

1. You keep stocks of flies of specific genotypes. You have a fly that has normal wings (dominant phenotypes). Flies with short wings are homozygous for a recessive allele of wing-length gene. You need to know if this fly with normal wings is pure-breeding or heterozygous for the wing-length trait. What cross would you do to determine the genotype, and what results would you expect for each possible genotype? (10 points)
2. A mating of one strain of pure-breeding yellow mice with pure-breeding brown mice resulted in black hybrids. A cross between the black F_1 hybrids produces 42 black, 18 brown, and 20 yellow offspring. At least two different models of genetic constitution conform to the observed data. (a) Please describe these models of genetic constitution and use the *Chi*-square test for goodness-of-fit to evaluate how the model conforms to observed results. (10 points) (b) In order to validate which model is correct, please design a crossing scheme and explain how the expected phenotypes of progenies in this cross are able to distinguish the aforementioned models. The two parents of this crossing scheme must come from the existed mice. (10 points)

Critical values of the χ^2 distribution

<i>df</i>	1	2	3	4
$P=0.05$	3.841	5.991	7.815	9.488

3. The genotypes of four loci in the rice plant X are all heterozygous, represented as *Aa Bb Dd Ee*. The capital-letter alleles are dominant to the lowercase-letter alleles. The table on the right side shows the classification of 1000 testcrossed progenies of the rice plant X based on their genotypes. (a) Please use the Chi-square test of independence to verify how many loci are independent assorted from other loci, and draw a genetic map for the genetically linked loci. A genetic map includes the order of linked loci and recombination frequencies between them. (10 points) (b) Assume that the rice plant X was obtained from the cross of two inbred lines. Please deduce the genotypes of these two inbred lines (for all possible combinations). (10 points)

genotype	number
<i>Aa Bb Dd ee</i>	110
<i>Aa bb Dd Ee</i>	60
<i>Aa Bb dd ee</i>	15
<i>Aa bb dd Ee</i>	317
<i>aa Bb Dd ee</i>	320
<i>aa bb Dd Ee</i>	12
<i>aa Bb dd ee</i>	53
<i>aa bb dd Ee</i>	103

4. It took more than 50 years to convince the scientific community that DNA is the molecule of heredity. Three important genetic experiments such as (1) "transformation" that Dr. Frederick Griffith conducted in *Streptococcus pneumoniae* bacteria and mice in 1928, (2) "identification of the transformation principle" done by Dr. Avery's group in 1944, and (3) "Waring blender" experiment that Dr. Alfred Hershey and Martha Chase conducted in T2 bacteriophages in 1952 provided evidences for DNA as the genetic material. Please select ONE experiment from above and describe it in details. (10 points)
5. In the 1940s, George Beadle and Edward Tatum carried out a series of experiment on the bread mold *Neurospora* to support for "the one gene, one enzyme" hypothesis. In this similar experiment, A, B, C are the intermediates (in that order) in a biochemical pathway whose product is D. Z# mutants are found in five different complementation groups. Z1 mutants will grow on C or D, but not A or B. Z2 mutants will grow on B, C or D. Z3 mutants will only grow on D. Z4 mutants will grow on C or D. Finally, Z5 mutants will grow on A, B, C, or D. Please follow Beadle and Tatum's hypothesis and answer the following questions: (a) Please draw a pathway and place the five complementation groups Z# at the step in the order for synthesizing the corresponding products A, B, C, D. (5 points) (b) What does this genetic information reveal about the nature of the enzyme that carries out the conversion of B to C? (5 points)
6. The flow of genetic information from DNA to RNA to Protein is called "Central Dogma". Please provide short answer for following questions: (a) Where is the "Central Dogma" happened in the cell? (2 points) (b) What is the basic unit of the genetic code relating DNA to protein? (2 points) (c) To produce mature RNA, RNA processing needs to be done. Please describe the essential steps of RNA processing. (4 points) (d) What type of RNA is served as adapter molecule to mediate the translation of mRNA codons to amino acids? What is "wobble" and "wobble position"? (3 points) (e) A ribosome has two subunits, please describe the function of each unit. (4 points)

7. Mutations that alter the nucleotide pairs of DNA can modify any of the steps or products of gene expression.
- (a) Below are four types of mutation which occurs in a gene's coding sequence, please explain how each mutation affects gene's expression
- i. Silent mutation (1 points)
 - ii. Missense mutation (1 points)
 - iii. Nonsense mutation (1 points)
 - iv. Frameshift mutation (1 points)
- (b) What is "gain-of-function" allele? Why are they almost always dominant to wild-type alleles? (5 points)
- (c) Your professor used EMS mutagen to treat Nipponbare rice seeds for several hours. After carefully screening for mutant phenotypes and let the mutants to self-propagate for several generations, you received two mutants, both have purple flowers, but the wild-type Nipponbare has white flower. The professor asked you to make a cross between these two mutants, do you know the rational? Please explain the purpose of this experiment and the genetics behind it. (6 points)

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