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**ROSSMOYNE SENIOR HIGH SCHOOL**

**Science**

**Semester 1, Examination 2021**

**Unit 3 Biology ATBLY**

**MARKING GUIDE**

|  |  |
| --- | --- |
| Section One: Multiple–choice | 30% (30 Marks) |

|  |  |
| --- | --- |
| **Question** | **Answer** |
| **1** | c |
| **2** | a |
| **3** | b |
| **4** | d |
| **5** | c |
| **6** | d |
| **7** | b |
| **8** | a |
| **9** | a |
| **10** | d |
| **11** | a |
| **12** | b |
| **13** | d |
| **14** | b |
| **15** | c |
| **16** | d |
| **17** | b |
| **18** | c |
| **19** | c |
| **20** | d |
| **21** | b |
| **22** | d |
| **23** | b |
| **24** | b |
| **25** | D |
| **26** | a |
| **27** | b |
| **28** | a |
| **29** | b |
| **30** | c |

1. The DNA 'backbone' is comprised of

(a) sugar and deoxyribose.

(b) ribose and phosphate.

(c) deoxyribose and phosphate.

(d) purines and pyrimidines.

2. The three main mechanisms that drive genetic variation within a species are

(a) mutation, meiosis and sexual reproduction.

(b) natural selection, sexual reproduction and mutation.

(c) independent assortment, crossing over and fertilisation.

(d) sexual selection, mutation and fertilisation.

3. Pangolins, anteaters and echidnas all share similar morphological structures adapted to a diet of ants and termites. However, these animals do not share common ancestry. This is an example of

(a) adaptive radiation.

(b) convergent evolution.

(c) divergent evolution.

(d) homologous structures.

4. A group of science students were designing their own biology experiment for the first time. During their discussion, they became confused about the experimental variables. Which of the following statements is **true** regarding experimental variables?

(a) At least one dependent variable should be manipulated.

(b) All variables are subject to some degree of manipulation.

(c) Both independent and dependent variables are manipulated during an experiment.

(d) At least one independent variable is manipulated.

5. Which of the following does **not** occur during mitosis?

(a) The nuclear envelope breaks down.

(b) Homologous chromosomes replicate and produce sister chromatids.

(c) Homologous chromosomes are paired and exchange genetic material.

(d) Two diploid daughter cells are formed.

The diagram below relates to question 6.

Diagram, schematic

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6. The pattern of inheritance shown in the pedigree above is most likely

(a) autosomal dominant.

(b) autosomal recessive.

(c) X-linked dominant.

(d) X-linked recessive.

7. During transcription, RNA polymerase transcribes a new mRNA molecule from the DNA:

(a) coding strand.

(b) template strand.

(c) sense strand.

(d) degenerate strand.

8. How many different gametes can be produced through the process of independent assortment for the genotype *EeFfGgHH*, assuming that each gene is found on a different chromosome?

(a) 8

(b) 16

(c) 4

(d) 64

9. Non-disjunction may occur during meiotic division. Non-disjunction is caused by

(a) homologous chromosomes failing to separate properly.

(b) genetic information being exchanged between homologues.

(c) exposure to a chemical mutagen.

(d) abnormal spindle fibre formation.

10. A transgenic organism

(a) contains plasmids from the bacteria *Agrobacterium tumefaciens.*

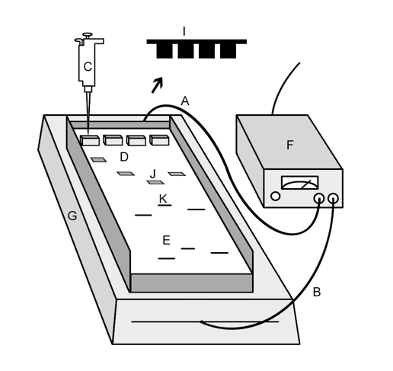
(b) is infertile due to genetic manipulation.

(c) is resistant to antibiotics.

(d) can express a gene not normally present in its genome.

Questions 11 and 12 refer to the diagram below.

The diagram below shows equipment that is used to complete gel electrophoresis.



11. What direction/s will DNA move?

1. A to B.
2. B to A.
3. A to B and B to A.
4. Neither A to B or B to A.

12. Which position indicates the **smallest** DNA particles?

1. D
2. E
3. J
4. K

13. Germ line mutations lead to evolutionary change within a species as a result of

(a) changes in the appearance of an organism.

(b) the introduction of new alleles into the gene pool.

(c) increasing incompatibility of gametes.

(d) differences in the function and/or structure of proteins between individuals.

14. Restriction enzymes 'cut' DNA at specific areas called

(a) cleavage sites.

(b) recognition sites.

(c) recombinant sites.

(d) attraction sites.

The image below relates to question 15.

