Welcome to the Second Genetics Exam!

BIOL 213 GENETICS: Exam October 23, 2000

RULES OF THE GAME: As before, open book, open notes, closed people.

ANSWER SHEET: As before, turn in the answer sheet plus any accompanying papers. Keep the questions.

MEANING OF WORD-RESTRICTIONS: As before, write few words. If you need more space (you probably should not), provide your best short answer in the space, followed by a E, and spill over onto the back or onto another sheet.

WEIGHTS OF QUESTIONS: As before, they're given in parentheses for each question.

MULTIPLE CHOICE QUESTIONS: As before, more than one answer may be correct, or none may be correct.

NEED A FACT? As before, state your assumptions if you're making any.

NEED ANYTHING ELSE? A sheet of paper? A look at the textbook? A clue? Ask.

The News

Well, the Big Guy's down. When I left him last night, he and Asha were at the hospital fightin' to get that baby out. They're giving it all they have, but you know, I'm going to tell you something I've kept to myself. The last thing he said to me before he went into that room, he looked at me and said, "sometime when the team's up against it, and the breaks are going against them, tell them to go out there with all they've got and win just one for the Gipper….". Well, what do you say?

The Questions

1. (1 pt) If you have neither received nor given aid regarding this exam, nor have you gained or given knowledge concerning a previous or future administration of this exam, then sign your name. Otherwise sign someone else's name.

2. (1 pt) Entering this exam, my mental state is:

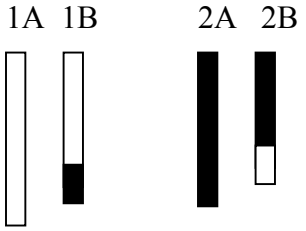
- **A.** Eager, reverent, and hopeful.
- **B.** Cautious and wary, but generally optimistic
- **C.** Devoid of feeling
- **D.** Drained and pessimistic
- **E.** Suicidal
- **F.** Whoopee!
- **G.** Other (specify)

3. (2 pts) The monumental work of a 19th century monk resulted in the enunciation of:

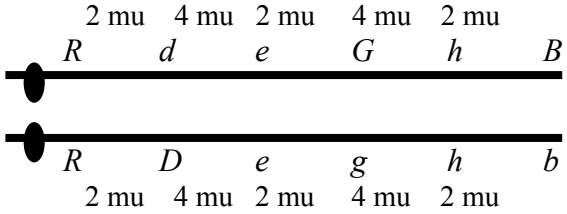
A. Mendel's Principle of Independent Assortment
B. Morgan's Postulate of Chromosomal Recombination
C. Einstein's Theory of Special Relativity
D. The monk took a vow of silence, so we'll never know

4. (2 pts) A diploid organism has the genotype *DdEEggHh*. Assuming that each of the genes on a separate chromosome pair, what proportion of the organism's gametes will carry the genotype *DEgh*?

5. (4 pts) A diploid organism (2N=4) is phenotypically wildtype even though it inherited normal chromosomes from one parent and a balanced translocation from its other parent as shown below. When this individual matures and makes gametes of its own, what proportion of its gametes will carry a full haploid set of genetic information? If you had to make any assumptions, please state them in 30 words or less along with your answer.



6. (8 pts) A diploid organism has the following genotype for one of its homologous chromosome pairs (with the map units between genes shown).

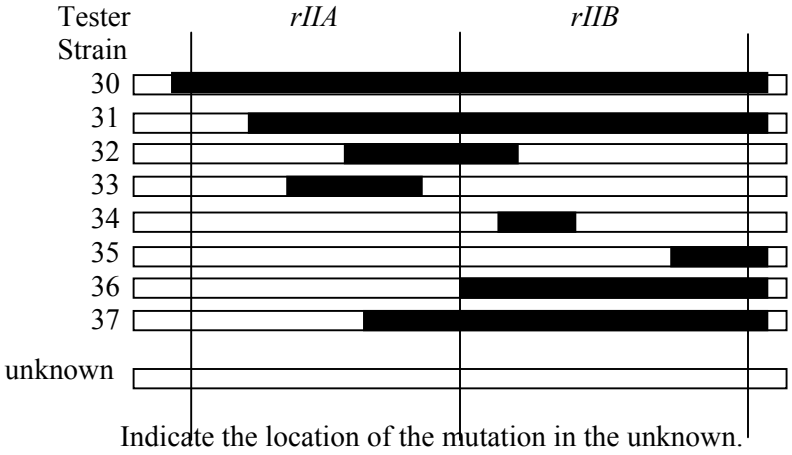


6a. On the replica of the chromosome pair shown on the answer sheet, draw the minimal number of recombinations needed to get a gamete with *RdeGhb*.

