UNAM

FACULTY	AGRICULTURE, ENGINEERING AND NATURAL SCIENCES		
DEPARTMENT	FISHERIES AND OCEAN SCIENCES		
SUBJECT	GENETIC FOR AQUATIC RESOURCES		
SUBJECT CODE	F36310G		
DATE	JUNE/JULY 2026		
DURATION	3 HOURS	Marks	100

FIRST OPPORTUNITY EXAMINATION

Examiners: Mrs M. K. Ikechukwu

Internal moderator: Prof. N. N. Gabriel

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INSTRUCTIONS:

Section A: Answer **All** questions.

Section B: Answer **All** questions.

Section C and D: Choose **EITHER** Section C OR Section D. Do not answer both.

Write neatly and legibly.

This question paper consists of nine (9) pages excluding this front page.

SECTION A: Multiple choice questions

Question: Answer ALL questions – 2 marks each **[40 marks]**

1.1. A specific sequence of DNA that determines a trait in tilapia is known as a:

A. Allele
B. Phenotype
C. Gene
D. Punnett Square

1.2. A tilapia with the genotype "Tt" for growth rate is considered:

A. Homozygous dominant
B. Homozygous recessive
C. Heterozygous
D. True-breeding

1.3. In Nile tilapia, red colour (RR) and black colour (rr) are different versions of the same gene. These are examples of:

A. Genotypes
B. Alleles
C. Phenotypes
D. Hybrids

1.4. Which of the following best summarizes the Central Dogma of molecular biology?

A. Protein → RNA → DNA
B. DNA → Protein → RNA
C. RNA → DNA → Protein
D. DNA → RNA → Protein

1.5. Where does transcription occur in a eukaryotic cell?

A. Ribosome
B. Cytoplasm
C. Nucleus
D. Endoplasmic reticulum

1.6. Where does translation occur in a eukaryotic cell?

A. Nucleus
B. Ribosome
C. Nucleolus
D. Mitochondria

1.7. The type of RNA that carries the genetic code from DNA to the ribosome for protein synthesis in salmon is:

A. tRNA
B. rRNA

C. mRNA
D. snRNA

1.8. During translation, the sequence of nucleotides in mRNA is read in groups of three called:

A. Exons
B. Introns
C. Codons
D. Anticodons

1.9. The physical appearance of an oyster, such as having a dark or light shell, is its:

A. Genotype
B. Allele
C. Phenotype
D. Heredity

1.10. Which of the following tools is a diagram used to predict the probability of offspring genotypes in a fish breeding program?

A. Pedigree chart
B. Punnett Square
C. Genetic map
D. Allelic frequency table

1.11. If a shrimp has two identical alleles for a trait (e.g., rr), it is:

A. Heterozygous
B. Homozygous
C. Dominant

D. A hybrid

1.12. In a cross of tilapia, the combination of alleles (such as Pp) represents the organism's:

A. Phenotype
B. Trait
C. Genotype
D. Dominance

1.13. Which of Mendel's laws states that an organism inherits two alleles for each trait, and these alleles separate during gamete formation?

A. Law of Dominance
B. Law of Segregation
C. Law of Independent Assortment
D. Law of Uniformity

1.14. A cross between a true-breeding red tilapia (RR) and a true-breeding black tilapia (rr) produces all red F1 offspring. This demonstrates:

A. Law of Segregation
B. Law of Independent Assortment

C. Law of Dominance
D. Incomplete Dominance

1.15. During a dihybrid cross in zebrafish (e.g., body colour and fin shape), the alleles for the two traits are inherited independently of each other. This is explained by:

A. Law of Segregation
B. Law of Independent Assortment
C. Law of Dominance
D. Chromosomal Theory of Inheritance

1.16. According to the Law of Segregation, a heterozygous tilapia (Aa) will produce gametes in what ratio?

A. 3 A : 1 a
B. 1 A : 1 a
C. All A
D. All a

1.17. A salmon with the genotype RrYy is crossed with another RrYy salmon. The appearance of new combinations of traits in the offspring (e.g., fast-growing with forked tail and slow-growing with normal tail) is best explained by:

A. Law of Segregation
B. Law of Dominance
C. Law of Independent Assortment
D. Incomplete Dominance

1.18. The Law of Independent Assortment applies most clearly to genes that are:

A. On the same chromosome
B. Located on different chromosomes
C. Always inherited together
D. Responsible for the same trait

1.19. If a trait exhibits complete dominance in oysters, what phenotypic ratio is expected in the F2 generation of a monohybrid cross?