A picture containing text

Description automatically generated

15. During which cellular process would you find DNA condensed into the characteristic 'X' shape, as shown in the image above?

(a) Transcription

(b) Translation

(c) Mitosis

(d) Cytokinesis

16. A test cross was performed between two adult mice to determine their genotype for a particular trait. If the allelic frequency of the resulting offspring was 25% homozygous dominant, 50% heterozygous and 25% homozygous recessive for the trait, the parent mice must be

(a) both homozygous dominant.

(b) homozygous dominant and homozygous recessive.

(c) heterozygous and homozygous recessive.

(d) both heterozygous.

The table below relates to question 17.

|  |  |
| --- | --- |
| **Species** | **Hybrid DNA denaturation temperature (oC)** |
| T | 72 |
| U | 78 |
| V | 55 |
| W | 49 |

17. Molecular hybridisation involves the heating of DNA molecules to break the hydrogen bonds between the two strands. An investigation was conducted which compared the DNA of a known species, S, to that of four different organisms, T, U, V and W. Single- stranded DNA from species S was hybridised with homologous DNA from each of the four species. The samples were reheated and the temperature at which the hybridised molecules denatured was recorded. Based on these temperatures, which species is **most** closely related to species S?

(a) T

(b) U

(c) V

(d) W

18. Which of the following statements regarding comparative embryology is **true**?

Comparative embryology

(a) reveals similarities in the embryonic development of mammals.

(b) compares the pattern of embryonic development between vertebrate groups.

(c) reveals embryonic structures common to all vertebrates.

(d) identifies the different stages of embryonic development in mammals.

19. Skin pigmentation in humans is determined by a number of different genes across the genome. This type of inheritance is termed

(a) multiple allelic.

(b) polymorphic.

(c) polygenic.

(d) transgenic.

20. Which of the following statements is **true** of analogous structures? They

(a) are present in all vertebrates in the embryonic stage.

(b) are similar in structure but possess a different function.

(c) show a shared evolutionary origin of different taxonomic groups.

(d) are different in structure while sharing a similar function.

The diagram below refers to questions 21 and 22.

Diagram

Description automatically generated

21. An evolutionary biologist was investigating the genetic relatedness for species of black cockatoos throughout Australia. A phylogenetic tree for black cockatoo relatedness is shown above. A common ancestor for species A and D is **most** likely at point

(a) 1

(b) 2

(c) 3

(d) 4

22. Which of the following two species shown on the diagram are **most** distantly related?

(a) A and C

(b) C and B

(c) E and F

(d) B and F

23. Index fossils

(a) contain radioactive isotopes that enable scientists to determine their exact age.

(b) are used to determine the relative age of rock strata and fossils they contain.

(c) are the remains of species that persisted over a long geological timeframe.

(d) provide evidence for evolution as they exhibit morphologies common to both ancestral and descendent species.

24. The separation and subsequent geographical isolation of a species gene pool is an essential component for

(a) genetic drift.

(b) allopatric speciation.

(c) the founder effect.

(d) natural selection.

25. Use the table to identify the amino acid sequence that would be produced from the following mRNA code.

AAA AUG GCC UGA CCC UCA CUC

**First Base in Code**

**Third Base in Code**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Lysine | Arginine | Isoleucine | Threonine | **A** |
| **A** | Lysine | Arginine | Methionine | Threonine | **G** |
|  | Asparagine | Serine | Isoleucine | Threonine | **U** |
|  | Asparagine | Serine | Isoleucine | Threonine | **C** |
|  | Glutamic Acid | Glycine | Valine | Alanine | **A** |
| **G** | Glutamic Acid | Glycine | Valine | Alanine | **G** |
|  | Aspartic Acid | Glycine | Valine | Alanine | **U** |
|  | Aspartic Acid | Glycine | Valine | Alanine | **C** |
|  | *Stop Codon* | *Stop Codon*  **Second Base in Code** | Leucine | Serine | **A** |
| **U** | *Stop Codon* | Tryptophan | Leucine | Serine | **G** |
|  | Tyrosine | Cysteine | Phenylalanine | Serine | **U** |
|  | Tyrosine | Cysteine | Phenylalanine | Serine | **C** |
|  | Glutamine | Arginine | Leucine | Proline | **A** |
| **C** | Glutamine | Arginine | Leucine | Proline | **G** |
|  | Histidine | Arginine | Leucine | Proline | **U** |
|  | Histidine | Arginine | Leucine | Proline | **C** |
|  | **A** | **G** | **U** | **C** |  |

1. Lysine, Methionine, Alanine, Proline, Serine, Proline.
2. Lysine, Methionine, Alanine, Proline, Serine, Leucine.
3. Methionine, Alanine, Proline, Serine, Leucine.
4. Methionine, Alanine

26. The evolution of DDT resistance in mosquitoes is a result of natural selection. Resistance to this pesticide **most** likely emerged because

(a) alternate alleles were present in the gene pool.

