

YOUR NAME:

PLEASE ENTER THIS NUMBER
ON ALL PAGES OF THE EXAM

**Biology 151
Spring 2002**

**First Midterm Exam
February 15, 2002**

This exam has six pages; check to see that you have all of them.

Part I. Short answer. Write *brief* answers to the following questions. Six points each.

1. . What are Mendel's Laws (also called Mendel's Principles or Mendel's Rules)?

First Law: Segregation. Explain briefly:
Two members of a gene pair (i.e., two alleles) segregate (separate) from each other in the formation of gametes, so that half the gametes carry one allele and half carry the other. You needed to say something about genes/alleles coming apart and being passed separately to offspring. It's wrong to say that "traits" segregate because traits are phenotypic and Mendel's Laws explain genetic behavior.

Second Law: Independent assortment. Explain briefly:
Genes for different traits assort independently of one another during the production of gametes. You needed to make clear that this law applies to different genes (not different alleles of one gene).

For the following two questions, assume that color blindness is an X-linked recessive characteristic.

2 John and Cathy both have normal color vision. After ten years of marriage to John, Cathy gives birth to a colorblind daughter. John files for divorce, claiming that someone else must be the father. Is John justified in believing that he is not the father? Explain why or why not.

He has a case. If the daughter is colorblind then she must have inherited two copies of the mutant allele from her parents; that is, she must be homozygous for this recessive trait. Cathy could be heterozygous and therefore not show colorblindness. But John is hemizygous; he only has one X chromosome. So if he is carrying the mutant allele, he should be colorblind. Since he's not colorblind, he has reason to be suspicious. (Note that John could in fact be the father of the colorblind daughter. In that case, the source of the colorblind allele would have to be a mutation in some of his own gametes, or the daughter could have Turner syndrome (see question #3). Recall Queen Victoria's family where her ancestors had no sign of hemophilia and many of her offspring did; a new mutation must have arisen from scratch in one of her parents. There are other ways to determine who the father of a child is, and John should be tested to determine whether he's really the dad. But maybe he should also stop being so suspicious of Cathy).

3. A colorblind female and a male with normal color vision have three sons and six daughters. All of the sons are colorblind. Five of the daughters have normal color vision, but one of them is colorblind. The colorblind daughter is 18 years old, is short for her age, and has never undergone puberty.

What genetic syndrome might explain all the features of her condition? What is a likely explanation of how she acquired this syndrome?

She may have Turner syndrome, because she has only one X chromosome (is XO). If so, she inherited the “colorblind” X chromosome from mom (because dad has normal vision) and no X chromosome from dad, because of nondisjunction during formation of his sperm cells. The daughter’s symptoms—shortness, failure to undergo puberty, and colorblindness—are all consistent with Turner syndrome’s XO genotype.

Part I. Genetics problems. Point value for each one as indicated.

4. (12 points) A pea plant from a pure breeding-strain that is tall with purple flowers is crossed to a plant from a pure-breeding strain that is a dwarf with white flowers. The F1 plants are all tall with purple flowers. Briefly explain how you got your answers.

a. (6 points) What phenotypes would you expect to see in the F2? In what ratios?

This is a standard dihybrid cross—two genes with dominant and recessive alleles. We’d expect to see 4 phenotypes: tall, purple :dwarf, purple: tall, white: dwarf, white in a 9:3:3:1 ratio.

Genotypes: T-P-; ttP-; T-pp; tpp

b. (6 points) What phenotypes, in what ratios, would you expect if you backcrossed the F1 plants with the dwarf, white-flowered parents?

Same four phenotypes as in part a, but in a 1:1:1:1 ratio; Genotypes: TtPp; ttPp; Ttpp; tpp

5. (16 points) *C/c*, *O/o* and *I/i* are three independently segregating pairs of alleles in chickens. *C* and *O* are dominant alleles, both of which are necessary for pigmentation. *I* is a dominant inhibitor of pigmentation. Individuals of genotypes *cc*, or *oo*, or *Ii*, or *II* are white, no matter what other genes they possess.

