# *Scientific Method Answer Key*

2021

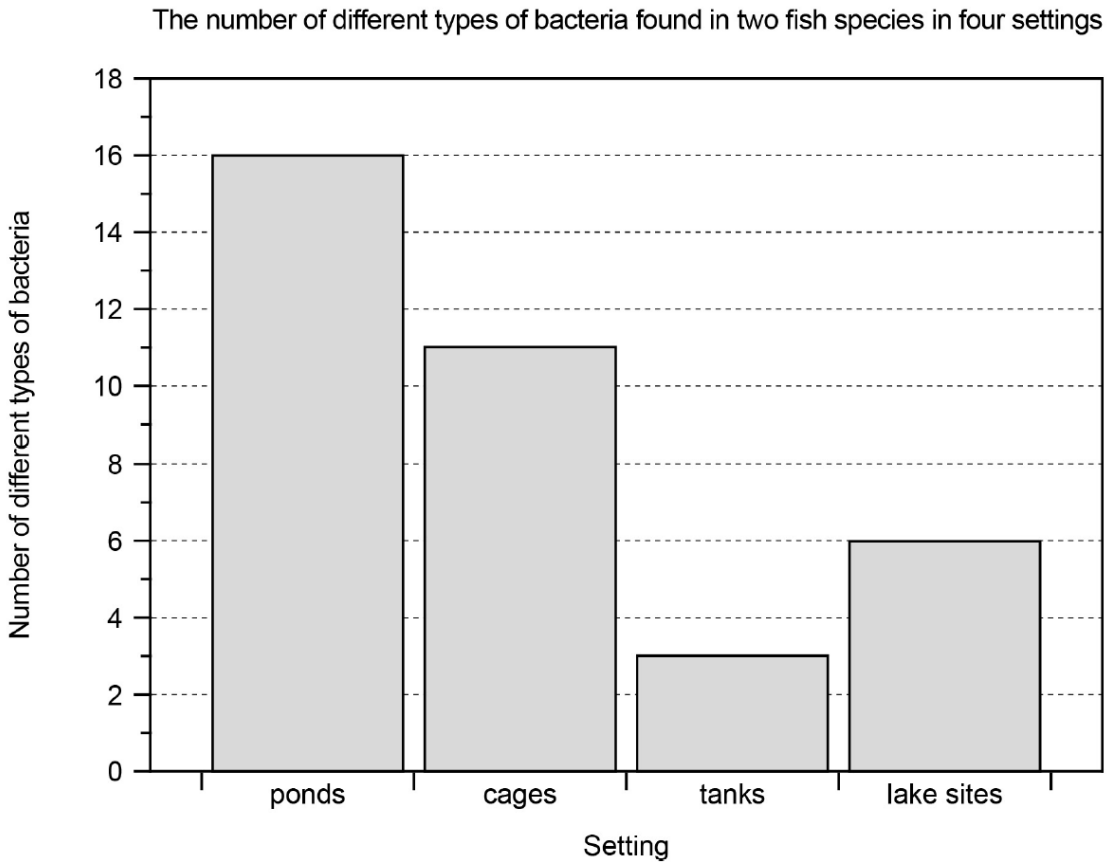
**Question 33** **(19 marks)**

Fish farming is the fastest-growing agricultural sector in the world. In this method of farming, fish are grown in ponds, cages, tanks or other types of enclosures, usually for food.

(a) Complete the table by determining the number of different types of bacteria found in fish from cages. (1 mark)

| Description | Marks |
|---|---|
| 11 | 1 |
| **Total** | **1** |

(b) Draw a bar graph to show the number of different types of bacteria found in fish in each of the four settings. (5 marks)




| Description | Marks |
|---|---|
| title - must include both variables | 1 |
| appropriate scale | 1 |
| y axis label | 1 |
| x axis label | 1 |
| plotting – data plotted accurately | 1 |
| **Total** | **5** |

(c) (i) List the settings in which *Pseudomonas fluorescens* was found. (1 mark)

| Description | Marks |
|---|---|
| ponds, cages and lake/lake sites | 1 |
| **Total** | **1** |

(ii) Identify which type of bacteria was found in ponds, cages and tanks but not from lake sites? (1 mark)

| Description | Marks |
|---|---|
| *Edwardsiella tarda* | 1 |
| **Total** | **1** |

(d) A fish farmer reviewed the data and concluded that fish in tanks have fewer different types of bacteria than those in ponds, cages or the lake. Evaluate this conclusion. (4 marks)

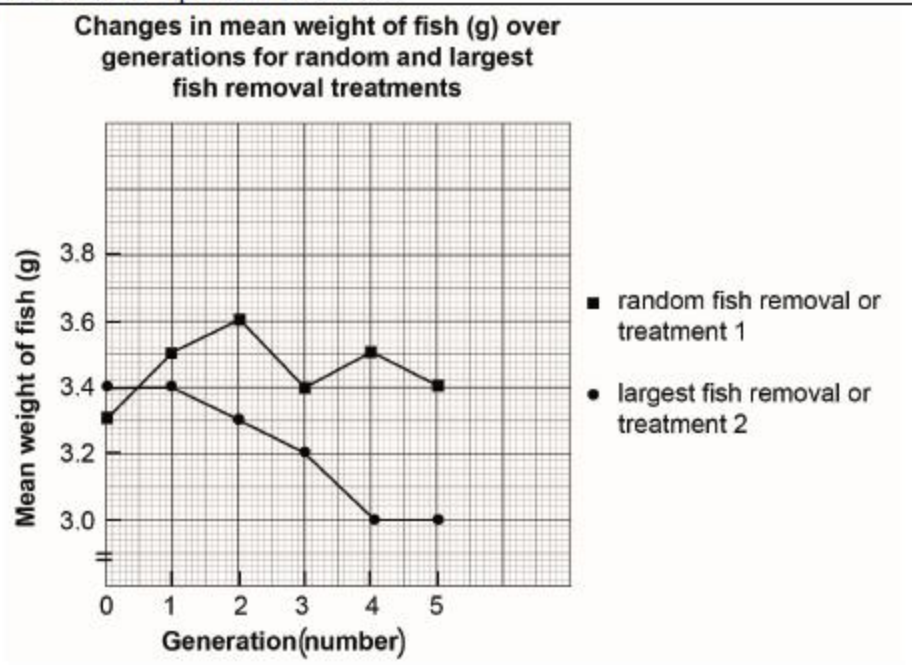
| Description | Marks |
|---|---|
| Any **four** of: | |
| • not correct **or** need more information to be sure<br>• tanks had the lowest number of bacterial types however, (far) fewer tanks were sampled than was the case for other settings<br>• need to correct data according to the number of each setting sampled **or** the number/percentage of bacterial types found per tanks/cages/lake sites sampled was less than that for tanks<br>• the (two) sampled tanks may not have been representative of the number of bacterial types (due to chance) **or** need to sample more tanks (to be sure of the data for tanks)<br>• unclear if other variables/number/types/condition of fish were controlled **or** influenced the results | 1–4 |
| **Total** | **4** |

**2020**

**Question 32** **(20 marks)**

(a) Graph the mean weight of fish for both the random fish removal treatment and the large fish removal treatment against generation. (6 marks)

| Description | Marks |
|---|---|
| title must include both variables | 1 |
| data plotted separately for treatments 1 and 2 including key | 1 |
| correct axes (X and Y) | 1 |
| appropriate scale | 1 |
| labelling – accurate labelling on both axes including units | 1 |
| plotting – data plotted accurately and joined (line graph) | 1 |
| Total | 6 |
| Note: 'mean' is required in Y axis label | |




(b) (i) Identify the dependent variable in the experiment. Give a reason for your answer. (2 marks)

| Description | Marks |
|---|---|
| mean weight/size of fish left in tank | 1 |
| this is the variable that was measured/depends on the independent variable | 1 |
| Total | 2 |