(b) the population size of mosquitoes was very large.

(c) mosquitoes reproduce sexually.

(d) only female mosquitoes were affected

27. Gene expression refers to

(a) the synthesis of mRNA from functional genes.

(b) the synthesis of a functioning protein using the DNA code.

(c) the control of mRNA synthesis in the nucleus.

(d) the modification of mRNA following transcription.

28. Which of the following statements does **not** describe a similarity between sexual selection and natural selection?

(a) Selection always involves direct competition between individuals of the same species.

(b) For both types of selection to occur, there must be genetic variation within a population.

(c) Individuals with favourable genetic traits or variations produce more offspring than other individuals.

(d) Variation must be heritable.

29. Which of the following is **true** of macroevolution?

(a) The rate of evolutionary change is constant.

(b) Changes occur over long periods of geological time.

(c) Macroevolution only occurs in response to geological isolation.

(d) The introduction of new alleles into a population drives macroevolution.

The image below relates to question 30.



30. The *Tiktaalik*, shown above, is a 375-million-year-old fossil that was unearthed in the Canadian arctic. It has been described as having the head of a crocodile and gills of a fish. Additionally, *Tiktaalik* had scales and fins like most fish, and sturdy bones in its wrists, neck and shoulders like four-legged vertebrates. As such, *Tiktaalik* is considered a transitional form by palaeontologists. Which statement **best** describes how a transitional form provides evidence for the theory of evolution?

(a) Transitional forms possess characteristics that are a blend of those from both common ancestors and direct descendants.

(b) Transitional fossils have been uncovered in places where their descendants are known to exist.

(c) Transitional forms possess a combination of features that show an evolutionary transition between their ancestors and descendants.

(d) The characteristics of transitional forms provide a phylogenetic link between vertebrate groups.

**End of Section One**

**Section Two: Short answer 50% (100 Marks)**

**Question 31 (20 marks)**

Ultraviolet (UV) radiation is a form of short wavelength radiation (4 - 400nm) with mutagenic properties. When cells are exposed to UV radiation, the DNA absorbs the energy and normal base-pair structures can be disrupted. UV radiation causes the formation of pyrimidine dimers - adjacent thymine or cytosine molecules become linked by covalent bonds (see image below).

Diagram

Description automatically generated

While both prokaryotic and eukaryotic cells have evolved different mechanisms to repair UV damage, excessive exposure can result in severe mutations, cancer and cell death. Most bacteria are killed by the effects of UV radiation, so it is often used to sterilise clinical equipment and surfaces.

(a) Describe how the formation of pyrimidine dimers could affect normal cellular processes. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Three** points for **one** mark each. Examples include | |
| * DNA replication disrupted as normal base pairing cannot occur (producing mutated daughter cells). * Transcription affected and mutated mRNA may be produced. * Translation may not result in correct polypeptide/protein due to mutated mRNA. * Production of faulty proteins/enzymes affects normal cell function. | 1 - 3 |
| **TOTAL** | **3** |

(b) Construct a line graph of the data in Table 1 on the grid below. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Title | 1 |
| Correct axes - scale and variables. | 1 |
| Labelled axes with units | 1 |
| Correctly plotted points joined with lines (line of best fit acceptable). | 1 - 2 |
| Key/legend | 1 |
| **TOTAL** | **6** |

*\*Please note: WACE Biology exams expect graphs to be constructed as line graphs unless otherwise stated.*

Mean % bacterial growth following different time exposure to UV radiation

Chart, line chart

Description automatically generated

*E. coli*

*S. aureus*

(c) Explain why the bacteria broth and inoculated Petri dishes were incubated at 37oC.

(2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Human body temperature is around 37oC. | 1 |
| Optimal bacterial growth/reproduction would be at 37oC/human body temp.  or  Both bacteria grow and reproduce best in the human body. | 1 |
| **TOTAL** | **1** |

(d) Suggest **two (2)** reasons for inoculating 10 Petri dishes with the bacteria broth for each UV exposure time. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Two** points for **one** mark each. Examples include, but **not** restricted to | |
| * Calculate the mean/average. * Reduces effect of experimental error, increasing data validity. * Reduces the effect of outliers on data. * Increases the chance of representative sampling/reduces chance effects. * More reliability in drawing conclusions. | 1 - 2 |
| **TOTAL** | **2** |

(d) Use your graph to estimate the UV exposure time required to completely inhibit growth of;

(i) *Escherichia coli* (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 15 minutes | 1 |
| **TOTAL** | **1** |

(ii) *Staphylococcus aureus* (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 30 minutes | 1 |
| **TOTAL** | **1** |

