CHUKA UNIVERSITY

Knowledge is Wealth *(Sapientia divitia est)* Akili ni Mali

DEPARTMENT OF BIOLOGICAL SCIENCE

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BOTA 223_PRINCIPLES OF MOLECULAR GENETICS_MAIN EXAM_ APRIL 2025

BACHELOR OF SCIENCE IN MICROBIOLOGY AND BIOTECHNOLOGY

SECTION A (30 MARKS)

INSTRUCTIONS

Answer **ALL the questions in section A** and any **TWO** question in section B.

Use of calculators and statistical tables is allowed.

Do not write anything on the question paper.

SECTION A (30 MARKS): ANSWER ALL QUESTIONS

1. In your plant breeding program, you observed that some traits do not follow simple Mendelian inheritance patterns. Using Mendel's laws, explain the role of the following genetic laws in shaping inheritance patterns observed in your breeding experiments:
   a. Explain the application of Mendel's Law of Dominance in predicting the appearance of dominant and recessive traits in the F_1 generation of a monohybrid cross between pure-breeding tall and short garden pea plants. (2 marks)
   b. Describe the role of Mendel's Law of Segregation in producing the 3:1 phenotypic ratio observed in the F_2 generation of a monohybrid cross. (2 marks)
   c. Explain the impact of genetic linkage, where genes are linked on the same chromosome, on deviations from Mendel's Law of Independent Assortment and its effects on inheritance patterns in your breeding program. (2 marks)

2. A geneticist in a diagnostic laboratory is analyzing patient samples to identify structural differences in chromosomes. Provide accurately labeled diagrams illustrating different types of chromosomes. (4 marks)

3. Discuss applications of five molecular markers in plant breeding or disease diagnosis. (5 marks)

4. List five types of point mutations and explain their effects on protein structure and function in genetic disorder (5 marks)
5. Outline the steps involved in gene transfer through transduction using a bacteriophage. (5 marks)
6. Outline six key properties that would make a vector ideal for gene therapy (5 marks)

SECTION B (40 MARKS): ANSWER ANY TWO QUESTIONS

7. (a) Explain the Jacob-Monod Hypothesis based on the lac operon as well as trp operon (10 marks)

   (b) Explain the horizontal gene transfer of prokaryotic cells through conjugation and transformation (10 marks)

8. You are tasked with producing a specific protein in a lab using *in vitro* process.
   (a) Describe the process of transcription and explain its role in protein production. (5 marks)
   (b) Describe the process of translation and its significance in protein production. (5 marks)
   (c) Explain the role of understanding transcription and translation in optimizing protein production for pharmaceutical purposes (10 marks)