6b. On the replica of the chromosome pair shown on the answer sheet, draw the minimal number of recombinations needed to get a gamete with *RDeGhb*.

6c. What proportion of the organism's gametes will be *RDeGhb*? Please show your equation along with your answer. (hint: think about the meaning of a map unit)

7. (5 pts) You are given an unknown T4 rII- mutant. Given your mastery of Lab #4, you carry out complementation and recombination tests using some of the same tester strains from Lab #4 (the location of the deletions in the tester strains are shown on your answer sheet). From the data you collect below, determine the area within which the unknown mutation must lie and state whether it is a point mutation or a deletion mutation.



Complementation Tests

unknown + tester 33	No Lysis!
unknown + tester 34	No Lysis!

Recombination Tests

unknown x tester 32	No plaques on 10^{-1}, 10^{-2}, or 10^{-3}
unknown x tester 33	A few plaques on 10^{-1}, no plaques on 10^{-2} or 10^{-3}
unknown x tester 34	No plaques on 10^{-1}, 10^{-2}, or 10^{-3}
unknown x tester 35	A few plaques on 10^{-1}, no plaques on 10^{-2} or 10^{-3}
unknown x tester 36	No plaques on 10^{-1}, 10^{-2}, or 10^{-3}

8. (15 pts) The classic true breeding "High Jumper" fleas have a short football-shaped thorax and very long hind legs as compared to their other legs. The recently introduced true breeding "High Stepper" fleas have an elongated thorax and their hind legs are just as short as their other legs. In an attempt to break into the small (pun intended), but lucrative flea circus market, you breed virgin "High Jumper" females with "High Stepper" males. The F1 progeny are a great disappointment. All of them are "High Jumpers" with a short football-shaped thorax and long hind legs. Undaunted, you selfcross the F1 progeny and get the following F2 progeny:

Number	Phenotype
7352	High Jumpers (short football-shaped thorax, long hind legs)
2352	High Steppers (elongated thorax, hind legs just as short as others)
148	High Stepper/Jumpers!! (elongated thorax, long hind legs)
148	Low Crawlers!!! (short football-shaped thorax, hind legs just as short as others)

8a. What is the dominant form of each trait?

8b. What are the genotypes of the original parent strains?

8c. What would be the expected number of each F2 phenotypic class based on a hypothesis of a typical Mendelian dihybrid cross with independent assortment?

8d. Set up the proper chi-squared test to determine your confidence in the independent assortment hypothesis. You do not have to show the final calculated value, but rather just the initial equation with the proper numbers. Based on your equation, derive a rough estimate of what your chi-squared value will be and use that estimate to draw a conclusion concerning the hypothesis (conclusion in 15 words or less, please).

8e. You take one of your F1 females and mate it with a High Stepper male. Use the testcross progeny data below to draw as many additional conclusions as you can (in 20 words or less).

Number	Phenotype
4854	High Jumpers (short football-shaped thorax, long hind legs)
4846	High Steppers (elongated thorax, hind legs just as short as others)
151	High Stepper/Jumpers!! (elongated thorax, long hind legs)
149	Low Crawlers!!! (short football-shaped thorax, hind legs just as short as others)

9. (10 pts) You are working with three true breeding *Drosophila melanogaster* mutant strains: tiny eyes (TE), bristleless (BR), and leg-like antennae (LA). Your job is (a) to determine if the three genes lie on the same chromosome or on different ones, and (b) to determine the map distance between any genes on the same chromosome. You have two options. You can work with dihybrid crosses or you can work with a 3-point cross. Both options give the same answer.

Option #1: Dihybrid Crosses

(1) **P:** ♀tiny eye x ♂ bristleless

F1: all wildtype

F1 females x tester males:
213 bristleless
210 tiny eye
91 tiny eye, bristleless
86 wildtype

(2) **P:** ♀ leg-like antennae x ♂tiny eyed

F1: all leg-like antennae

F1 females x tester males
152 tiny eye
150 leg-like antennae
50 wildtype
48 leg-like antennae, tiny eye

(3) **P:** ♀ bristleless x ♂ leg-like antennae

F1: all leg-like antennae

F1 females x tester males
125 wildtype
125 bristleless
125 leg-like antennae
125 bristleless, leg-like antennae

