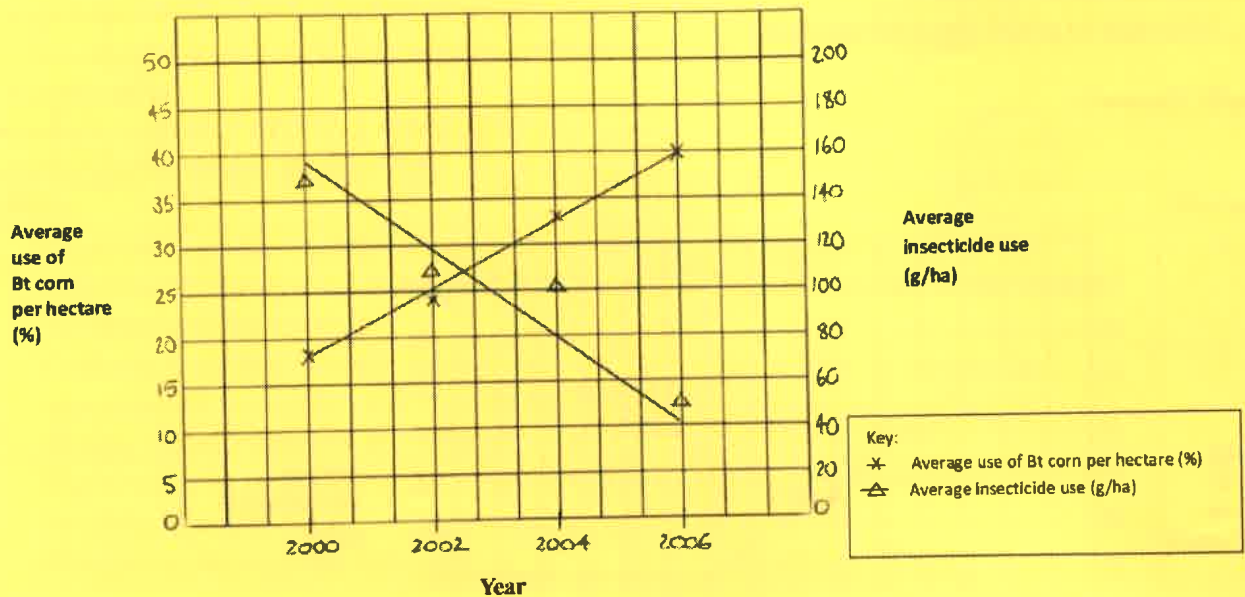
Outcomes Assessed: BIO12-4, BIO12-13

Targeted Performance Bands: 3-5

Criteria	Marks
<ul style="list-style-type: none"> Correctly estimates the average amount of pesticide use per hectare (%), and correctly demonstrates this on the graph 	1

Sample Answer:

36% (dependent on student's graph)



mark only
- detail & 3 - accurate } 2 marks
- reason = 100

data 2 + 4 → incorrect
reason = experiment design
lack away } 2 marks

assess each - 1 mark →

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Question 24 (6 marks)

(a) (2 marks)

Outcomes Assessed: BIO12-5, BIO12-12

Targeted Performance Bands: 3-5

Criteria	Marks
• Describes the base pairing that occurs between both pairs of nucleotides (including hydrogen bonding)	2
• Describes the base pairing that occurs between a pair of nucleotides (including hydrogen bonding) OR	1
• Describes the base pairing between both pairs of nucleotides (excluding hydrogen bonding)	

Sample Answer:

Adenine and thymine pair with two hydrogen bonds while cytosine and guanine pair with three hydrogen bonds.

(b) (4 marks)

Outcomes Assessed: BIO12-5, BIO12-12

Targeted Performance Bands: 3-5

Criteria	Marks
• Assesses the accuracy of all of the data collected	4
• Assesses the accuracy of some of the data collected	3
• Describes the accuracy of some of the data collected	2
• Provides some relevant information	1

Sample Answer:

The data on species 1 and 3 is accurate because when you calculate the total percentage of bases in each species it adds up to 100%. The data for species 2 & 4 is inaccurate due to the fact that when you add the percentages for the bases it does not equal 100% as expected. There must have been an error in the experimental design or during data collection to obtain inaccurate results.