(ii) Would conducting the experiment for more generations improve the reliability or validity of the experiment? Give a reason for your answer. (2 marks)

| Description | Marks |
|---|---|
| validity | 1 |
| this would improve accuracy of experiment or the ability to determine whether removing largest fish had an effect | 1 |
| Total | 2 |

**Question 32(b)** (continued)

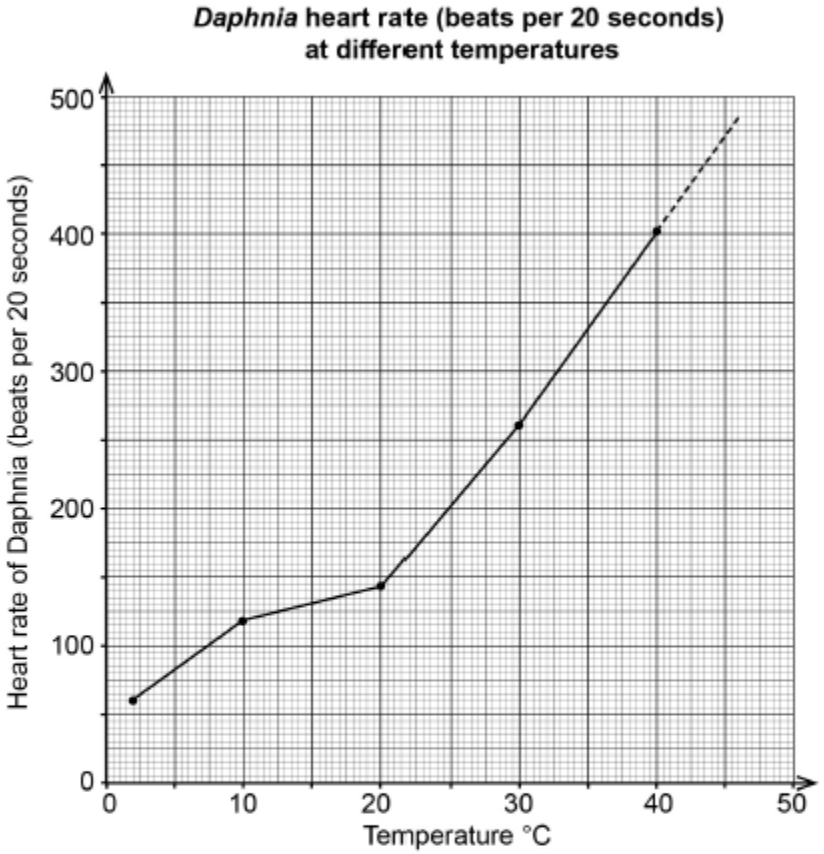
(b) (iii) Why did the biologists remove fish at random from the two tanks in Treatment 1. (2 marks)

| Description | Marks |
|---|---|
| control | 1 |
| so the only difference between treatments was the size of the fish that were removed or to determine what would happen if fish were removed from tank regardless of weight/size | 1 |
| Total | 2 |

**2019**

**Question 32** **(21 marks)**

(a) Graph the mean heart rate of the *Daphnia* against temperature. (6 marks)




| Description | Marks |
|---|---|
| accurate title that includes both variables | 1 |
| choose appropriate graph/line graph | 1 |
| correctly allocates independent/dependent variables to X and Y axes respectively | 1 |
| scale uses correct intervals and graph size is appropriate for grid size | 1 |
| correct labelling of both axes including units | 1 |
| data points are accurate and accurately joined | 1 |
| Total | 6 |

**Question 32** (continued)

(b) (i) Estimate the heart rate for *Daphnia* at 15 °C. (1 mark)

| Description | Marks |
|---|---|
| 135 beats/20 seconds (accept 130–140, must have units) | 1 |
| **Total** | **1** |

(ii) Estimate the heart rate for *Daphnia* at 45 °C. (1 mark)

| Description | Marks |
|---|---|
| 470 beats/20 seconds (accept 460–480, must have units) | 1 |
| **Total** | **1** |

(iii) In which estimate do you have the greater confidence? Give a reason for your answer. (2 marks)

| Description | Marks |
|---|---|
| heart rate at 15 °C or first estimate or (i) | 1 |
| this is an interpolation/within the range of the data or heart rate at 45 °C is an extrapolation/outside of range of data | 1 |
| **Total** | **2** |

(c) (i) What is the independent variable in this study? Give a reason for your answer. (2 marks)

| Description | Marks |
|---|---|
| temperature | 1 |
| it is the variable that the investigator controls/changes | 1 |
| **Total** | **2** |

(ii) State one way of improving the reliability of the study. (1 mark)

| Description | Marks |
|---|---|
| increase the sample size or use more *Daphnia* or repeating experiment | 1 |
| **Total** | **1** |
| Note to markers: Must have only one statement to improve reliability. | |

(iii) Propose an hypothesis for the study. (1 mark)

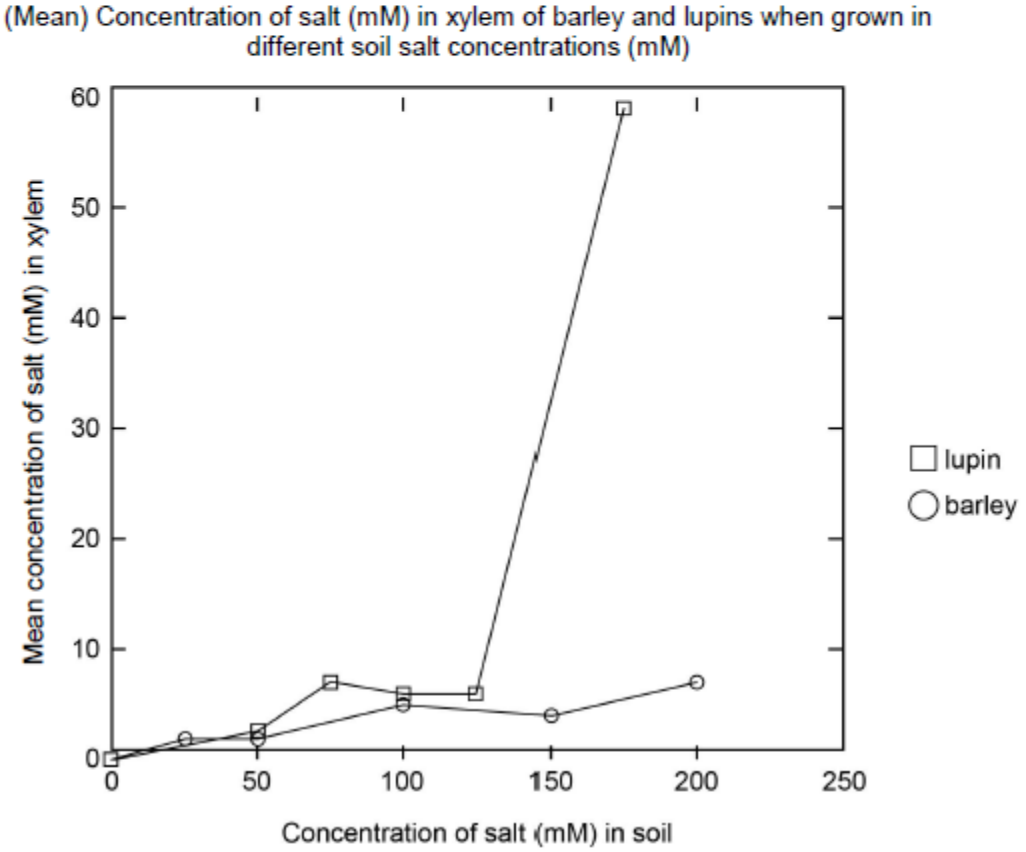
| Description | Marks |
|---|---|
| heart rate in *Daphnia* is affected by temperature or heart rate in *Daphnia* is not affected by temperature or *Daphnia* heart rate increases with increasing temperature or increasing water temperature increases heart rate in *Daphnia* | 1 |
| **Total** | **1** |

