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University Examinations 2024/2025

SECOND YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF MEDICAL LABORATORY

HML 3211: MOLECULAR BIOLOGY AND GENETICS

DATE: JANUARY 2025 **TIME: 3 HOURS**

INSTRUCTIONS:
Answer ***All*** *questions*
Ensure that all your answers are properly numbered
Part I multiple Choice Questions (MCQ): Write the correct answer on the space provided in the answer booklet. Each MCQ is one mark
Part II: Short Answer Questions – Answer questions following each other on the answer booklet
Part III: Long Answer Questions – Answer each question on the answer booklet

SECTION A: MULTIPLE CHOICE QUESTIONS (20 marks)

1. Which characteristic of DNA provides stability to the double helix structure and protects the genetic information from degradation?
   A. Hydrogen bonding between base pairs
   B. Covalent bonding between nucleotides
   C. Hydrophobic interactions between nitrogenous bases
   D. Ionic interactions between phosphates
2. What aspect of RNA makes it more prone to hydrolysis compared to DNA?
   A. Presence of uracil instead of thymine

B. Ribose sugar with a 2' -hydroxyl group

C. Single-stranded nature

D. Lack of hydrogen bonding between bases

3. In eukaryotic transcription, what role do promoter region play?

A. Bind directly to RNA polymerase Il

B. Facilitate mRNA splicing

C. Increase the rate of transcription by binding transcription factors

D. Suppress the activity of the operon

4, During translation, how is the correct amino acid incorporated into the growing polypeptide chain?

A. Ribosome selects amino acid based on its chemical properties

B. Base-pairing between tRNA anticodon and mRNA codon

C. Peptidyl transferase ensures proper amino acid placement

5. Which of the following enzymes is directly responsible for reducing the torsional strain that builds up ahead of the replication fork during DNA replication?

A. Helicase

B. DNA polymerase

C. Topoisomerase

D. Ligase

6. In a case of incomplete dominance, what phenotype would result from a cross between two heterozygotes?

A. A phenotype resembling one of the two parents

B. A blend of both parental phenotypes

C. A new trait that neither parent shows

D. Phenotypic variation based on environmental influence

7. What is the primary consequence of gene linkage on genetic inheritance?

A. Independent assortment of alleles

B. Increased recombination between linked genes

C. Decreased likelihood of genes separating during meiosis

D. Mutations arising in linked genes

8. Which type of genetic mutation is most likely to result in a non-functional protein?

A. Missense mutation

B. Silent mutation

C. Frameshift mutation

D. Intragenic suppressor mutation

9. What distinguishes polygenic diseases from monogenic diseases?

A. Polygenic diseases follow Mendelian inheritance patterns

B. Monogenic diseases are more influenced by environmental factors

C. Polygenic diseases involve multiple genes contributing to the phenotype

D. Monogenic diseases always exhibit complete penetrance

10. In a PCR reaction, what is the function of Taq polymerase?

A. Denatures double-stranded DNA

B. Synthesizes new DNA strands using the template

C. Ligates the DNA fragments

D. Breaks down unwanted RNA sequences

11. Which of the following would you most likely use if you were interested in quantifying the expression levels of a specific mRNA?

A. Southern blot

B. RT-PCR

C. Sanger sequencing

D. Northern blot

12, How does CRISPR-Cas9 enable precise gene editing?

A. It binds to promoter regions to inhibit transcription

B. It induces double-strand breaks at specific genomic loci using guide RNA

C. It synthesizes new DNA strands during replication

D. It silences genes by methylating DNA

13. What is a significant ethical concern surrounding the use of germline gene editing in humans?

A. Inability to accurately edit genes

B. Unforeseen impacts on somatic cells

C. Potential for heritable changes affecting future generations

D. Lack of knowledge on gene function

14. What is the primary function of histone proteins in chromatin?

A. Catalyze DNA replication

B. Facilitate recombination events

C. Package and organize DNA into nucleosomes

D. Serve as templates for transcription

15. The term "epigenetic modification" refers to which of the following processes?

A. Direct alteration of DNA sequence

B. Covalent modification of histones and DNA that affects gene expression

C. Recombination between homologous chromosomes

D. Gene rearrangement leading to new protein formation

16. In eukaryotic cells, what modification of pre-mRNA is essential for its stability and transport from the nucleus?

A. Addition of a 5' methyl cap

B. Cleavage of introns

C. Formation of the TATA box

D. Binding to the ribosome

17. Which technique is most suitable for identifying a specific DNA sequence within a large genome?

A. RT-PCR

B. Northern blotting

C. Sanger sequencing

D. DNA cloning

18. What feature of plasmid vectors makes them useful for DNA cloning?
    A. Their large size allows for more DNA insertion
    B. They carry antibiotic resistance genes, allowing for selection of transformed cells
    C. They are linear and easier to manipulate
    D. They replicate independently of the bacterial genome
19. In Mendelian genetics, what is the expected phenotypic ratio in the offspring of a monohybrid cross between two heterozygotes (Aa x Aa)?
    A. 1:2:1
    B. 3:1
    C. 9:3:3:1
    D. 1:1
20. Which step in PCR involves the separation of double-stranded DNA into single strands?
    A. Annealing
    B. Denaturation
    C. Extension
    D. Elongation

SECTION B: SHORT ANSWER QUESTIONS (30 MARKS)

a) Describe the structure of RNA (5 marks)
b) Describe the three key laws of genetics formulated by Mendel (6 marks)
c) Describe the principle of separation in gel electrophoresis (6 marks)
d) Describe the factors contributing to the development of complex diseases in genetics (6 marks)
e) Briefly explain the key steps in DNA/ RNA extraction (6 marks)
f) Describe the Sanger sequencing process (8 marks)
g) List the Next Generation Sequencing platforms (3 marks)

SECTION C: LONG ANSWER QUESTIONS,CHOOSE ANY TWO (20 MARKS)

QUESTION ONE

a) Discuss the common types of genetic variation (14 marks)

b) Describe the differences between DNA and RNA (6 marks)

QUESTION TWO

Discuss gene expression and regulation (20 marks)

QUESTION THREE

Discuss Techniques for Gene Manipulation and their application (20 marks)