

I. True or False (2 points for each question, 20 points)

1. Ribose sugars have a hydroxyl on the 2' carbon.
2. The pyrimidine bases in nucleic acids are cytosine, thymine, and uracil.
3. Okazaki fragments are involved in both lagging and leading DNA strand synthesis.
4. The proofreading function of DNA polymerases involves 5' → 3' exonuclease activity.
5. A promoter is a sequence where DNA replication is initiated.
6. All eukaryotic genes contain an intron.
7. Like nucleic acids, polypeptides have polarity.
8. The codon for methionine appears only at the beginning of the mRNA for a protein, not in the middle or in the end.
9. A special tRNA that does not have an attached amino acid binds to stop codons to terminate translation.
10. In eukaryotes, the 5' cap and the 3' poly(A) tail are involved in translation initiation.

II. Multi-Choice (4 points for each question, 20 points)

1. Please choose the correct descriptions below:
 - (a) A single gene can only have two alleles.
 - (b) Pleiotropy is the condition where a single gene affects multiple phenotypic traits.
 - (c) A trait exhibiting incomplete penetrance is not expressed to the same degree among all individuals expressing it.
 - (d) An incomplete dominance indicates that the F1 progenies show phenotypes that resemble one of the two parents.
2. Haploid cells have
 - (a) One set of chromosomes
 - (b) Two sets of chromosomes
 - (c) One homologous chromosome
 - (d) A pair of homologous chromosomes
3. Which of the following events does not take place in **meiosis I**?
 - (a) Synthesis of DNA
 - (b) Contraction of chromosomes
 - (c) Crossing over
 - (d) Separation of homologous chromosomes
4. What does '50% recombination frequency between two loci' mean for constructing a genetic map between a pair of genes?
 - (a) They are apart for 50 cM on the genetic map
 - (b) They are on the different chromosome.
 - (c) They are on the different linkage group.
 - (d) They are independent assortment.

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5. Please choose the correct descriptions below:

- (a) The chromosome number of a nullisomy is $2n-1$.
- (b) The globe mutant of the Jimson weed was trisomy which is dominant to wild-type and had 25% of progeny showed the globe mutant phenotype when self-fertilized.
- (c) Individuals with Down syndrome, Turner syndrome, or Klinefelter syndrome are aneuploid.
- (d) Non-disjunction in mitosis can results in aneuploids.

III. Assay (60 points)

1. A farmer grew F1 hybrid seeds obtained from a cross of a corn plant setting round purple seeds and a plant setting wrinkled purple seeds. He received four classes of seed phenotypes from 200 F1 hybrids: 28 yellow round, 24 yellow wrinkled, 70 purple round, and 78 purple wrinkled. Are these results consistent with the hypothesis that independently assorting genes control seed color and seed shape, each segregating two alleles? (Note: A1A1, A2A2, B1B1, and B2B2 genotypes show phenotypes for yellow seed, purple seed, round seed, and wrinkled seed, respectively. A and B are two loci controlling seed color and seed shape, respectively.)

- (a) Write down the genotypes of two parents and each class of progenies, and indicate which alleles are dominant. (10 points)
- (b) Verify the hypothesis using the Chi-square independence test. (10 points)

2. In rice, a cross between two inbred lines was made. The hull color of inbred line A is yellow and the hull color of inbred line B is black. All the F1 plants set black hull. Two different hull colors were found in the F2 progenies: 111 for yellow and 153 for black. When the F1 plant backcross to the inbred line A, two different hull colors were also found in the backcross progenies: 52 for yellow and 18 for black. Nevertheless, when the F1 plant backcross to inbred line B, all the progenies produced black hull. Please answer questions below:

- (a) Write the genotype of the inbred lines A and the genotype of the inbred line B using clear defined gene symbols. Please explain the relationships between alleles and/or between genes (epitasis) when it applied. (10 points)
- (b) Please do chi-square goodness-of-fit test to verify your answers using the F2 progenies and the backcross progenies. (10 points)

3. A heterozygous corn with three recessive mutations, *d* (*dwarf*), *tb* (*teosinte branched*), and *sh* (*shrunk*), was testcrossed. The obtained progenies are listed in the right table:

d^+	tb^+	sh^+	67
d	tb^+	sh^+	54
d^+	tb	sh^+	8
d	tb	sh^+	368
d^+	tb	sh	68
d^+	tb^+	sh	347
d	tb	sh	78
d	tb^+	sh	10
Total			1000

- (a) Please use the Chi-square independence test to determine whether these loci are genetically linked. (10 points)
- (b) Draw the genetic map – to indicate the linkage phase, the locus order, genetic distance between loci, and interference if applied. (10 points)

Critical values of the χ^2 distribution					
df	1	2	3	4	5
P=0.05	3.841	5.991	7.815	9.488	11.07