(e) Does this investigation have an appropriate control? Explain your response. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Either 'Yes' or 'No'. | 1 |
| For 'Yes'   * Zero exposure time plate * controlled for growth under normal conditions. | 1 - 2 |
| For 'No'   * Petri dishes containing no bacteria should be included * Should include Petri dish with no UV exposure * as a comparison for growth against UV treated plates. | 1 - 2 |
| **TOTAL** | **3** |

(f) State **two (2)** ways in which the students could improve the reliability of the investigation. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Two** points for **one** mark each. Examples include, but **not** restricted to | |
| * Tighter/closer time intervals for UV exposure.   Examples of ways to increase sample size   * Longer incubation time for inoculated Petri dishes. * Apply UV at different strengths (as kJ m-1). * More petri dishes inoculated for each time trial. * Test other types of bacteria * Replicate/Repeat experiment – Either of these only receive 1 mark.   Cant state average as must mention ways to improve. Means have been calculated | 1 - 2 |
| **TOTAL** | **2** |

**Question 32 (20 marks)**

(a) Define the following terms.

(i) Genotype (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Specific combination of alleles for each gene locus that belongs to an individual or cell | 1 |
| **TOTAL** | **1** |

(ii) Phenotype (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Visible/expressed characteristic (based on the genotype). | 1 |
| **TOTAL** | **1** |

(ii) Genome (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| All the genetic material contained in a cell (coding and non-coding). | 1 |
| **TOTAL** | **1** |

(b) Explain the difference between a gene and an allele. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| A gene is a sequence of nucleotides coding for a trait/protein | 1 |
| Alleles are variant forms of a gene (inherited from each parent). | 1 |
| **TOTAL** | **2** |

(c) Identify the factors that determine an organism's phenotype. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Genotype | 1 |
| Environment/selective pressures | 1 |
| **TOTAL** | **2** |

In snow peas, the pod shape can be either flat or curled, with flat pods showing dominance over curled pods. A market gardener wanted to ensure all future snow pea crops only produced flat pods.

(d) Explain how the market gardener could determine whether a snow pea plant is homozygous or heterozygous for flat pods. Use the Punnett squares below to help support your answer. (8 marks)

|  |  |  |
| --- | --- | --- |
|  | F | F |
| f | Ff | Ff |
| f | Ff | Ff |

|  |  |  |
| --- | --- | --- |
|  | F | f |
| f | Ff | ff |
| f | Ff | ff |

Homozygous cross Heterozygous cross

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Punnet squares | |
| Two correctly completed Punnett squares - one showing homozygous dominant cross and one showing heterozygous cross. | 1 - 4 |
| Explanation | |
| Cross a flat pod pea plant with a homozygous curled plant | 1 |
| Homozygous dominant plant will only produce offspring showing 100% flat pea pod phenotype when crossed with a curled pod pea plant | 1 |
| Heterozygous plant cross will produce ratio of genotypes 1:1 for Ff, ff. | 1 |
| Heterozygous phenotypes of offspring will be 50% flat pea pod and 50% curly pea pod. | 1 |
| **TOTAL** | **8** |

While harvesting the snow peas, the market gardener noticed several plants had produced pods that were twice as big as the 'normal' pea pods. His neighbour suggested it was the result of a mutation that is not uncommon in plants.

(e) Identify and describe the type of mutation that could cause this phenomenon. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Polyploidy | 1 |
| Chromosomal mutation during meiosis. | 1 |
| Cells contain more than two haploid (n) sets of chromosomes. | 1 |
| **TOTAL** | **3** |

(f) Explain **one (1)** issue associated with growing crops with a high level of homozygosity. (2 marks)



|  |  |
| --- | --- |
| **Description** | **Marks** |
| Examples include, but are not restricted to; | |
| Less/decreased genetic variation. | 1 |
| Reduces population 'fitness'.  or  Population more susceptible to catastrophic events. | 1 |
| **TOTAL** | **2** |

**Question 33 (20 marks)**

(a) Compare the process of mitosis and meiosis by completing the table below. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **One** mark per correct comparison (refer to table below). | 1 - 6 |
| **TOTAL** | **6** |

|  |  |
| --- | --- |
| **Mitosis** | **Meiosis** |
| One chromosomal division | Two chromosomal divisions |
| No bivalent pairing/ No pairing of homologous chromosomes | Homologous pairs form bivalents/Homologous chromosomes pair |
| No crossing over/exchange of genetic material (between homologues) | Crossing over occurs (meiosis I) |
| Two (2) daughter cells produced | Four (4) daughter cells/gametes produced |
| Daughter cells are diploid (2n) | Daughter cells are haploid (n) |
| Division of somatic (body) cells | Division of sex cells/gametes |
| Daughter cells are genetically identical | Daughter cells are genetically unique |
| Process for Growth & repair | Process for production of gametes |

Bacteria do not reproduce sexually and yet they are the most diverse group of organisms on Earth.

