

※ 注意：全部題目均請作答於試卷內之「非選擇題作答區」，請標明題號依序作答。

**I. Vocabulary: Choose the phrase from the lower column (a-h) that best fits the terms (1-5) (2 points each)**

- \_\_\_\_\_ 1. conjugation
- \_\_\_\_\_ 2. DNA polymorphism
- \_\_\_\_\_ 3. allele
- \_\_\_\_\_ 4. histone
- \_\_\_\_\_ 5. morphogen

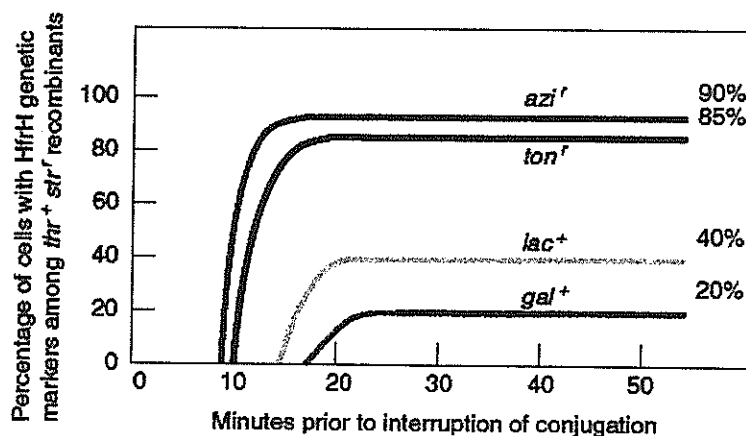
- A. combination of alleles at multiple tightly linked loci that are transmitted together
- B. DNA sequence that occurs in two or more variant forms
- C. require supplements in medium for growth
- D. the transfer of genetic material between bacterial cells by direct cell-to-cell contact
- E. the change in the frequency of a gene variant (allele) in a population due to random sampling
- F. when a null allele is dominant to a wild-type allele
- G. substance whose concentration determines cell fates
- H. the basic unit of DNA packaging in eukaryotes

**II. Multiple Choice: Choose the best answer from a list of options (3 points each)**

1. The presence of a homeodomain in a protein suggests what about its function?
  - A. It has kinase activity
  - B. It is a membrane bound receptor
  - C. It is a secreted protein
  - D. It is a transcription factor
  - E. none of above

2. Jonny did interrupted mating experiments in *E. Coli*. Based on the following results, please determine the gene order as

- A. *azi gal lac ton*
- B. *ton gal lac azi*
- C. *lac ton azi gal*
- D. *azi ton lac gal*
- E. not enough information



3. There are 300 individuals in sample group #1 taken from population X. Seventy-five individuals of sample group are homozygous for the trait in question ( $I^A I^A$ ). Seventy five individuals are homozygous for the trait ( $I^B I^B$ ). Everyone else is heterozygous ( $I^A I^B$ ) for the trait. What is the frequency of allele A in the sample group, assuming the trait is controlled by a single gene?

- A. 0
- B. 0.375
- C. 0.5
- D. 0.75
- E. 1

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4. The hallmark of quantitative traits is that
- Mendel's laws do not apply to these traits.
  - the environment does not influence phenotype.
  - there is never more than one gene involved.
  - they vary continuously in a population of individuals.
  - All of these
- 5-6. Shu-ichi Nakano reported in *Science* in February 2000 that "the RNA enzyme (ribozyme) from hepatitis delta virus catalyzes self-cleavage of a . . . [chemical] . . . bond." This reaction is inherently slow due to the formation of an unfavorable negative charge on the ribozyme. The author goes on to show that this self-cleavage is made faster by joining it with an acid-base reaction that neutralizes the negative charge. Nakano's model describes a positively charged cytosine base on the ribozyme acting as the acid and magnesium hydroxide acting as the base. Specifically, the cytosine donates its proton (H+) to neutralize the unstable negative charge that would have formed on the ribozyme.
5. Which of the following chemical bonds do you think Nakano is referring to in his quote?
- peptide
  - glycosidic
  - phosphodiester
  - ionic
  - hydrogen
6. Refer to Nakano's quote from *Science*. If the cytosine is positively charged (+) before self-cleavage, what would its charge be after self-cleavage?
- + (positive)
  - (negative)
  - 0 (neutral)
  - random between + and -
  - There is no way to predict.
7. In a human karyotype, chromosomes are arranged in 23 pairs. If we choose one of these pairs, such as pair 14, which of the following do the two chromosomes of the pair have in common?
- length and position of the centromere only
  - length, centromere position, and staining pattern only
  - length, centromere position, staining pattern, and traits coded for by their genes
  - They have nothing in common except that they are X-shaped.
  - None of above
8. Quaking aspen can send out underground stems for asexual reproduction. Sexual reproduction is not as common, but when it does happen, the haploid gametes have 19 chromosomes. How many chromosomes are in the cells of the underground stems?
- 9
  - 10
  - 19
  - 38
  - both 19 and 38

