INSTRUCTIONS

1. Write your **Student Personal Identification Number (SPIN)** on the top right hand corner of this booklet.
2. Answer ALL QUESTIONS. Write your answers in the spaces provided in this booklet.
3. If you need more space for answers, ask the Supervisor for extra paper. Write your SPIN on all extra sheets used and clearly number the questions. Attach the extra sheets at the appropriate places in this booklet.

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Check that this booklet contains pages 2-24 in the correct order and that none of these pages is blank.

**YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.**
Question 1: ANIMALS AND PLANTS BEHAVIOUR

a. California grunion *Leuresthes tenuis* is found on the shores of Southern California. This marine fish is famous for its unique spawning behavior. The highest high tides, called the semi lunar tides, occur twice a month around the times of the full and new moon.

From April to June 3-4 nights after full moon, the fish actually emerged from the ocean, riding on high waves onto shore to spawn on the sandy beaches. The Female fish dug into the soft sand with her tail and released her eggs, while the male fish curled around her on the sand to fertilize the eggs. Then, on a subsequent large wave, the fish are washed back into the ocean.

The eggs remain terrestrial, buried in the damp sand above the tidemark, until the subsequent high semi lunar tides, approximately two weeks later. At that time, the fully developed eggs are washed free from the sand by high waves, and the larvae hatch out and catch a ride to the sea.

i. Name the environmental factor that affects the spawning behavior of grunion fish.

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ii. State the risk of terrestrial spawning that the grunion fish may encounter.

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iii. Describe how the danger of terrestrial exposure of the embryo is reduced.

b. Plants exhibit a number of other growth responses to environmental stimuli. One of these, *thigmotropism*, occurs in response to touch and is common in climbing plants, e.g., beans, young rata seedlings.

*Figure 3* Bean plant climbing on the stem of another plant

Discuss the advantages of *thigmotropism* to a climbing plant.
Question 2: INTRASPECIFIC INTERACTION

Two species of barnacle, *Cthalamus* and *Balanus*, both live on intertidal rocks. These rocks are mostly exposed at low tide and mostly covered at high tide. While each can survive being exposed to the air for a time, *Cthalamus* can last longer in the air than *Balanus*. Both barnacles are happy being completely submerged. Use this information to answer the questions that follow:

![Figure 4 Distribution of two species of barnacles on a rocky shore](image)

a. Based on the information above, relate the ideal niche of barnacles to its level of tolerance.

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b. Many freshwater and marine zooplankton moves vertically daily up and down in the water column. They move up to the surface of the water at dusk (early evenings) where they graze on phytoplankton at night. Then, at dawn, they move down below the water surface and stay at the bottom during the day and the daily cycle of vertical migration begins again.

State the environment cue that caused these daily migrations.

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c. Black swans were introduced to New Zealand in the 1800s and have since spread throughout the country. On smaller ponds and lagoons, they occupy territories during the breeding season.

Black swans use a range of aggressive displays to defend their territories. Relate the use of these aggressive displays to their survival.

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Question 3: HOMING

a. The diagram below shows the migratory pattern of five species of salmon in the Pacific, namely Sockeye, Chum, Chinook, Pink and Coho species. The salmon spend the majority of their lives in the North Pacific traveling the coastlines; some even go to the Bering Sea and the Arctic Ocean. Salmon feed at sea and migrate up rivers to spawn. They swim up the same river in which they hatched using some type of chemical memories. They deposit their eggs in shallow holes called “redds,” fertilized then buried, the adults protect the nest until they die.

![Migratory pattern of five species of salmon](image)

Figure 7 Migratory pattern of five species of salmon

i. What does the annual movement of animals from their breeding area to another area where they do not breed, and then return their journey back again refer to?

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ii. Discuss the environmental changes made by humans that could affect the homing behavior or salmon.

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iii. Describe how the salmon shows parental care and why is this advantage.

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b. In North America, monarch butterflies perform one of the longest migrations known in insects. They spend the northern hemisphere summer in the northern United States, but migrate south to Mexico for the winter. The butterflies feed extensively during the migration.

