GENETICS
(BIOT 3101)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Which of the following pair is wrongly matched?
(a) Factors – Discrete units (b) Multiple alleles - ABO blood group
(c) Female Drosophila – Heterogametic (d) Inborn error - Phenylketonuria.

(ii) Albinism, lack of pigmentation in humans, results from an autosomal recessive gene. Two parents with normal pigmentation have an albino child. What is the probability that their next child will be an albino girl?
(a) ½ (b) ¼ (c) 1/8 (d) 1/16.

(iii) In a population of fruit flies the allele for large wings is dominant over the allele for small wings. Two heterozygous parents are crossed and produce sixteen offspring. How many of these offspring will have large wings?
(a) Twelve (b) Four (c) Sixteen (d) Eight.

(iv) Genetic recombination between bacterial cells is first demonstrated by
(a) Ochoa and Kornberg (b) Har Gobind Khorana
(c) H. J. Muller (d) Lederberg and Tatum.

(v) Which of the following is a classic example of point mutation?
(a) Sickle cell anaemia (b) Thalassemia
(c) Phenyketonuria (d) Haemophilia.

(vi) The first tumour suppressor gene to be studied was associated with which type of cancer?
(a) Myeloma (b) Sarcoma (c) Retinoblastoma (d) Carcinoma.

(vii) Which of the following bacteriophages are responsible for specialized transduction?
(a) T_4 phages (b) Lysogenic phages (c) Lytic phages (d) Both (b) and (c).

(viii) In a Poisson distribution, if 'n' is the number of trials and 'p' is the probability of success, then the mean value is given by
(a) m = np (b) m = $(np)^2$ (c) m = np(1-p) (d) m = p

(ix) In _____ ways can we select 6 people out of 10, of which a particular person is not included?
(a) $^{10}C_3$ (b) $^{9}C_5$ (c) $^{9}C_6$ (d) $^{9}C_4$

(x) What does p^2 in the below mentioned Hardy-Weinberg equation indicate?
$(p+q)^2 = p^2 + 2pq + q^2$
(a) Individuals that are heterozygous dominant
(b) Individuals having a lethal allele
(c) Individuals that are homozygous dominant
(d) Individuals that are homozygous recessive.

Fill in the blanks with the correct word

(xi) The substitution of a purine base with a pyrimidine base is known as_____.

(xii) Albinism, an autosomal recessive trait, has an incidence of about 1/10,000. The percentage of heterozygous population for this gene is _____.

(xiii) The cross between an F_1 hybrid and recessive homozygote is called _____.

(xiv) A sampled population has 36% of homozygous recessive genotype (aa). Then the frequency of allele "a" is _____.

(xv) The part of the DNA is transferred by bacteriophage from one bacterium to another by a process called _____.

Group - B

2. (a) Female Drosophila heterozygous for ebony (e), scarlet (sc) and spineless (ss) were test-crossed and the following progenies were obtained:

Progeny phenotypes	Number
wild type	67
ebony	8
ebony scarlet	68
ebony spineless	347
ebony scarlet spineless	78
scarlet	308
scarlet spineless	10
spineless	54

(i) Write the genotypes of the flies involved in the parental cross and test cross.
(ii) Construct the genetic map of the 3 genes indicating the map distance and correct sequence of the genes.
(iii) Calculate the coefficient of coincidence. *[(CO1,2)(Evaluate/HOCQ)]*

(b) Analyze the phenomenon of Bombay Phenotype. *[(CO1,2)(Analyze/IOCQ)]*

(c) In a maternity ward of a hospital, four babies were accidentally mixed up. The blood groups of the four babies are known to be O, A, B and AB. The ABO types of the four sets of the parents are determined. Indicate which baby belongs to each set of parents.
(i) AB x O, (ii) A x O, (iii) A x AB, (iv) O x O. *[(CO1,2)(Justify/HOCQ)]*

(2 + 2 + 2) + 2 + (1 × 4) = 12

3. (a) Describe with an example how maternal influence plays an important role in sex determination. *[(CO1,2)(Understand/LOCQ)]*

(b) What do you mean by sex-limited and sex-influenced inheritance? Analyze with examples. *[(CO1,2)(Analyze/IOCQ)]*

(c) Explain with a diagram the salient features of a Polytene chromosome. *[(CO2)(Understand/LOCQ)]*

4 + 4 + 4 = 12

Group - C

4. (a) A single nucleotide polymorphism changes one nucleotide in a gene sequence. As a result, the gene gains a stop codon 500 base pairs to soon and the protein — when it is translated — is truncated or cut short. Which type of mutation was the cause behind this event? Explain with reasons. *[(CO4)(Analyze/IOCQ)]*

(b) Describe the mechanism behind 'Frameshift mutation' with an example. *[(CO4)(Understand/LOCQ)]*

(c) Cite one example of a human disease caused by genetic mutation. Mention its reason, cellular pathophysiology and symptoms. *[(CO4)(Remember/LOCQ)]*