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Question 25 (4 marks)

Outcomes Assessed: BIO12-6, BIO12-12

Targeted Performance Bands: 3-5

Criteria	Marks
<ul style="list-style-type: none">• Uses the data to justify the type of inheritance• Explains that the inheritance is non-Mendelian and identifies data as codominance• Relates differences in the phenotypic trend shown in the data to the type of inheritance• Communicates information succinctly using appropriate scientific terminology	4
<ul style="list-style-type: none">• Explains that the inheritance is codominance• Relates differences in the phenotypic trend shown in the data to the type of inheritance• Communicates information logically using appropriate scientific terminology	3
<ul style="list-style-type: none">• Describes the inheritance as non-Mendelian or codominance and gives one appropriate reason	2
<ul style="list-style-type: none">• Identifies some relevant information about Mendelian OR non-Mendelian inheritance	1

Sample Answer:

This data shows a type of non-Mendelian inheritance called *codominance*. This is because there are three phenotypes shown: red, white and a phenotype where the two alleles are both expressed called 'roan'. If a pure-bred red bull was crossed with a pure-bred white cow, the F₁ generation would have 100% roan offspring, and the F₂ generation would thus produce a ratio of 1:2:1 (red:roan:white) which is indicated in the observed percentages. Mendelian inheritance states that there are only two phenotypes, one dominant and one recessive. If the colour of cattle was a Mendelian trait, the data would show only two phenotypes represented in the ratio 3:1 (Dominant: Recessive), and not the 1:2:1 ratio as shown in this data.

Answers could include:

A Punnett Square demonstrating the 3:1 ratio of Mendelian inheritance OR co-dominance.

- ① mentioning its co-dominance - 1 mark
- ① Reason its codominance / use Punnett square to represent - 1 mark (link to stimulus)
- ① mention its not Mendel's law
what is Mendelian inheritance
- Reason why its not Mendelian inheritance
- ② use Punnett square to represent and linking to stimulus

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Question 26 (4 marks)

Outcomes Assessed: BIO12-2, BIO12-5, BIO12-6, BIO12-14, BIO12-15

Targeted Performance Bands: 4-5

Criteria	Marks
<ul style="list-style-type: none">• Describes succinctly TWO studies and/or investigations AND <ul style="list-style-type: none">• Shows evidence of the use of controls and/or features of epidemiological techniques	4
<ul style="list-style-type: none">• Describes ONE study or investigation with evidence of use of a control AND <ul style="list-style-type: none">• Outlines one other study or investigation	3
<ul style="list-style-type: none">• Describes ONE study or investigation OR <ul style="list-style-type: none">• Outlines TWO studies and/or investigations	2
<ul style="list-style-type: none">• Identifies some relevant information	1

Sample Answer:

The following studies or investigations, or a combination of them might help confirm the hypothesis that the public water supply was the source of the cryptosporidiosis (*any TWO of the following*):

- a case-control study - go to hospital and identify patients arriving with symptoms, versus those that did not report those symptoms (control subjects). Ask about their source of drinking water.
- a community survey - Randomise recipients within target population (those in area possibly affected) households, business etc in the area, requesting information about their age, sex, occupation, source of drinking water (well/bore or public water source) and questions to identify those that have been sick with symptoms (abdominal pain and diarrhea) and those who have not. Compare their sources of drinking water (bore or public water system).
- an evaluation of the public water system (for ex: inspection of the source water, a tour of the water treatment facility, examination of water treatment processes and equipment, and record review at multiple locations).
- collection and testing of historical water samples for Cryptosporidium (e.g., water from water bottles and ice in refrigerators, refrigerator filters, toilet tanks in houses where residents have been away, storage tanks, taps at seldom-used locations). Compare this to samples of water taken freshly from public water systems
- testing of treated and untreated (raw) water from the public water system for Cryptosporidium pathogen/protozoal oocytes.

