Alleles, Phenotype & Genetic interaction

Problem Set #2 Answers:

1. (a). 2
(b). 6
(c). 10
(d). 8
(e). 7
(f). 5
(g). 9
(h). 3
(i). 4
(j). 1

2. Dominance relationships are between alleles of the same gene. Only one gene is involved. Epistasis involves two genes. The alleles of one gene "mask" or "hide" the effects of alleles at another gene.

3. This could be explained by incomplete dominance. RR = red; Rr = pink; rr = white.

4. The long allele (L) is completely dominant to the short allele (l). The flower color trait shows incomplete dominance. PP = purple; Pp = pink; pp = white.

5. The nucleotide sequence of a mutation says nothing about whether it will be dominant or recessive. Dominance and recessiveness depend on the function of the gene and how the phenotype is analyzed.

6 (a). ii (phenotype O) or iI^A (phenotype A) or iI^B (phenotype B).
(b). iI^B (phenotype B) or I^BI^B (phenotype B) or I^BI^A (phenotype AB).

7 (a). Marble and dotted.

(b). spotted and dotted, marbled, and spotted in a 1:2:1 ratio.

8. (a). A^Ya Bb Cc X Aa bb Cc
(b). Six phenotypes are possible: albino, yellow, brown agouti, black agouti, brown, black.

9. The 9:7 ratio in the F2 indicates that two genes are involved in green pigment formation. We'll call the two genes A and B. The genotypes of the parental plants that would produce a 9:7 ratio are AA BB and aa bb. A cross between these plants would result in Aa Bb F1 plants. Thus, a test cross of the F1 plants would result in the following genotypes and phenotypes: Aa Bb, aa Bb, Aa bb and aa bb in equal proportions: 1/4 green and 3/4 yellow fruit.

10. 1/4 would appear to have O type blood, 3/8 have A, and 3/8 have AB.

11 (a). The male would produce bands of 900, 150, 100 and 50 base pairs. The female would produce bands of 500, 400, 200 and 100 base pairs.

(b). Since both parents are homozygous for the RFLP marker, their children will contain the top and bottom form. The children will therefore have bands of 900, 500, 400, 200, 150, 100 and 50 base pairs. Since the parents can only make one type of gamete, all the children will have the same banding pattern.

12 (a). The dihybrids have the genotype A^yA^+Cc, and since the alleles affect coat color, there is probably some epistatic interaction between these genes. Notice that the ratios are not like any that we've discussed for two genes, but looks closest to 9:4:3. Draw a Punnett square and predict the phenotypes. How can you get from the predicted phenotypes to the observed? You need to eliminate 3 from the yellow group, and one from the albino group. Notice from your square that only one genetic combination is consistent with this: those that are homozygous for A^y. If you eliminate any mice that are homozygous for A^y, you arrive at the correct phenotypic ratios, and this is the only allele that, when eliminated, produces the observed ratios. A^y therefore probably encodes an allele that is lethal when homozygous.
(b). To test this, you can examine offspring from an $A^yA^+ \times A^yA^+$, and look for 1:2 normal:yellow; the lethality of the $A^y\ A^y$ homozygotes could be verified by analyzing embryos in utero- this class genotype should be represented.

13 (a). The trait appears mostly in males, and in daughters of an afflicted male (IV-V and IV-VI). For sex-linked traits in mammals, females have two X-chromosomes and transmit one X-chromosome to their sons. Males have a single X-chromosome and transmit this chromosome to all their daughters. Sex linkage could account for this inheritance. In addition, the trait is recessive since unaffected parents give rise to affected offspring (eg IV-1-3), daughters of affected fathers appear to be carriers (eg III-2, III-8) half of sons (on average) of carrier females will display the trait. Since a person outside the family displays the trait (III-7), the trait is likely to be common. The trait is likely to be sex-linked, recessive, and common. However, this pedigree is also consistent with an autosomal recessive pattern of inheritance.

(b). Since III-5 does not display the trait, he must be hemizygous normal. Individual III-6 does not display the trait, she is homozygous normal. Therefore, none of the sons and none of the daughters will have the trait.