**2018**

**Question 34** **(20 marks)**

(a) Graph the mean salt concentration found in the xylem for both barley and lupins against the salt concentration in the soil. (6 marks)

| Description | Marks |
|---|---|
| Title must include both variables | 1 |
| Line graph; data plotted separately for barley and lupins with key | 1 |
| Correct axes (X and Y) | 1 |
| Correct scale | 1 |
| Labelling – accurate labelling on both axes including units | 1 |
| Plotting – data points accurate and accurately joined | 1 |
| **Total** | **6** |
| Note: 'mean' is required in Y axis label | |

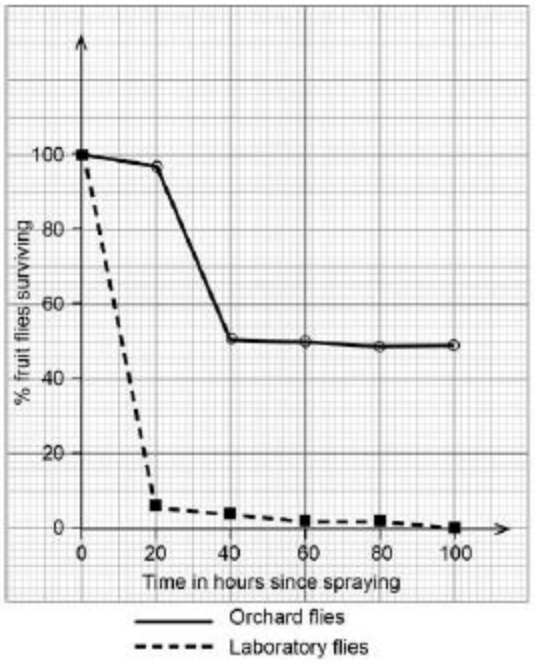


**2017**

**Question 33** **(20 marks)**

(a) On the grid below, graph the percentage of fruit flies surviving over time for both the fruit flies from the orchard and those from the laboratory. (6 marks)

**Survival rates of fruit flies from an orchard and a laboratory when sprayed with an insecticide**




| Description | Marks |
|---|---|
| Title, must include both variables | 1 |
| Line graph, data plotted separately for each group of flies with key | 1 |
| Correct axes (X and Y) | 1 |
| Correct scale | 1 |
| Labelling – accurate labelling on both axes including units | 1 |
| Plotting – data points accurate and accurately joined | 1 |
| Total | 6 |

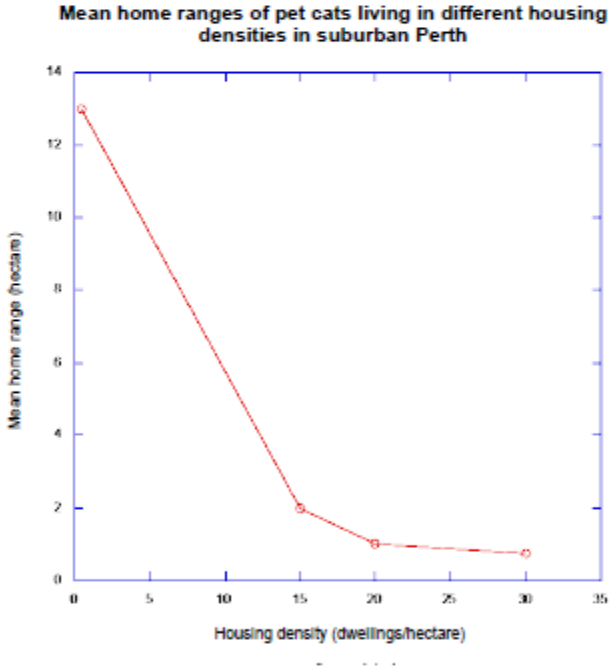
**2016**

**Question 33** **(20 marks)**

(a) The table below was constructed to summarise the data. Some cells are filled in as examples. Complete the summary table by placing the requested data in the empty cells. (3 marks)

| Housing density (dwellings/ hectare) | Number of cats | Mean home range (hectare) | Median home range (hectare) | Range of home range (hectare) |
|---|---|---|---|---|
| 0.5 | 4 | 13.0 | 13.5 (1 mark) | 6.0-19.0 |
| 15.0 | 6 (1 mark) | 2.0 | 2.0 | 1–3 (1 mark) |
| 20.0 | 6 | 1.0 | 1.0 | 1.0-1.0 |
| 30.0 | 4 | 0.75 | 0.75 | 0.5-1.0 |

(b) Graph the relationship between the mean home range (hectare) of cats and housing density (dwellings/hectare). (6 marks)




| Description | Marks |
|---|---|
| Title - must include both variables | 1 |
| Line graph | 1 |
| Correct axes | 1 |
| Correct scale | 1 |
| Labelling - accurate labelling on both axes, including units | 1 |
| Plotting - data points accurate and accurately joined | 1 |
| Total | 6 |

(c) (i) Using your graph, estimate the mean home range (hectare) of cats at the housing densities (dwellings/hectare) below. (2 marks)

| Description | Marks |
|---|---|
| 8 dwellings/hectare = 7.2 hectares (accept 7.0 to 7.4), must include units | 1 |
| 22 dwellings/hectare = 1 hectare (accept 0.8 to 1.2), must include units | 1 |
| Total | 2 |

(ii) In which of the above estimates should you have the greater confidence? Give a reason for your answer. (2 marks)

| Description | Marks |
|---|---|
| 22 dwellings/hectare | 1 |
| Because there are more data points around 22 hectares<br>or<br>Because there are few data points around 8 hectares | 1 |
| Total | 2 |

(d) Does the study on home range in cats have an independent variable? Explain your answer. (3 marks)

| Description | Marks |
|---|---|
| Any three of: | |
| • Yes/There is an independent variable<br>• Housing density was the independent variable<br>• Effect of housing density on cat home range was investigated<br>• An independent variable is one that is changed to determine its effect on the dependent variable | 1–3 |
| Total | 3 |

(e) (i) Explain an advantage of using more cats in the study. (2 marks)

| Description | Marks |
|---|---|
| Increase reliability | 1 |
| Reduces the chance of random errors or that the cats used were not representative or limits the effects of outliers | 1 |
| Total | 2 |

(ii) Explain a disadvantage of using more cats in the study. (2 marks)

| Description | Marks |
|---|---|
| Any one of the following answer sets, one mark per point | |
| increase costs<br>will require more labour and equipment | 1–2 |
| ethical considerations<br>should minimise/reduce numbers of animals used in studies | 1–2 |
| Total | 2 |

# *DNA, Cell Reproduction, Protein Synthesis Answer Key*

(a) Explain the relationship between DNA, genes and chromosomes. (3 marks)

Chromosomes are made up of DNA that is coiled tightly around histones (1).
DNA is made up of four nucleotides (ATGC) (1)
Genes are sequences of DNA that code for a certain protein (1)

(b) Name the enzyme that would transcribe the gene shown above. (1 mark)
RNA Polymerase

(c) State whether the top or bottom strand would serve as a template if the enzyme from question (a) above were to transcribe the gene from left to right. (1 mark)
Top strand (3' – 5' direction)

(d) Write the sequence of mRNA that will be produced.Include the position of the 3' and 5' ends. (2 marks)
5' - CCGUAUACGCUAUCAGCU – 3'

(e) Describe the three events that occur allowing the mRNA strand to be translated. (6 marks)

Initiation
Ribosome attaches to the mRNA (1)
Begins at the START (AUG) codon (1)
Elongation
tRNA brings corresponding amino acid to each codon (1)
via the anticodon (1)
Termination
Reading of the STOP codon (1)
Ends synthesis and releases protein (1)

(f) Asides from the change of Thymine to Uracil, describe two (2) other differences between DNA and mRNA in regards to protein synthesis (4 marks)
Any two (2) differences with suitable reason for two marks each:
Differences:
mRNA is single stranded, whilst DNA is double stranded (1)
DNA forms a double helix, whilst RNA does not (1)
mRNA is shorter / smaller than DNA (1)
ribose sugar in RNA, and deoxyribose in DNA (1)
Reasons:
double stranded/double helix mRNA would inhibit/delay protein synthesis (1)
ribose has –OH group leaving mRNA single stranded (1)
this is because it is required to leave the nucleus to be translated (1)

(g) State the type of mutation shown above. (1 mark)
Addition

(h) Define the term mutagen. (1 mark)
A physical or chemical agent that causes mutations.