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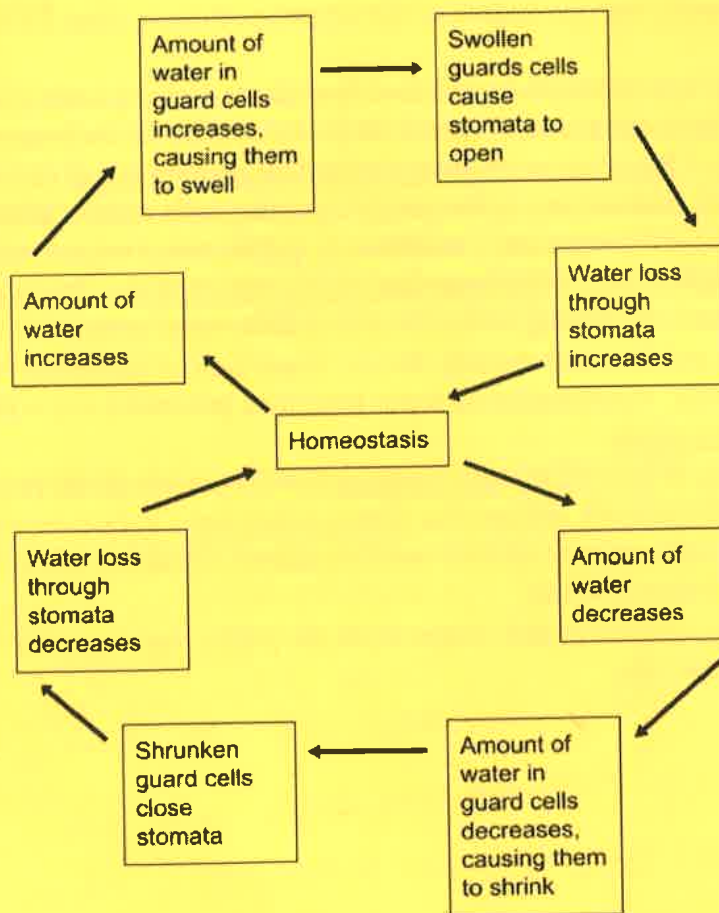
Question 27 (4 marks)

Outcomes Assessed: BIO12-15, BIO12-7

Targeted Performance Bands: 4-5

Criteria	Marks
<ul style="list-style-type: none"> Constructs a negative feedback loop using correct conventions, including arrows, demonstrating both an increase and decrease in water levels Correctly includes all relevant information, including: <ul style="list-style-type: none"> Shrivelling/swelling of guard cells Opening/closing of stomata Increase/decrease of water loss through evaporation/transpiration 	4
<ul style="list-style-type: none"> Constructs a negative feedback loop using correct conventions, including arrows, demonstrating both an increase and decrease in water levels Correctly most relevant information 	3
<ul style="list-style-type: none"> Attempts to construct a negative feedback loop using correct conventions Correctly some relevant information 	2
<ul style="list-style-type: none"> Identifies relevant information 	1

Sample Answer:



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Question 28 (7 marks)

(a) (3 marks)

Outcomes Assessed: BIO12-15, BIO12-5

Targeted Performance Bands: 5-6

Criteria	Marks
<ul style="list-style-type: none"> Provides a thorough description of the trends for both males and females shown in the graph Provides a plausible reason for the difference between males and females 	3
<ul style="list-style-type: none"> Identifies at least one trend for both males and females shown in the graph Provides a plausible reason for this difference between males and females <p>OR</p> <ul style="list-style-type: none"> Provides a thorough description of the trends for both males and females shown in the graph 	2
<ul style="list-style-type: none"> Identifies one trend in the data for males OR females 	1

Sample Answer:

Males have a significantly higher incidence rate of mesothelioma per 100,000 compared to females from 1982-2014. Whilst the incidence rate for males continues to fluctuate, there is an overall downward trend from about 2006, whereas the incidence rates in females appears to be increasing overall.

A possible reason for the higher incidence rate overall in males is that a higher number of males work in industries which come into contact with asbestos which is known to cause mesothelioma.

