

I. True or False (1.5 points for each question, 30 points)

1. RNA was first identified as the genetic material of the tobacco mosaic virus (TMV) by differential radiolabeling of protein and RNA.
2. The double helical structure of DNA can adopt various forms, which B-DNA is the conformation under physiological conditions; A-DNA occurs in a partially dehydrated environment; the Z-form of DNA is sequence-specific and has a defined role *in vivo*.
3. Centromeres have been exchanged between chromosomes and have been shown to be fully functional at promoting chromosomal segregation of sister chromatids.
4. Polymerases, both prokaryotic and eukaryotic, have 3' → 5' exonuclease activity.
5. Alternative resolutions of the Holliday intermediate are responsible for whether or not crossing over or gene conversion occurs.
6. Most differentiated cells retain most, if not all, of their genes and retain the ability to express those genes under certain circumstances.
7. The wobble hypothesis proposed that the distance and steric constraints of the 3' nucleotide of the anticodon would not allow all types of base pairing with the complementary mRNA to take place.
8. In bacterial and eukaryotic cells, AUG encodes a modified type of methioine, *N*-formylmethionine.
9. Some proteins have signal sequence which helps direct a protein to a specific location within the cell, after which the sequence is retained for full function.
10. Transposable elements are responsible for mutations in a wide variety of organism, in which they can create many alleles for one locus.
11. A geneticist interests in a chemical mutagen, EMS, induces random mutations in a number of genes in rice and then determines which of the resulting mutant lines have impaired function of starch synthesis. This is an example of forward genetics.
12. To use RFLPs for gene mapping because the restriction endonuclease will recognize and cut at different sequences in different samples of the same DNA and the distribution of restriction sites will be different in different individuals.

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13. A population may be in Hardy-Weinberg equilibrium for one locus but not for others.
14. If we examined 20 rabbits all homozygous for genes that produce usual numbers of digits and we found only 18 rabbits having normal number of digits. The heritability would be 0.9.
15. Non-disjunction in mitosis can result in aneuploids.
16. Banana is an autopolyploid plant.
17. The F' bacterial cells contain an F plasmid that has acquired bacterial chromosomal genes.
18. It is possible for two different genes located on the same chromosome to assort independently.
19. Epistasis involves intra-allelic gene interaction.
20. Testercross can be used to build linkage group.

II. Assay (70 points)

1. (12 points) In tomato, a cross between two varieties, 'Yellow Pear' and 'Sweet Princess' was made. The fruit color of 'Yellow Pear' is yellow and the fruit color of 'Sweet Princess' is red. All the F<sub>1</sub> plants set red fruits. However, three different fruit colors were found in F<sub>2</sub> progenies: 51 for red, 18 for orange, and 19 for yellow. When the F<sub>1</sub> plant backcross to 'Yellow Pear', three different fruit colors were also found in the backcross progenies: 8 for red, 10 for orange, and 21 for yellow. Nevertheless, when the F<sub>1</sub> plant backcross to 'Sweet Princess', all the progenies only produced red fruits. Please answer questions below:
  - (a) Write the genotypes of the two parental lines 'Yellow Pear' and 'Sweet Princess' using clear defined gene symbols. Please explain the relationships between alleles (dominance, recessive, or codominance) and/or between genes (epitasis) when it applied. (6 points)
  - (b) Please explain how you deduce the parental genotypes. (6 points)
2. (12 points) You are investigating the inheritance of seed dormancy in sorghum, and you were noticed that this character is likely controlled by genetic maternal effect.

- (a) Please design an experiment to verify the existence of the genetic maternal effect. (6 points)
- (b) If you want to conduct genetic mapping experiment for a trait controlled by the genetic maternal effect using molecular markers, how you can use the genetic materials you created previously in (a) to map gene(s). Please also indicate what generation you will conduct genotyping and phenotyping. (6 points)
3. (24 points) In pea, the following alleles were used in a cross: Y = yellow seeds, y = green seeds; R = round seeds, r = wrinkle seeds; L = long pod, l = short pod. A pea with yellow round seed and long pod is crossed with a pea with green wrinkle seed and short pod, and the F1 progenies were obtained: 18 yellow round long, 21 yellow wrinkle long, 19 green round short, 22 green wrinkle short, 4 yellow round short, 5 yellow wrinkle short, 5 green round long, 6 green wrinkle long.
- (a) What were the genotypes of the two parents in the cross? (4 points)
- (b) Please use the Chi-square independence test to verify genetically linked loci (15 points).
- (c) Please draw the genetic map for these three loci and calculate the genetic distance between adjacent loci. Please use 'map units' to present the genetic distance. (5 points)

Critical values of the $\chi^2$ distribution				
df	1	2	3	4
P=0.05	3.841	5.991	7.815	9.488

4. (5 points) Please write down the major contribution of the following scientists: (a) Fred Griffith, (b) Alfred Hershey and Martha Chase, (c) Rosaline Franklin, (d) James Watson and Francis Crick, and (e) Matthew Meselson and Franklin Stahl.
5. (6 points) PCR (Polymerase Chain Reaction) has been extensively utilized in researches of molecular biology and molecular breeding. Please describe
- (a) the major ingredients and its function in a PCR reaction (2.0 points)
- (b) the major temperature settings and its function for a PCR reaction (1.5 points)
- (c) the major function(s) of primer(s) (1 point)
- (d) the limitations of PCR (1.5 points)
6. (6 points) Describe the roles of each components involving transcription: (a) sigma factor, (b) core RNA polymerase, (c)TFIID, (d) rho factor.
7. (5 points) Positional cloning is used to identify genes corresponding to phenotypes without any knowledge of genes' products. Please describe how to use the positional cloning approach to isolate a target gene and justify which step is critical in the post genomic era.