(i) Explain the possible effects of this mutation on the GFI protein. (5 marks)

No effect (1) - silent mutation / protein is not affected (1)
Protein is altered (1) and resultant protein may confer either a negative (1) or positive (1) effect.

10. State the three different types of mutagens and describe their effects on DNA using an example.

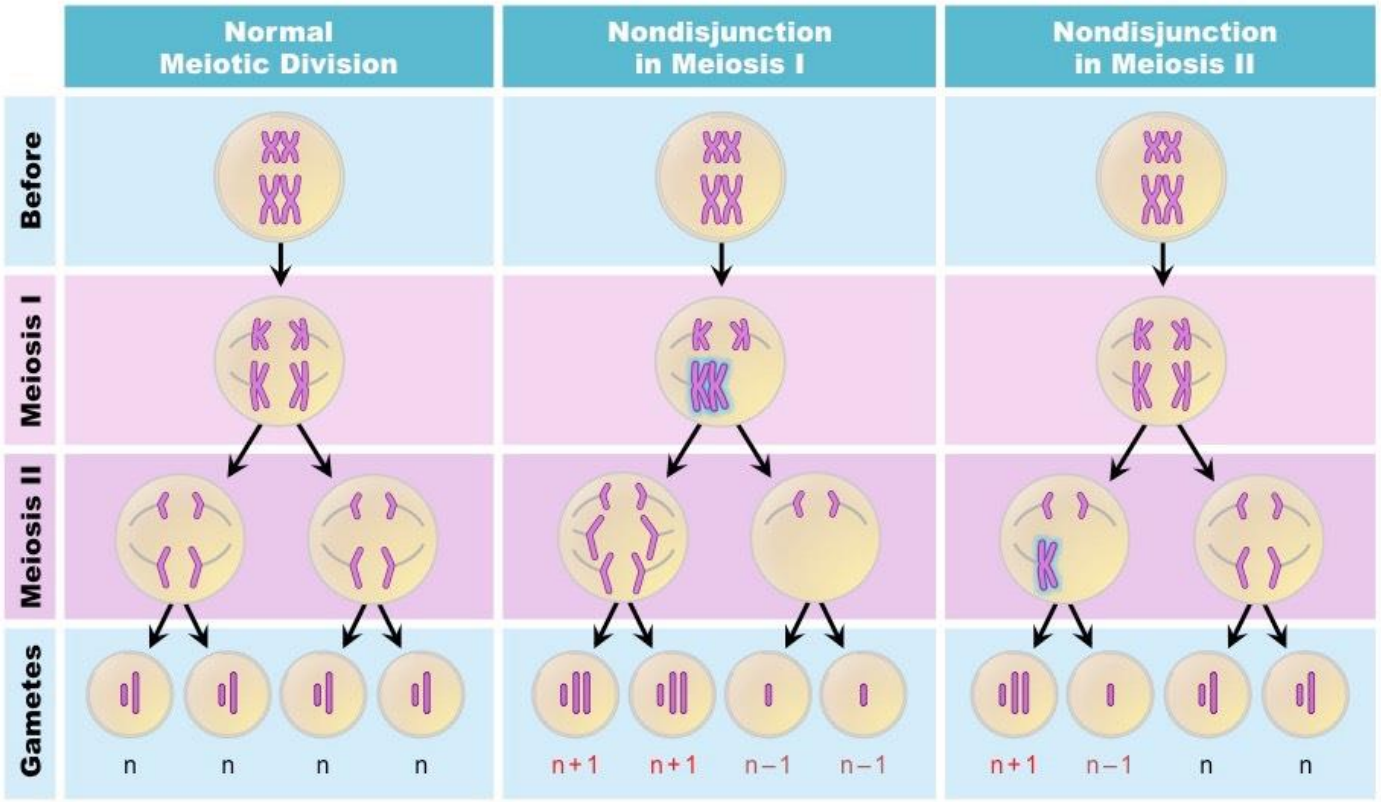
| Mutagen | example | Effect on DNA |
|---|---|---|
| Chemical | Mustard gas | Example: mustard gas causes guanine in DNA to be replaced by other bases |
| Physical | UV light | Interferes with base pairing<br>Breaks the hydrogen bonds between bases<br>Free bases pair with neighboring bases on the same strand<br>Usually thymine or cytosine<br>Genes do not function or don't function properly. Parents may pass mutations onto offspring |
| Biological | Bacteria | some bacteria produce toxins that damage DNA. A virus can damage DNA when they insert their genome into the DNA of the cell |

11. Use pages 97 – 100 in Biology WA ATAR Units 3 & 4 to summarise the types of point mutations and their effects on a protein by completing the table beloW

| Type of Point Mutation | Definition | Type of Mutation substitution, insertion or deletion mutation | Definition | Effect of mutation on a coded protein |
|---|---|---|---|---|
| Substitution | One nucleotide is replaced by another | Synonymous or Silent | Occurs when the substituted base results in a triplet/codon that codes for the same amino acid as the original triplet/codon | No change to the protein encoded by the mutated gene. It is identical to that encoded by the original sequence |
| | | Missense | Occurs when a single substituted nucleotide changes the amino acid – because this substitution changes the codon | Potentially the protein will not function, if the amino acid that is coded for does not have the same properties as the original amino acid.<br><br>If the amino acid does have the same properties the polypeptide |

| | | | | |
|---|---|---|---|---|
| | | | | sequence will be different but the protein will function the same as the original |
| | | Nonsense | Occurs when the substitution of a single nucleotide results in a STOP codon within the original gene sequence | This results in the early termination of translation of the transcribed gene sequence. The remaining codons downstream of the stop codon will not be translated which results in the production of an incomplete polypeptide |
| Insertion | The addition of one or more nucleotides at a site within the original gene sequence | Frameshift mutation | Causes the reading frame for the corresponding amino acids to be nudged/moved/shifted away from the original & all the triplets downstream of the mutation are affected | If a frameshift occurs the consequence for the translated protein is that the amino acids downstream of the mutation are not the same to those of the original polypeptide |
| Deletion | Loss of nucleotides (one or more) from a site within the original gene sequence | | | If a frameshift occurs the consequence for the translated protein is that the amino acids downstream of the mutation are not the same to those of the original polypeptide |

12. Draw 2 diagrams to show how Non-disjunction occurs (see page 101 in Biology WA ATAR Units 3 & 4)




13. Define the following terms:

| Term | Definition |
|---|---|
| Monoploidy | |
| Polyploidy | |
| Aneuploidy | A genome that varies varies from the conventional genome through the loss or addition of one or a few chromosomes |

14. Describe the 3 different types of variations in chromosome structure and the affects on an organism of each type

| Change in structure | description | Affect on organism |
|---|---|---|
| Duplication | ▪ Extra copy is made of a section of chromosome & inserted either into the same chromosome or another chromosome<br>▪ Change the number of copies of particular genes | The various genes that control different haemoglobins produced in human red blood cells are thought to have arisen by duplications |
| Deletion | ▪ Chromosome may undergo double-stranded breaks at two positions & the section between may drop out, removing all its genes with it | Williams syndrome in humans a condition that affects 1 in 10 000 people. Characterised by certain physical and temperamental features |
| Inversion | ▪ Chromosome breaks in 2 places & the segment in the middle rotates 180 degrees before being re-joined with the chromosome<br>▪ Reverses the normal sequence of genes<br>▪ Usually less dramatic that other types of chromosome mutations as genes are not lost or gained & the genes within the inverted segment can still function normally | May disrupt a gene in which it occurs or cause 2 genes to become fused together. If the chromosome does not align properly during meiosis, the affected individual may have reduced fertility |
| | | |
| Translocation | ▪ When a section of one chromosome breaks off & re-attaches to another chromosome | ▪ in humans when a segment of chromosome 8 ends up with chromosome 14 or vise versa, the normal control over the genes in that sequence is lost, resulting in a form of cancer |

