Alleles, Phenotype & Genetic interaction

Problem Set #2 (not for credit):
(thanks to Steve Jackson for some of these problems)

1. For each of the terms in the left column, choose the best matching phrase in the right column

(a). epistasis	1. one gene affecting more than one phenotype.
(b). modifier gene	2. the alleles of one gene mask the effect of alleles of another gene.
(c). conditional lethal	3. both parental phenotypes are expressed in the F1 hybrids.
(d). permissive condition	4. a heritable change in DNA.
(e). reduced penetrance	5. a trait produced by the interaction of alleles of at least two genes or from interactions between gene and environment.
(f). mutifactorial trait	6. genes whose alleles subtly alter phenotypes produced by the action of other genes.
(g). incomplete dominance	7. less than 100% of the individuals possessing a particular genotype express it in their phenotype.
(h). codominance	8. environmental conditions that allow conditional lethals to live.
(i). Mutation	9. the hetrozygote resembles neither homozygote.
(j). pleiotropy	10. a genotype that is lethal in some situations (e.g., high temperature) but viable in others.

2. Explain the difference between epistasis and dominance. How many loci are involved in each case?

3. A cross between two plants that both have pink flowers produces 80 offspring plants, of which 38 have pink flowers, 22 have red flowers, and 20 have white flowers. If one assumes that this variation in color is due to variation at a single locus, what is the genotype associated with each flower color, and how can you describe the inheritance of flower color?

4. A wild legume with white flowers and long pods is crossed to one with purple flowers and short pods. The F1 offspring are allowed to self-fertilize, and the F2 generation has 301 long purple, 99 short purple, 612 long pink, 195 short pink, 295 long white, and 98 short white. How are these traits being inherited?

5. Does the nucleotide sequence of a mutation tell you whether it will be dominant or recessive?

6. (a). If a girl has blood type O what could be the genotype (and corresponding phenotype) of her parents?
(b). If a girl has blood type B and her mother has blood type A, what could be the genotype (and corresponding phenotype) of her father?

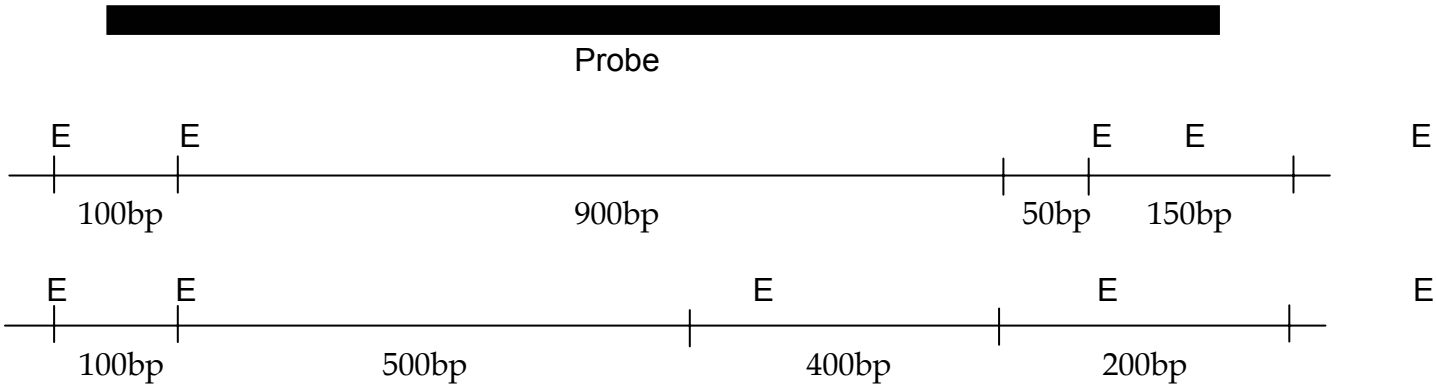
7. Alleles of a gene that determines seed coat patterns in lentils can be organized in a dominance series: Marbled > spotted or dotted (codominant alleles) > clear. A lentil homozygous for the marbled seed coat pattern allele was crossed to a lentil homozygous for the spotted pattern allele. In another cross, a homozygous dotted lentil was crossed to one homozygous for clear. An F1 plant from the first cross was then mated to an F1 plant from the second cross.
(a). What are the expected phenotypes of the two F1 plants from the two original parental crosses?
(b). What phenotypes in what proportions are expected from this mating between the two F1 types?