(b) Name the process by which bacteria reproduce. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Binary fission (do not accept mitosis). | 1 |
| **TOTAL** | **1** |

(c) Explain **two (2)** ways the genetic diversity of a bacterial species can be increased.

(4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Mutation  DNA mutation introduces new alleles into gene pool. | 1 - 2 |
| Conjugation/horizontal gene transfer  Process by which adjacent bacterial cells copy and share plasmid DNA. | 1 - 2 |
| **TOTAL** | **4** |

*Agrobacterium tumefaciens* is a species of soil-borne bacteria that can infect plant cells and cause crown gall disease. *A. tumefaciens* is widely used in recombinant DNA technology as a vector for gene transfer.

(d) Construct a labelled flow diagram outlining the stages involved in the development of a transgenic plant using *Agrobacterium tumefaciens*. (6 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Identifies correct stages in correct order with arrows (refer to example diagram below).  *\*NB: accept correct flow diagrams without illustrations.* | 1 - 6 |
| **TOTAL** | **6** |



(e) Describe how scientists identify which bacterial cells contain recombined DNA. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Antibiotic resistance gene also inserted into plasmid with foreign gene. | 1 |
| 'Recombinant' bacterial cells are grown in medium containing antibiotic. | 1 |
| Cells that grow on medium contain recombined plasmid. | 1 |
| **TOTAL** | **3** |

**Question 34 (20 marks)**

There are six subspecies of carpet python (*Morelia spilota*) in Australia. The table below contains information relating to two subspecies of the carpet python.

|  |  |  |
| --- | --- | --- |
|  | **A snake on a leaf  Description automatically generated with low confidenceJungle carpet python** | **A picture containing reptile, snake, close  Description automatically generatedMurray Darling carpet python** |
| **Colouration** | Black with bright yellow diamond banding. | Black and grey mottled skin with cream underside. |
| **Habitat** | Tropical rainforest | Inland open eucalypt forest and rocky outcrops. |

(a) Explain how natural selection allowed for the evolution of these subspecies. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Genetic variation exists in gene pool. | 1 |
| Populations inhabiting different habitats have different selective pressures from the environment. | 1 |
| Individuals with phenotypes favoured in each habitat/population survive and reproduce more frequently. | 1 |
| Traits are passed onto successive generations. | 1 |
| Genotypic frequency changes over time leading to evolution of subspecies. | 1 |
| **TOTAL** | **5** |

A scientist used mitochondrial DNA (mtDNA) to determine subspecies divergence times.

(b) Suggest **three (3)** reasons why mtDNA was used in this investigation. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Three** points for **one** mark each. Examples include | |
| * Mutation rate high (greater than nuclear DNA). * mtDNA inherited from maternal line only. * mtDNA abundant in cells. * No genetic recombination as only inherited from mother. * Useful for comparing recent divergence (= or >20 million years). | 1 - 3 |
| **TOTAL** | **3** |

(c) Describe how each of the following provide evidence for evolution.

(i) Homologous structures (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Similar structures/underlying anatomy with a different function. | 1 |
| Reveals shared evolutionary origin - ancestral organisms evolved into distinct forms due to differing selection pressures (adaptive radiation). | 1 |
| More similar the structure between groups/species the closer the relatedness/more recent divergence. | 1 |
| **TOTAL** | **3** |

(ii) Vestigial organs/structures (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Reduced and/or functionless remnants of organs or structures once present in ancestral species. | 1 |
| Changes in selective pressures reduce use/need of structure over time. | 1 |
| Demonstrates divergence from past behaviour or activity in ancestral species. | 1 |
| **TOTAL** | **3** |

(iii) Biogeography (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Distribution of organisms over geographical areas. | 1 |
| Closely related species usually found in close geographical proximity.  or  Closely related species may be found in previously connected land masses. | 1 |
| Fossils found in these geographical areas resembling living species suggests common ancestry. | 1 |
| **TOTAL** | **3** |

(d) Use a specific example to explain how sexual selection may increase the frequency of a trait that does not improve an organism's chance of survival and reproductive success. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Appropriate example.  E.g. peacock tail, bright plumage in male birds, courtship rituals, building impressive structures, large horns. | 1 |
| Sexually selected trait/phenotype may make organism more susceptible to predation (no camouflage or cumbersome structures). | 1 |
| Only those male individuals with most impressive trait will be selected to mate while most may never mate and pass on genes. | 1 |
| **TOTAL** | **3** |

**Question 35 (20 marks)**

A large wildlife sanctuary was monitoring the breeding behaviour of a population of the carnivorous agile antechinus (*Antechinus agilis*). Like most species from the family Dasyuridae, the agile antechinus is highly promiscuous. Each female is able to produce a litter of up to 12 offspring by multiple fathers.