15.

i) Draw a diagram of a labelled nucleotide (1 mark)

Phosphate – deoxyribose sugar - nitrogenous base (1)

ii) The two DNA strands run in a counter current direction. In which direction are new nucleotides added? (1 mark)

iii) 5' to 3' (can only be added to the sugar end)

iv) Write the correct name for DNA. (1 mark)

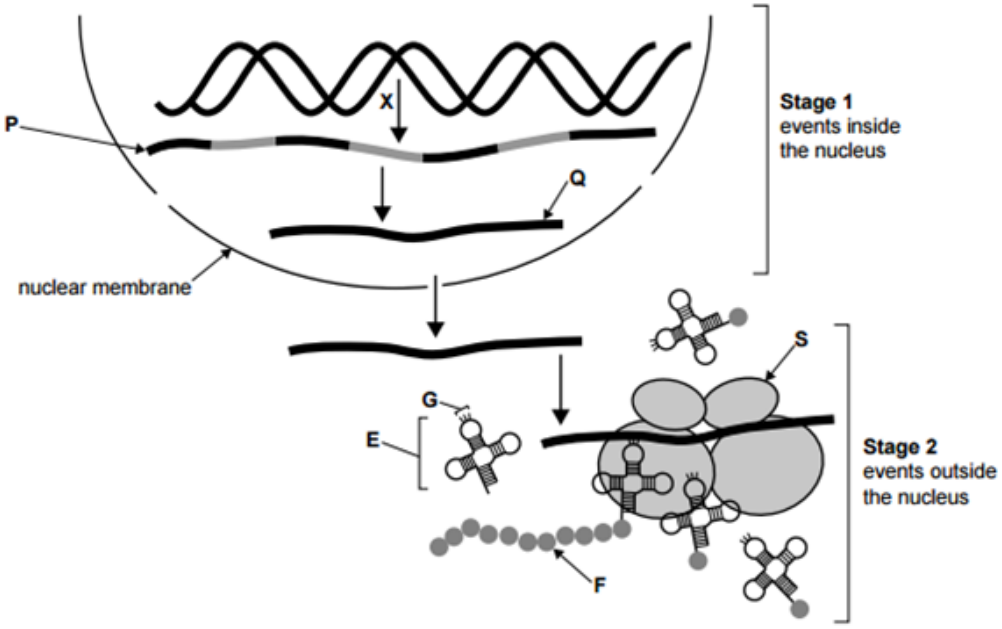
Deoxyribose Nucleic Acid

i) Write the corresponding tRNA code for the following DNA strand: (1 mark)

| | |
|---|---|
| DNA | T A T C G G C T A C A A T T |
| tRNA | U A U C G G C U A C A A U U |

ii) At which anticodon is translation initiated? (1 mark)

UAC




Label:

i) Process X: **Transcription**
ii) Structure Q: **mRNA**
iii) Structure E: **tRNA** (3 marks)

d) Describe the events occurring in stage 2, including the role of each of the structures S, F, E and G. (4 marks)

- **mRNA binds with ribosome**
- **tRNA anticodon matches mRNA codon and carries corresponding amino acid**
- **Next tRNA moves into place**
- **Peptide bond**

e) Describe codon degeneracy and its biological importance. (4 marks)

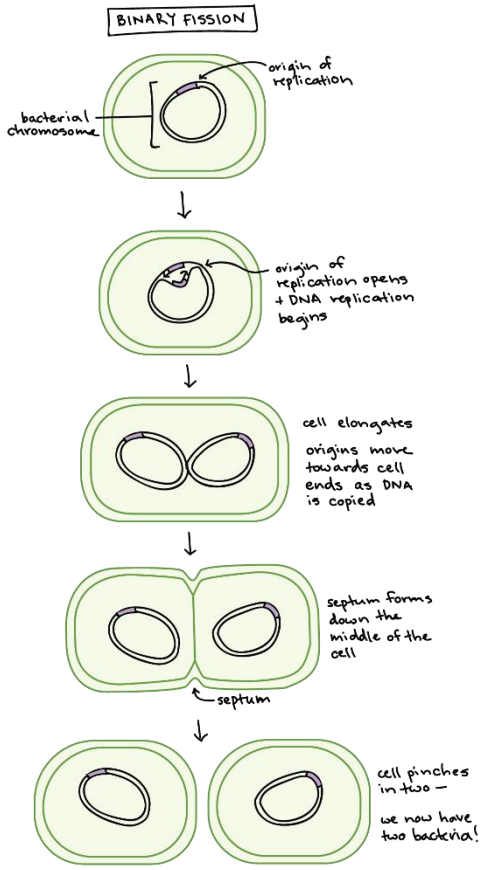
- 20 amino acids and 4 nucleotide bases A, T, C, G.
- unique code for each amino acid requires three bases to code for each (a triplet code);
- Two bases only give 16 combinations. **However,** three bases give 64 combinations.
- **Therefore because** there are more possible codes than amino acids the system is degenerate.
- **Biological significance: Point mutation does not always result in a phenotype change**

f) The complimentary DNA (cDNA) strand can be synthesised using the analysis of the amino acids. However, if scientists use this analysis of the protein to form cDNA, it may not have the same code sequence as cDNA formed using mRNA.

Discuss why this situation occurs. (4 marks)

- **Due to** degeneracy of the code / more codes than amino acids, there is more than one code for each amino acid
- **So** if you know the amino acid sequence of the protein produced there will be a variety of different sequences of DNA that may have produced it.
- **However,** when cDNA is produced from an mRNA sequence there can only be one sequence the cDNA can have.
- This sequence may or may not be the same as the cDNA sequence produced from the protein.

22. Draw a diagram detailing how bacteria reproduce



23. Describe the effect of the environmental factor on the expression of genes in the following:

a. Soil pH affect on flower colour in Hydrangeas
b. Environmental temperature a sex in sea turtles
c. Environmental temperature and fur colour in the Himalayan Rabbit

| | Environmental condition | Example of effect on gene expression | Description of the effect on gene expression |
|---|---|---|---|
| a | Soil pH | Hydrangea flower colour | • The range of colours in hydrangea flowers can be traced back to the pH in the soil.<br>• A more acidic soil is conducive to blue flowers.<br>• The pH does not change the genome because the genotype does not change. It is the interaction of the environment with either the gene or the protein that determines the flower colour in hydrangeas. |
| b | Environmental temperature | Sex determination in sea turtles | • Sean turtles bury their eggs in the sand<br>• The temperature of the sand determines the sex phenotype<br>• Cooler temps produce males and warmer temps produce females |
| c | Environmental temperature | • enzymes of some genes are affected by external environment **because the** environment may prevent the enzyme from functioning at high or low temperatures | • Himalayan rabbits are white except for black extremities because the enzyme needed to produce black fur only functions at low temperatures<br>• Himalayan rabbits carry the C gene, which is required for the development of pigments in the fur, skin, and eyes, and whose expression is regulated by temperature<br>• Specifically, the C gene is inactive above 35°C, and it is maximally active from 15°C to 25°C. This temperature regulation of gene expression produces rabbits with a distinctive coat coloring. In the warm, central parts of the rabbit's body, the gene is inactive, and no pigments are produced, causing the fur color to be white<br>• Meanwhile, in the rabbit's extremities (i.e., the ears, tip of the nose, and feet), where the temperature is much lower than 35°C, the C gene actively produces pigment, making these parts of the animal black. |