8. You picked up two mice (one female and one male) that had clearly escaped from experimental cages in the animal facility. One mouse is yellow in color and the other is brown agouti. You happen to know that this mouse facility has different alleles at only three coat color genes: the agouti (A) or non-agouti (a) or yellow alleles (A^Y) of the A gene (A^Y dominant to A and a; A dominant to a), the black (B) or brown allele (b) of the B gene (B dominant to b), and the albino (c) or non-albino (C) alleles of the C gene (C dominant to c). The C gene exhibits recessive epistasis to B and A (i.e., cc homozygotes mask the phenotype of B and A). However, you don't know which of these alleles are present in each of the animals that you've captured. To determine the genotypes, you breed the animals. The first litter has only three pups. One is albino, one is brown (non-agouti) and the third is black agouti.
(a). What alleles of the A, B, and C genes are present in the two mice you caught?
(b). After raising several litters from these two parents, you have many offspring. How many coat color phenotypes (in total) do you expect to see expressed in the population of offspring? What are the phenotypes?

9. You do a cross between two true-breeding strains of zucchini. One has green fruit and the other has yellow fruit. The F1 plants are all green, but when these are crossed, the F2 plants consist of 9 green to 7 yellow. Indicate the phenotype, with frequencies, of the progeny of a test cross of the F1 plants.

10. "Secretors" (genotype SS and Ss) secrete their A and B blood group antigens into their saliva and other body fluids, while "nonsecretors" (ss) do not. What would be the apparent phenotypic blood group proportions among the offspring of an $I^A I^B$ Ss woman and an $I^A I^A$ Ss man if typing was carried out using saliva?

11. A male and female are homozygous, respectively for each of the chromosomes diagrammed below. You obtain DNA from these individuals, digest the DNA with restriction enzyme E, and hybridize with the indicated radiolabeled probe:

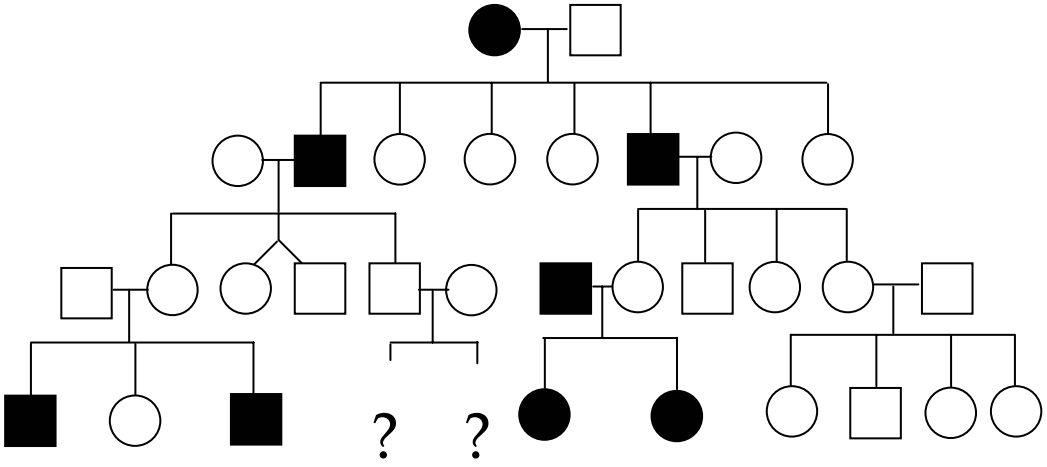


(a). What pattern of bands would expect to result from your Southern blot analysis DNA obtained from each of these individuals?

(b). What pattern would you expect to see for the first-born child from the mating of these two individuals? What about the second-born?

12. One of the genes that control coat color in mice is called *agouti*. An allele of this gene producing yellow coat color, A^y, is dominant to the normal allele, A^+. A second coat color gene (denoted as *C*), determines whether any melanin pigment is made. Homozygotes for the recessive allele (*c*) have albino coats. From a colleague, you obtain two mice that are dihybrid for both loci. When crossed together, the phenotypes of their progeny are normal, albino, and yellow in a 1:1:2 ratio, respectively.
(a). How can you account for this phenotypic ratio?
(b). How could you test this?