Researchers profiled the DNA of four juvenile agile antechinus from one litter, against the DNA from the three possible fathers. The purpose of this research was to select juveniles with different fathers for a breeding program at the Melbourne Zoo.

A selection of comparable short tandem repeats (STRs) was isolated from the genome of each antechinus.

(a) Define 'short tandem repeat'. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Segment of non-coding DNA | 1 |
| with the same sequence of nucleotides repeated. | 1 |
| **TOTAL** | **2** |

(b) Explain why STRs are used in genetic profiling. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Three** points for **one** mark each. Examples include | |
| * Unique to each individual. * Inherited from both parents. * Many different STRs in genome. * Useful for proving paternity/parentage. | 1 - 3 |
| **TOTAL** | **3** |

Gel electrophoresis was used to visualise and compare the antechinus DNA.

(c) Outline the basic principles behind the use of gel electrophoresis for DNA profiling.

(5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Five** points for **one** mark each. | |
| * DNA has an overall negative charge. * DNA fragments are separated based on size/number of bases/molecular weight. * Process uses an electric current passed from a positive to negative probe. * DNA fragments placed in wells in the gel at negative probe end. * Small fragments migrate further through the gel than large fragments. * Migration of DNA fragments from each well creates a DNA 'fingerprint' or unique band pattern. * Band patterns can be compared with other samples for similarities. | 1 - 5 |
| **TOTAL** | **5** |

Possible Fathers Juveniles

A picture containing rectangle

Description automatically generated

(d) Using the information above, identify the father of each juvenile antechinus. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Juvenile 1 - B | 1 |
| Juvenile 2 - B | 1 |
| Juvenile 3 - A | 1 |
| Juvenile 4 - B | 1 |
| **TOTAL** | **4** |

(e) Based on the paternity results, which of the offspring would be most suitable for the breeding program? Explain your choice. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| * Juvenile 3 * Juvenile 3 has a different father to the other juvenile antechinus.   OR   * Juvenile 3 and one other from 1, 2 or 4. * Juvenile 3 has different father and only one can be chosen from the remaining as they share the same father. | 1 - 2 |
| **TOTAL** | **2** |

Captive bred animals are eventually released into their natural habitat.

(f) Discuss **one (1)** factor that should be considered prior to their release. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **One** mark for appropriate factor and **one** mark for explanation. Examples include, but are not restricted to | |
| * Habitat size - is the natural habitat a suitable size to allow a sufficient population to grow or allow for territorial behaviours. * Habitat fragmentation - is the natural habitat connected to adjacent areas via wildlife corridors to allow gene flow between populations. * Existing natural population - is the population of existing animals large enough or genetically diverse enough to support conservation efforts. | 1 - 2 |
| **TOTAL** | **2** |

(g) Identify **two (2)** other applications of gel electrophoresis in biotechnology. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Two** points for **one** mark each. Examples include, but not restricted to | |
| * Forensic testing (crime analysis). * Genetic disease diagnosis. * Phylogenetics - species comparison. * Protein separation. * Identification of unknown samples (e.g. illegal wildlife trade). * Testing restriction enzymes. * Conservation genetics. | 1 - 2 |
| **TOTAL** | **2** |

**End of Section Two**

|  |  |
| --- | --- |
| **Section Three: Extended answer** | **20% (40 Marks)** |

**Part A**

Choose **either** Question 36 **or** Question 37.

**Question 36 (20 marks)**

1. Describe the process of DNA replication. Include a description of the role of key enzymes.

(10marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Key enzymes | |
| * DNA helicase – responsible for unwinding/unzips and separating the DNA strand * RNA Primase – attaches primer, shows DNA polymerase where to start. * DNA polymerase – responsible for adding free nucleotides according to complimentary base pairing rules. * DNA Ligase – joins fragments of DNA together on the lagging strand. (when it catalyses the formation of the phosphodiester bonds). | 1-4 |
| **Subtotal** | **4** |
| Process | |
| Any **six** of | |
| * DNA strands are laying antiparallel/3’ to 5’ and 5’ to 3’ * DNA helicase breaks hydrogen bonds * Produces replication forks (junctions between single and double stranded DNA) * DNA polymerase works in 5’ to 3’ direction (adding new complimentary nucleotides) –meaning it works in opposite direction on the two strands. * This happens continuously on the leading strand (5’ to 3’) and discontinuously on lagging strand (3’ to 5’). * Fragments on lagging strand are known as Okazaki fragments * Okazaki fragments are joined by DNA ligase * Results in one double stranded DNA molecule becoming two identical DNA molecules * The process is described as semi-conservative | 1-6 |
| **Subtotal** | **6** |
| **Total** | **10** |

(b) Discuss positives and negatives of producing genetically modified agricultural crops.

