KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN BIOTECHNOLOGY

SBC 321: GENE MAPPING TECHNIQUES

DATE: Monday, 2nd April, 2012 TIME: 11.00 a.m. – 1.00 p.m.

SECTION A: Answer ALL the questions (20 marks)

Choose the most correct Answer

1. Linked genes:
   A. are located near each other on the same chromosome.
   B. violate the law of independent assortment.
   C. segregate together during meiosis.
   D. All of the above.
2. What was unique about the chromosomes studied by Creighton and McClintock?
   A. They carried different alleles for two linked genes.
   B. They were unable to cross over.
   C. These chromosomes were unable to synapse during meiosis I.
   D. Physical structures of the chromosomes allowed them to be distinguished from each other.
3. Using tetrad analysis, a ratio of 1 PD: 1 NPD: 4 T indicates that the two loci being tested are:
   A. allelic
   B. linked
   C. centromere linked
   D. unlinked
4. The pairwise map distances for four linked genes are as follows: A-B = 22 m.u., B-C = 7 m.u., C-D = 9 m.u., B-D = 2 m.u., A-D = 20 m.u., A-C = 29 m.u. What is the order of these four genes?

A. ABCD
B. ADBC
C. ABDC
D. BADC

5. The measured distance between genes D and E in a two point test cross is 50 map units. What does this mean in physical terms?
   A. D and E are on different pairs of chromosomes.
   B. D and E are linked and exactly 50 map units apart.
   C. D and E are linked and at least 50 map units apart.
   D. either a or c
6. In Drosophila, the genes b, c and sp are linked and in the order given, the distances being b-c = 30 m.u. and c-sp = 20 m.u. These intervals exhibit 90% interference. How many double crossovers would be recovered in a three-point cross involving b, c and sp out of 1000 progeny?
   A. 3
   B. 6
   C. 54
   D. 60
7. In tetrad analysis, NPD asci result from:
   A. independent assortment of unlinked genes.
   B. double crossovers between linked genes.
   C. single crossovers between a gene and a centromere.
   D. a or b
8. What is a convenient way to identify gene order in a trihybrid mapping cross?
   A. Look for double crossover progeny and identify the gene that was flipped relative to parentals.
   B. Look for the largest class of single crossovers and the two genes are the ones on the ends.
   C. Look for the smallest class of single crossovers to identify the genes which are closest together.
   D. A and B only.
9. Why is tetrad analysis useful for studying genetics?
   A. Cells within a tetrad are haploid so genotype is directly reflected in the phenotype.
   B. Cells within a tetrad reflect the events of meiosis.
   C. Analysis of simple systems can elucidate general rules that apply more broadly.
   D. All of the above.
10. You set up a mapping cross involving two genes in *Aspergillus* and determine the following percentages of tetrad types: parental ditype 51%, nonparental ditype 49%. What can you say about your genes?
   A. They are closely linked.
   B. They are unlinked.
   C. They are lethal.
   D. They are not expressed in the phenotype.

11. Which of the following processes can generate recombinant gametes?
    A. Segregation of alleles in a heterozygote.
    B. Crossing over between two linked heterozygous loci.
    C. Independent assortment of two unlinked heterozygous loci.
    D. b and c
12. Which of these is a key characteristic of a molecular marker?
    A. It is a known gene.
    B. It is located at a known site on the chromosome.
    C. It is only useful for linkage and physical mapping studies.
    D. None of these.
13. Which of these describes a contig?
    A. A complete genomic library including overlapping clones.
    B. A complete mRNA library.
    C. A chromosome-specific library of overlapping clones.
    D. An ordered genomic library.

14. Sequencing of genomes other than humans is potentially valuable because:
    A. Disorders of cellular function can be studied in relatively simple model systems.
    B. Comparison of gene sequences between different species can allow prediction of disease-causing mutations.
    C. Genes may have a similar function in other species, giving us a place to start with functional analysis of similar genes.
    D. None of these.
15. Which of the following is a description of generalized transduction?
    A. Inaccurate excision of prophage can occasionally remove a small portion of the bacterial chromosome.
    B. Random pieces of bacterial DNA can become incorporated into a phage coat.
    C. Pieces of bacterial DNA may be released into the culture medium when a cell is lysed.
    D. All of these.
16. In deletion mapping, mutations can be localized to a region of the gene because:
    A. the mutation fails to complement other mutations in the gene.
    B. the mutation fails to complement a deletion of a known portion of the gene.
    C. the gene sequence can be determined.
    D. A and B.
17. Packaging of chromosomal DNA into a virus produces a(n):
    A. transposable element
    B. Hfr strain
    C. plasmid
    D. transducing phage
18. Isolation of bacteria resistant to penicillin would be considered a _____, while isolation of bacteria able to utilize lactose as a carbon source is a _____.
    A. screen; selection
    B. selection; screen
    C. transformation; conjugation
    D. conjugation; transformation

19. To demonstrate transformation in the lab, you would need
    A. donor DNA and recipient cells
    B. recipient DNA and DNA ligase
    C. male and female cells
    D. any of the above is correct
20. Specialized transduction can be distinguished from generalized transduction by the fact that
    A. homologous recombination is involved in the former but usually not the latter
    B. transducing particles are involved in the former but usually not the latter
    C. a selective medium is required to demonstrate the former but usually not the latter
    D. lysogeny is involved in the former but usually not the latter

SECTION B: Answer ALL the questions (5 Marks each; 30 Marks))

1. a) A strain of Neurospora with the genotype MN is crossed with a strain that is mn. Half the progeny are MN and half are mn. Explain these results. (1 Mark)

c) In another Neurospora strain, the cross AB x ab was made and 100 asci were scored:

I	II	III	IV	V	VI	VII
A B	A B	A B	A B	A B	A b	A b
A B	A B	A B	A B	A B	A b	A b
A B	A b	a B	a b	a b	a B	A b
A B	A b	a B	a b	a b	a B	A b
a b	a B	A b	A B	A b	A b	a B
a b	a B	A b	A B	A b	A b	a B
a b	a b	a b	a b	a B	a B	a B
a b	a b	a b	a b	a B	a B	a B
39	16	32	2	6	4	1

i. Which classes are the PDs, NPDs & Ts? (1 mark)
ii. Which class(es) are second division segregations? (1 Mark)
iii. What is the map of these genes and any linked centromere(s)? (2 Marks)
iv. How do we know that crossing-over is reciprocal? (1 Mark)

2. How are the following techniques used in eukaryotic gene mapping?
    a) Somatic hybridisation (21/2 marks)
    b) Restriction mapping (21/2 marks)
3. List five (5):
    a) objectives of human genome project. (21/2 Marks)
    b) envisaged applications of human genome project. (21/2 Marks)

4. a) Explain why geneticists prefer to perform one three-point cross rather than three two-point crosses when mapping three genes, why do geneticists? Give two reasons. (2 Marks)

b) Five sex-linked recessive genes of *Drosophila* (*ec*, *sc*, *v*, *cv*, and *ct*) produce traits called echinus, scute, vermilion, crossveinless, and cut, respectively. Echinus is a mutant producing rough eyes with large facets. Scute manifests itself by the absence or reduction in the number of bristles on certain parts of the body. Vermilion is a bright orange-red eye color. Crossveinless prevents the development of supporting structures in the wings. Cut produces scalloped and pointed wings with manifold (pleiotropic) effects in other parts of the body. At the beginning of our experiments we do not know the gene order. From the results of the following three experiments, construct a genetic map for this region of the X chromosome. Whenever possible use weighted averages. (3 Marks)

Experiment 1. Echinus females crossed to scute, crossveinless males produced all wild-type females and all echinus males in the F^1. When the F^1 females were testcrossed, the results (including both male and female progeny) were as follows:

810	echinus	89	scute
828	scute, crossveinless	62	echinus, scute
88	crossveinless	103	echinus, crossveinless

Experiment 2. Crossveinless females crossed to echinus, cut males produced all wild-type females and all crossveinless males in the F_1. When the F_1 females were testcrossed, the results (including both male and female progeny) were as follows:

2207	crossveinless	223	crossveinless, cut
2125	echinus, cut	217	echinus
273	echinus, crossveinless	5	wild type
265	cut	3	echinus, crossveinless, cut

Experiment 3. Cut females crossed to vermilion, crossveinless males produced all wild-type females and cut males in the F_1. When the F_1 females were testcrossed, the results (including both male and female progeny) were as follows:

766	vermilion, crossveinless	73	vermilion
759	cut	85	crossveinless, cut
140	vermilion, cut	2	wild type
158	crossveinless	2	vermilion, crossveinless, cut

5. Define the following terms with respect to gene mapping in bacteria (1 Marks each)
   a) Competent cells
   b) Cotransformation
   c) Abortive infection
   d) Interrupted mating
   e) Transducing phage

6. What is linkage? Outline Morgan's experiment in support of the view that linkage is not always complete (5 Marks)

SECTION B: Answer ALL the questions (5 Marks each; 30 Marks))

1. a) With the aid of a flow diagrams illustrate the basic features of an experiment to map genes in a bacterium (2 marks)

b) In *E. coli,* four Hfr strains donate the following genetic markers shown in the order donated:

Strain 1:	Q	W	D	M	T
Strain 2:	A	X	P	T	M
Strain 3:	B	N	C	A	X
Strain 4:	B	Q	W	D	M

All of these Hfr strains are derived from the same F^+ strain. What is the order of these markers on the circular chromosome of the original F^+?

a) In an Hfr × F^- cross, *leu*$^+$ enters as the first marker, but the order of the other markers is unknown. If the Hfr is wild type and the F^- is auxotrophic for each marker in question, what is the order of the markers in a cross where *leu*$^+$ recombinants are selected if 27 percent are *ile*$^+$, 13 percent are *mal*$^+$, 82 percent are *thr*$^+$, and 1 percent are *trp*$^+$?

b) A cross is made between an Hfr that is *met*$^+$*thi*$^+$*pur*$^+$ and an F^- that is *met*$^-$*thi*$^-$*pur*$^-$. Interrupted-mating studies show that *met*$^+$ enters the recipient last, so *met*$^+$ recombinants are selected on a medium containing supplements that satisfy only the *pur* and *thi* requirements. These recombinants are tested for the presence of the *thi*$^+$ and *pur*$^+$ alleles. The following numbers of individuals are found for each genotype:

met$^+$ *thi*$^+$ *pur*$^+$	280
met$^+$ *thi*$^+$ *pur*$^-$	0
met$^+$ *thi*$^-$ *pur*$^+$	6
met$^+$ *thi*$^-$ *pur*$^-$	52

i) Why was methionine (Met) left out of the selection medium?

(1 Mark)

ii) What is the gene order? (4 Marks)

iii) What are the map distances in recombination units? (3 Marks)

1. Explain the principles underlying the applications of the following techniques in mapping
   a) Somatic hybridisation (5 Marks)
   b) Fluorescent *in situ* hybridisation (FISH) (5 Marks)

2. Distinguish between
   a) Contig maps and cytogenetic maps (5 Marks)
   b) VNTRs and STRs (5 Marks)