4 + 4 + 4 = 12

5. (a) Analyze the cellular events behind formation of 'Philadelphia Chromosome'. *[(CO3)(Analyse/IOCQ)]*

(b) What was the significance of the "Fluctuation test" (1943) conducted by Luria and Delbruck? *[(CO4)(Remember/LOCQ)]*

(c) As a genetic counsellor, you are asked to assess the risk for a couple who plans to have children. Both the husband and wife are phenotypically normal, but the husband has a sister with familial retinoblastoma in both eyes. What is the probability that this couple will have a child with retinoblastoma? Are there any tests that you could recommend to help in this assessment? *[(CO1,3)(Examine/HOCQ)]*

4 + 4 + 4 = 12

Group - D

6. (a) Imagine a situation where two novel mutations have been identified in a bacterium. Design an experiment to test whether these mutations are present in the same gene or not. *[(CO4)(Design/HOCQ)]*

(b) Five deletion mutations within the B cistron of the rII region of the phage T_4 were tested in all pairwise combinations for wild type recombinants. In the following table of results, + = recombination, 0 = no recombination. Construct a topological map for these deletions. *[(CO4)(Calculate/HOCQ)]*

	1	2	3	4	5
1	0	+	+	0	0
2		0	+	0	+
3			0	+	0
4				0	0
5					0

(c) Comment on the bizarre conditions caused by mutations in the homeotic genes in *Drosophila*. *[(CO4)(Understand/LOCQ)]*

4 + 4 + 4 = 12

7. (a) Explain with a diagram the Holliday model of genetic recombination. *[(CO4)(Remember/LOCQ)]*

(b) Differentiate between the three main types of bacterial homologous recombination. *[(CO4)(Differentiate/IOCQ)]*

(c) DNA was extracted from a wild type strain of bacteria and used to transform a mutant strain unable to synthesise the amino acids alanine (ala), proline (pro) and arginine (arg). The trasnformant classes are as follows:
8400 ala^+ pro^+ arg^+ ; 840 ala^+ pro^- arg^- ; 2100 ala^+ pro^- arg^+ ; 1400 ala^+ pro^+ arg^- ; 420 ala^- pro^+ arg^+ ; 840 ala^- pro^+ arg^- ; 8400 ala^- pro^- arg^+

(i) What are the linkage distances between the genes?

(ii) What is the linkage order? *[(CO4)(Calculate/IOCQ)]*

4 + 4 + (2 + 2) = 12

Group - E

8. (a) How can you predict the allele frequency of a population from the genotype frequency? Deduce with the help of Hardy-Weinberg Law. *[(CO6)(Deduce/IOCQ)]*

(b) In order to find the effect of Azolla growth on the rice field and experimentally grown Azolla in 10 similar field plots before rice planting and other 10 similar plots were taken as control without Azolla growth. Rice was grown in all these plots and yields were noted.

Plot no	1	2	3	4	5	6	7	8	9	10
With Azolla	15.3	15.8	16.1	17.0	15.5	16.5	16.2	15.5	17.1	16.3
Without Azolla	14.5	13.8	15.9	13.9	14.8	14.9	15.2	15.0	14.1	13.7

Verify whether there is any significant effect of Azolla growth on the gain of yield of rice. Given that $t_{0.05,\,18} = 2.10$. *[(CO5)(Calculate/HOCQ)]*

(c) How many mammalian cells would be killed if an irradiation dose administered to a cell population was sufficient for an average of 5 lethal hits per target, when in fact only 2 hits are needed for lethality? (Given $e^{-m} = 0.0067$). *[(CO5)(Calculate/HOCQ)]*

4 + 4 + 4 = 12

9. (a) Write the theorems of probability. *[(CO5)(Remember/LOCQ)]*

(b) The probability that a person A who is now 25 years old, lives for another 30 years is 2/5 and the probability that a person who is now 45 years old lives for another 30 years is 7/16. Find the probability that at least one of these persons will be alive for 30 hence. *[(CO5)(Analyse/IOCQ)]*

(c) In a study of patients the following data was obtained. Find the median and standard deviation.

Age (in years)	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89
Number of cases	1	3	1	10	17	36	9	3

[(CO5)(Analyse/IOCQ)]

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	33.33	35.42	31.25

Course Outcome (CO):

After the completion of the course students will be able to:

1. Understand the basic principles of Mendelian mode of inheritance and also analyze the reasons behind the exceptions to this phenomenon.
2. Interpret the different modes of linkage, sex determination patterns and chromosomal abnormalities.
3. Identify and analyze the genetic network of carcinogenesis to reach out for novel therapeutic strategies.
4. Comprehend the mechanism of action of microbial genetics and genetic patterns of embryonic development.
5. Apply the mathematical and biostatistical models in biological systems for testing of hypotheses, estimation of group differences and case-control studies.
6. Use the Hardy-Weinberg model to quantify the allele frequency in a population for better understanding of evolutionary changes and gene flow.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*