(10 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Students must discuss at least **five** different **benefits/positives** relating to the production ofgenetically modified crops. Eachpoint discussed is worth **one** mark. Examples include, but are not restricted to | |
| * Improved nutritional value of food - higher vitamin content, more protein. * Crops can be grown in drought affected areas with a better yield - drought resistant genes. * Production of crops without known allergens - used by more people. * Crops can be modified to be herbicide resistant - weeds can be killed without harm to crop. * Crops can be produced to be resistant to insect damage - gene inserted and expressed to inhibit insect consumption. * Increased shelf life of some crops - less spoilage and food waste. * More economic to produce crops that produce a greater yield with less external input - less water, nutrients, land and pesticides required. * Crops can be modified to produce different ratios of oil for biodegradable, plant-based plastic production - reduces petrochemical use and plastic waste. | 1 - 5 |
| Students must discuss at least **five** different **risks/negatives** relating to the production ofgenetically modified crops. Eachpoint discussed is worth **one** mark. Examples include, but are not restricted to | |
| * New traits introduced into crop plant genome could have adverse health effects - allergic responses. * Removing traits from plants could have unknown future effects - on nutrition, plant function. * Limit biodiversity of local environment by competing with native species. * Cross pollination may produce superweeds that cause ecological problems. * Genetically modified crops may be patented by large companies that monopolise the industry. * Regulation of GM product use is variable from place to place making it difficult to govern/manage. * GM crops may inadvertently pollinate 'organic' crops, causing loss of certification and income. | 1 - 5 |
| **TOTAL** | **10** |

**Question 37 (20 marks)**

1. Describe the process of translation in a cell.

(10 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Description of translation should include **10** points from below. Each point is worth **one** mark. | |
| * Translation involves the synthesis of a new polypeptide/protein. * Translation occurs at the ribosomes. * mRNA leaves the nucleus and binds with a ribosome/ribosomal subunit (at initiation site). * mRNA is read by the ribosome in a 5' to 3' direction from the START codon. * Each codon on mRNA codes for an amino acid. * tRNA (transfer RNA) molecules contain an anticodon complementary to each mRNA codon. * tRNA deliver specific amino acids to the ribosome. * As the ribosome reads the mRNA the complementary tRNA delivers the correct amino acid. * tRNA attaches to the complementary mRNA codon. * Ribosome reads the next mRNA codon and another tRNA (carrying the required amino acid) is attached. * A peptide bond is formed between the adjacent amino acids. * The first tRNA is released from the mRNA/ribosome, leaving the amino acid behind. * The ribosome moves along the mRNA to the next codon and another tRNA is attached (carrying corresponding amino acid). * A new peptide bond is formed between the amino acid and the new polypeptide chain (1st and 2nd amino acids). * The second tRNA can now be released from the ribosome. * This process is repeated as the ribosome moves along the mRNA molecule until a STOP codon is reached. * The completed polypeptide chain is released from the ribosome and delivered to the Golgi apparatus for processing. | 1 - 10 |
| **TOTAL** | **10** |

(b) Discuss how biotechnology can help to reduce the risk of extinction for endangered species.

(10 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Discussion should include **10** points from the following worth **one** mark each. Examples of how biotechnology can help reduce risk of extinction include, but are not restricted to | |
| * **DNA Profiling** * DNA profiling of individuals in species populations to monitor gene pool. * Identification of populations most at risk. * Identification of hybrids in populations. * Assess gene pool diversity for captive breeding programs. * Selection of suitable individuals from the population to breed. * Identification of genetically different individuals from other populations for translocation. | 1 - 4 |
| * **Genetic modification/recombinant DNA technology** * Introduction of a new gene from an alternate, diverse population. * Introduction of a gene from a different species to express a trait that will increase chance of survival. * Directly edit a species genome to produce genetically superior individuals. * Genetically modified or transgenic individuals are better adapted to respond to future threats (disease, climate change). | 1 - 3 |
| * **Artificial propagation** * Plant tissue culture used to propagate endangered species. * Propagated species can be translocated into the natural environment to increase numbers and diversity. * In vitro fertilisation using donor eggs and/or sperm from endangered species. | 1 - 3 |
| **TOTAL** | **10** |

**Part B**

Choose **either** Question 38 **or** Question 39.

Indicate the question you will answer by ticking the box next to the question. Write your answer on the pages provided.

**Question 38 (20 marks)**

(a) Describe how gene flow and mutation influence genetic variation in populations.