Option #2: 3-Point Cross

P: ♀ wildtype x ♂ tiny eye, bristleless, leg-like antennae

F1: all leg-like antennae

F1 females x tester males
241 wildtype
239 tiny eye, bristleless,
138 tiny eye, leg-like antennae
137 bristleless
113 leg-like antennae
112 tiny eye, bristleless
10 tiny eye
10 bristleless, leg-like antennae

10. (12 pts) Females who carry either a defective allele in either of two genes, *BRC1* or *BRC2,* are predisposed to breast cancer. At least one wildtype *BRCA1* allele and one wildtype *BRCA2* allele are required for viability (embryos homozygous for either mutation do not complete development [Suzuki et al (1997) Genes Devel 11:1242-1252], but it is possible to be heterozygous at both *BRC1* and *BRC2* [Tsongalis et al (1998) Arch Path Lab Med 122:548-550]. The frequency of defective alleles vary considerably amongst different subpopulations. In females diagnosed early with breast cancer who can trace their roots to Ashkenazi Jews, the frequency of the $BRC1^-$ allele is 21% [FitzGerald, et al. (1996) New Engl J Med 334:143-149]. Suppose the frequency of the $BRC2^-$ allele in this same population is 10%.

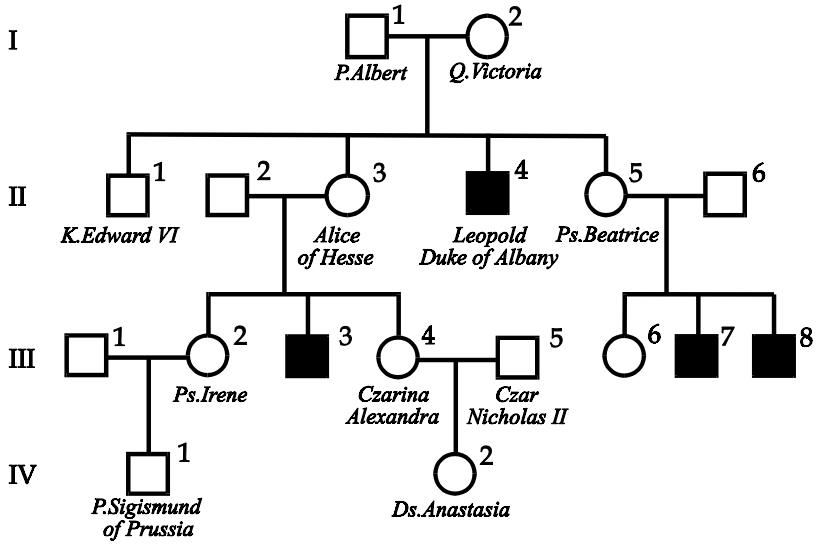
A patient comes to you, a genetic counselor, for advice. Her mother was diagnosed at a very early age with breast cancer. She describes herself as an Ashkenazi Jew and wants to know what are the chances that she is at risk. You judge that she is at risk if she carries either of the two alleles. What probability do you give her? (Show equations)

11. (8 pts) Although you won't find it in the family records, one of Brad's greatgrandfathers on his mother's side was the legendary but scandal-ridden Italian tenor, Bernardo Fettucini, known for his ability to shatter glass with his high E's. As chance would have it, Fettucini is also Asha's greatgrandfather, by another marriage. Piercing shrieks, a la Fettucini, is an autosomal recessive trait. Give the probability that daughter Ramsey Goodner (who at press time is still waiting in the wings) will have this rare trait (in not too long, Brad will tell us if she does or does not). In the space provided, draw the relevant pedigree along with whatever jottings may have helped you arrive at the answer.

12. (12 pts) Examine the partial pedigree in the figure to the right of a family including many of the crowned heads of Europe. You will note that many of Queen Victoria's descendants were afflicted with hemophilia.

12a. Describe the apparent mode of inheritance of the disease (e.g. autosomal dominant).

12b. Write the genotypes of all individuals shown in the partial pedigree provided on the answer sheet, to the extent possible.

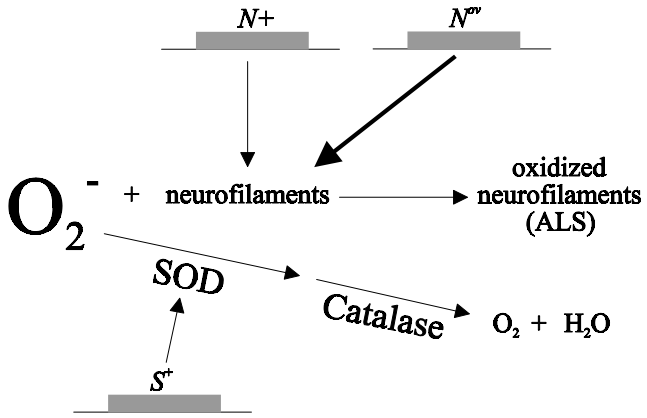


Partial pedigree of the descendants of Queen Victoria of Great Britain. Filled in symbols indicates symptoms of hemophilia.

