

## Bio 97 Section D 2006 solved exam

Bio97 Section D

NAME: \_\_\_\_\_

MULTIPLE CHOICE: Each is worth 1 point.

1. If there is one crossover in every 50 cells undergoing meiosis, this is equivalent to:
  - A. 10 centiMorgans
  - B. 2% recombination
  - C. 0.5% recombination
  - D. 0.5 map units
  - E. 1 centiMorgan**
  
2. Toby discovers that butterflies in his garden make a bigger protein than butterflies in everybody else's garden. He believes this may be why they are particularly beautiful. Toby finds that the beauty protein in his butterflies is 20 amino acids longer than the normal beauty protein. This could be due to:
  - A. hypermorphic mutation
  - B. missense mutation
  - C. conditional mutation
  - D. frameshift mutation**
  - E. silent mutation
  
3. In a mating between Hfr and F<sup>-</sup> cells,
  - A. The Hfr donor becomes F<sup>+</sup> and the F<sup>-</sup> recipient remains F<sup>-</sup>
  - B. The Hfr donor becomes F<sup>+</sup> and the F<sup>-</sup> recipient becomes Hfr
  - C. The Hfr donor becomes F<sup>-</sup> and the F<sup>-</sup> recipient becomes F<sup>+</sup>
  - D. The Hfr donor remains Hfr and the F<sup>-</sup> recipient becomes F<sup>+</sup>
  - E. The Hfr donor remains Hfr and the F<sup>-</sup> recipient remains F<sup>-</sup>**
  
4. Which one of the following statements is TRUE:
  - A. Transposable elements are mutagenic.**
  - B. When DNA is damaged, it always leads to mutations.
  - C. All mutagens damage DNA in the same way.
  - D. A transition substitution replaces a pyrimidine with a purine.
  - E. Humans have very few transposable elements.
  
5. A coefficient of coincidence of 0.25 means that:
  - A. The frequency of double crossovers is 1/4.
  - B. The frequency of double crossovers is 1/4 of the number expected if there were no interference.**
  - C. There were four times as many single crossovers as double crossovers.
  - D. There were four times as many single crossovers in one region as there were in an

- adjacent region.
- E. There were four times as many parental as recombinant progeny.
6. Selection for or against a recessive allele in diploids is inefficient when  
**A. the recessive allele is rare.**  
B. the recessive allele is frequent.  
C. the frequencies of the recessive allele in males and females are different.  
D. the population is not in Hardy-Weinberg equilibrium.
7. A process in which DNA is transferred from a bacterial donor cell to a recipient cell by cell-to-cell contact is known as  
A. specialized transduction.  
B. generalized transduction.  
C. transformation.  
**D. conjugation.**  
E. recombination.
8. Based on your knowledge of the following processes, which of the following are major contributors to the rapid spread of antibiotic resistance among bacteria?  
A. transduction  
B. conjugation  
C. transposition  
**D. B and C**  
E. A, B and C
9. An enzyme that cleaves DNA at sequence-specific sites is called  
A. DNA polymerase  
B. ligase  
**C. restriction endonuclease**  
D. exonuclease  
E. integrase
10. The technique to look for possible gene function by mutating wildtype genes is called  
A. gene therapy.  
**B. reverse genetics.**  
C. transgenetics.  
D. contig building.  
E. gene mapping.
11. What is the reaction catalyzed by the enzyme reverse transcriptase?  
**A. Synthesis of DNA from a single-stranded RNA molecule**  
B. Synthesis of RNA from a DNA template

- C. Circularization of restriction fragments
- D. Cleavage of DNA at a sequence-specific site
- E. Ligation of DNA fragments