Question 28

(b) (4 marks)

Outcomes Assessed: BIO12-15, BIO12-5

Targeted Performance Bands: 5-6

Criteria	Marks
<ul style="list-style-type: none"> Provides a thorough explanation of TWO or more benefits of engaging in an epidemiological study Describes how epidemiological study can inform possible directions for future research Clearly links these benefits to the case study and data provided 	4
<ul style="list-style-type: none"> Provides a sound explanation of ONE benefit of engaging in an epidemiological study Identifies how epidemiological study can inform possible directions for future research Attempts to link this benefit to the case study and data provided 	3
<ul style="list-style-type: none"> Describes ONE benefit of engaging in an epidemiological study 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

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3 marks - at least 1 benefit / or 2 points (clearly) / data points

data
2

1

2 trends - 1 mark each

data used

reason - 1m

or describe asbestos work

Sample Answer:

Epidemiological studies play a major role in identifying trends and patterns in the incidence, prevalence, distribution and mortality rates of infectious and non-infectious diseases. Engaging in an epidemiological study of mesothelioma could assist in determining the possible cause(s) of the disease and whether certain groups are more affected than others. For instance, this data allows analysis of trends in incidence of mesothelioma in the overall population, as well as within the subset of males versus females. In this case the trend in the data shows that males are affected at a higher rate than females. This is the first step in determining the cause of mesothelioma which can then inform strategies that could be effective in controlling the disease in a population.

In terms of future directions for research, once priority groups are identified and causation is hypothesised, it allows treatment and management plans to be implemented, such as public health campaigns or introducing improved workplace health and safety standards. Data could then be collected again and compared to determine the effectiveness of the treatment and management of the disease.

① Through understand
① define epidemiological studies.

2 marks \Rightarrow 1 mark each for
a benefit

- could assist in determining the
possible causes of the disease

- inform strategies that could be
effective in controlling the disease

1 - mark \Rightarrow treatment & management
plans eg:

(1 mark off if not related to
stimulus)

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Question 29 (8 marks)

(a) (2 marks)

Outcomes Assessed: BIO12-15, BIO12-5

Targeted Performance Bands: 4-6

Criteria	Marks
<ul style="list-style-type: none">Explains (cause and effect statement) linking lifestyle choices to increased risk of development of bowel cancerExplains using a specific example how a mutagen damages DNA in bowel cells	2
<ul style="list-style-type: none">Explains (cause and effect statement) linking lifestyle choices to increased risk of development of bowel cancer ORIdentifies a mutagen	1

Sample Answer:

Lifestyle choices have a direct impact on the risk of developing bowel cancer. Ingested chemicals including alcohol, tar in tobacco smoke and chemicals in food that is charred or fatty foods can all contain mutagens. Over time consuming these chemicals mutagens increases the chances that these will damage the DNA of cells of the bowel which can result in cancer. An example is cooking processed foods at high temperature can cause nitrites (often used as preservatives) and amines to combine forming carcinogenic nitrosamines to form.

(b) (2 marks)

Outcomes Assessed: BIO12-15, BIO12-5

Targeted Performance Bands: 4-6

Criteria	Marks
<ul style="list-style-type: none">Defines oncogenes as mutated proto-oncogenes and causing uncontrolled production of cells and prevents deathOutlines the role of oncogenes in causing cancer	2
<ul style="list-style-type: none">Defines role of oncogenes in causing cancer	1

Sample Answer:

Oncogenes are mutated forms of Proto-oncogenes. Proto-oncogenes code for proteins that stimulate cell growth. Oncogenes cause uncontrolled cell growth and prevents cell death resulting large clusters of disorganised cells called adenomas. These can turn to cancer with time.

