
Student Number

NORTH SYDNEY GIRLS HIGH SCHOOL

2024
HSC
Assessment Task 4

Biology

General Instructions

- Reading Time – 5 minutes
- Working Time – 3 hours
- Write using a blue or black pen.
- Draw diagrams using pencil.
- NESA approved calculators may be used.
- Write your student number at the top of this booklet.
- Write your answers in the space provided. Extra writing space is available on page 34 – 35.

Total Marks – 100

Weighting – 30%

Section I **20 Marks**

- Attempt Question 1 – 20
- Allow about 35 minutes

Section II **80 Marks**

- Attempt Question 21 – 37
- Allow about 2 hours and 25 minutes

Section I

20 marks

Attempt Questions 1 – 20.

Allow about 35 minutes for this section.

Use the multiple-choice answer sheet provided for Questions 1 – 20.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you have changed your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

correct ↙

A ⊗ B ⊗ C ○ D ○

If you must use blank paper instead, clearly indicate an answer of EITHER A, B, C or D for each question from 1 – 20.

1. Giardia is a pathogen which infects the intestines of vertebrates if consumed. The pathogen becomes encased within hard shells called cysts when it is passed in faeces, which allows them to survive outside the intestines for months. Giardia possesses a cell membrane but lacks a cell wall.

   What is Giardia best classified as?

   A. Fungus
   B. Protozoan
   C. Bacterium
   D. Prion

2. Progesterone and oestrogen are produced initially by the corpus luteum. As pregnancy progresses this function is taken over by the

   A. uterine lining.
   B. ovary.
   C. placenta.
   D. anterior pituitary.

3. Which of the following is the ultimate source of all variation?

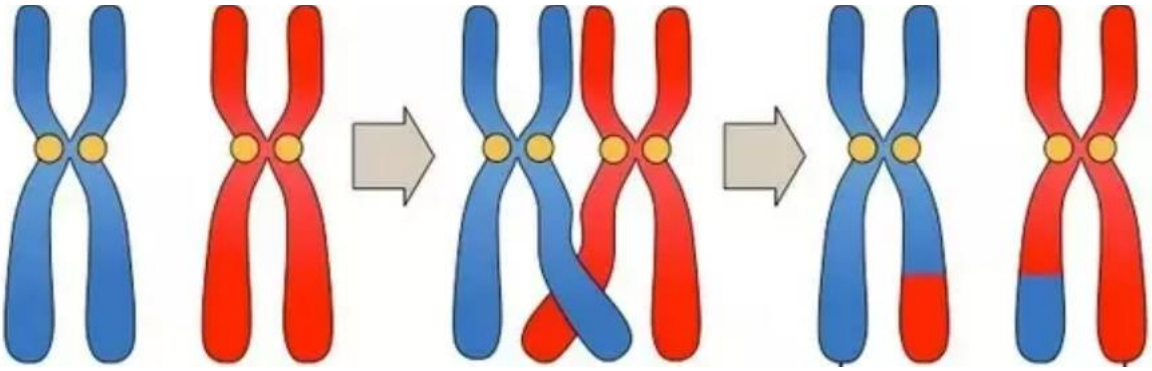
   A. Crossing over in meiosis
   B. Random fertilisation
   C. Mutation
   D. Random mating

4. An elderly person caught COVID-19. In hospital, they were given antibody serums to recover more quickly from the disease.

   What type of immunity is this an example of?

   A. Artificial passive immunity
   B. Artificial active immunity
   C. Natural passive immunity
   D. Natural active immunity

Use the following diagram to answer Questions 5 – 6.



5. The diagram above shows the process of
   A. mitosis.
   B. crossing over.
   C. DNA replication.
   D. complementary base pairing.

6. The process shown above occurs in which of the following cells?
   A. Gametes
   B. Somatic cells
   C. Cancer cells
   D. Oocytes

7. Which of the following statements is NOT correct?
   A. Isolation can reduce gene flow in a population.
   B. Genetic drift has a smaller impact on smaller populations.
   C. Genetic drift can remove alleles from a population.
   D. Gene flow can introduce new alleles in a population.