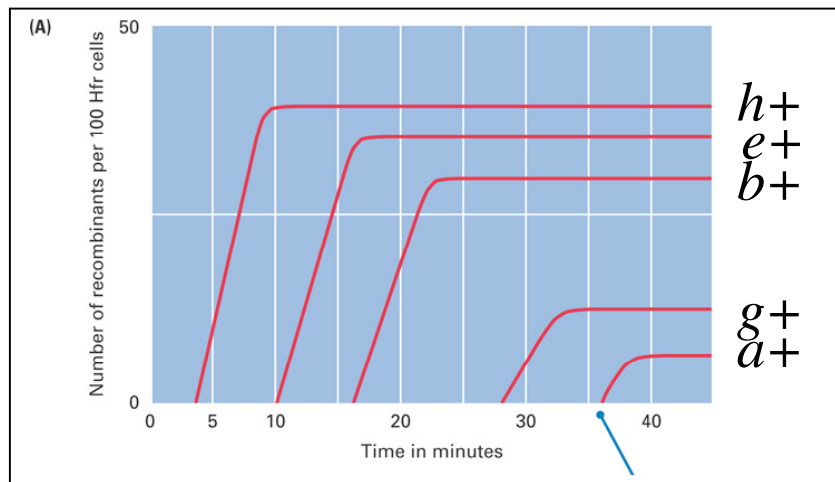
12. Three crosses were performed involving the linked genes *Apa*, *Bass* and *Dmb*. The *Apa* gene has alleles *A* and *a*, the *Bass* gene has alleles *B* and *b*, and the *Dmb* gene has alleles *D* and *d*. The genotypes obtained, and the frequency at which they were obtained, is given below:

AB/ab x ab/ab	41% AB, 39% ab, 9% Ab, 11% aB
BD/bd x bd/bd	37% BD, 33% bd, 16% Bd, 14% bD
AD/ad x ad/ad	43% AD, 44% ad, 7% Ad, 6% aD

The best map of the *Apa*, *Bass* and *Dmb* genes is:

- A. *Apa* ---20cM--- *Bass* ---30cM--- *Dmb*
- B. *Bass* ---10cM--- *Apa* ---6cM--- *Dmb*
- C. *Dmb* ---13cM--- *Apa* ---20cM--- *Bass***
- D. *Bass* ---30cM--- *Dmb* ---13cM--- *Apa*
- E. *Dmb* ---15cM--- *Apa* ---15cM--- *Bass*

13. At time zero, an *Hfr* strain was mixed with an *F*- strain, and at various times after mixing, samples were removed and agitated to separate conjugating cells. The samples were plated onto selective media to identify recombinants in the recipient strain. A graph of the number of recombinants against time is shown in the accompanying figure.



Which of the following statements is TRUE? (there may be more than one). THROWN OUT BECAUSE the scantron cannot grade more than one right answer.

- A. All cells that received *a+* from the *Hfr* in the chromosome transfer process must also have received *b+*.**
- B. The order of gene transfer from *Hfr* to *F*- was *a+* first, then *g+*, then *b+*, then *e+* and finally *h+*

- C. All of the  $b^+$  recombinants plated at 25 minutes are also  $e^+$ .**  
D. None of the  $e^+$  recombinants plated at 30 minutes are also  $g^+$ .  
E. All cells that received  $e^+$  from the *Hfr* in the chromosome transfer process must also have received  $b^+$ .
14. Phenylketonuria is an inborn error of metabolism caused by autosomal recessive gene. The frequency of this allele in the population is 0.03. Assuming Hardy-Weinberg equilibrium, what is the expected incidence of phenylketonuria among the offspring of all matings in which both parents are found to be carriers?  
A. 0.0009  
B. 0.03  
**C. 0.25**  
D. 0.5  
E. 0.0145
15. Recombination frequencies THROWN OUT  
A. are the same for all genes  
B. arise from completely random genetic exchange  
C. are not the same for *cis* and *trans* heterozygotes  
D. decrease with distance  
E. are not always related to distance
16. In a population in Hardy-Weinberg equilibrium, the frequency of the allele for Hartnup disease is 0.008. What is the percentage of the population that is heterozygous for this allele?  
A. 0.008%  
B. 0.08%  
**C. 1.59%**  
D. 3.2%  
E. 98.4%
17. Inbreeding results in  
A. increased frequency of heterozygotes.  
**B. increased frequency of homozygotes.**  
C. increased frequency of rare recessive alleles.  
D. increased frequency of dominant alleles.
18. Which of the following processes does not contribute to changing allele frequencies in populations?  
A. Mutation

**B. Inbreeding**

- C. Migration
- D. Natural selection
- E. Genetic drift

19. The difference in the mean length of corolla tube between two lines of tobacco is 6 mm and the genotypic variance is estimated as  $1.12 \text{ mm}^2$ . What is the minimum number of genes affecting this trait?  $M' = M + h^2(M^* - M)$ ;  $n = D^2/8s_g^2$ ;  $H^2 = s_g^2/s_p^2$

- A. 1
- B. 2
- C. 4**
- D. 8
- E. 12

20. Cancer cells are characterized by

- A. activation of apoptosis.
- B. increased contact inhibition.
- C. low telomerase activity.
- D. uncontrolled proliferation.**
- E. All of the above

21. Which one of the following statements is FALSE:

- A. Recombinant protein can be generated through transcription and translation of a vector in a eukaryotic cell.
- B. Recombinant DNA is generated in the laboratory.
- C. A transgenic mouse maintains a plasmid episomally in all of its cells.**
- D. To clone a mammal you need to inject a nucleus from an adult cell into an enucleated embryonic cell and implant this into a surrogate mother.
- E. GM foods are basically transgenic plants or animals.

