

I. Multiple choice (choose the best answer) 3 points each

1. DNA is not completely stable; the spontaneous loss of amino group from adenine, for example, results in hypoxanthine, an unnatural base, opposite thymine. What combination of molecules could the cell use to repair such damage?
 - a. Nuclease, DNA polymerase, DNA ligase
 - b. Telomerase, primase, DNA polymerase
 - c. Telomerase, helicase, single-strand binding protein
 - d. DNA ligase, replication fork proteins, adenase
 - e. Nuclease, telomerase, primase
2. Restriction fragment length polymorphisms
 - a. can be used to detect differences in DNA among individuals
 - b. have been used to identify the Huntington' gene
 - c. can be used to analyze fetal cells to detect disorders prenatally
 - d. are produced through the use of restriction enzymes
 - e. all of the above
3. The establishment of the dorsal-ventral axis in a developing fruit fly embryo is crucial aspect of
 - a. pattern formation
 - b. transcriptional regulation
 - c. apoptosis
 - d. cell division
 - e. induction
4. A gene gun
 - a. blasts DNA into cells, using microscopic pellets
 - b. is used to break DNA apart for analysis
 - c. is used in forensic medicine
 - d. is used to introduce genes into bacteria
 - e. creates RFLPs
5. In *Drosophila*, which genes initiates a cascade of gene activation that includes all other genes in the list?
 - a. homeotic genes
 - b. gap genes
 - c. pair-rule genes
 - d. egg-polarity genes
 - e. segment-polarity genes
6. Mei-Fong and Ming-Da each have a sibling with sickle-cell disease. Neither Mei-Fong, Ming-Da, nor any of their parents has the disease. Based on this incomplete information, calculate the probability that if this couple has a child, the will have sickle-cell disease.
 - a. $1/4$
 - b. $1/16$
 - c. $9/16$
 - d. $1/3$
 - e. $1/9$

7. A man with group A blood marries a woman with group B blood, the blood type of their child may be
- A
 - B
 - O
 - AB
 - All of the above
8. In a population in Hardy-Weinberg equilibrium, the phenotypic frequencies of a tri-allelic locus are $f(AA) = 0.04$, $f(BB) = 0.09$, $f(CC) = 0.25$, $f(AB) = 0.12$, $f(AC) = 0.20$, $f(BC) = 0.50$. Thus the allelic frequency of C is:
- 0.2
 - 0.3
 - 0.4
 - 0.5
 - 0.6
9. In cats, a cross between a cream-colored cat and a red cat always yields a coat color that is pink. However, crosses between pink cats yield cream, pink and red in an approximate 1:2:1 ratio. This type of inheritance is referred to as
- Overdominance
 - Codominance
 - incomplete dominance
 - complete dominance
 - multiple alleles
10. Which of the following statement is correct?
- Skin cells and gametes of the same animal contain the same number of chromosomes.
 - Any chromosome may pair with any other chromosome in the same cell in meiosis.
 - Of ten chromosomes in a mature sperm cell, five are always maternal.
 - Of 22 chromosomes in a primary oocyte, 15 may be paternal.
 - All the sperm from one human male are genetically identical.
11. Which of the following statements is not true for a disease that is inherited as rare X-linked dominant?
- All daughters of an affected male will inherit the disease.
 - Sons will inherit the disease only if their mothers have the disease.
 - Both affected males and affected females will pass the trait to half the children.
 - Daughters will inherit the disease only if their father has the disease.
 - None of above.
12. In *Escherichia coli*, which of the following repair system does not require the activity of DNA polymerase?
- excision repair
 - mismatch repair
 - photoreactivation
 - SOS repair
 - None of above

13. Which of the following mutants will stop synthesizing Okazaki fragments after a shift to nonpermissive temperatures in rapidly growing cultures of mutants defective in the following functions:
- the DnaA proteins interacted with replication origin
 - DNA polymerase I
 - DNA polymerase III
 - DNA ligase (*lig*)
 - All of above
14. Specificity in translation is not maintained by using
- amino-acyl tRNA synthetases
 - ribosome
 - a degenerate triplet code having codons for each amino acid
 - RNA polymerase
 - an anticodon
15. In *Sciadopitys verticillata*, the somatic tissue has 20 chromosomes. What is the least linkage groups expected to be?
- 5
 - 10
 - 20
 - 40
 - 80
16. Choose the wrong statement about mutations.
- Mutations are caused by genetic recombination.
 - Mutations are heritable changes in genetic information.
 - Mutations can be induced by chemicals.
 - Mutations are not always beneficial to the development of the individuals in which they occur.
 - Mutations can be induced by individual needs.
17. Which of the following mutation will exert a mutator effect?
- mutation results in the loss of proof reading activity
 - mutation of the adenine methylation activity in *Escherichia coli*
 - mutation leads to a loss of mismatch repair
 - mutation promotes the transposition of an insertion element
 - all of above
18. Chromatids joined together by a centromere are called
- sister chromatids
 - homologs
 - alleles
 - bivalents
 - tetrads

19. In *Drosophila* mutants A, B, C, D, E, F, and G all have the same phenotype: the absence of red pigment in the eyes. In pairwise combinations in complementation tests the following results were produced, where + = complementation and - = no complementation.