13. Consider the following pedigree of a completely penetrant trait:



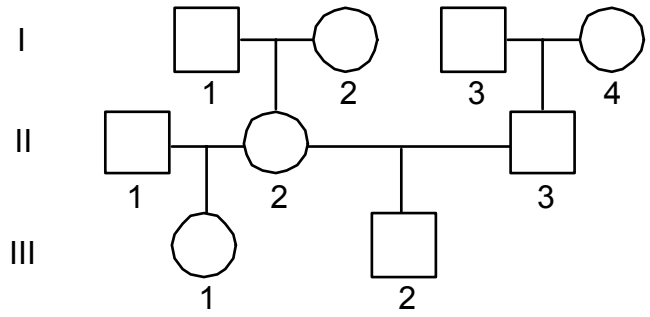
(a). Describe the genetic characteristics of this trait, including dominant/recessive, autosomal/sex-linked, common/rare. State your reasons.
(b). If III-6 is homozygous, what proportion of the sons of III-5 will have the trait? What proportion of his daughters will have the trait?
(c). How would your answer to part A change if the trait was not completely penetrant?

14. The Shepard's Purse plant produces two kinds of fruit, "heart-shaped" or "narrow". The shape of the fruit depends on the action of two duplicate (redundant) genes, *A* and *B*. When both genes are homozygous recessive, the fruit has a narrow shape.
(a). If 800 fruit from a dihybrid selfcross are examined, how many will you expect to be narrow?
(b). What proportion of the plants that have heart-shaped fruit in part A will give *only* heart-shaped fruit when self-crossed?

15. Two parents, with blood-type genotype iI^A and iI^B, have seven children.
(a). What is the probability that all seven children will have AB bloodtype?
(b). What is the probability that all seven children will have O bloodtype?

16. The production of substance H, the precursor to the blood type antigens requires a dominant allele of gene H. The table below shows the responses of blood samples from the individuals in the pedigree to anti-A and anti-B sera. A "+" in the anti-A row indicates that the red blood cells (RBCs) of that individual were clumped by anti-A serum and therefore the individual made A antigens, and a "-" indicates no clumping. The same notation is used to describe the test for the anti-B antigens.

	I-1	I-2	I-3	I-4	II-1	II-2	II-3	III-1	III-2
Anti-A:	+	+	-	+	-	-	+	+	-
Anti-B:	+	-	+	+	-	-	+	-	-



(a). Deduce the blood type of each individual from the data in the table.
(b). Assign genotypes (including H) for the blood groups as accurately as you can from this data and explain the pattern of inheritance shown in the pedigree.

17. What phenotypic ratios would you expect from crossing triply heterozygous flies if three genes affect a trait and one dominant allele of each gene is necessary to get a wild type phenotype?

18. m&ms are a useful model organism for exploring Mendelian inheritance patterns.
(a). For example, suppose the *shell* locus controls color and *filling* controls whether the m&m has a nut or not. Truebreeding blue m&ms crossed to truebreeding red m&ms give 100% purple progeny. Truebreeding peanut m&ms when mated to truebreeding plain m&ms lead to 100% "halfnut" progeny (the nut fills only one half of the shell, these candies are not yet available in stores). How do you explain the purple and halfnut phenotypes?
(b). A third locus (*crispy*) dictates whether the candy has a crispy or normal texture. Assume that *crispy* is an X-linked recessive trait and that sex determination of m&ms is like that of mammals. A crispy m&m male mates with a normal phenotype female. The F1 is made up of 37 crispy females, 54 crispy males, 46 normal females, and 65 normal males. What is the genotype of the parent m&ms?

19. A new all-white, true-breeding variety of Snapdragons has been developed by your local florist. When this variety is crossed to true-breeding red snapdragons, the dihybrids are white. However, when these dihybrids are self-crossed, the following phenotypes are observed: 129 white, 21 pink, and 11 red.
(a). What are the likely genotypes of the parents? Define any symbols you use.
(b). Can these results be explained if a homozygous recessive allele of one gene masks the phenotype of the other gene (recessive epistasis)? Test this hypothesis with a χ^2 test.
(c). Propose a genetic hypothesis for these results that passes a χ^2 test.