22. The variance calculated from a distribution of phenotypes equals zero when

- A. all individuals have different phenotype.
- B. the standard deviation equals one.
- C. approximately 50% of the population has the same phenotype.
- D. all individuals have the same phenotype.**
- E. the trait is a threshold trait.

23. Which one of the following statements is FALSE:

- A. Transformation mutations arise from mutations in homeotic genes.
- B. The homeotic genes encode transcriptional activator proteins.

**C. A determined cell is capable of differentiating into a complete organism.**

- D. Genes that are regulated by Bicoid have different sensitivities to its concentration.  
 E. Developmental genes are often controlled by gradients of gene products across parts of the embryo.

24. Your friend, Daisy, wants to know if she will also develop colon cancer. Her father developed colon cancer. He was adopted and nothing is known about his family. Because you are now an expert on cancer from your Genetics class, you reason that:

- A. Since Daisy's mother didn't have colon cancer, Daisy has a 50% chance of getting colon cancer.  
 B. Even though Daisy's mother didn't have colon cancer, Daisy could have a 50% chance of getting colon cancer since her mother could be a carrier.  
 C. Daisy has virtually 100% chance of getting colon cancer.  
**D. Daisy is just as likely to have a 0% chance of getting colon cancer as she has a 50% chance of getting colon cancer.**  
 E. Your brain is mush and you can't reason anything out!

SHORT ANSWER SECTION: **Answer on the answer sheet that follows this section.** Write legibly and keep your answers as short as possible. Points are indicated for each question.

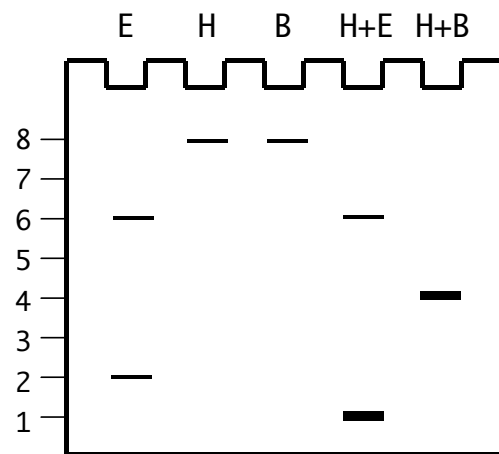
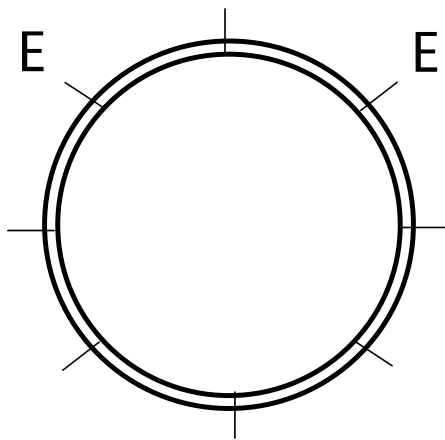
25. In a mating of Hfr *pro*<sup>+</sup> *trp*<sup>+</sup> *ala*<sup>+</sup> *tet-s* x F<sup>-</sup> *pro*<sup>-</sup> *trp*<sup>-</sup> *ala*<sup>-</sup> *gly*<sup>+</sup> *tet-r*, cells are interrupted after several minutes and plated on the media containing various amino acids shown below. The tet marker is known to be transferred very late. Based on the number of colonies, what is the order of gene transfer? 2 PTS

<u>Amino acid free media with the following amino acids added</u>	<u># of colonies</u>
proline + alanine	290 colonies
tryptophan + proline	120 colonies
tryptophan + alanine	45 colonies

**Ans: The gene order is *trp-ala-pro*.**

**NOTE: amino acid free media supplemented with tryptophan and proline is selective for alanine. no partial**

26. You have asked Esmé to digest an 8 kb plasmid with the restriction endonucleases EcoRI, BamHI and HindIII. She runs the resulting fragments on a gel and shows the gel to you. Fill in the necessary sites on the plasmid that are consistent with the gel Esmé has shown you. E = EcoRI, H = HindIII, B = BamHI. The plasmid has been divided into 1 kb increments for you and 2 EcoRI sites are indicated. 1PT