	A	B	C	D	E	F	G
G	+	-	+	+	+	+	-
F	-	+	+	-	+	-	
E	+	+	-	+	-		
D	-	+	+	-			
C	+	+	-				
B	+	-					
A	-						

How many genes are responsible for the phenotype?

- 1
 - 2
 - 3
 - 4
 - 5
- 20 For the complementation analysis results shown in question 19, which mutants have defects in the same gene?
- D, E, G
 - A, B, C, E
 - A, E
 - A, D, F
 - A, D

II. Filling blank (Please write answers in designated area)

1. Mutation can alter the function of an operon; in fact, it was the effects of various mutations that enabled Jacob and Monod to figure out how the *lac* operon works. Predict how the following mutations would affect *lac* operon function in the presence and absence of allo-lactose (an "inducer"). (8 points)

Put down "+" or "-" for expression or no expression

- Mutation of regulatory gene; repressor will not bind to lactose.
- Mutation of regulatory gene; repressor will not bind to operator.
- Mutation of operator; repressor will not bind to operator.
- Mutation of promoter; RNA polymerase will not bind to promoter.

2. Although the human genome project is largely completed, mappings of certain human genes, particular those sequences are not yet known, are still relied on the "hybridized cells" technique. Consider the following set of eight hybridized human-mouse cell lines:

Cell line	Human Chromosome								
	1	2	6	9	12	13	17	21	X
A	+	+	-	q	-	p	+	+	+
B	+	-	p	+	-	+	+	-	-
C	-	+	+	+	p	-	+	-	+
D	+	+	-	+	+	-	q	-	+
E	p	-	+	-	q	-	+	+	q
F	-	p	-	-	q	-	+	+	p
G	q	+	-	+	+	+	+	-	-
H	+	q	+	-	-	q	+	-	+

Each cell line may carry an intact (numbered) chromosome (+), only its long arm (q), only its short arm (p), or it may lack the chromosome (-).

The following human enzymes were tested for their presence (+) or absence (-) in cell line A-H:

Enzyme	Cell line							
	A	B	C	D	E	F	G	H
Steroid sulfatase	+	-	+	+	-	+	-	+
Phosphoglucomutase-3	-	-	+	-	+	-	-	+
Phosphofructokinase	+	-	-	-	+	+	-	-

Identify the chromosome carrying each enzyme locus. Where possible, identify the chromosome arm. (6 points)

III. Short essay

1. The normal sequence of marker on a certain *Drosophila* chromosome is

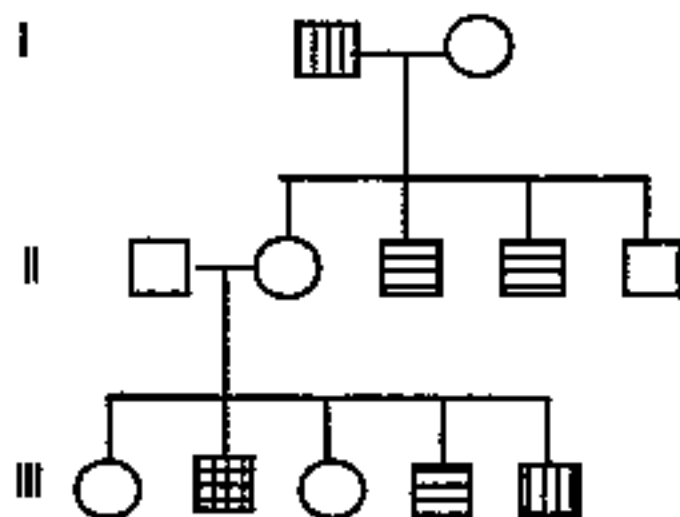
123 • 456789

where the dot represents the centromere. Some flies were isolated with chromosome aberrations that have following structures:

- (a) 123 • 476589
 (b) 123 • 46789
 (c) 123 • 4566789.

- a. Name each type of chromosome mutation (3 points)
 b. Draw diagrams to show how each would synapse with the normal chromosome (6 points).

2. In the following pedigree, the vertical lines stand for protan color blindness (p), and the horizontal lines stand for deutan color-blindness (d). These are separate conditions causing different misperceptions of colors; each is determined by a separate gene.



- Does the pedigree show any evidence that the genes are linked? (3 points)
 - If there is linkage, does the pedigree show any evidence of crossing-over? Explain both your answers with the aid of the diagram. (4 points)
3. Two fruit flies of wild-type phenotype were crossed, and in the progeny there were 202 females and 98 males.
- What is unusual about this result? (3 points)
 - Provide a genetic explanation. (4 points)
 - Provide a test of your hypothesis. (3 points)