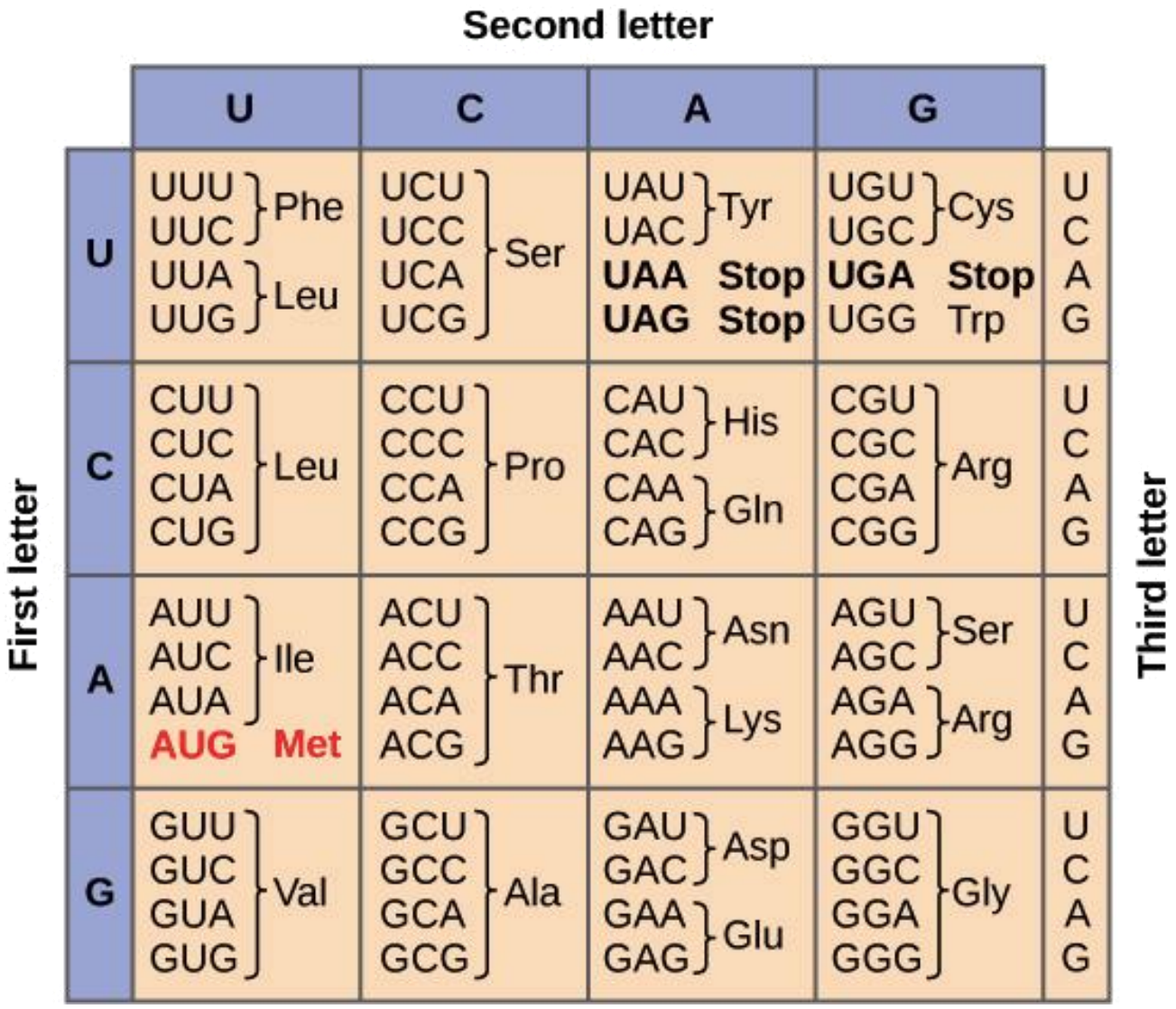
9. (a) Describe the mechanism of splicing in eukaryotic nuclei (10 marks)
   (b) A single base addition and a single base deletion approximately 15 base pairs apart in the DNA coding for an enzyme caused a change in the amino acid sequence from,

   ----lys-ser-pro-ser-leu-asn-ala-ala-lys------

   to the abnormal form,

   --- lys-val-his-his-leu-met-ala-ala-lys------

   i. From the available codon information (see attached genetic code), determine the segment of mRNA for both the original polypeptide and that resulting from the double mutant. (8 marks)
   ii. Identify the base added? (1 mark)
   iii. Identify the base deleted? (1 mark)


Second letter
First letter
Third letter
U
C
A
G
UUU UUC Phe
UUA UUG Leu
UCU UCC UCA UCG Ser
UAU UAC Tyr
UAA Stop
UAG Stop
UGU UGC Cys
UGA Stop
UGG Trp
CUU CUC CUA CUG Leu
CCU CCC CCA CCG Pro
CAU CAC His
CAA CAG Gln
CGU CGC CGA CGG Arg
AUU AUC AUA Ile
AUG Met
ACU ACC ACA ACG Thr
AAU AAC Asn
AAA AAG Lys
AGU AGC Ser
AGA AGG Arg
GUU GUC GUA GUG Val
GCU GCC GCA GCG Ala
GAU GAC Asp
GAA GAG Glu
GGU GGC GGA GGG Gly