**H between two E's and B directly opposite H 1 PT NO PARTIAL CREDIT**

27. Toby has isolated genomic DNA from 10 healthy volunteers. His plan is to identify those volunteers that are homozygous for the same allele of SSR9212. But he has no idea how to proceed. Use the given list and order the FOUR steps Toby should take. 2 PTS 2 PTS, YOU HAD TO HAVE THE RIGHT PROCEEDURE IN THE RIGHT STEP TO GET 0.5 PTS FOR EACH STEP.

- 1. restriction digest**

- |  |   |
|--|---|
| 2. run a DNA agarose gel   | hybridize probe homologous to<br>SSR9212  |
| 3. transfer the gel to a<br>membrane/Southern blot                           | restriction digest<br>transform bacteria/recover lots of<br>DNA   |
| 4. hybridize probe homologous to<br>sequence directly adjacent to<br>SSR9212 | inject into Drosophila<br>PCR amplify<br>run a DNA agarose gel<br>hybridize probe homologous to<br>sequence directly adjacent<br>to SSR9212<br>ligate into vector<br>transfer gel to<br>membrane/Southern blot<br>ligate into P element vector<br>find an SSR |

28. The ability to taste the compound PTC is controlled by a dominant allele. In a population in Boston, 126 individuals could taste the compound and 54 could not. Of the 126 individuals that could taste the compound, how many were heterozygous for this allele? 2 PTS

**Ans: The allelic frequency are calculated as follows:  $q^2 = 54/180 = 0.3$ . Therefore,  $q = 0.547$  and  $p = (1 - 0.5472) = 0.45$ . The genotypic frequencies are  $p^2 = 0.205$ ,  $2pq = 0.492$  and  $q^2 = 0.299$ . answer is  $.495 \times 180 = 89.1$ .**

**(90 accepted for those few students who rounded .495 to .5 and then multiplied .5 x 180 to get 90)**

29. The mean length and variance of stem length in two highly homozygous varieties of roses and their progeny are shown below. Calculate the broad-sense heritability.

$H^2 = \sigma_g^2 / \sigma_p^2$  2 PTS

Variety	Mean Length (cm)	Variance (cm <sup>2</sup> )
I short	40.47	3.124
II long	93.75	3.876
F <sub>1</sub>	63.90	4.743
F <sub>2</sub>	68.72	47.708

**Ans: the F1 generation variance is entirely due to environmental variance so  $4.743 = s_e^2$ . The F2 generation variance is the total variance so  $47.708 = s_p^2$ . Subtract to get  $s_g^2 = 47.708 - 4.743 = 42.965 = \text{genetic variance}$   
 $42.965 / 47.708 = .90 = H^2$  NO PARTIAL**

30. Bax is a protein that promotes apoptosis and is normally kept inactive in healthy cells by Bcl-2. Mutations in Bax are found in cancer cells. 1.5 PTS, 0.5 pts each

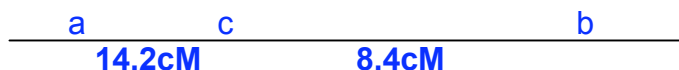
- What sort of gene is Bax? **tumor suppressor gene**
- What type of mutations might be found in this gene in cancer cells?  
**loss of function**
- Will these mutations be recessive or dominant?  
**recessive**

**For this question we accepted many answers that showed that you had the right idea (i.e. hypomorph or cancer suppressor or many other variations)**

31. Construct a genetic map based on the progeny genotypes from the three-point cross below in which the  $F_1$   $a/+ \cdot b/+ \cdot c/+$  was crossed to  $a/a \cdot b/b \cdot c/c$ . Show the order of the genes and the distances between them. Be sure to indicate the units you use in the map. 3 PTS

$+$	$+$	$+$	1242
$+$	$+$	$c$	7
$+$	$b$	$+$	128
$a$	$+$	$+$	206
$+$	$b$	$c$	218
$a$	$+$	$c$	114
$a$	$b$	$+$	15
$a$	$b$	$c$	1216
Total:			3146