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(c) (4 marks)

Outcomes Assessed: BIO12-15, BIO12-5

Targeted Performance Bands: 4-6

Criteria	Marks
<ul style="list-style-type: none">Assesses the benefits of regular bowel screening including identifying and explaining the benefits of regular screeningDemonstrates comprehensive knowledge and understanding of mutations AND oncogenes AND/OR tumour suppressor genes in causing cancerDemonstrates an understanding that genetic changes can occur at any stage in the sequence of carcinoma developmentMakes reference and correctly interprets diagram	4
<ul style="list-style-type: none">Assesses a benefit of regular bowel screening including identifying a benefit to regular screeningDemonstrates a thorough understanding of mutations OR oncogenes OR tumour suppressor genes in causing cancerDemonstrates an understanding that genetic changes can occur at any stage in the sequence of carcinoma developmentMakes reference and correctly interprets diagram	3
<ul style="list-style-type: none">Assesses the importance of regular bowel screening by linking further mutations over timeDemonstrates sound knowledge of mutations in causing cancerDemonstrates an understanding that genetic changes can occur at any stage in the sequence of carcinoma development	2
<ul style="list-style-type: none">Provides a reason for regular screening	1

Sample Answer:

Screening for bowel carcinoma in people over the age of 50 is important because it allows for the detection of changes in the epithelium to be picked up before a carcinoma forms. The diagram shows that there are multiple opportunities for mutations to occur over time to both proto-oncogenes and tumour suppressor genes.

Some of these changes to the cells may not be evident at the first screening. For example, early in the sequence microadenomas may form below the surface of normal epithelium. An early bowel screen will not pick up a microadenoma. The diagram shows that a microadenoma is caused by the inactivation of the APC tumour suppressor gene (a gene that slows down or stops cell growth and mitosis). The APC tumour suppressor gene accounts for up to 85% of sporadic bowel cancers.

When adenomas are left, they often grow and provide multiple opportunities for further mutations to occur. As small adenomas turn into a large adenoma, a KRAS mutation may occur (KRAS mutation cancers account for 40% of bowel cancers). This suggests that leaving small adenomas without treatment increases the risk of cancer.

With regular screening of the bowel, small and large adenomas can be removed thus removing the opportunity for further mutations of both proto-oncogenes and tumour suppressor genes and the development of carcinoma.

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explain process - 2 marks

Question 30 (6 marks)

(a) (3 marks)

Outcomes Assessed: BIO12-12, BIO12-14

Targeted Performance Bands: 3-5

Criteria	Marks
<ul style="list-style-type: none"> Identifies the type of pathogen that causes African sleeping sickness AND describes a process by which it reproduces 	3
<ul style="list-style-type: none"> Identifies the type of pathogen that causes African sleeping sickness AND identifies a process by which it reproduces 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample Answer:

The pathogen is a protozoa and it reproduces through binary fission or budding. In binary fission, the protozoan duplicates its genetic material and then divides into two parts with each new organism receiving one copy of DNA. In budding, daughter nuclei produced by mitotic division migrate into a bud which is later separated from the mother cell by fission. *(Both types of reproduction do not need to be discussed.)*

(b) (3 marks)

Outcomes Assessed: BIO12-14

Targeted Performance Bands: 3-5

Criteria	Marks
<ul style="list-style-type: none"> Explains TWO main features of the innate immune response that causes the symptoms to develop in an infected individual. 	3
<ul style="list-style-type: none"> Explains ONE main features of the innate immune response that causes the symptoms to develop in an infected individual. 	2
OR	
<ul style="list-style-type: none"> Describes two main features of the innate immune response that causes the symptoms to develop in an infected individual. 	
<ul style="list-style-type: none"> Provides some relevant information. 	1

Just identified 2 (1)

Sample Answer:

Two main features of the innate immune response are fever and inflammation. Fever enhances the innate immune defences by stimulating white blood cells to kill pathogens. The rise in body temperature also may inhibit the growth of many pathogens. Inflammation allows for more blood to the site of infection to actively brings immune cells to fight the pathogen.