A. 1:1
B. 3:1
C. 9:3:3:1
D. 1:2:1

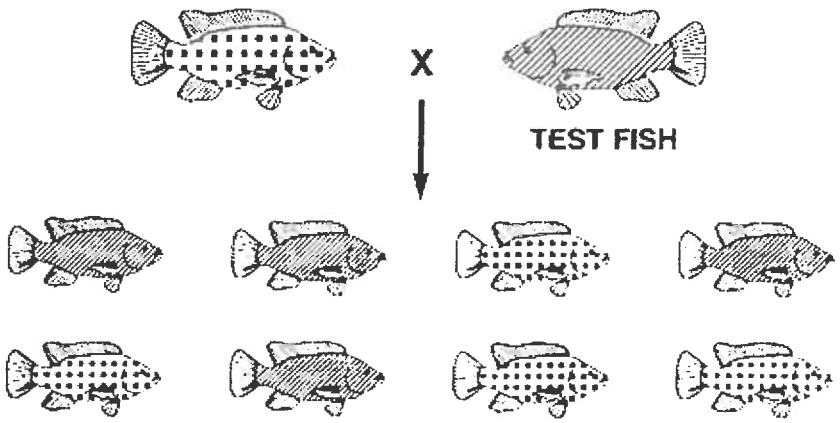
1.20. A scientist crosses two tilapia strains that differ in two traits (scale colour and fin shape) and observes a 9:3:3:1 phenotypic ratio in the offspring. This provides evidence for:

A. Law of Segregation only
B. Law of Dominance only
C. Law of Independent Assortment
D. Both Segregation and Independent Assortment

SECTION B: A fish farmer wants to eliminate an unwanted recessive coloration allele from their breeding stock. He performs the cross shown in the diagram below to determine the genotype of a prime 'Test Fish.

QUESTION 2

Based on the phenotypic results of the offspring, answer the following questions **[30 marks]**



2.1. a) Based on the offspring phenotypes shown, what is the genotype of the "TEST FISH" in the image? **(1 mark)**

b) The test fish has a red coloration. Is red dominant or recessive? Explain how you deduced this from the cross. **(2 marks)**

c) Why would a commercial aquaculture breeder choose to cull a red fish displaying a desirable phenotype? **(3 marks**

2.2. a) If this specific test fish is crossed with a non-red fish, what proportion of the resulting offspring will be red? Show your working. **(3 marks)**

b) Construct a Punnett square to illustrate the cross described in 2.2 (a). **(3 marks**

2.3. a) Define the term test cross as used in aquaculture genetics. **(2 marks)**

b) Why must a breeder perform a test cross on a dominant-phenotype fish rather than just selecting it visually for breeding? **(2 marks)**

c) If a test cross involving a dominant red fish produces 100% red offspring across a large sample size, what is the definitive genotype of that red parent? **(2 marks)**

2.4. a) What does the term "cull" mean within the context of livestock or aquaculture genetic selection? **(2 marks)**

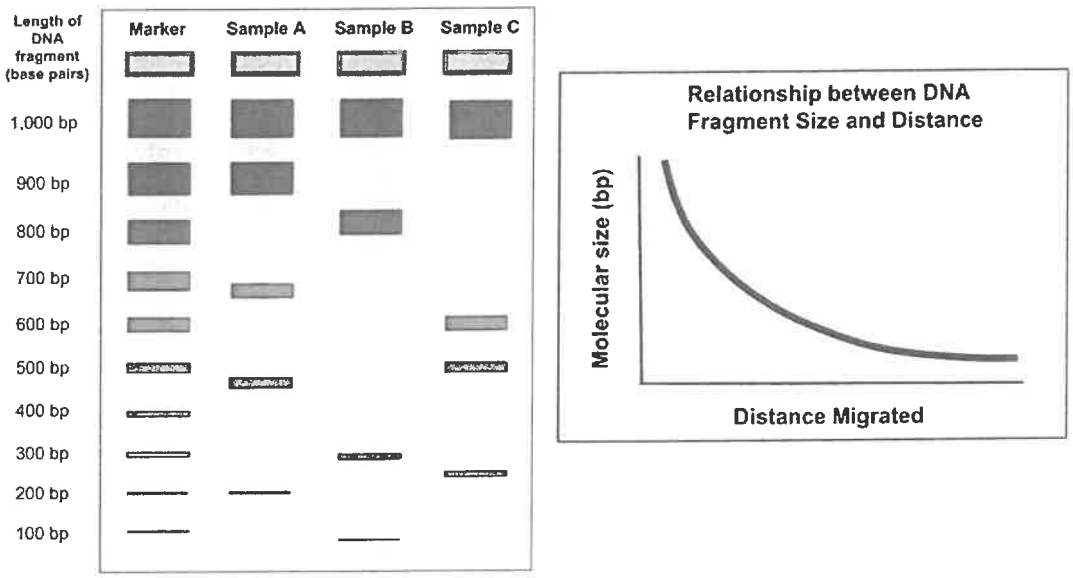
b) If the breeder takes two red fish from the F1 generation of this cross and mates them together, what proportion of the red offspring will be homozygous dominant? Show your calculations. (4 marks)

