

**I. True or false (2.0 points for each question, 20 points):**

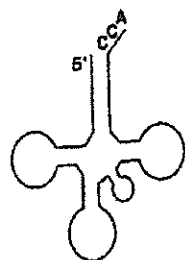
1. In a diploid organism, one gene possesses always two alleles across the species.
2. Entropy and base stacking are the primary factors contributing to the stability of double-stranded DNA.
3. Melting temperature of a DNA sequence depends solely on its GC content.
4. All enzymes are proteins.
5. During electrophoresis, DNA migrates towards the positive end.
6. More an organism is complex, bigger its genome is.
7. The consequence of mobile elements insertion is loss-of-function.
8. Fidelity in DNA replication is assured at each cell cycle.
9. Homologous recombination is not always required for meiosis.
10. A mutation outside the coding region can cause a change in the phenotype of the cell or organism.

**II. Choice (2.0 points for each question, 20 points):** ※ 注意：請於試卷內之「選擇題作答區」依序作答。

1. DNA replication is fully completed at the end of which strand(s) in chromosomes? (A) Leading strand in circular chromosomes (B) Leading strand in linear chromosomes (C) Lagging strand in circular chromosomes (D) All of the above (E) Neither strand
2. Which of the following is not consistent with the other options to describe a given diploid organism? (A)  $2n = 6x = 42$  (B) This organism may be derived from the merging of six different genomes (C) 84 or more than 84 chromosomes can be found in a cell of this organism (D) The ancestor of this organism may have gone through whole genome duplication (E) This organism can be an allopolyploid.
3. Which of the following definitions best describes the term "chromatin"? (A) The basic repeating unit of DNA packaging in eukaryotes (B) The highly condensed DNA structure formed during cell division (C) The whole DNA string (D) The complex of DNA and proteins that forms the eukaryotic chromosome (E) The two copies of DNA that held together at the centromere.
4. Transcriptional regulation requires complex cross-talks between different components. Which one of the following statement is not correct? (A) Epigenetic changes contribute to the regulation of gene expression (B) Modifications on histones influence on gene expression (C) Both histone and DNA methylations are associated to the repression of transcription (D) Most activators and repressors act at the level of transcription initiation (E) Eukaryote regulations use a range of DNA-bind domains, such as helix-loop-helix motif.
5. Electrophoresis is a common tool in molecular biology. Which of the following situation cannot be solved by performing electrophoresis? (A) Examine the size of PCR product (B) Separate topoisomers (C) Identify unknown rice variety using one SSR (D) Preliminary classification of proteins extracted from wheat seedling (E) All of the above.
6. Which of the following is a correct statement regarding a physical change in DNA and a possible resulting informational change? (A) A deletion is most likely to result in a missense mutation (B) Transversions are a common cause of frameshift mutations (C) An insertion will always result in a frameshift mutation (D) A transition mutation can lead to splicing errors (E) Sequence disruptions often result in silent mutations.
7. Phosphorylation of lysine residue number four on the N-terminal tail of core histone protein 2B can ultimately result in the increased expression of nearby gene clusters. Such example is of what level of gene regulation? (A) Transcriptional (B) Translational (C) RNA stability (D) Post-translational (E) Chromatin packing
8. If a replicating cell encounters significant DNA damage during S phase, what is the most likely result? (A) It will arrest in the S phase checkpoint and undergo repair (B) It will immediately trigger apoptosis and die (C) It will utilize bypass polymerases to complete S phase (D) It will utilize telomerase to extend past the damage (E) It will undergo a reductive division.
9. Which one of the following is incorrect? (A) Homologous recombination occurs between any DNA molecules with extensive regions of similar sequence (B) Cell makes use of double strand breaks as a means to increase DNA variation (C) Recombination between repeated sequences can result in chromosome translocation (D) Loss of heterozygosity is rare after recombination through homology (E) Gene conversion can occur after mismatch correction of heteroduplex.

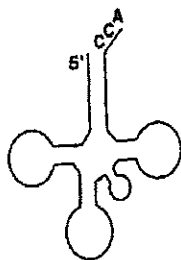
10. Which of the tRNA molecules below is least likely to exist in nature?

(A)



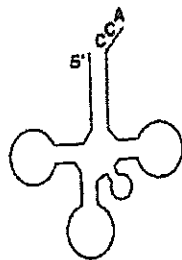
UGA

(B)



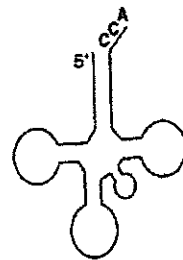
GUU

(C)



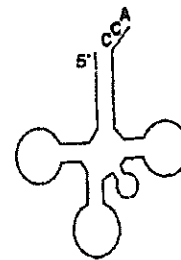
UUC

(D)



CUA

(E)



CAU

III. Assay (60 points):

- (10 points) In the squirting cucumber *Echballium elaterium*, there are two separate sexes (it is dioecious [雌雄異株]), determined not by heteromorphic sex chromosomes, but by specific genes. It is known that the genes involved are *M* (male fertility), *m* (male sterility), *F* (female sterility), and *f* (female fertility). In populations of this plant, individuals can be male (approximately 50 percent) or female (approximately 50 percent). In addition, a hermaphrodite type is found, but only at a very low frequency. The hermaphrodite has male and female sex organs on the same plant. What must be the full genotypes of a male plant, a female plant, and a hermaphrodite plant? How does the possible way that the population maintain an approximately equal proportion of males and females?
- (20 points) Some inbred strains of the weedy plant *Arabidopsis thaliana* flower early in the growing season, but other strains flower at later times. Four different *Arabidopsis* plants (1-4) were crossed, and the resulting progeny was tabulated as follows:

Mating	Progeny
1 x 2	77 early: 81 late
1 x 3	134 late
1 x 4	32 early: 93 late
2 x 3	111 late
2 x 4	65 early: 61 late
3 x 4	126 late

Please ascribe genotypes to each of the four plants. You need to give clear explanations of your answers, including annotation of alleles, the relationships between alleles and their corresponding phenotypes, and interactions between alleles/loci.

- (20 points) *Drosophila* females heterozygous for each of three recessive autosomal mutations with independent phenotypic effects (thread antennae [*th*], hairy body [*h*], and scarlet eyes [*st*]) were testcrossed to males showing all three mutant phenotypes. The 1000 progeny of this testcross were:

<i>th, h, st</i>	432
wild-type	429
<i>th, h</i>	37
<i>th, st</i>	35
<i>h</i>	34
<i>st</i>	33

Draw the best genetic map. You need to explain how you conclude your answer.

- (10 points) *Sub1* is a major locus controlling submergence tolerance in rice (*Oryza sativa*). It has been first identified in a  $F_{2:3}$  population of 169 families as a major locus explaining 69% of the phenotypic variation in an interval of 11 cM, which was further fine mapped to an interval shorter than 1 cM. (A) What would you do to identify the possible candidate gene(s) within the interval? (B) What would you do to provide evidences that your candidate is really responsible for submergence tolerance? (C) What would you do to apply the results to a rice breeding program? (A), 4 points ; (B), 3 points ; (C), 3 points)