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Question 31 (8 marks)

Outcomes Assessed: BIO12-6, BIO12-7, BIO12-13, BIO12-14

Targeted Performance Bands: 2-6

Criteria	Marks
<ul style="list-style-type: none"> • A <u>comprehensive analysis</u> of the impact of increased understanding in biology leading to the development of a least <u>TWO biotechnologies</u> • Demonstrates an <u>extensive understanding</u> of <u>TWO named biotechnologies</u>. • Refers to the table <u>(stimulus)</u> • <u>Explanation of ONE current and ONE future development</u> in medical biotechnology 	8
<ul style="list-style-type: none"> • An analysis of the impact of increased understanding in biology has led to the development of at least <u>TWO biotechnologies</u> • Demonstrates a thorough understanding of <u>ONE current and ONE future development</u> in medical biotechnology • <u>Explanation of ONE future biotechnology</u> 	7
<ul style="list-style-type: none"> • Explains the impact of increased understanding in biology has led to the development of at least <u>TWO biotechnologies</u> • Demonstrates a sound understanding of <u>ONE current and ONE future development</u> in medical biotechnology • <u>Describes TWO future biotechnologies</u> 	6
<ul style="list-style-type: none"> • Describes the impact of increased understanding in biology that has led to the development of at least <u>TWO biotechnologies</u> • Demonstrates a sound understanding of <u>ONE current and ONE future development</u> in medical biotechnology • <u>Describes ONE future biotechnology</u> 	5
<ul style="list-style-type: none"> • <u>Outlines of the impact of increased understanding in biology that have led to the development of a biotechnology AND identifies ONE biotechnology</u> • <u>Outlines ONE current OR future biotechnology</u> 	4
<ul style="list-style-type: none"> • <u>Outlines of the impact of increased understanding in biology that has led to the development of a biotechnology</u> • <u>Identifies ONE biotechnology</u> 	3
<ul style="list-style-type: none"> • <u>Identifies of the impact of our increased understanding in biology has led to the development of a biotechnology</u> <p>OR</p> <ul style="list-style-type: none"> • <u>Identifies ONE biotechnology</u> 	2
<ul style="list-style-type: none"> • <u>Provides some relevant information</u> 	1

Sample Answer:

(partial the judgement)

Over the last twenty years there has been an increase in approval of new monoclonal treatments as shown in the table above. This has come about because of the increasing understanding of biology, which has also been crucial for the development of new genetic biotechnologies.

Recombinant DNA technology is an example of a technology that was developed by our understanding of the structure of DNA and how DNA replicates.

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The work of James Watson and Frances Crick as well as Maurice Wilkins and Rosalind Franklin in the early 1950s not only determined the structure of DNA but informed the realisation that complementary base pairing could be used to predict how DNA is copied. The understanding that each strand in DNA serves as a template for the synthesis of new complementary DNA strands was required to produce new technologies that could be used to manipulate DNA.

① or History of an application

Discover/Describe

Scientists use their ability to genetically engineer precise changes to DNA sequences in recombinant DNA technology. In this technique, restriction enzymes, such as EcorR1, are used to cut both a plasmid from E. coli and the human gene, to produce complementary sticky ends that bind to each other. DNA ligase is used to close the plasmid that now includes the desired human gene. This plasmid is then inserted back into E. coli bacterial cells. Each time the bacterial cell replicates, the plasmid will also replicate.

① Explain process

Recombinant DNA technology can be used to produce large volumes of proteins like insulin or to quickly produce large volumes of other human genes for use in gene therapy. This technology has revolutionised the industrial production of medical insulin production, replacing the need to extract insulin from animals.

Implications

Application

Recombinant DNA technology can also be used to genetic engineer transgenic species that can be used in medical industries. A transgenic species is a species that has a gene inserted into its DNA from another species. The gene is inserted either directly into a fertilised egg cell or in the germline cell. A medical example is Human Factor IX transgenic sheep that have the human blood clotting gene incorporated in their cells. These sheep produce blood clotting factor in their milk that can be extracted and used for medical treatment.

Implications

Our understanding of the adaptive immune response has allowed scientists to develop vaccinations against bacteria and viruses. These vaccinations result in the production of active acquired immunity, allowing the immune system to produce memory cells (B cells). These memory B cells produce antibodies that provide long term, acquired immunity that prevent a disease from developing following exposure to a pathogen. The understanding of the adaptive immune system has also assisted in producing treatments that induce passive immunity.