8. A researcher conducted a survey to determine the phenotype prevalence of rabbits that had floppy ears in comparison to the number that had upright ears in a population of rabbits. She asked her colleagues to describe the ear type of their rabbits and tallied the results. Out of 50 rabbits that were counted, she found that 36% of the rabbits had floppy ears and 64% had upright ears, and that the trait did not follow a Mendelian ratio.
Which of the following best explains why the results did not follow a Mendelian ratio?

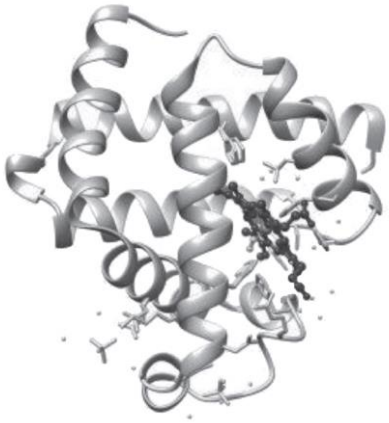
   A. The colleagues were not sure whether their rabbit had floppy or upright ears.
   B. The trait for rabbit ear type may be controlled by more than one gene.
   C. The researcher made an error in counting the rabbits.
   D. Rabbit ear type is an X-linked trait.

9. What is passed to the next generation as a result of sexual reproduction?
   A. Homologous chromosomes from the mother
   B. A chromatid from every chromosome of the father
   C. *n* chromosomes from the mother
   D. All alleles from each parent

10. Mutation A alters a pair of nucleotides in Gene A, affecting only the skin cells of an individual. Mutation B resulted from nondisjunction in meiosis I.
Which of the following correctly identifies both mutations?

	Mutation A	*Mutation B*
A.	Point, somatic	Point, germline
B.	Point, somatic	Chromosomal, germline
C.	Chromosomal, germline	Point, somatic
D.	Chromosomal, germline	Chromosomal, somatic

11. In the 1950s, scientist John Kendrew determined the structure of myoglobin. Myoglobin was found to be a single polypeptide chain with one heme group, as shown below.



The protein structure shown above would best be described as myoglobin's

A. primary structure.
B. secondary structure.
C. tertiary structure.
D. quaternary structure.

12. Fertilisation of the ovum during sexual reproduction contributes to genetic variation within a population by

A. combining alleles from two parent organisms.
B. combining nucleotides from two parent organisms.
C. creating opportunities for mutation to occur.
D. gene flow.

13. Refer to the DNA sequence below.

    3’ TAC TGG GCA AAT CTC ACT 5’

    Which of the following correctly identifies the corresponding mRNA sequence?

    A. 5’ AUG ACC CGU UUA GAG UGA 3’
    B. 3’ AUG ACC CGU UUA GAG UGA 5’
    C. 5’ UAC UGG GCA AAU CUC ACU 3’
    D. 3’ UAC UGG GCA AAU CUC ACU 5’