White Leghorn chickens are *CC OO II*, White Wyandotte chickens are *cc OO ii*, and White Silkies are *CC oo ii*.

a. (2 points) Would a chicken of genotype *CcOoIi* be white or pigmented? *White because of the I allele that prevents pigmentation*

b. (2 points) Would a chicken of genotype *CcOoii* be white or pigmented? *Pigmented because there are dominant alleles at both the C/c and O/o loci and the I/i locus is homozygous recessive*

What is the probability of obtaining white and pigmented chicks from each of the following crosses? Explain your conclusion.

c. (6 points) White Silkie X White Wyandotte: *CCooii x ccOOii* gives all *CcOoii*, which is pigmented—see part b

White: Zero

Pigmented: 100%

d. (6 points) White Leghorn X White Wyandotte $CCOOH \times ccOOii$ gives all $CcOOIi$. This genotype is going to be white—see part a

White: 100%

Pigmented: Zero

6. (12 points) The pedigree below illustrates the inheritance of Nance-Horan Syndrome, a rare genetic condition in which affected individuals have cataracts (opaque areas in the lens of their eyes) and abnormally shaped teeth.

- a. (4 points) On the basis of this pedigree, what do you think is the most likely mode of inheritance for Nance-Horan Syndrome? Explain your conclusion.
1. Autosomal recessive
 2. Autosomal dominant
 - 3. Sex-linked recessive**
 4. Sex-linked dominant

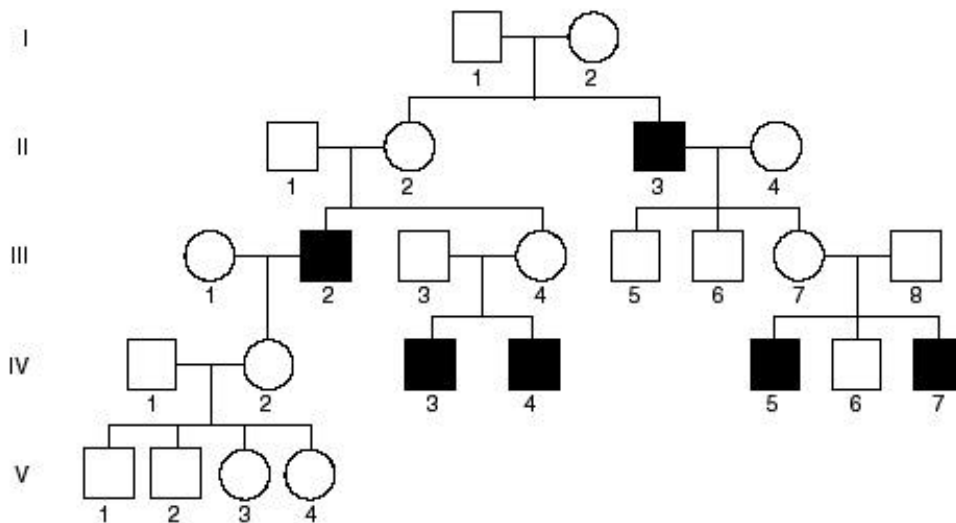
Recessive because affected children don't have affected parents. Sex (X-) linked because it affects only males and is therefore probably associated with the X chromosome.

b. (4 points) If couple III-7 and III-8 have another child, what is the probability that the child will have Nance-Horan Syndrome? Explain how you obtained your answer.

1. 1/1 *Answer 1/4: The mother (III-7) must be a heterozygous carrier (because she doesn't have the syndrome) and the father is wild type, because he doesn't. Half the mother's sons will inherit her carrier X chromosome and half won't. All the daughters will inherit the father's wild type sex chromosome. So the odds are 1/2 of having a son and 1/2 of the son's having the carrier X chromosome: $1/2 \times 1/2 = 1/4$ chance that their next child will have the syndrome.*

c. (4 points) If IV-2 and IV-7 had children, what is the probability that one of their children would have Nance-Horan Syndrome? Explain how you obtained your answer.