(c). Traits that are incompletely penetrant do not display the phenotype uniformly among genetically identical individuals. If the trait is not completely penetrant, the pedigree can be explained several ways, the most obvious being that it is common, autosomal and dominant, or common, autosomal and recessive.

14 (a). Redundant genes produce a 15:1 phenotypic ratio. You would therefore expect 1/16 to be to be homozygous recessive at both genes. 800/16= 50 can be expected to be narrow.
(b). This problem is helped by drawing the Punnett square. Any plants from part A that are homozygous dominant at *at least* one of the loci will produce only heart-shaped offspring when selfed, because the gametes they produce will have only dominant alleles. The correct answer is 7/15.

15 (a). Each of the offspring has a 1/4 chance of being I^AI^B. Thus, the probability of having 7 children all of this genotype = $(1/4)^7$.

(b). Again each offspring has a 1/4 chance of being ii. The probability is again = $(1/4)^7$.

16.

	I-1	I-2	I-3	I-4	II-1	II-2	II-3	III-1	III-2
Phenotypes:	AB	A	B	AB	O	O	AB	A	O
Genotypes:	I^AI^B	I^A?	I^B?	I^AI^B	*ii*	*IA?*	I^AI^B	I^A?	??
	Hh	*Hh*	*H?*	*H?*	*H?*	*hh*	*Hh*	*Hh*	*hh*

17. 27/64 would be wild type and 37/64 would exhibit the mutant phenotype.

18 (a). Alleles that are codominant produce progeny that exhibit both of the parental phenotypes. Since purple results from the combination of blue and red pigments, the purple phenotype can be explained by codominance of the blue and red alleles. Alleles that demonstrate incomplete dominance produce progeny with phenotypes that are intermediate between the two parental traits. The halfnut phenotype is therefore the result of incomplete dominance of the peanut allele relative to the plain allele.

(b). For sex-linked traits in mammals, females have two X-chromosomes and transmit one X-chromosome to their sons. Males have a single X-chromosome and transmit this chromosome to all their daughters. The progeny are found to be approximately 1:1 crispy:normal males, meaning that the female was heterozygous (If Xc= crispy, XC=normal, then female was XcXC, her sons are XcY and XCY). Since the male father was crispy, he had to be XcY. When mated with the XcXC female, he will produce daughters that are either XcXc (crispy) or XcXC (normal) in a 1:1 ratio.

19 (a). Snapdragon petal color is determined by a gene (here, defined as *I*) with two alleles: *I*, gives red color, and *i* no red color (white), with *I* incompletely dominant to *i*. The incomplete dominance may be able to account for the pink color. Suppose that there is a second gene, here called *N* that is a dominant inhibitor of the *I*-locus, and it needs to be homozygous recessive (*nn)* in order to see the phenotype produced by the *I*-locus. If that is the case, the dihybrid self-cross will produce 13:3 ratio of inhibited:colored. However, since the *I*-locus is incompletely dominant, plants that have the genotype *Iinn* will be pink, and there will be 2 of this class. This accounts for the 13:2:1 phenotypic ratio. The parents are therefore probably *IInn* (red), and *iiNN* (white).

(b). There are 161 total plants. If recessive epistasis is responsible for these phenotypes, we would expect to see 9:4:3 distribution of phenotypes this translates to 90.6 white, 40.2 pink and 30.2 red. Plug these values into the equation to get a χ^2 value:

$\chi^2 = (129-90.6)^2/90.6 + (21-40.2)^2/40.2 + (11-30.2)^2/30.2 = 37.7$.

In this test, there are two degrees of freedom. Look on the table: the P value is so low, it's off the charts. Threrefore, the observed deviations from what this hypothesis predicts cannot be explained by chance; this hypothesis must be discarded.

(c). There are two different explanations for the observed phenotypic distribution. First, if one gene masked the phenotype of another, and the homozygous recessive as a weak phenotype (dominant epistasis), we should see a 12:3:1 ratio. This is close to the observed 129:21:11 ratio. If this were true, we'd expect to see 120.8 white, 30.2 pink, and 10.1 red. Plug these values into the equation to get a χ^2 value:

$\chi^2 = (129-120.8)^2/120.8 + (21-30.2)^2/30.2 + (11-10.1)^2/10.1 = 3.388$. With DF=2, we get a P value of about 0.17. This is greater than 0.05, and so this hypothesis is acceptable. However, it ignores what is known about petal color in snapdragons; this hypothesis requires that the red phenotype is due to homozygous recessive.