**Ans:** The way to deduce the genotype of the triply heterozygous parent is to note that the most common classes of offspring are nonrecombinants, in this case  $a+ b+ c+$  and  $aa bb cc$ , hence the genotype in question is  $+++/abc$ . To deduce what gene is in the middle it is necessary to find out double recombinant classes and compare them to parental types. Double recombinants are the least common, in this case  $a+ b+ cc$  and  $aa bb c+$ . Only alleles of  $c$  have changed their position with respect to the parental combination, therefore the order of the genes is  $a c b$  (or  $b c a$ ). The distance between  $a$  and  $c$ , is  $R_1 = (206 + 218 + 15 + 7)/3146 = 0.142$ , or 14.2%; the distance between  $c$  and  $b$ , is  $R_2 = (128 + 114 + 15 + 7) = 0.084$ , or 8.4%



OR  $\frac{b}{8.4cM} \quad \frac{c}{14.2cM} \quad a$

also correct if used map units or %, correctly. YOU NEEDED TO INDICATE UNITS TO GET CREDIT—THE PROBLEM STATED THAT. WE ACCEPTED ANSWERS THAT ROUNDED CORRECTLY TO THE NEXT WHOLE NUMBER.

32. In a chromosome region having the map A—8cM—B—20cM—D, and a coefficient of coincidence equal to 0.2, how many progeny of the phenotype  $A\_bbdd$  will there be among 1000 progeny of the testcross  $ABD/abd \times abd/abd$ ? 4 PTS

looking for one-half of the single recombinants between a and b.  
 $.08 \times .2 \times .2 = .0032 = \text{dco observed}$   
 $.08 - .0032 = .0768$   
 $.0768/2 = .0384$   
 The answer is 38.

33. You have been given the task in your Bio199 research lab to determine whether the *Drosophila* genes *b* and *vg* are linked. 2 PTS, 0.5 pts each part

*b* = black body, recessive  
*b*<sup>+</sup> = gray body  
*vg* = small wings, recessive  
*vg*<sup>+</sup> = normal wings

You testcross the F1 female that is heterozygous for both loci; recessive loci are in *trans* in this F1 female.

- A. What is the genotype of the female in the testcross?  
 **$vg^+ b / vg b^+$  INCORRECT USE OF NOMENCLATURE—0 PTS**
- B. What is the genotype of the male in the testcross?

**$vg b / vg b$**

You observe the following (phenotypes and genotypes left out—you don't need to fill this out, it is only to help you work out the problem):

phenotype of progeny	genotype of maternal gamete	# of flies
normal wings, black body	$vg^+ b$	335
small wings, gray body	$vg b^+$	339
normal wings, gray body	$vg^+ b^+$	165
small wings, black body	$vg b$	161

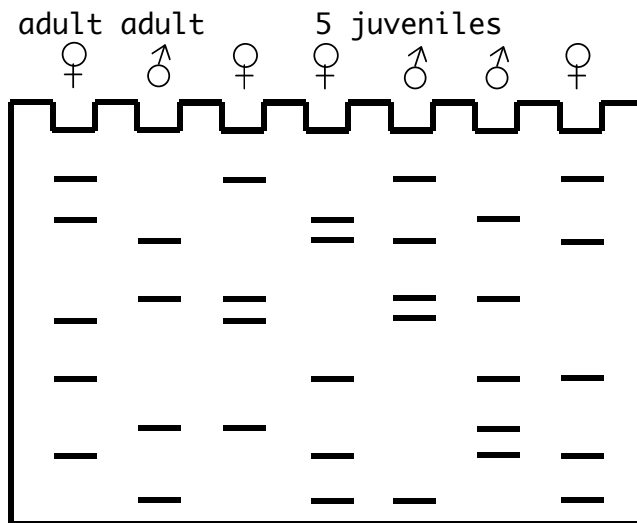
- C. Give ONE of the two possible phenotypes and corresponding maternal gamete for the class with 165 flies.  
 a.  **$g^+ b$ , normal wings, black body OR  $vg b^+$  small wings, gray body**  
**had to write both phenotype and maternal gamete to get the 0.5 pts for this**

part

D. What is the map distance (in map units) between the black and vestigial genes?

$161+165/1000 = 326/1000 = 32.6$  map units

34. An ancient grave is found with two adults, male and female, and 5 juveniles. Maggie, the great DNA detective, is called in to determine whether this is a family group. She performs an analysis of an SSR with sequence AGC. Her AGC-specific Southern blot is depicted below. 1.5 PTS



Are the two adults the parents for ALL, SOME or NONE of the children? **ALL**