12c. It was common for marriages to be arranged amongst members of the extended royal family. Suppose that a union is contemplated between Prince Sigismund of Prussia and

Anastasia, Duchess of Russia. What is the probability that a child of theirs would have hemophilia. Show all pertinent work.

13. (10 pts) At least in some cases, the neurodegenerative disease, amyotrophic lateral sclerosis (ALS), is caused by a genetic defect in the gene encoding superoxide dismutase (SOD). SOD, along with another enzyme called catalase, normally converts the toxic superoxide radical (O_2^-) to harmless molecular oxygen and water. When SOD is not present, the buildup of superoxide causes damage, eventually leading to neurodegeneration. Heterozygotes lack sufficient enzyme to prevent the condition.



Some believe that superoxide acts on neurofilaments, the primary protein of which (lets say) is encoded by the wildtype gene N^+. When neurofilaments are overproduced by the mutant allele N^{ov}, ALS is avoided, whether or not SOD is defective, presumably because more neurofilaments are produced than can be destroyed by superoxide.

To study the interaction of superoxide and neurofilaments, Kong and Xu [Neurosci Lett (2000) 281:72-74] employed a mouse model system. ALS symptoms were exhibited in mice carrying a defective SOD allele. They also made a mouse that carried an N^{ov} allele. Mice carrying both had a delayed onset of ALS (let's call them normal). Suppose two such mice, each carrying one mutant S^- allele and one mutant N^{ov} were crossed, producing 96 progeny (it took a while).

13a. Which allele do you expect to act in a dominant fashion: S^+ or S^-?

13b. Which allele do you expect to act in a dominant fashion: N^+ or N^{ov}?

13c. What phenotypes do you expect in the 96 progeny and with what numbers?

14. (1 pt) Repeat question 2, using the same choices to describe your mental state upon finishing the exam.

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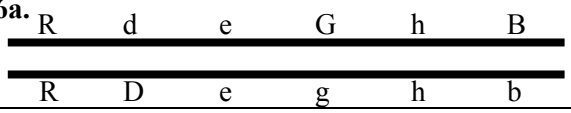
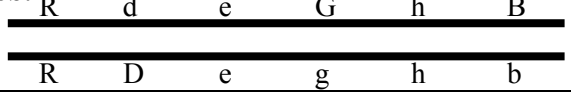
4

5

6a.

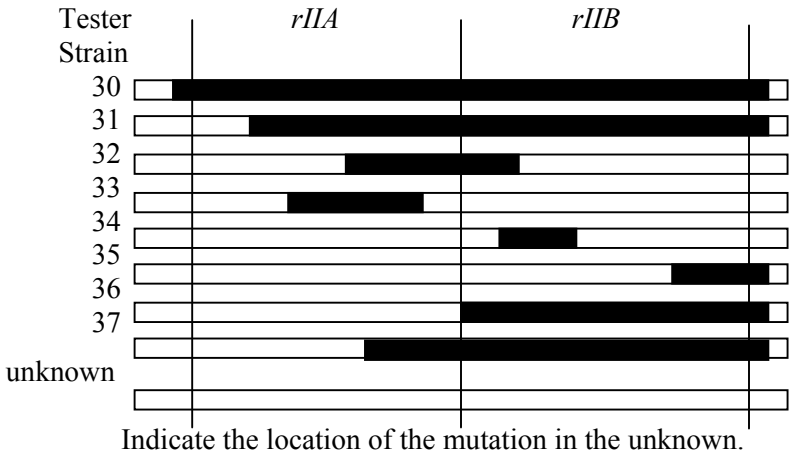


6b.



6c

7



Indicate the location of the mutation in the unknown.

8a

8b

8c

8d

8e

9a

9b

10

<table>
<tr><td colspan="2" rowspan="2">11</td><td colspan="2">12b</td></tr>
<tr><td colspan="2">12c</td></tr>
<tr><td colspan="4">12c</td></tr>
<tr><td>13a</td><td>13b</td><td colspan="2">13c</td></tr>
<tr><td colspan="4">14</td></tr>
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Remember to turn in at least the first page of the article along with your summary!