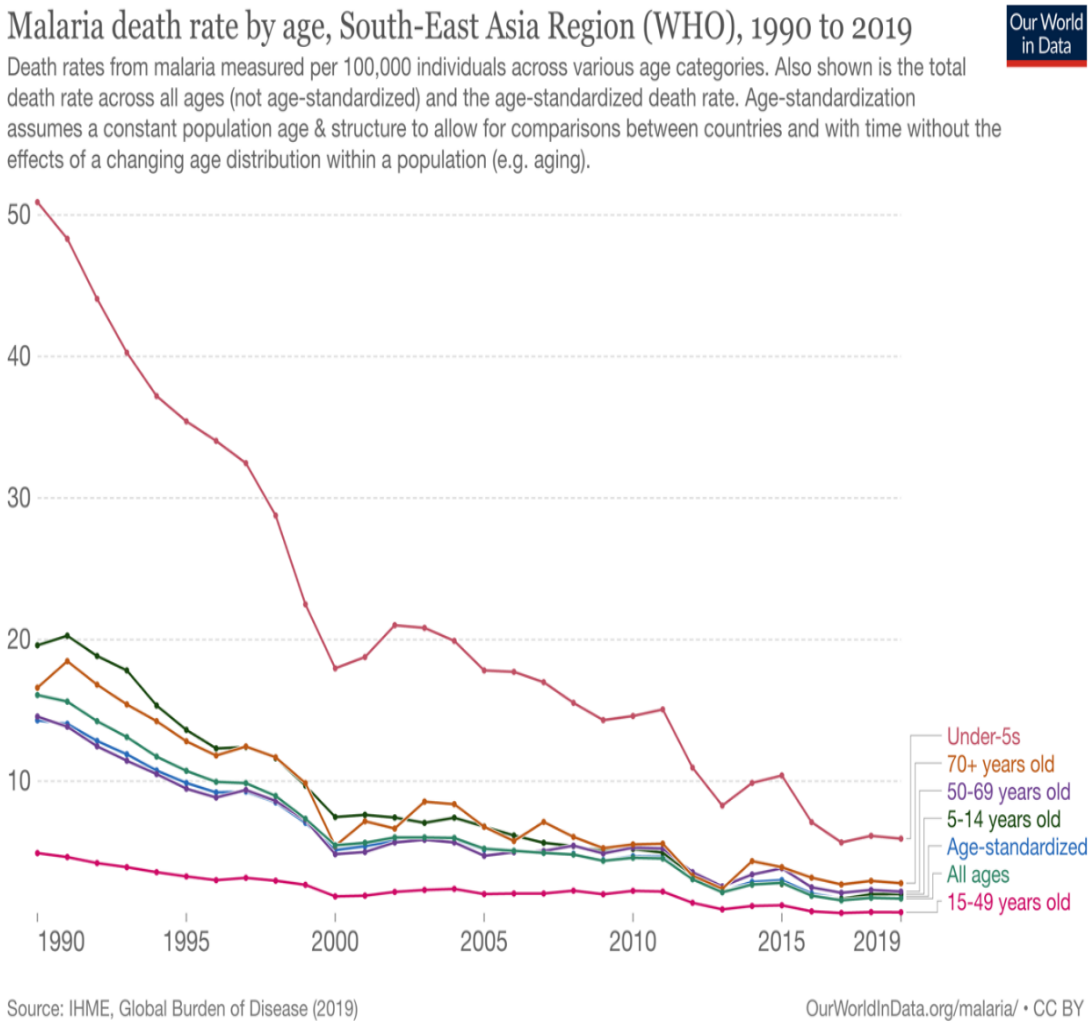
14. The damage cause by X-rays depends on the frequency of exposure and the type of tissues being exposed to the radiation. The table below shows the equivalent period of natural background radiation for a range of medical X-ray procedures.

Area of body	*Type of X-ray*	*Equivalent period of natural background radiation*
Chest	Simple X-ray	A few days
Chest mammography	Simple X-ray	A few months to a year
Chest	CT scan	A few years
Head	CT scan	A few months to a year
Head	Simple X-ray	A few weeks
Spine	Simple X-ray	A few months to a year

    If carried out in the same short period of time, which of the following would be the most damaging to the body?

    A. Several chest simple X-rays
    B. Several head simple X-rays
    C. Several head CT scans
    D. Several chest CT scans

15. The graph below shows the mortality rate of malaria in the South-East Asia region from 1990 to 2019.



Which of the following can be concluded from the data?

A. Children under 15 years old have the highest mortality rate.

B. South-East Asia has the highest death rate of malaria in the world.

C. The transmission of malaria has decreased across all age groups.

D. The mortality rate of the 15 – 49 age group has remained unchanged throughout the study period.

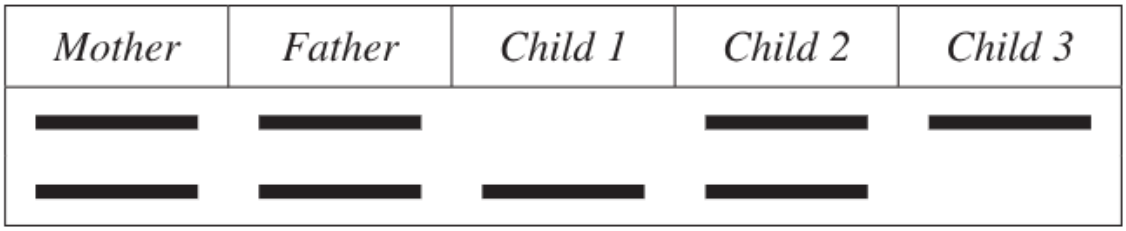
16. A scientist identified a single-stranded molecule with the structure shown below.

