

INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
DEPARTMENT OF BIOSCIENCES AND BIOENGINEERING
Genetics (BT 204)

Mid-Semester Examination

Date: September 21, 2024

Time: 2 hours

Total Marks: 30

Read the questions carefully. All questions are compulsory

1. A cell has two pairs of submetacentric chromosomes, which we will call chromosomes I_a , I_b , II_a , and II_b . Where Chromosomes I_a and I_b are homologs, and chromosomes II_a and II_b are homologs. Allele M is located on the long arm of chromosome I_a , and allele m is located at the same position on chromosome I_b . Allele P is located on the short arm of chromosome I_a , and allele p is located at the same position on chromosome I_b . Allele R is located on chromosome II_a and allele r is located at the same position on chromosome II_b . Answer the following: [Marks 4]

A. Draw these chromosomes, identifying genes M , m , P , p , R and r , as they might appear in Metaphase-I of meiosis. Assume that there is no crossing over.

B. Taking into consideration the random separation of chromosomes in Anaphase-I, draw the chromosomes (with genes identified) present in all possible types of gametes that might result from this cell's undergoing meiosis. Assume that there is no crossing over.

2. Give the expected phenotypic ratios and name the blood types of the offspring from these parents:

a) $I^A I^A \times I^B I^B$

b) $I^A I^O \times I^O I^O$

c) $I^A I^B \times I^A I^O$

d) $I^A I^O \times I^B I^B$

[Marks 1 x 4= 4]

3. Red colour in Wheat Kernels is produced by the genotypes R^2B^2 . White by the double recessive genotypes ($rrbb$). The Genotypes R^2bb and rrB^2 produced Brown kernels. A Homozygous Red variety is crossed to a White variety. (i) What type of genetic interaction is this? (ii) What phenotypic results are expected in F_1 and F_2 progeny? Explain with the cross. [Marks 4]

4. In guinea pigs, the allele for black fur (B) is dominant over the allele for brown (b) fur. A black guinea pig is crossed with a brown guinea pig, producing five F_1 black guinea pigs and six F_1 brown guinea pigs. How many copies of the black allele (B) will be present in each cell from an F_1 black guinea pig at the following stages, assuming that no crossing over takes place: [Marks 4]

(i) At G_1 stage of cell cycle

(iii) At Metaphase of Mitosis

(v) At Metaphase II of Meiosis

(ii) At G_2 stage of cell cycle

(iv) At Metaphase I of Meiosis

(vi) After second cytokinesis following Meiosis

5. Palomino horses have a golden yellow coat, Chestnut horses have a brown coat, and Cremello horses have a coat that is almost white. A series of crosses between the three different types of horses produced the following offspring: [Marks 4]

Parental Cross	Offspring
Palomino x Palomino	13 Palomino, 6 Chestnut, 5 Cremello
Chestnut x Chestnut	16 Chestnut
Cremello x Cremello	13 Cremello
Palomino x Chestnut	8 Palomino, 9 Chestnut
Palomino x Cremello	11 Palomino, 11 Cremello
Chestnut x Cremello	23 Palomino

[A] What type of inheritance is occurring in horses Palomino, Chestnut, Cremello phenotypes? Explain briefly.

[B] Assign symbols for the alleles that determine these phenotypes, and list the genotypes of all parents and offsprings given in the preceding table.

6. Differentiate between the following, draw the figure wherever required:

[Marks 2 x 5= 10]

- Acentric and Acrocentric chromosomes
- Chromomere and Chromonemata
- Telomere and Telocentric Chromosome
- Dominance and Epistasis
- Polytene Chromosomes and Lampbrush Chromosome

1. a) Write stepwise equation for DNA curving using k , t and N^* [p = pitch, k = curvature, t = twist, N^* = bp steps in complete one turn]
b) Write stepwise equation for DNA curving using P , k and t [p = pitch, k = curvature, t = twist, N^* = bp steps in complete one turn]
2. Assume that Histone Octamers form a cylinder of diameter 12 nm with a height of 6 nm, where human genome has 35 million nucleosomes
a) What **volume** of nucleus (having 8-micron diameter) is occupied by Histone octamers?
b) What **fraction** (in percent) of the nuclear volume do the DNA and Histone Octamers occupy?
3. Assume that 30 nm chromatin fiber contains about 30 nucleosomes (1 nucleosome= 200 bp) per 75 nm of DNA.
a) Calculate the degree of compaction of DNA associated with the level of chromatin structure.
b) What fractions (in percent) of 15000-fold condensation does this DNA packing represent?
4. Show the steps of Meselson and Stahl's experiment. If Meselson and Stahl's experiment is continued for 4 generations in *E. coli*, then what would be the ratio of $^{15}\text{N}/^{15}\text{N}$: $^{15}\text{N}/^{14}\text{N}$: $^{14}\text{N}/^{14}\text{N}$ in the end?
5. Excess of ^3H labeled DNA replicated in a medium with ^{32}P dCTP. Incubation was continued for the cell cycles and then DNA was extracted by CSCI gradient. Show the graph(s) **radioactivity vs time** for i) one cycle ii) two cycle of replication.
6. A 200 nucleotide segment is responsive for replication of a gene X of a cell. It is found that this segment is moved different places in genome and those new sites are also amplified in cells.
a) Sketch the amplified DNA cluster.
b) Calculate the fold of DNA amplification after 6 round of replications.
c) What is the role of 200 nucleotide amplification control element of the gene X cluster?
7. Explain with diagram why Okazaki fragments are formed during DNA replication?
8. What are the steps in base excision repair? Show the diagram.
(Marks: 3 x 8= 24)
9. a) What are the major activities of Klenow enzyme?
b) Write the final structure when the partial DNA (shown below) is placed in a mixture containing four dNTPs, buffer and Klenow enzyme? [Bold letters indicate the complementary bases]