![Monarch Butterfly](image)

Figure 8 The monarch butterfly

Relate how this migration benefits the monarch butterflies.

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Question 1: MUTATIONS

a. Haemoglobin (Hb) is an iron rich protein found in red blood cells. It enables the blood cells to carry oxygen from lungs to the rest of the body. The genes for these polypeptides are found on different chromosomes. The β-chain gene is found on chromosome 11. A mutation that occurs in chromosome 11 results in an abnormal change in the genes that instructs the body to produce haemoglobin causing sickle cell anemia.

The diagram below illustrates how this occurs:

![Diagram of normal and mutant gene transcription and translation]

*Figure 9 Mutation that cause sickle cell anemia*

i. Identify the codon where the mutation occurs in the mutant gene.

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ii. Write the transcribed mRNA codes for the mutant gene.

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b. Polyploidy is a type of aneuploidy, shown in the karyotype below. Study it and answer the questions that follow:

![Karyotype from a human cell](image)

Figure 10 Karyotype from a human cell

i. Define **aneuploidy** with reference to the karyotype above.

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ii. Explain how this genetic disorder occurs.

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c. The graph below shows the relationship between maternal ages and birth of Down syndrome:

![Graph showing the effect of maternal age on birth of Down syndrome](image)

Using information in the graph, describe the effect of maternal age on the likelihood of Down syndrome.

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Question 2: DNA REPLICATION

a. In DNA replication, a handful of enzymes help the process by changing and moving parts of the DNA molecules, as shown in the diagram below:

![Diagram of DNA replication](image)
i. State the role of DNA ligase in DNA replication.

ii. State the role of DNA helicase in the process of DNA replication.

iii. Describe what happens on the leading strand during DNA replication.

iv. Compare and contrast the leading strand and lagging strand.
v. Predict what would happen to the cell, if DNA failed to replicate.

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Question 3: GENE – GENE INTERACTION

a. The beak of the rare purple-beaked gooney bird, the albatross of the North Pacific is purple because of two enzymes encoded by two separate genes. Enzyme A, the product of Gene A, converts a white molecule into a red pigment. Enzyme B, the product of Gene B, converts the red pigment into a purple pigment. The recessive alleles of these two genes produce non-functional enzymes.

i. Name the type of gene-gene interaction described above.

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ii. Compare the phenotypes produced by the Aabb and aaBB genotypes.

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iii. In a cross between two AaBb gooney birds, predict the fraction of the offspring that would show each phenotype. Show all working.

iv. Explain how the same phenotype can be produced from many genotypes.
Question 4: SEX-LINKAGE

a. The pedigree below shows the inheritance of colorblindness in three generations. Colour blindness is a genetic condition usually inherited from the parents. The gene, which is responsible for the condition, is carried on the X chromosome. The shaded individuals are colorblind.

Use this diagram to answer the questions that follow:

![Pedigree diagram showing inheritance of colourblindness in three generations]

Figure 13 Pedigree showing inheritance of colourblindness in three generations

i. State the genotype of individual no.6.
   No.6 : ________________________________________________________

ii. If No.13 marries a normal male, predict the probability that their sons will be colourblind? Show all working.

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Question 1: NATURAL SELECTION

a. Diagram A below shows the changes in a population of beetle over a period of one year:

<table>
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<tr>
<td>More Green Beetles</td>
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<td><img src="image1.png" alt="Figure 14 Population of Beetles" /></td>
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i. Use the diagram above to explain how mutation can cause the changes in beetle after one year.

ii. Natural selection and genetic drift are also mechanisms of evolutionary change. If the population of beetles were 100% green. Discuss the effect this would have on each mechanism of evolutionary change.
b. Selective breeding has been used to improve the milk yield of cattle herds at Hango Agricultural College.

i. Define selective breeding to illustrate how it differs from random mating.

ii. State the impact of selective breeding on genetic variability in a herd of cattle.