Exon	Intron	Exon	Intron	Exon	Intron
50 bases	150 bases	70 bases	80 bases	120 bases	40 bases

This molecule can be identified as

A. mature mRNA.
B. pre-mRNA.
C. template DNA.
D. coding DNA.

17. Cystic fibrosis is an autosomal recessive genetic disorder. In a family, the parents are both known to be carriers of the mutation that causes cystic fibrosis. The couple has one unaffected child (Child 1) and is now expecting fraternal twins. They have had a genetic screening test to determine whether the twins (Child 2 and Child 3) will have cystic fibrosis.



Which of the statements below is correct?

A. The parents are both homozygous.
B. Child 2 will have cystic fibrosis.
C. Child 3 will have cystic fibrosis.
D. Both Child 2 and Child 3 will have cystic fibrosis.

Use the following information to answer Questions 18 – 19.

A study was conducted to compare the transmissibility and virulence of COVID-19 in individuals who were fully vaccinated and partially vaccinated. The study obtained the average number of infections for both groups, and of those infected, the average number of hospitalisations and deaths were recorded.

The table below shows the data from the study.

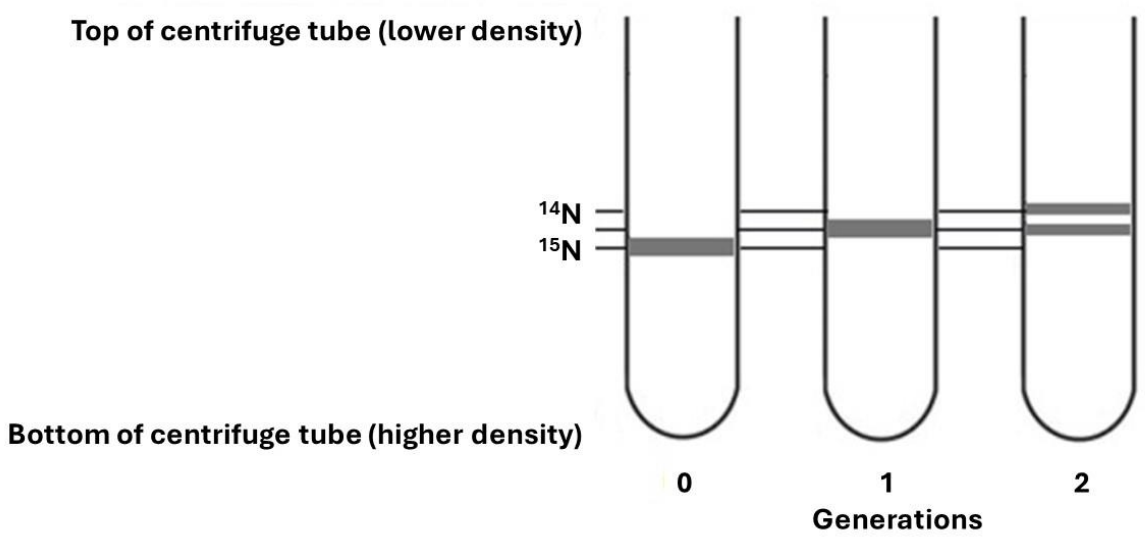
	Average number of infections	*Average number of hospitalisations*	*Average number of deaths*
Fully vaccinated	132	4.9	0.1
Not fully vaccinated	374	18.3	1.1

18. Which of the following statements about the study is correct?
    A. Fully vaccinated individuals are approximately 3 times less likely to contract COVID-19 compared to not fully vaccinated individuals.
    B. No individual who had a full course of vaccination died due to COVID-19.
    C. There was a total of 506 individuals who were infected with COVID-19.
    D. Individuals in the fully vaccinated group were approximately 10 times more likely to die than individuals in the not fully vaccinated group.

