Department of Biotechnology
Indian Institute of Technology Kharagpur

Subject: Genetics (BT31009)/ Genetics and Genetic Engineering (BT31201)

Mid-Autumn Semester–2022 Examination
Date of Exam: September 26, 2022 Monday
Number of students: 54 (2+52)

Full Marks: 30
Time: 02 hours (09:00 AM– 11:00 AM)

Instruction: *This question paper has <u>three parts</u>- A, B and C. Answer Part-A, Part-B and Part-C separately on the <u>single answer script</u>. You may write Part-A/B/C first, followed by Part-B/C/A or C/A/B. Do not intermingle the Part-A, Part-B and Part-C. Answer all the components of one question in one designated place. Answer precisely to the point.*

Part-A (MKM):   Total marks = 15

Note: *Perform/show the rough works/calculations corresponding to each question number in the right-hand-side or in a separate page mentioning question number.*

Q1. (A) In a mouse breeding program, an egg with the genotype *fghQr* got fertilized with a sperm of genotype *fGHQR*. What would be **(i)** the genotype of the zygote thus formed and **(ii)** the possible genotypes of gametes that may be produced by the adult developing from the aforementioned zygote?   *[1+1]*

(B) In a rat breeding program after several years of observation, the breeder noticed that two brown rats upon mating produced 52 brown and 17 white progeny in total. **(i)** Explain the results of the inheritance pattern. **(ii)** Determine the genotypes of the parents and progeny after assuming the suitable allele designation.   *[1+1]*

Q2. (A) In a mouse breeding program over several years, the male with genotype *AabbDdEeGgHh* and the female with the genotype *AaBbddEeGghh* were crossed. If the total progeny consisted of 1024 individuals, how many individuals will be of the specific genotype *AaBbddEEGghh* ?   *[2]*

(B) The breeding program in a farm animal species has established that the recessive "*a*" phenotype, dominant "*B*" phenotype, recessive "*c*" phenotype, and the dominant "*D*" phenotype are having important commercial values. If the hybridization between *AaBbCcDd* and *AaBbCcDd* genotypes produced a total of 1000 progeny, how many individuals would exhibit the combined trait of economically desired phenotypes?   *[2]*

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Q3. (A) In a plant species, the 'R' and the 'r' alleles control red and white flower phenotypes, respectively. Upon test cross between appropriate plants, the following progeny phenotypes were obtained in two different experiments:

      (i) 5000 red and 5400 white flowered plants

      (ii) 500 red and 540 white flowered plants

Which of the following results would fit to the Mendelian inheritance pattern, and why? *[1+1]*

(B) In F_2 population of a dihybrid F_1 plant, the following phenotypic classes were obtained:

Hairy leaves, round fruit:	178
Hairy leaves, elongated fruit:	62
Smooth leaves, round fruit:	56
Smooth leaves, elongated fruit:	24

(i) Does this inheritance of traits follow the Mendelian law of independent assortment? (ii) Suggest genotype of parents, F_1 and F_2 plants. *[1+1]*

Q4. Write short note on the followings: *[@0.5 X 6 = 3]*

(i) Quantitative genetics (ii) Molecular genetics (iii) Molecular breeding (iv) Haploid (v) Heterozygous (vi) DNA polymorphism

Table: Chi-Square Probabilities

df	0.995	0.99	0.975	0.95	0.90	0.10	0.05	0.025	0.01	0.005
1	---	---	0.001	0.004	0.016	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	6.251	7.815 ·	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	9.236	11.070	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	13.362	15.507	17.535	20.090	21.955

End of Part-A

Part-B (RD):   Total marks = 7.5

Q5. Consider two genes X and Y present on chromosome 3 in the human genome. The human population contains two alleles for gene X (viz., X_1 and X_2) and two alleles for gene Y (viz., Y_1 and Y_2). The recombination rate between the two genes $r=0.1$. In generation 't', the frequencies of alleles X_1, X_2, Y_1 and Y_2 are 0.6, 0.4, 0.3, and 0.7 respectively. What would be frequencies of all possible haplotypes in generation 't+1'?   What is the level of linkage disequilibrium in the population in generation 't+1'?   [2+1=3]

Q6. An autosomal gene M has four alleles in a diploid frog population – M_1, M_2, M_3 and M_4.
(a) If the allele frequencies are 0.3, 0.25, 0.2, and 0.25 respectively, calculate the genotype frequencies assuming random mating.
(b) If the frequencies of genotypes M_1M_1, M_1M_2, M_1M_3, and M_1M_4 are 0.12, 0.08, 0.05, and 0.1 respectively, what is the frequency of allele M_1 in the population?

[1.5+1.5=3]

Q7. (i) A human baby was born with 47 chromosomes. What would you call this genetic constitution?
    A. Haploidy   B. Tetraploidy   C. Euploidy   D. Aneuploidy

(ii) Hemizygosity can be
    A. X-linked   B. Autosomal   C. Both A & B   D. None of the above

(iii) If the frequency of two alleles in a gene pool is 90% A and 10% a, what is the frequency of individuals in the population with the genotype Aa?

    A. 0.01   B. 0.09   C. 0.18   D. 0.198

[3x0.5=1.5]

End of Part-B

Q8. If the recognition sequence of a restriction enzyme is GAATTC, then how many covalent bonds will be broken by the enzyme in the following DNA molecule?   *[1]*

5' GCTGTGAATTCAGTGGCTGTGAATTCAGT 3'
3' CGACACTTAAGTCACCGACACTTAAGTCA 5'
   (A) 0
   (B) 1
   (C) 2
   (D) 4 ✓

Q9. State three important properties of a plasmid that are useful for cloning of a gene.   *[1.5]*

Q10. After performing Sanger DNA sequencing, you have run a sequencing gel and the bands read as following (bottom to top of the gel): TGACCGTACGTA. What is the sequence of the template used for sequencing?   *[2]*

Q11. Design primers (show sequence with direction) for the following gene that you want to amplify using the polymerase chain reaction (PCR).
 5'CTCGAGGTGAATATGAAAG----------------CATTTGGCGCGTAATCGATA3'
 3'GAGCTCCACTTATACTTTC------------------GTAAACCGCGCATTAGCTAT5'

      [2]

Q12. You have joined a microbial genetics lab for your internship. You want to engineer bacteria that will make messenger DNA (mDNA) instead of messenger RNA (mRNA) after transcription. If successful, do you think this engineered bacterium (with mDNA) will have an advantage or disadvantage compared to natural bacteria (with mRNA)? Give proper reasoning.   *[1]*

→ modifies
→ Ribosae - Translation ×
→ Too stable, no degrade

End of Part-C