1. 1/1 *Answer: 1/2 IV-2 is a heterozygous female and IV-7 is a hemizygous male. Thus the mother*
- 2. 1/2** *will pass the Nance-Horan allele to half her sons and they will have the syndrome. She*
3. 1/4 *will also pass the allele to half her daughters. All the daughters will receive the recessive allele from the father, so half will be heterozygous and not show the trait, while half will be homozygous, recessive and show the trait. In other words half of their children, both daughters and sons, will develop the N-H Syndrome.*



7. (12 points) The plant *Haplopappus gracilis* is diploid and $2n = 4$. There are one long pair and one short pair of chromosomes. The diagrams below represent individual cells in anaphase of meiosis or mitosis in a plant that is genetically a dihybrid ($A/a; B/b$) for genes on different chromosomes. The lines in the figure represent chromosomes or chromatids and the points of the V shapes represent centromeres. Using the following letters, indicate next to each chromosomal arrangement what stage of cell division is pictured.

- mitosis
- meiosis I
- meiosis II
- Not possible (If not possible, explain why not).

- d. Because this shows different genes, rather than different alleles, on homologous chromosomes.*
- c*
- c*
- c*
- a*
- d. Because sister chromatids are shown with different alleles; sister chromatids are identical and therefore should have the same alleles. This can't be explained by crossing over, because crossing over happens in meiosis, but not mitosis, which is what this appears to be.*
- d. Because the pictures in 7, 8 and 9 all show too many (8) chromosomes, twice the diploid number. Four chromosomes paired up for meiosis will look like the sets in 10-12.*
- d*
- d*
- b*
- d. All alleles of each gene (A and a; B and b) should still be present at meiosis I, which this appears to be*
- d. See explanation for #1*

Part III: Simple Multiple Choice. Circle the correct answer. Three points each

8. Four of the following events occur in both meiosis and mitosis, but one occurs only in meiosis.

Which one?

- a. Chromatid formation
- b. Spindle formation
- c. Chromosome condensation in prophase
- d. Chromosome pairing at metaphase**
- e. Chromosome movement to poles in anaphase

9. Interphase is a period corresponding to the cell cycle stages of

- a. M.
- b. S.
- c. G1 + G2.
- d. G1 + S + G2.**
- e. G1 + S + G2 + M.

10. If a genetic disease is inherited as an autosomal recessive, which of the following would you expect to be true?

- a. Two unaffected individuals will never have an affected child.
- b. Two affected individuals never have an unaffected child.**
- c. Two affected individuals have affected male offspring but no affected female offspring.
- d. If a child has the disease, one of his/her grandparents must have had it.
- e. All the children of an affected individual and unaffected individual will be unaffected.

11. Chromatids joined together by a centromere are called

- a. Sister chromatids.**
- b. Sister chromosomes.
- c. Homologs.
- d. Alleles.
- e. Tetrads.

12. In which of the following organs would you expect to find meiotic cells?

- a. Liver
- b. Brain
- c. Heart
- d. Skin
- e. Ovaries**

Part IV: Complex Multiple Choice. There may be zero, one or more correct answers to the question. Circle all the correct answers. Five points each

13. An individual of genotype *AABbCcddEe* is crossed with an individual of genotype *AabbCCDdEE*. Which of the following are possible genotypes of their offspring? (Hint: consider the genes individually).

- a. *AabbccDdEE*
- b. *AAAbbCCDdEe***
- c. *AaBbCcDdEe***
- d. *AABBCcDdEE*
- e. *AABbCCddEE***

14. If a rare genetic disease is inherited on the basis of an X-linked dominant gene, one would expect to find which of the following?

- a. Affected fathers have 100 percent affected sons.
- b. Affected fathers have 100 percent affected daughters**
- c. Affected mothers have 100 percent affected daughters
- d. Affected mothers have 100 percent affected sons
- e. No matter which parent is affected, half of all children will be affected.**

Part V: Fill in the blanks (5 points).

15. Fill the blanks in the following sentences so that the completed sentences make sense genetically, using the terms from the twelve listed below

For each of its genes an organism will have at most two alleles, each associated with a homologous chromosome. This combination makes up the organism's genotype, which in turn contributes to its phenotype.

allele
chromatid
chromosome
gamete
gene
genotype

heredity
karyotype
phenotype
offspring
somatic cell
zygote.

Extra Credit (2 points): Lewis & Clark College Professor Kellar Autumn is gaining renown for his work with:

- a. Fruit flies
- b. Garden peas
- c. Geckos**
- d. English ivy