25. Explain both the advantages and disadvantages of asexual reproduction.

**Advantages – maximum 4 marks:**

Rapid increase in offspring (1) increasing the frequency of their genes (1)

Do not require a mate (1) meaning it does not have to spend time or energy finding a suitable mate before reproducing (1)

Does not require mobility (1) meaning that reproductive success is greater (1)

Prevailing conditions suit phenotype of parent so will suit offspring (1)

**Disadvantages – maximum 4 marks:**

Inheritance of mutations/defects (1) due to exact copy of genes (1)

Less ability to adapt (1) due to decreased genetic variety (1)

Changes in the environment can have major consequences (1) owing to the lack of diversity (1)

26. Describe the differences between meiosis and mitosis.

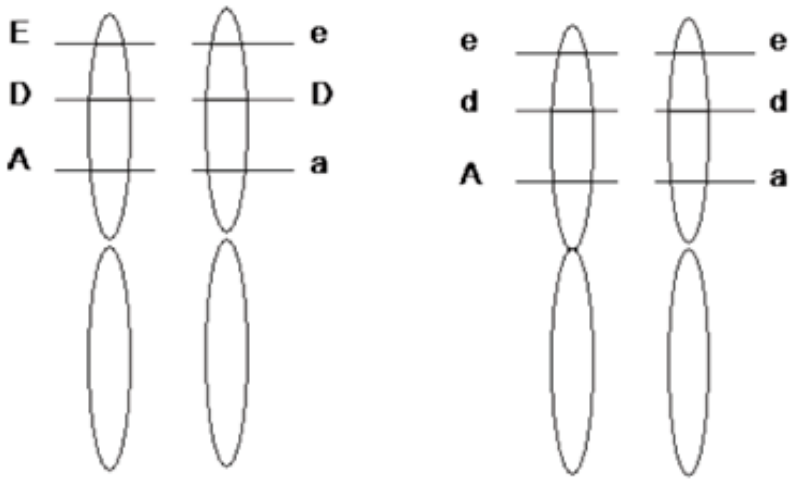
| **Mitosis** | **Meiosis** |
|---|---|
| In all body cells, including germline | In germline cells only |
| Crossing over does not occur | Crossing over occurs |
| Two daughter nuclei same as parent | Four daughter nuclei different to parent |
| One division | Two divisions |
| Individually line up at equator | Homologous pairs line up at equator |
| Diploid daughter cell | Haploid sex cells |
| For repair, growth and replacement | To create gametes (egg/sperm) |
| | |

# *Inheritance Answer Key*

26. A species of mammal has 20 chromosomes in its cells, including 18 autosomal chromosomes plus a pair of sex chromosomes (XX or XY, as in humans). Some of the genes on autosomal chromosome number 1 are shown in the table below.

| Characteristic controlled | Alleles |
|---|---|
| Ear shape | E – ear rounded<br>e – ear pointed |
| Coat colour | D – coat dark grey<br>d – coat light grey |
| Eye size | A – eye large<br>a – eye small |

The number 1 autosomal chromosomes of a mating pair of this species are shown below.




Male parent  Female parent

(a) (i) List the **characteristics** for which the male parent is heterozygous. (2 marks)

**Ear shape (1), Eye size (1), pay only (1) mark for phenotype**

(ii) List the **characteristics** for which the female parent is homozygous. (2 marks)

**Ear shape (1), Coat colour (1), pay only (1) mark for phenotype**

(b) Give the probability of an offspring of this pair having pointed ears. Explain your answer, showing your working. (4 marks)

**Genotypes (2), Offspring (1), Probability ½ or 50% (1)**

| | E | e |
|---|---|---|
| e | Ee | ee |
| e | Ee | ee |

(c) (i) Describe the phenotype of the male parent for all characteristics. (2 marks)

**Round ears, Dark grey coat, Large eyes (must have all correct)**

(ii) Describe the phenotype of the female parent for all characteristics. (2 marks)

**Pointed ears, Light grey coat, Large eyes (must have all correct)**

(d) Is it possible that the male parent's mother had a light-grey coat? Explain your answer, showing your working. (4 marks)

**No (1)**
**Male genotype DD (1)**
**Must have received a D from father, D from mother (2)**
**Or**
**Would have to be dd to have light grey coat, mother could not as she passed on D allele (2)**
**Or**
**Equivalent punnet squares as evidence**

(e) What is the probability that the first offspring of this pair is a female with rounded ears and a dark coat? Show your working. (4 marks)

**Female = ½ (1)**

**Round ears = ½ (1)**

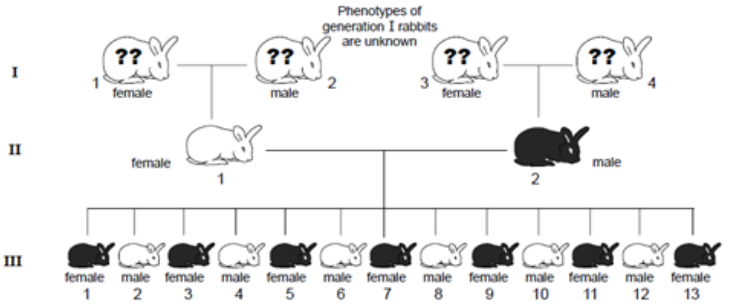
| | E | e |
|---|---|---|
| e | Ee | ee |
| e | Ee | ee |

**Dark coat = 1/1 or 100% (1)**

| | D | D |
|---|---|---|
| d | Dd | Dd |
| d | Dd | Dd |

**Overall probability = ½ x ½ x 1 = ¼ (1)**

6. The pedigree below represents a family of rabbits. The shaded rabbits have inherited a disease. The phenotypes of rabbits I-1, I-2, I-3 and I-4 are not known.




On the basis of the offspring from generations II-1 and II-2 it has been suggested that the disease is an **X-linked dominant** characteristic.

a) What evidence from generations II and III support this suggestion? (1 mark)

**Affected male (II2) has passed on to all daughters in generation III (1)**

b) If the mode of inheritance suggested is correct, complete the table below to show the possible phenotypes and genotypes of rabbits I-1, I-2, I-3 and I-4. For each rabbits phenotype, select from (4 marks)

- Has the disease
- Does not have the disease
- Impossible to tell from the information given

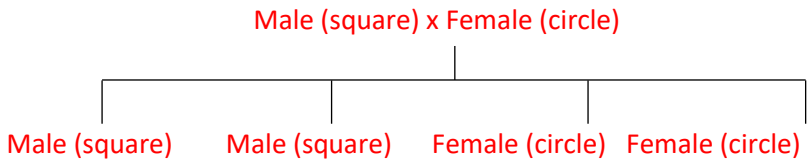
| | Phenotype | Possible genotypes |
|---|---|---|
| **Rabbit I 1** | **Impossible to tell** | $X^dX^d$, $X^DX^d$ |
| **Rabbit I 2** | **Does not have** | $X^dY$ |
| **Rabbit I 3** | **Has disease** | $X^DX^D$/$X^DX^d$ |
| **Rabbit I 4** | **Impossible to tell** | $X^dY$, $X^DY$ |

**(1/2 mark each)**

9. (i) Use the space below to draw a family tree to show the following. (3 marks)

| Description | Marks |
|---|---|
| • Two parents and four offspring<br>• Squares for males and circles for females<br>• Pups in correct order male, male, female, female | 1-3 |
| **Total** | **3** |

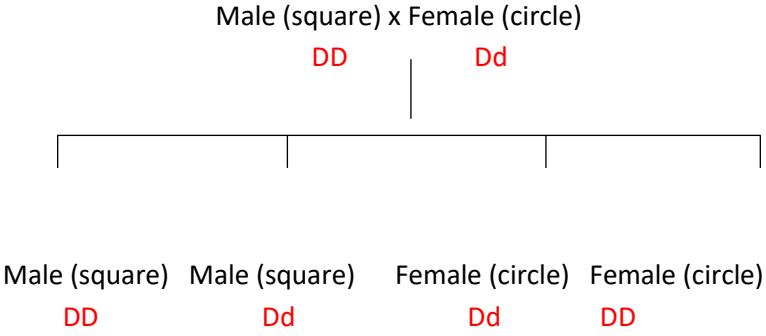
Example below




(ii) Using 'D' to show the dominant allele and 'd' for the recessive allele, identify the genotypes of each individual. Show your answers on the family tree. (2 marks)

| Description | Marks |
|---|---|
| • Individuals that are DD are father, first male pup and first female pup<br>• Individuals that are Dd are mother, second male pup and last female pup | 1-2 |
| **Total** | **2** |

Example below.