D & E
Immune system

Understanding of the structure and function of antibodies has allowed the development of monoclonal antibody treatments that are used to trigger the immune response against diseases such as cancer. Monoclonal antibodies are engineered molecules that mimic the immune system antibodies. A development in this area of research is the ability to deliver drugs to cancer cells using monoclonal antibodies. In this biotechnology, monoclonal antibodies can be engineered to carry chemotherapy drugs, or in future radioactive particles, directly to cancer cells, reducing the effects of the drugs on healthy cells.

MCA
Explain
Application
Implications

Our understanding of biology, such as genetics and the immune system, has allowed us to develop biotechnologies including recombinant DNA technology, vaccines, and monoclonal antibodies that are used for many medical applications. Future biotechnologies can be developed from this understanding, such as delivering radioactive particles to kill cancer cells.

Final judgement

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Question 32 (5 marks)**Outcomes Assessed:** BIO12- 14, BIO12-6**Targeted Performance Bands: 2-6**

Criteria	Marks
<ul style="list-style-type: none"> • Demonstrates a thorough understanding of the adaptive immune response • Refers to the trends shown in the data for both the initial and booster vaccinations and clearly relates this to the adaptive immune response • Provides an explanation of benefits and/or limitations of using this data in a public health campaign • Logical progression of ideas 	5
<ul style="list-style-type: none"> • Demonstrates a sound understanding of the adaptive immune response • Refers to the trends shown in the graph for the initial and/or booster vaccination and attempts to relate this to the adaptive immune response • Outlines a benefit and/or limitation of using this data in a public health campaign 	4
<ul style="list-style-type: none"> • Describes some features of the adaptive immune response <p>AND</p> <ul style="list-style-type: none"> • Attempts to describe some features of the graph <p>OR</p> <ul style="list-style-type: none"> • Relates this to a benefit and/or limitation of using the data in a public health campaign 	3
<ul style="list-style-type: none"> • Outlines one feature of the adaptive immune response <p>OR</p> <ul style="list-style-type: none"> • Outlines some features of the graph 	2
<ul style="list-style-type: none"> • Provides some relevant information 	1

Sample Answer:

The adaptive immune response involves the humoral response (release of antibodies from B cells) and the cell-mediated response (the transformation of T cells into cytotoxic/'killer' T cells which seek out and destroy infected body cells). This response is specific to each type of pathogen as each T and B cell has receptors that recognise only one antigen). It also has memory as once an antigen is destroyed, the cloned B cells remain in the body.

When a pathogen is first encountered by the body, the primary immune response occurs. As demonstrated in the graph, this initial response is fairly fast (it shows an increasing trend until about Day 14) but is short lived (it steadily decreases from Day 14 to Day 21 however the number of antibodies never goes back to zero). The number of antibodies produced after the initial vaccination is smaller than if the body is exposed to the same pathogen on subsequent occasions. As shown in the steep increasing trend in the graph, following the booster vaccination on Day 21 the memory T and B cells allow a much more rapid response and higher number of antibodies produced. The number of antibodies produced is significantly higher following the booster vaccination and takes only 4-5 days to reach the peak.

This graph would be very effective in a public health campaign, as it clearly demonstrates how the immune response improves with a booster vaccination. This could be used a tool to persuade members of the public to receive their booster vaccination, as it produces a faster response and higher number of antibodies, meaning that the person receiving the booster would be unlikely to be as sick.

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Question 33 (9 marks)