(10 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Discussion of the influence of **gene flow** on genetic variation should include at least **six** points from below. Each point is worth **one** mark. | |
| * Gene flow refers to the movement/transfer of genes or alleles between interbreeding populations of the same species. * Gene flow is an important mechanism for transferring genetic diversity amongst populations. * Gene flow within a population can increase the genetic variation of the population. * Migration between populations can change the allelic frequencies of the populations. * The introduction of new alleles (via gene flow) increases variability within the population and provides the possibility for new trait combinations. * Migration changes the distribution of genes and genetic diversity within populations. * High rates of gene flow can reduce the genetic differentiation between gene pools and increase homogeneity of alleles. * High gene flow reduces possibility of speciation by constraining the development of genetic differences between populations. * Reduced gene flow between populations becoming genetically distinct. * Reduced gene flow promotes divergence between populations and a greater degree of genetic variation between populations. | 1 - 6 |
| Discussion of the influence of **mutation** on genetic variation should include at least **four** points from below. Each point is worth **one** mark. | |
| * Mutations are random changes in the genetic composition of an organism due to changes in the base sequence of DNA. * Mutations that occur in germ line cells (gamete production) introduce new alleles into a population, increasing variation. * Mutations are the raw material of genetic variation and drive evolution. * Mutations can alter the product or a gene (function of the protein/enzyme) which introduces a different trait into the population/gene pool. * Mutations that influence variation can be advantageous, deleterious or indifferent to the 'fitness' of an organism and/or population. * Mutations can introduce phenotypes into a population that are favoured through natural selection, causing a change in the phenotypic frequency. | 1 - 4 |
| **TOTAL** | **10** |

(b) Discuss the concept of genetic drift and associated effects on genetic diversity.

(10 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Genetic drift** overview should include at least **four** points. Each point is worth **one** mark. Examples include | |
| * Genetic drift is the change in the composition of a gene pool as a result of a random or chance event/sampling error. * Genetic drift has a greater impact on small populations because chance effects have a bigger impact on the gene pool. * Genetic drift may result in the loss of alleles from a gene pool, decreasing diversity of the population. * Larger populations are less affected by random/chance events and retain stable allele frequencies with low genetic drift. * Genetic drift can result in the fixation of an allele/s (beneficial and deleterious) in the gene pool. | 1 - 4 |
| **Founder effect** discussion should include **three** points worth **one** mark each. Examples include | |
| * A small group breaks away from the main population to colonise a new area. * The new founding population does not contain the same level of genetic diversity as the main population. * Alleles may be completely lost from the gene pool of the founding population. * The small population with reduced diversity will be subject to a higher level of genetic drift. * As the founding population increases in number, their gene pool no longer represents the original population. | 1 - 3 |
| **Bottleneck** discussion should include **three** points worth **one** mark each. Examples include | |
| * Population bottlenecks occur when natural or human events cause a dramatic reduction in the size of a species population. * The surviving population contains less genetic diversity/variation and therefore a reduced gene pool. * Alleles can be completely lost from the population during a bottleneck event. * As the surviving population is re-established, it is no longer representative of the original population or gene pool. | 1 - 3 |
| **TOTAL** | **10** |

**Question 39 (20 marks)**

1. Explain how populations of a species may, over time, become different species.

(10 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| * Process of allopatric speciation | 1 |
| * Gene flow is disrupted between populations- Leads to two or more subpopulations * As a result of geographical/physical isolation * Student demonstrates an understanding of geographical/physical isolation barriers (e.g. water for terrestrial creatures, mountains, ocean etc) | 1-3 |
| * Each sub population is in a different environment with different selection pressures. * This leads to natural selection processes that are different for each of the populations | 1-2 |
| * Genetic drift may also occur with this particularly significant in smaller populations | 1 |
| * Small micro-evolutionary changes accumulate over time, these becoming large changes.   OR   * In responses the different sub populations evolve/diverge/changes in allele frequencies so that they become genetically different | 1 |
| * When the range of the different subpopulations once again overlaps these are so different that they are no longer able to interbreed and produce viable offspring /The groups are now reproductively isolated * Student demonstrates an understanding of reproductive isolation | 1-2 |
| **Total** | **10** |

1. Describe comparative genomics and biochemistry and explain how these may be used to understand the evolutionary relationships between organisms. (10 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Description – Comparative genomics   * Field of research that compares whole sets of genes of a species with those of other species * Requires genes to be sequencing of genomes (RNA and or DNA) | 1-2 |
| Description – Comparative Biochemistry   * Study of different kinds of proteins including enzymes. * Looks at the amino acid sequences | 1-2 |
| Processes use bioinformatics to assist with handling vast quantities of data. | 1 |
| **Subtotal** | **5** |
| Use to understand evolutionary relationships – Comparative genomics   * (Conserved) DNA that is present is compared with DNA from other species * The DNA similarities allows researcher to see if organisms are derived from same species/share a common clade | 1-3 |
| The more similar the genome/proteins/amino acid sequence in a protein the more closely related the species  the less similar the genome/proteins/amino acid sequence in a protein, the less closely related are the species. | 1 -2 |
| **Subtotal** | **5** |
| **Total** | **10** |