(iii) On maturity, the second male pup and the first female pup interbreed. What is the chance that their first pup will have inbreeding depression? Show working.

(3 marks)

| Description | Marks |
|---|---|
| Punnett square showing<br>• Heterozygous male crossed with heterozygous female<br>• Four pups as DD, Dd, Dd, dd | 1-2 |
| • Statement that ¼, 25% **or** 1 in 4 pups would be expected to have inbreeding depression | 1 |
| **Total** | **3** |

# *Natural selection and evolution Answer Key*

(a) Explain the impact the group dynamic would have on genetic diversity. (2 marks)

| Description | Marks |
|---|---|
| Any **two** of: | |
| • There would be low genetic diversity/all individuals would have high levels of similarity<br>• High level of inbreeding due to the closed nature of the population. | 1-2 |
| **Total** | **2** |

(b) Explain how sexual reproduction within the group could lead to variety. (2 marks)

| Description | Marks |
|---|---|
| Any **two** of: | |
| • Independent assortment of chromosomes during meiosis 1<br>• Crossing over of chromosomes during meiosis 1 | 1-2 |
| **Total** | **2** |

(c) Is this an example of gene flow or genetic drift? Provide an explanation. (4 marks)

| Description | Marks |
|---|---|
| • Gene flow | 1 |
| • Mating between groups allows transfer of genetic information between one group and another<br>• Genetic drift is a factor that reduces genetic diversity<br>• For example, founder effect or population bottleneck | 1-3 |
| **Total** | **4** |

(d) Identify **two** benefits of the behaviour. (2 marks)

| Description | Marks |
|---|---|
| Any **two** of: | |
| • Enables outbreeding/greater genetic diversity<br>• Populations are more resilient/adaptable in the face of change | 1-2 |
| **Total** | **2** |

(e) Explain how the behaviour of females mating with males from neighbouring territories during battles would have evolved. (5 marks)

| Description | Marks |
|---|---|
| • Natural selection | 1 |
| • There were females that inbred with males from their own population and females that outbred with males from other populations during clashes<br>• The pups/young of banded mongoose of outbreeding females had higher survival rates than pups of individuals that continued to inbreed.<br>• Pups that had higher survival rates are more likely to survive and have offspring as a result of the genetically inherited behaviour.<br>• They pass these outbreeding traits on to the further generations. | 1-4 |
| **Total** | **5** |

The Western Ground Parrot is a critically endangered species. Small populations have been found in Fitzgerald National Park and Cape Arid National Park. Reduced home ranges, predation and competition from introduced species have greatly affected their numbers. The selection pressures that they have been exposed over the past 200 years are very different to those that they were exposed to previously. With the small numbers of parrots remaining, wildlife officers are not sure if they still have a viable gene pool.

a) Natural selection occurs when selection pressures in the environment confer a selective advantage on a specific phenotype to enhance its survival and reproduction. State the outcome of natural selection to a population. (1 mark)

The advantageous genotype/phenotype increases in frequency

b) What is a gene pool? (1 mark)

The total of all genes in a population

c) Explain what is meant by "a viable gene pool" (2 marks)

enough variation to ensure survival

d) What is meant by the term "extinction"? (1 mark)

no descendants of species remains

c) Name the **three (3)** areas that conservation planners consider important to maintain viable gene pools of a specific species. (3 marks)

- Biogeography
- Reproductive behaviour
- Poplation dynamics

d) Establishing small breeding populations of Western Ground Parrots, exposes them to fluctuations in allele frequencies.

Explain the meaning of random genetic drift and bottleneck effect with relation to allele frequencies (2 marks)

| Term | Explanation |
|---|---|
| **Genetic drift** | Change in allele frequency due to random fluctuations in small populations |
| **Bottleneck effect** | Catastrophic event resulting a population who's gene pool is not representative of the parent population |

Artificial, or selective breeding, is a term utilised by Charles Darwin to help explain the concept of natural selection. It is currently used in the Australian agricultural industry in Australia and allows for the rapid development of individuals with certain desirable traits.

State the main difference between artificial selection and natural selection.

Describe how the rapid changes in phenotypes of organisms occur due to artificial selection.

(c) Describe the main features of the evolution of the forefeet in horses over the past 50 million years. (4 marks)

| Description | Marks |
|---|---|
| Any **four** of: | |
| • (progressively) reduced the number of digits<br>• started with four digits<br>• digit five was lost early on<br>• digits two and four have also been reduced<br>• forefeet of modern horse comprises only one (main) digit/digit three<br>• accurate quote from the figure that gives time, taxon name and details of forefeet<br>• forefoot elongates/widens/more robust over time (as horse height increases) | 1–4 |
| **Total** | **4** |
| Note: can use fingers or phalanges instead of digits but maximum of three marks if candidate refers to toes in answer | |

(d) Explain how biologists know about the evolution of the forefeet in horses over the past 50 million years. (4 marks)

| Description | Marks |
|---|---|
| Any **four** of: | |
| • fossils/fossil record<br>• preserved bones (from forefeet)<br>• bones are likely to be preserved/common in the fossil record<br>• compare fossil evidence with forefoot in modern horse/comparative anatomy<br>• can age fossils using index fossils/date bones/date rock (in which the fossil was found) | 1–4 |
| **Total** | **4** |

(e) Is the evolution of horse forefeet an example of microevolution or macroevolution? Explain your answer. (4 marks)

| Description | Marks |
|---|---|
| Macroevolution | 1 |
| Any **three** of: | |
| • evolution above the level of the species<br>• major or large-scale changes<br>• over a long period of time/millions of years<br>• trend within a large group/taxon<br>• accumulation of many small/microevolutionary changes | 1–3 |
| **Total** | **4** |
| Note: if states microevolution then zero marks for explanation | |

**Question 35** **(20 marks)**

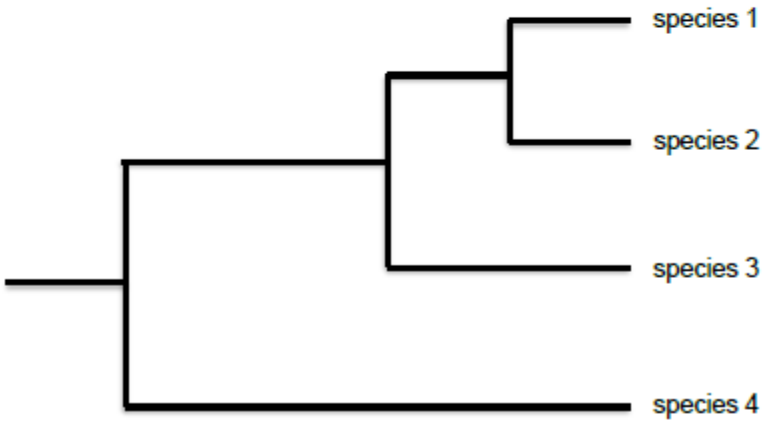
(a) A biologist calculated the percentage similarity in DNA sequence among four species of *Drosophila*. The results are presented in the table below.

| Species | Percentage similarity with species 1 |
|---|---|
| 1 | - |
| 2 | 95 |
| 3 | 90 |
| 4 | 80 |