19. What is the percentage of infected individuals who had been hospitalised and died in the not fully vaccinated sample?
    A. 0.052%
    B. 5.2%
    C. 0.049%
    D. 4.9%

20. Meselson and Stahl investigated DNA replication by first feeding bacteria with bases containing only ^{15}N (heavy) to produce Generation 0: bacteria whose DNA contains only nitrogen which is heavier than ordinary nitrogen in its nucleotides. Generation 0 and subsequent generations were fed with bases containing only ^{14}N (light).

    The DNA from the bacteria was collected and centrifuged. The results are shown in the diagram below.



    From this information, what would be the composition of the DNA in Generation 3 as indicated by the banding pattern in the test tube?

    A. There will be one ^{14}N band.
    B. There will be a ^{15}N band and a ^{14}N band.
    C. There will be a ^{14}N band and an intermediate band.
    D. There will be a ^{15}N band, a ^{14}N band and an intermediate band.

Section II

80 marks

Attempt Question 21 – 37.

Allow about 2 hours and 25 minutes for this section.

Question 21 (3 marks)

Plants can reproduce both sexually and asexually.

a. Identify a method of asexual reproduction used by plants. **1**

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b. Outline ONE advantage and ONE disadvantage of sexual reproduction compared to asexual reproduction in plants. **2**

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Question 22 (2 marks)

Complete the following table to compare and contrast artificial insemination and artificial pollination. **2**

	Artificial insemination	*Artificial pollination*
Similarity 1	…… ……	
Similarity 2	…… ……	
Difference 1	…… …… …… ……	…… …… …… ……
Difference 2	…… …… …… ……	…… …… …… ……

Question 23 (2 marks)

Pathogens have a range of adaptations to aid their entry into host cells and organisms. Contrast the adaptations of two types of pathogens which facilitate their entry into a host. **2**

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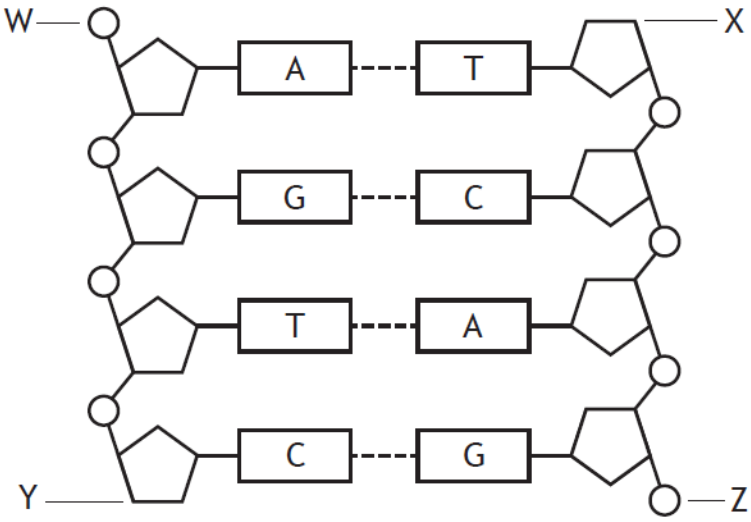
Question 24 (7 marks)

The diagram below represents the structure of a section of DNA.



a. Identify one letter from the diagram that labels the 3′ end of the DNA strand. **1**

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b. Complete the following table to compare and contrast prokaryotic and eukaryotic DNA. **4**

	Prokaryotic DNA	*Eukaryotic DNA*
Similarity 1	…… ……	
Similarity 2	…… ……	
Difference 1	…… ……	…… ……
Difference 2	…… ……	…… ……

c. A biologist analysed the base composition of a DNA molecule and a mRNA molecule. **2**
The analysis showed that the number of cytosine bases was the same as the number of guanine bases in the DNA molecule but not in the mRNA molecule.
Explain this observation.

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Question 25 (2 marks)

Describe ONE specific application of recombinant DNA technology in medicine. **2**

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Question 26 (3 marks)

In labradors, coat colour is controlled by a pair of genes known as the B gene and the E gene. The B gene determines the amount of dark pigment in the coat: black is dominant (B) and brown is recessive (b). The second gene determines the ability to express the dark colour: the 'ability to express a dark coat' is dominant (E) and the 'inability to express a dark coat' (e) is recessive. Dandelion is a yellow labrador.