C. The quality and yield of milk in cattle has been improved by artificial insemination in which semen from a selected bull is used. Describe how the use of artificial insemination may intervene in the evolutionary process.

d. The diagram below shows a peacock displaying its fancy feathers. This is an example of sexual selection, a special case of natural selection.

*Figure 16 Peacock displaying its tail*

What is the purpose of this peacock’s proud display of its tails?
Question 2: SPECIATION

a. The Isthmus of Panama is a narrow strip of land that joins North and South America. The land bridge formed approximately 3 million years ago.

![Map showing Isthmus of Panama](image1)

Snapping shrimps, genus *Alpheus*, can be found on either side of the land bridge. The two groups are phenotypically similar. However, when the males and females from either side of the land bridge were brought together they snapped aggressively at each other and would not mate. They are now considered to be two different species.

i. Identify the physical barrier that separates the gene pools of the shrimp species.

ii. When the two groups of slamming shrimps could not mate, explain why there is not enough evidence to refer to them as different species?
b. Geographic isolation leads to reproductive isolation. In plants, sympatric speciation produce new, reproductively isolated species due to polyploidy.

i. Define the condition known as ‘polyploidy’.

ii. Discuss why it is more common to have polyploidy occurring in plants and less common in animals.
Question 3: EVOLUTION

a. Colonies of stinging acacia ants occupy the small swollen-thorns of the bullhorn acacia plants. The hollowed-out thorns defend the tree against harmful insects, browsing mammals and epiphytic or hanging vines. The acacia ants also cut and clear vegetation from around the tree and feed from protein-lipid Beltian bodies from the leaflet tips of the acacia plants as well as carbohydrate-rich nectar from glands on its leaf stalk. During its development, the acacia trees form symbiotic relationships with acacia ants to promote healthy growth for both the ant and the tree. The acacia trees get protection and the ants with their larvae are provided with a home and nutrients.

Figure 17: Ants emerging from a thorn of Bullhorn acacia plant

Figure 18: Ants feeding on food bodies on leaflets of acacia plants

i. Name the pattern evolutionary relationship between the ant and the acacia.

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ii. Name the type of ecological relationship that exist between the ants and the acacia plant.

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b. Wing colouration in the scarlet tiger moth (*Panaxia dominula*) is shown to behave as a single locus, two-allele system with incomplete dominance. In a population of 1612 tiger moths, the following genotypes and phenotypes were obtained:

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<tr>
<th>Phenotype</th>
<th>Genotype</th>
<th>No. of Moths</th>
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<tr>
<td>White Spotted</td>
<td>AA</td>
<td>1469</td>
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<tr>
<td>Intermediate</td>
<td>Aa</td>
<td>138</td>
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<tr>
<td>Little Spotting</td>
<td>aa</td>
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i. Calculate the allele frequencies for the Little Spotting species.

ii. Calculate the allele frequency for the White Spotted species.
c. Compare **convergent** and **divergent evolution**.
Question 1: DNA PROFILING

a. The diagram below shows the DNA fingerprints from Sample 1, 2 and 3 of three people suspected of a crime and Sample 4 shows the DNA fingerprint from the scene of crime. Gel electrophoresis technique was used to separate these nucleic acids.

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i. Identify the differences between the molecules represented by letters A and B.

ii. Describe the effect of the DNA sizes on the speed of its movement and separation along the gel.

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iii. Examine the DNA fingerprints of Sample 1, 2 and 3 above and confirm the identity of the suspect.

b. Gene cloning is a common practice in molecular biology. It is used by researchers to create copies of a particular gene using the traditional technique. However, the more recent technique of Polymerase Chain Reaction (PCR), is illustrated below:

i. State the advantage of using PCR over traditional gene cloning.
ii. State the purpose of the ‘Denaturation’ and ‘Annealing’ stage of PCR.

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c. DNA sequences can be cut in two ways, as shown in the diagram below:

[Diagram showing Blunt Ends and Sticky Ends]

Explain why the cutting that produces two strands with sticky ends would be useful for DNA cloning.

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