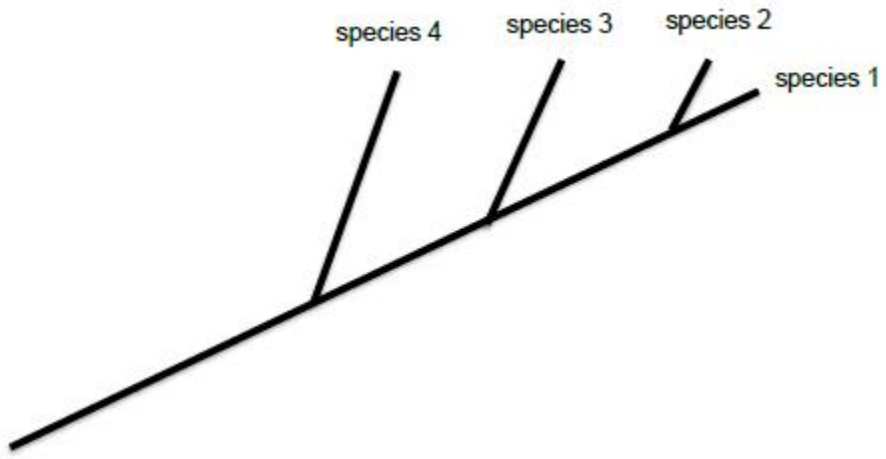
Use these data to construct a phylogenetic tree showing the evolutionary relationships among these species. Draw your tree in the space below. Include a title with your drawing. (4 marks)

| Description | Marks |
|---|---|
| See Tree below | |
| Branches placing species 1 and 2 together (must have species labels) | 1 |
| Branch/section placing species 3 on the outside of species 1 and 2 (must have species label) | 1 |
| Branch/section placing species 4 on the outside of species 3 (must have species label) | 1 |
| Title | 1 |
| **Total** | **4** |

Phylogenetic tree showing the evolutionary relationships among four *Drosophila* species




**or**



(b) Explain how fossils, comparative anatomy, comparative embryology and comparative genomics can each provide evidence for the theory of evolution. (10 marks)

| Description | Marks |
|---|---|
| Fossils | |
| Any **three** of: | |
| • Show past life/extinct species or show traces of past life/extinct species<br>• Can be dated or assigned to a time period<br>• Can follow changes in a trait/organisms/species over time<br>• Show transitional/intermediate/ancestral forms (which show how one group evolved from another)<br>• Specific example, Archaeopteryx/forms that show features of both birds and dinosaurs | 1–3 |
| Comparative anatomy | |
| Any **three** of: | |
| **Either**<br>• Homologous structures<br>• Structures developed from the same plan<br>• Different functions<br>• Shows the relationships among organisms (despite modification for different functions)<br>• Specific example, e.g. pentadactyl limb of vertebrates<br>**or**<br>• Convergent evolution or analogous structures<br>• Different structures<br>• Same function<br>• Evolved independently<br>• Specific example, e.g. wing of bat and insects<br>**or**<br>• Vestigial structures<br>• Structure that is no longer functional/reduced in size<br>• Can be traced to functional structure in other organisms<br>• Shows evidence of relationships among organisms<br>• Specific example, e.g. appendix in humans | 1–3 |
| Comparative embryology | |
| Any **two** of: | |
| • (Embryos) show features that are not present/obvious in adults<br>• These features can show relationships among organisms or ancestry of organisms<br>• Specific example, e.g. embryo of whales have limb buds | 1–2 |
| Comparative genomics | |
| Any **two** of: | |
| **Either**<br>• Large amounts of genetic/sequence data are compared<br>• The closer the sequence (DNA/RNA/Amino acid) the more closely related the organisms.<br>• Build phylogenetic trees<br>• Determine evolutionary relationships (from phylogenetic trees)<br>**or**<br>• Genetic code is (almost) universal<br>• Implies that all organisms have descended from a common ancestor | 1–2 |
| **Total** | **10** |

# *Biotechnology*

c) The process of DNA replication requires enzymes. Identify the main **two (2)** enzymes that attach to the DNA molecule and describe their function. (4 marks)

i. Enzyme 1: DNA helicase (1)

Function: unwinds the DNA molecule so other molecules can attach to it(1)

ii. Enzyme 2: DNA polymerase (1)

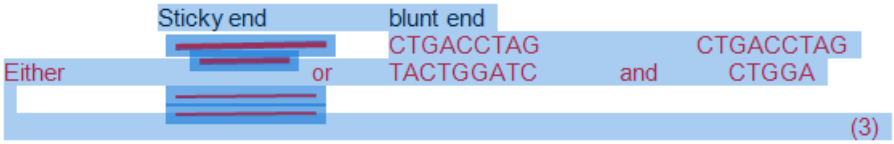
iii. Function: binds to the DNA and synthesises a new complimentary strand of DNA (1) from the 5' to 3' end.

iv. Or ligase….

d) Summarise the difference between DNA sequencing and DNA profiling (2 marks)

DNA sequencing enables mapping of species genomes; DNA profiling used compare unique samples

e) Draw a labelled diagram to show the difference between a sticky end and blunt end strand of recombinant DNA (2 marks)




f) Describe the technique of recombinant technology in producing transgenic organisms, using the production of human insulin as an example. (7 marks)

4 Isolate the Gene of Interest using Restriction Enzymes
- Matches the sequence of nucleotides in the DNA
- Cuts at the specific location
- Creates Sticky/Blunt ends

1 Cut/Digest vector DNA with same Restriction Enzyme

1 Ligation
- Ligase enzymes form hydrogen bonds between nucleotides
- DNA-ase helps form bonds forming side strand

2. Introduce plasmid to bacterium/production vat/Antibiotics

(6)

g) Name **two (2)** areas where animal geneticists are using biotechnology to improve agricultural and horticultural practices in Australia. (2 Marks)

h) produce blowfly-resistant sheep
i) produce cattle that can withstand greater temperature and water stresses
j) increase wool production
k) reduce diseases in aquaculture
l) improve defences against stock animal disease
m) improve pig welfare
n) protect cattle against tick-borne diseases
o) any other relevant area

Among Australia's key cotton pests is the global insect nemesis of agriculture; *Helicoverpa armigera*, better known as the bollworm. Since the mid-1990s, Australia's cotton breeders have begun creating transgenic, or genetically modified, organisms by incorporating genes from a common soil bacterium, *Bacillus thuringiensis* (Bt). These genes encode for the production of toxic insecticidal proteins.

(a) Explain the desirable traits that Bt cotton has been engineered for. (3 marks)

Contains the Bt gene that produces a toxin that kills/harms the bollworm (1). This improves the yield (1) and reduces the need to spray insecticide (1).

(b) Outline the sequence of events most likely undertaken to produce the Bt cotton. (5 marks)

Identify and isolate the Bt gene that kills/harms bollworms (1)
Extract / cut Bt gene out of DNA along with plasmid / agrobacterium (1)
Splice / ligate Bt gene into a plasmid / agrobacterium (1)
Transfer / transform / introduce recombinant plasmid / agrobacterium into tissue culture of cotton (1)
Culture / Grow Bt cotton plants (1)

(c) As with many technological advances, concerns have been raised in regards to recombinant technology. Discuss the adverse effects that genetically modified crops may have on genetic diversity and the environment. (4 marks)

Any two of the following three, with appropriate reasoning:

| | |
|---|---|
| Gene Flow | - reduced genetic diversity / lack of variation<br>- increased risk of extinction / weak adaptation to change |
| Effects on non-target species | - other organisms may ingest the toxins and die |
| Pesticide-resistant species | - Rapid evolution of resistant insect pests and weeds |

DNA sequencing can be achieved by using the Sanger method, which utilises dideoxynucleotides (ddNTPs).

(d) State what DNA sequencing is. (1 mark)

Process of determining the precise order of nucleotides within a DNA mocelcule.

(e) Describe why ddNTPs are used in the Sanger method of DNA sequencing. (2 marks)

Inhibit the elongation of DNA / terminates the DNA chain (1), and allows different lengths and the sequence of the DNA to be found (1).