Outcomes Assessed: BIO12-12; BIO12-14; BIO12-7

Targeted Performance Bands: 2-6

*2 mark - 1 Identify
1 discuss*
*2m -> 1 d
1 c*

Criteria	Marks
<ul style="list-style-type: none"> Describes at least TWO DNA techniques, including steps, and linked to insect identification Justifies the value of maintaining biodiversity in agriculture Identifies value to farmers in the early identification of pests Thoroughly describes the harm of pesticides use, for example, the reduction of genetic diversity OR pesticide resistance Communicates scientific information succinctly and logically using precise scientific terminology 	9
<ul style="list-style-type: none"> Describes at least TWO DNA techniques, including steps Justifies the value of maintaining biodiversity in agriculture Identifies value to farmers in the early identification of pests Thoroughly describes the harm of pesticides use, for example, the reduction of genetic diversity OR pesticide resistance Communicates scientific information succinctly and logically using precise scientific terminology 	8
<ul style="list-style-type: none"> Outlines OR provides main steps of TWO DNA techniques Justifies the value of maintaining biodiversity in agriculture Identifies value to farmers in the early identification of pests Thoroughly describes the harm of pesticides use, for example, the reduction of genetic diversity OR pesticide resistance Communicates scientific information logically using precise scientific terminology 	7
<ul style="list-style-type: none"> Outlines main steps of a named DNA technique Justifies the value of maintaining biodiversity in agriculture Identifies value to farmers in the early identification of pests Describes the harm of pesticide use, for example, the reduction of genetic diversity OR pesticide resistance Communicates scientific information logically using scientific terminology 	6
<ul style="list-style-type: none"> Provides some relevant information about ONE DNA technique Explains the value of maintaining biodiversity in agriculture Identifies value to farmers in the early identification of pests Describes the harm of pesticide use, for example, the reduction of genetic diversity OR pesticide resistance Communicates scientific information logically using scientific terminology 	5
<ul style="list-style-type: none"> Identifies ONE DNA technique Explains the value of maintaining biodiversity in agriculture OR outlines value to farmers in the early identification of pests Describes the harm of pesticide use Communicates scientific information using scientific terminology 	4
<ul style="list-style-type: none"> Provides some relevant information about genetic technologies Makes reference to information provided Communicates scientific information using scientific terminology 	3
<ul style="list-style-type: none"> Provides some information about the importance of biodiversity OR a population's genetic information Makes reference to scenario 	2
<ul style="list-style-type: none"> Provides relevant information about Genetics OR Biodiversity 	1

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Sample Answer:

To amplify a fragment of DNA collected from the air around a farm, you could use PCR. The sample is first heated so the DNA denatures, or separated into two pieces of single-stranded DNA. Next, an enzyme polymerase builds two new strands of DNA, using the original strands as templates. This process results in the duplication of the original DNA, with each of the new molecules containing one old and one new strand of DNA. Then each of these strands can be used to create two new copies, and so on, and so on. The cycle of denaturing and synthesizing new DNA is repeated as many as 30 or 40 times, leading to more than one billion exact copies of the original DNA segment.

To sequence DNA means determining the order of the four chemical building blocks - called bases that make up the DNA molecule. DNA polymerase and DNA nucleotides are added to the sample DNA fragment to be identified with a primer attached. Then special dyed DNA is added. The solution is heated and cooled a few times so that more DNA can be synthesized. The solution is then put into a gel electrophoresis. Long fragments move slowly and short fragments move quickly, and from the colours of the dye present, an order to the DNA sample sequence can be determined. This sequence is then compared to the reference database, and insects present in the area are identified.

Early identification of pests, found by analysing the results of the eDNA collection means that if pesticides ARE used, it could be done in a controlled and specific way, rather than sprayed regularly. This could result in less cost to the farmer. The pests could be detected before they had reproduced and destroyed crops. (Benefit for farmer) - 1 mark

Use of pesticides, especially wide-spectrum ones not only kill the pest desired, but also other insects - including beneficial ones like crop pollinators. Less pollinators means that crop growth could be negatively impacted or more intrusive means are needed to pollinate crops. Additionally, widespread use of pesticides may result in pests that are naturally resistant to the pesticide surviving and reproducing. This produces pesticide resistance. This could be expensive for the farmer. Furthermore, runoff from pesticide-covered crops could be carried to freshwater bodies and harm insect populations downstream from the farm, causing widespread problems within the greater ecosystem. This reduces a farm's sustainability.

Biodiversity can support farm viability as each plant and animal have a role to play in ensuring healthy soils and nutrients for plants to grow. This might mean less money is spent on fertilisers. More genetic diversity means that plants and animals may be able to resist infectious pathogens carried by pests better than if the crop ecosystem was less diverse, as there may be present within a population a beneficial gene for an immune response. Justifies value of swab (1) judgement

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