20. You have identified two true-breeding varieties of tomato plant, one that gives red flowers and large tomatoes, and another variety that gives white flowers and small tomatoes. You proceed to cross the two varieties and observe that the F_1 offspring all produce small tomatoes and pink flowers. You then self-fertilize the F_1 hybrids and observe the following number of each offspring:
red, small (43) pink, large (24)

red, large (12) white, small (39)
pink, small (79) white, large (11)

(a). Provide a hypothesis that explains the inheritance pattern of the flower color and tomato size traits (i.e., define the dominance/recessiveness relationships for the flower color and tomato size traits).

(b). Test your hypothesis for the inheritance pattern of tomato size and tomato plant flower color using a χ^2 test and calculate the corresponding P value. Does this P value allows you to accept or reject your hypothesis in **(a)**.

(c). You decide to cross all of the pink-flowered, small F_2 plants to the pure-breeding white flower, small tomato variety to further test your hypothesis for the inheritance pattern of flower color. What would you expect from these crosses (in terms of flower color only) given your proposed inheritance pattern?

21. You have captured a female albino mouse in your home and have decided to keep it for a pet. A few months later, you catch a male albino mouse while on a camping trip. You wonder if the two mice are albino due to mutations in the same gene (albino is NOT the wildtype mouse coat color). What could you do to find out? (assume that the mutations are recessive).

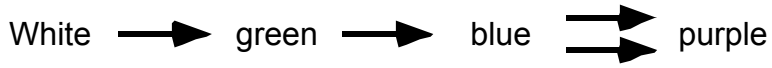
22. To understand the genetic basis of locomotion in the nemotode *C. elegans*, you have carried out a screen to identify mutants exhibiting uncoordinated movement. From this screen, you have recovered twelve *C. elegans* mutants (designated 1-12 below) that are homozygous for recessive mutations causing uncoordinated movement. The twelve mutants were intercrossed and the progeny of these crosses were examined to determine whether they exhibit wildtype (+) or uncoordinated movement (-). Results of this analysis are shown below (the intersection of this matrix represents the outcome of a cross between the given mutants).

	1	2	3	4	5	6	7	8	9	10	11	12
1	-	+	+	+	-	+	+	+	+	+	+	+
2		-	+	+	+	-	+	-	+	-	+	+
3			-	-	+	+	+	+	+	+	+	+
4				-	+	+	+	+	+	+	+	+
5					-	+	+	+	+	+	+	+
6						-	+	-	+	-	+	+
7							-	+	+	+	-	-
8								-	+	-	+	+
9									-	+	+	+
10										-	+	+
11											-	-
12												-

(a). What is the intercrossing experiment designed to test?

(b). How many different complementation groups (genes) affecting locomotion have been identified? How many alleles exists for each of the different complementation groups?

23. In a certain species of flowering plants with a diploid genome, four enzymes are involved in the generation of flower color. The genes encoding these four enzymes are on different chromosomes. The biochemical pathway involved is as follows:



The double arrow indicates that either of two different enzymes is able to convert a blue pigment into a purple pigment. A true-breeding green-flowered plant is mated with a true-breeding blue-flowered plant. All of the plants in the resultant F1 generation have purple flowers. F1 plants are allowed to self-fertilize, yielding an F2 generation. Indicate the fraction of F2 plants with the following phenotypes: White flowers, green flowers, blue flowers, and purple flowers.

24. One oak tree cell with 14 chromosomes undergoes mitosis.
(a). How many daughter cells are formed, and what is the chromosome number in each cell?
(b). If the same cell had undergone meiosis, how many daughter cells would have resulted, and what would have been the chromosome number in each?

25. A system of sex determination known as haplodiploidy is found in honey bees. Females are diploid and males (drones) are haploid. Male offspring result from the development of unfertilized eggs. Sperm are produced by mitosis in males and fertilize eggs in the females. Ivory eye is a recessive characteristic in honey bees. Wild type eyes are brown.
(a). What progeny would result from an ivory-eyed queen and a brown-eyed drone (give both the genotype and phenotype)?
(b). What would result from crossing a daughter from the mating in (a) with a brown-eyed drone?

26. (a). What are the four major stages of the cell cycle?
(b). What stages are included in interphase?
(c). What events distinguish G1, S and G2?

27. Somatic cells of chimpanzees contain 48 chromosomes. How many chromatids are present at:
(a). anaphase of mitosis?
(b). anaphase I of meiosis?
(c). anaphase II of meiosis?
(d). G1 of mitosis?
(e). G2 of mitosis?
(f). G1 just prior to meiosis I?
(g). prophase of meiosis I?