(2.5. a) Why is understanding the underlying genotype of the broodstock more valuable to a hatchery manager than simply observing the phenotype? **(2 marks)**

b) Suggest one practical molecular method a modern hatchery could use to determine the genotype of a red fish without undergoing a time-consuming test cross. **(2 marks)**

c) If the breeder successfully eliminates all heterozygotes and only breeds fish confirmed to be homozygous dominant (RR), what will happen to the frequency of the recessive allele (r) in the population over subsequent generations? **(2 marks)**

SECTION C: The diagram below illustrates a multi-locus DNA fingerprinting profile (RFLP analysis) used by a hatchery manager to assess genetic variation across three distinct fish samples (A, B, and C)



QUESTION 3

Answer all questions. **[30]**

3.1. a) Why is a molecular weight marker (DNA ladder) strictly required when running a multi-locus RFLP gel electrophoresis assay? **(2 marks)**

b) Compare the total multi-locus banding profiles of Sample A and Sample B. Explain whether these two individuals are homozygous or heterozygous at a single locus, or if they represent distinct multi-locus genomic fingerprints. **(2 marks)**

c) Which of the three samples (A, B, or C) displays the lowest genomic complexity (fewest restriction fragments) on this gel? **(2 marks)**

3.2. a) Briefly explain the genetic principle of using multi-locus DNA fingerprints to assign or exclude parentage in a closed aquaculture system. **(2 marks)**

b) Look at the lowest band in Sample B (located at approximately 100 bp). If Sample B is an offspring, what must be true about its parents' RFLP profiles regarding this specific band? **(2 marks)**

c) Why do modern hatcheries often prefer high-throughput Single Nucleotide Polymorphism (SNP) panels over traditional RFLP fingerprints for large-scale, automated parentage assignments? **(2 marks)**

3.3. a) Based on the complete banding patterns across all zones of the gel, can any of these three fish be classified as genetic clones? Justify your answer. **(2 marks)**

b) If a restriction enzyme mutation occurs at a specific recognition site in a broodstock fish, how would this alter the expected RFLP band profile of its offspring? **(2 marks)**

c) If an unexpected faint band appears in all sample lanes at the same horizontal position, what might this indicate to the laboratory technician? **(2 marks)**

3.4.a) Using the DNA marker lane as your calibration reference, estimate the molecular weight (in base pairs, bp) of the two middle bands unique to Sample B. **(2 marks)**

b) Suppose an offspring profile contains fragments at 200 bp, 450 bp, 670 bp, 900 bp, and 1,000 bp. Based on the gel, could Sample A be the true biological parent of this offspring? Explain your reasoning. **(2 marks)**

c) If a closed hatchery line undergoes severe inbreeding over several generations, what visual changes would you expect to observe in the RFLP profiles of the population? **(2 marks)**