Identify Dandelion's possible genotype/s and explain your reasoning. **3**

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Question 27 (4 marks)

Cat Scratch Disease is a rare bacterial infection caused by *Bartonella henselae*.
Approximately 40% of cats and kittens carry the bacteria in their mouths or under their claws. They get this by scratching or biting at infected fleas. Alternatively, cats can pick it up by fighting with other infected cats.
Most infected cats do not show any symptoms. But in serious cases, they could have trouble breathing or get infections in their mouth, eyes, or urinary tract.
If a cat that has *Bartonella henselae* bites or scratches a person hard enough to break the skin, then the bacteria can get into the body. If a person becomes infected with the bacteria, they may show some of the symptoms of Cat Scratch Disease, such as blistering at the scratch site, fever, headache and fatigue.

Individuals working in cat shelters regularly handle kittens and cats, and therefore have a high chance of contracting Cat Scratch Disease. **4**
Using the information provided and your knowledge on disease transmission, explain TWO relevant methods of preventing *Bartonella henselae* from entering a person who works in a cat shelter.

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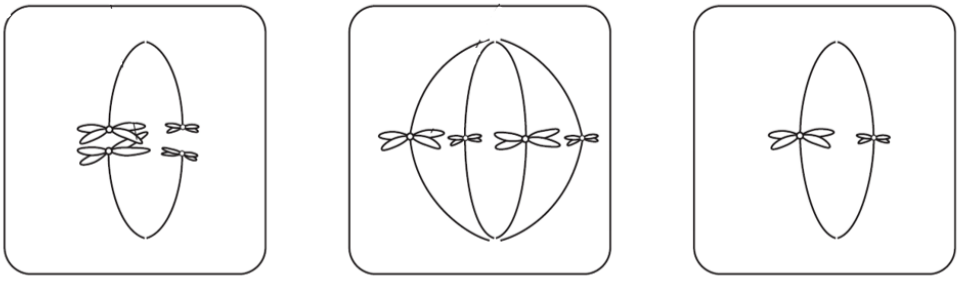
Question 28 (5 marks)

The diagram below shows three cells, B, C and D, from tissues in the same organism. Each cell is in a stage of either mitosis or meiosis.



Cell **B** Cell **C** Cell **D**

a. Complete the table with a tick if the cell shows the feature. **3**

	Cell B	Cell C	Cell D
Homologous chromosomes are present			
Shows a stage of mitosis			

b. Identify the stage of cell D and justify your answer. **2**

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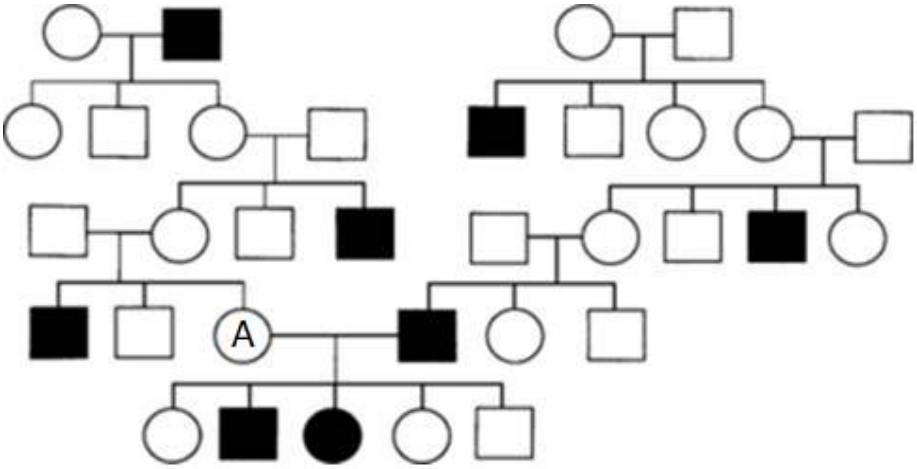
Question 29 (5 marks)

The pedigree below shows the occurrence of Becker muscular dystrophy in a family. Becker muscular dystrophy is an inherited condition which causes progressive degeneration of the muscles in the pelvis and legs.