9. Twins from two individual zygotes (dizygotic twins)
- A. are related genetically the same as monozygotic twins.
  - B. share 0% genetic similarities.
  - C. are similar in 100% of genetic sequences.
  - D. are related genetically the same as non-twin siblings.
  - E. are similar to the parents.
10. In trying to determine whether DNA or protein is the genetic material, Hershey and Chase made use of which of the following facts?
- A. DNA contains sulfur, whereas protein does not.
  - B. DNA contains phosphorus, whereas protein does not.
  - C. DNA contains nitrogen, whereas protein does not.
  - D. DNA contains purines, whereas protein includes pyrimidines.
  - E. RNA includes ribose, whereas DNA includes deoxyribose sugars.
11. What is a major difference between eukaryotic DNA replication and prokaryotic DNA replication?
- A. Prokaryotic replication does not require a primer.
  - B. Prokaryotic chromosomes have a single origin of replication, whereas eukaryotic chromosomes have multiple origins of replication.
  - C. DNA replication in prokaryotic cells is conservative. DNA replication in eukaryotic cells is semiconservative.
  - D. DNA replication in prokaryotic cells is semiconservative. DNA replication in eukaryotic cells is conservative.
  - E. DNA polymerases of prokaryotes can add nucleotides to both 3' and 5' ends of DNA strands; those of eukaryotes function only in the 5' → 3' direction.
12. Knockout mice have been genetically altered to knock out specific genes. How are these mice most often used in research?
- A. to study DNA replication in the defective genes (those that have been altered)
  - B. to determine the role of proteins coded for by those genes that are knocked out
  - C. to examine defects in DNA structure in those regions that have been altered
  - D. to study the effect of radiation on DNA
  - E. to study cell-cell communication
13. Which of the following is NOT synthesized from a DNA template?
- A. messenger RNA
  - B. amino acids
  - C. transfer RNA
  - D. ribosomal RNA
  - E. DNA
14. All three domains (Bacteria, Archaea, and Eukarya) follow the same genetic code. Therefore, which of the following statements would most likely be correct?
- A. The genetic code evolved three times.
  - B. The genetic code evolved twice in Bacteria and Arthaea independently.
  - C. The genetic code evolved before DNA replaced RNA as the unit of genetic information.
  - D. There were no mutations following the evolution of the genetic code.
  - E. The genetic code evolved before the different domains diverged.

15. The mutation resulting in sickle cell disease changes one base pair of DNA so that a codon now codes for a different amino acid, making it an example of a \_\_\_\_\_.

- A. nonsense mutation
- B. frameshift mutation
- C. silent mutation
- D. missense mutation
- E. nonsynonymous mutation

### III. Short answer questions

1. Explain tumor suppressor (TS) genes and the two-hit hypothesis. (5 points)
2. Describe the general microRNA biosynthesis pathway and how microRNAs regulate gene expression. (10 points)
3. Explain sex determination and dosage compensation in human. (5 points)
4. CRISPR/Cas9 is a modern technique for genome editing and has been applied to many organisms, including human. Explain how CRISPR/Cas9 works to generate genetic modified organisms and how it might cure single gene disorder in human. (10 points)
5. Two hypothetical lizard population found on opposite sides of a mountain in the Arizonan desert have two alleles ( $A^F$ ,  $A^S$ ) of a single gene A with the following three genotype frequencies: (10 points)

	$A^F A^F$	$A^F A^S$	$A^S A^S$
Population 1	38	44	18
Population 2	0	80	20

- a. What is the allele frequency of  $A^S$  in the two populations?
  - b. What is the heterozygosity in the two populations?
  - c. Do either of the two populations appear to be at Hardy-Weinberg equilibrium?
6. If a human trait is determined by maternal contribution, known as maternal effect, would an offspring more resemble his/her mother or his/her father. Explain your answer. (5 points)