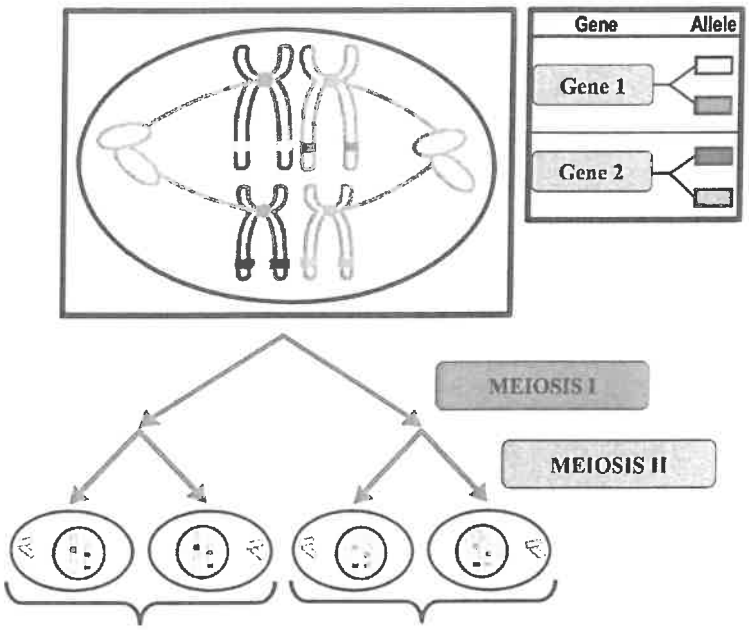
3.5. a) Define what a *co-dominant* genetic marker system means in the context of fragment-based DNA profiling. **(2 marks)**

b) Explain why co-dominant profiles offer a distinct analytical advantage over dominant systems (like RAPD) when calculating genetic diversity indices. **(2 marks)**

c) Identify the full biochemical names for the two common molecular techniques abbreviated as PCR and SNP. **(2 marks)**

d)You run a newly isolated Sample D and discover it shares the exact same four-band profile as Sample B. What conclusion can you safely draw regarding the genetic relationship between Sample B and Sample D? **(4marks)**

SECTION D: The diagram below models the chromosomal dynamics and allelic inheritance patterns across Meiosis I and Meiosis II for two unlinked performance traits in a broodfish.



Question 4: Analyze the diagram carefully and answer the following questions **[30 marks]**

4.1. a) Based on the physical layout of the chromosomes in the Metaphase I diagram are Gene 1 and Gene 2 linked or unlinked? Justify your answer using the visual evidence. **(2 marks)**

b) Define the term *allele* with direct reference to the color-coded bands shown in the explanatory box. **(2 marks)**

c) Name the exact sub-stage of Meiosis I during which the physical separation of the large red and blue homologous chromosomes occurs. **(2 marks)**

4.2. a) Differentiate between Meiosis I and Meiosis II regarding how they alter ploidy levels from the parent cell to the final gametes. **(2 marks)**

b) If a broodstock fish is a double heterozygote (AaBb) for these two unlinked genes, list all the possible allele combinations present in the resulting sperm or eggs. **(2 marks)**

c) Calculate the theoretical probability that a single gamete produced by this AaBb individual will carry both recessive alleles (a and b). **(2 marks)**

4.3. a) If Gene 1 and Gene 2 were tightly linked on the *same* chromosome, how would the visual layout of the Metaphase I diagram change? **(2 marks)**

b) Define *crossing over* and identify the specific meiotic sub-phase where it takes place. **(2 marks)**

c) If two diagnostic loci have a recombination frequency of 20%, what is the genetic distance between them in centimorgans (cM)? **(2 marks)**

4.4. a) Why must a hatchery manager understand the specific allele profiles of their broodstock when breeding for a quantitative trait like viral disease resistance? **(2 marks)**

b) A disease resistance allele (R) is completely dominant over the susceptibility allele (r). If a resistant broodfish is crossed with a susceptible individual and yields a 1:1 phenotypic ratio in the F1 generation, what is the definitive genotype of the resistant parent? **(2 marks)**

c) Explain how a breeder can exploit the law of independent assortment to simultaneously select for two distinct, unlinked performance traits (e.g., growth rate and fillet yield). **(2 marks)**

4.5. a) If the homologous pair for Gene 1 experiences complete nondisjunction during Meiosis I, describe the chromosomal consequences for the four resulting gametes. **(2 marks)**

b) In commercial aquaculture, triploid (3n) populations are frequently produced by applying temperature or pressure shocks to newly fertilized eggs to retain the second polar body. Which specific meiotic division is disrupted by this treatment? **(2 marks)**

c) Explain from a structural standpoint why triploid fish are typically sterile, referencing the chromosome dynamics shown in the Meiosis I diagram. **(2 marks)**