a. Identify the inheritance pattern shown in the pedigree and justify your answer. **3**

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b. Use a Punnett Square to calculate the percentage chance a future daughter of A (with the same partner) will be capable of passing on the allele for Becker muscular dystrophy. **2**

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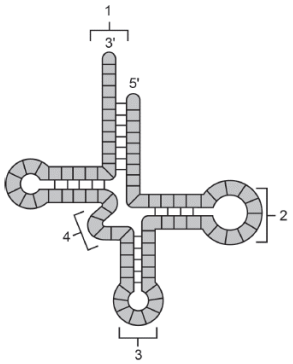
Question 30 (3 marks)

The diagram below shows the structure of a tRNA molecule.



Explain the function of tRNA in translation. **3**

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Question 31 (4 marks)

Influenza A is an intracellular pathogen. A teacher contracted influenza A at the end of the school term. By the time the school holidays had elapsed, he had recovered to the point he could return to school.

Explain the contribution of the cell-mediated response to the teacher's recovery. **4**

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Question 32 (4 marks)

Describe the response of a named Australian plant to a named pathogen. **4**

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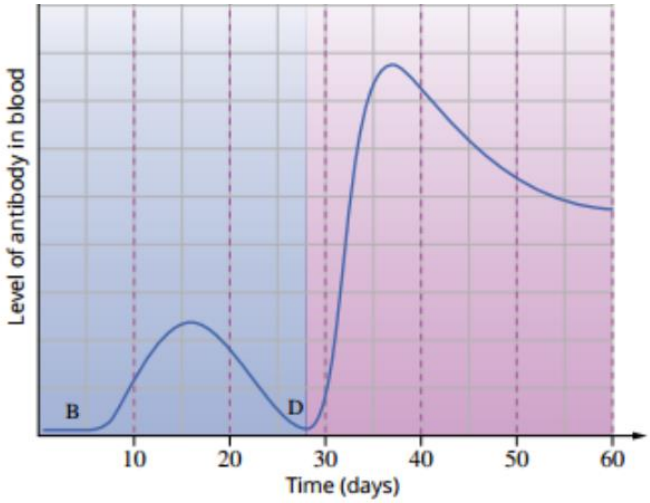
Question 33 (10 marks)

Whooping cough is a bacterial infection caused by *Bordetella pertussis*. It spreads when an infected person coughs or sneezes and you breathe it in. The bacteria affect the lungs and airways, causing a person to cough violently and uncontrollably. Whooping cough is particularly severe for babies under 6 months old; when contracted, it can result in hospitalisation and even death.

The pertussis vaccine is a whole-cell vaccine that protects against whooping cough. Pertussis vaccinations are recommended for all babies at six weeks, four months, six months, 18 months and at four years. An adult pertussis booster dose is then given at 12–13 years.

All babies less than six months old are at risk of catching whooping cough because they have not completed the three-dose primary vaccine course. Adults who want to reduce the likelihood of contracting the disease should consider having the vaccination every 10 years.

The diagram below shows changes in the antibody level in the blood of an adult over time. At B, the individual had their first pertussis vaccination administered in 20 years, and at D, the individual had been infected by the pathogen.



a. Describe the trend in the graph. **2**

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b. Using the graph and your own knowledge of the immune system, explain why the pertussis vaccination is important for long-term protection against whooping cough. **3**

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c. Describe one way that antibodies can eliminate a pathogen in an infected host. **2**

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Question 33 continues on the next page

Since the late 1980s, the incidence of whooping cough has risen. Doctors say this is due to large numbers of people refusing to vaccinate their children, and herd immunity being compromised as a result. **3**

d. Explain the significance of the pertussis vaccine in protecting vulnerable members of the community, such as babies.

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Question 34 (6 marks)

Non-coding regions of DNA were once thought to contribute only 'junk DNA'. As a result, mutations in non-coding regions were considered to be insignificant. **6**

Evaluate the relative significance of mutations in coding regions versus mutations in non-coding regions.