A better hypothesis is that the dominant allele of one gene masks the phenotype of the other, and the homozygous recessive looks the same as the masked phenotype (dominant suppression). Ordinarily, this gives 13:3 ratios, but in this case, the incomplete dominance makes the phenotypes of the "unmasked" class distinguishable (here, we can tell the difference between II and Ii). In this case, then, we expect a 13:2:1 distribution, and should see 130.8 white, 20.1 pink and 10.1 red. Plug these values into the equation to get a χ^2 value:

$\chi^2 = (129-130.8)^2/130.8 + (21-20.1)^2/20.1 + (11-10.1)^2/10.1 = 0.150$. Wid DF=2, P is around 0.9, so this hypothesis is acceptable as well.

20. (a). The large tomato phenotype is recessive to small.
The red and white flower color phenotypes show incomplete dominance.

(b).

Phenotype	Observed	Expected	$(O-E)^2$	$(O-E)^2/(E)$
red, small	43	39	16	0.41
red, large	12	13	1	0.08
pink, small	79	78	1	0.01
pink, large	24	26	4	0.15
white, small	39	39	0	0
white, large	11	13	4	0.31

χ^2: 0.96 df: 5 P: 0.9-0.975

This P value says that a discrepancy of the magnitude detected in this experiment from my hypothesis from a chance deviation alone would occur between 90 and 97.5% of the time this experiment is done. This P value is much greater than 0.05 so I accept my hypothesis.

(c). I would expect all of these crosses to produce pink flowered and white flowered offspring in equal proportions.

21. You can simply mate the two mice and monitor the phenotypes of the offspring. If the mutations conferring the albino phenotype are in different genes, complementation will be observed and the offspring will be wild type. If, on the other hand, the mutations affect the same gene, the mutations will fail to complement and the albino phenotype will be observed in all of the progeny (again, this assumes that the mutations are recessive!).

22. (a). this test is designed to identify the number of different genes that can mutate to a particular phenotype. In this test, the progeny resulting from a cross of two homozygous uncoordinated parents are examined for their locomotion phenotype. If the progeny exhibit uncoordinated locomotion the mutations fail to complement one another and are probably different alleles of the same gene (they represent different mutations affecting the same gene). If the progeny appear wild type, the mutations complement one another and the parents most likely carry alleles of different genes.

(b). There are five different complementation groups. 1 and 5 fail to complement (we'll call this complementation group A), 2, 6, 8, and 10 fail to complement (group B), 3 and 4 fail to complement (group C), 7, 11 and 12 fail to complement (group D) and 9 only fails to complement itself (group E). Group A and C each have two alleles, group B has four alleles, Group D has three alleles and group E has one allele.

23. The green-flowered plant must have recessive alleles in the genes responsible for conversion of green to blue pigment. There are two different genes that encode enzymes that can be used to convert blue to purple pigment and both genes appear to have recessive alleles preventing this conversion in the blue-flowered plant. Self fertilization among the F1 hybrids would result in the following ratio of offspring: 45 purple:16 green:3 blue.

24. (a). two daughter cells are formed during mitosis and the chromosome number should remain unchanged (2N).

(b). Four daughter cells would be formed and the chromosome number would be seven each (1N).

25. (a). Brown-eyed females (the queen would also give rise to ivory-eyed males).
(b). This mating would give rise to brown-eyed females (the daughter would also give rise to brown and ivory-eyed males at equal frequency).

26. (a). M, G1, S, G2.
(b). G1, S, and G2.

(c). Mitosis occurs during M phase. G1 represents the time gap between the completion of mitosis and DNA duplication. DNA synthesis occurs during S phase. G2 represents the period of time between DNA duplication and the beginning of mitosis.

27. (a). 96
(b). 96
(c). 48
(d). chromatids are not visible at this stage.
(e). chromatids are not visible at this stage.
(f). chromatids are not visible at this stage.
(g). 96