Question 35 (6 marks)

Although eye colour in humans is a polygenic trait, the OCA2 locus on chromosome 15 can feature several different alleles which contribute to eye colours from blue to brown. The OCA2 gene provides instructions for making a protein called the P protein, which is involved in the production of melanin. Melanin is the substance that gives skin, hair, and the irises in the eyes their colour. Melanin is also found in the light-sensitive tissue at the back of the eye (the retina), where it plays a role in normal vision.

The table below shows some of the more common alleles at the OCA2 locus.

Allele	*Impact/associated trait*
His615Arg	reduced function of the P protein, leading to less melanin production in the iris.
SNP T	reduced melanin production in the iris; associated with green eye colours
SNP C	high levels of melanin production in the iris; associated with brown eye colours
Oculocutaneous Albinism Type 2 mutation	rare form of albinism, characterized by reduced pigmentation in the skin, hair, and eyes. Causes vision problems due to reduced melanin in the retina. This form of albinism is diagnosable at birth.

a. Contrast the concept of a polygenic trait with that of multiple alleles. **2**

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A genetic analysis determined the genotypes of 5 individuals at the ORA2 locus and recorded their phenotype. The results are shown in the table below.

Individual	*Genotype*	*Phenotype*
1	SNP C | Oculocutaneous Albinism Type 2 mutation	Dark brown eyes; normal vision.
2	Homozygous for SNP C	Dark brown eyes; normal vision.
3	His615Arg | SNP C	Light brown eyes; normal vision.
4	SNP C | SNP T	Hazel (brownish-green) eyes; normal vision.
5	Homozygous for Oculocutaneous Albinism Type 2	Extremely pale skin, hair and eyes; vision problems.

b. Using the evidence in the table, discuss the possible inheritance pattern/s for the alleles at the ORA2 locus. **4**

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Question 36 (7 marks)

Roundup is a popular brand of herbicide that can be used to kill weeds. However, it is not very selective and can also kill agricultural crops. The active ingredient in Roundup is glyphosate, a chemical that inhibits an enzyme in plants that is normally used to synthesis amino acids.

The company that manufactured Roundup (Monsanto) also genetically engineered crops that are resistant to Roundup. Monsanto transferred a gene from a bacterial species that is resistant to glyphosate into crop plant species. These Roundup Ready crops include soybeans, corn, canola, alfalfa and cotton species.

Prior to Monsanto's transgenic crops, farmers needed to leave gaps between crop plants in order to plough their fields to remove undesired weeds that competed with their crops for nutrients and habitat. The practice of ploughing also depleted topsoil and released carbon dioxide. In contrast, farmers could plant Roundup Ready crops close together and use Roundup to ensure no weeds grew.

Each of the Roundup Ready crops are legally patented to Monsanto. These patents ensure that farmers must legally purchase the transgenic crop seeds from Monsanto and are banned from asexually propagating Roundup Ready crops. Most of the seeds produced by Monsanto are also sterile and will not give rise to a second generation of the transgenic plants.

a. Describe how a recombinant DNA plasmid is produced. **2**

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b. Analyse the benefits of using Roundup Ready crops in agriculture and the social implications of this example of a biotechnology. **5**

Question 37 (7 marks)

SNP analysis has been used to investigate the genetic basis of lactase persistence (the ability to digest lactose in adulthood). Lactose is a sugar which naturally occurs in milk. The primary genetic variation associated with lactase persistence is found in the MCM6 gene, which is located upstream of the lactase (LCT) gene. The MCM6 gene contains regulatory elements that influence the expression of the LCT gene.

Several SNPs within the MCM6 gene are strongly associated with lactase persistence. The most well-known SNP is referred to as the T allele. Individuals carrying the T allele are more likely to be lactase persistent, whereas those with the C/C genotype are typically lactase non-persistent.

The table below shows the frequencies of the T allele in populations with differing ancestry.

Population ancestry	*Region*	*Frequency of T Allele (%)*
British	Northern Europe	80
Maasai	East Africa	60
Italian	Southern Europe	25
Fulani	West Africa	10
Indian	South Asia	10
Han Chinese	East Asia	1

Explain how mutation, natural selection, genetic drift and gene flow could have led to these differences in the gene pools of populations with differing ancestry. **7**

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