BIOL 1400
Biology for General Education

PRACTICE PROBLEMS IN GENETICS

Questions 1-12 have to do with domestic cats. However, the same basic principles will apply (usually), no matter what animals or plants you're working with.

1. Short hair (**L**) is dominant to long hair (**l**). What are the possible genotypes of a shorthaired cat?

LL or Ll.

2. Suppose you have a shorthaired cat, and you don't know its genotype. To find out its genotype, you can breed it with a longhaired cat and study the phenotypes of the kittens. (Geneticists call this a *test cross*.) Explain why and how you could tell your cat's genotype in this way.

If your shorthaired cat has the LL genotype, then when you breed it with a longhaired cat (ll), all of the kittens will have short hair (and all will have the Ll genotype).
If your shorthaired cat has the Ll genotype, then then when you breed it with a longhaired cat (ll), about half of the kittens will have short hair (Ll genotype) and half will have long hair (ll genotype).

3. Black fur (**B**) is dominant to brown fur (**b**). Suppose you cross two black cats and some of the kittens are brown. What are the genotypes of both parents?

Both parents must have the Bb genotype. They're both black cats, so the must have at least one B allele each (we could write this as "B_". But if they have brown kittens, the kittens must have the bb genotype, and the only way that can happen is if each parent contributes a brown allele. Thus each parent must have the Bb genotype.

4. Suppose you have two brown cats, which have kittens, and some of the kittens are black. Why might this make you think that there's a hole in your fence?

Because this isn't possible. If both parents are brown, then both parents must have the bb genotype. But a black kitten must have received a B allele from at least one parent—and a parent that has a B allele would have to be a black cat. So some sneaky black tomcat from the neighborhood must be the kittens' daddy.

5. Another gene, *dilute*, has two alleles: **D** gives a dense, full color to the fur, whereas **d** lightens the color—thus a black cat with the *dilute* trait looks gray,

and a brown cat with the *dilute* trait looks beige (or "lilac", as breeders say). List all the possible genotypes that a gray cat could have.

6. You crossbreed two cats, one with the genotype **Bbdd** and one with the genotype **bbDd**. What are the phenotypes of these two parents?

Bbdd = gray cat
bbDd = brown cat

7. What are the expected phenotypes of the offspring, and how many of each phenotype would you expect to get? Draw up a Punnett square to answer this question.

Each cat passes on to each offspring one of each pair of alleles of each gene. The gray cat (Bbdd) can pass on either Bd or bd. The brown cat (bbDd) can pass on either bD or bd. So. . .

	Bd	bd
bD	BbDd	bbDd
bd	Bbdd	bbdd

In other words, about one in four of the kittens would be black (BbDd), one in four would be brown (bbDd), one in four would be gray (Bbdd), and one in four would be beige or lilac (bbdd).

8. Some of the kittens that you'd get from the above cross are black. Imagine that you take one of the black kittens, raise it to maturity, and then mate it with a lilac / beige cat. What are the expected phenotypes of the offspring, and how many of each phenotype woul d you expect to get? Draw up a Punnett square to answer this question.

A black kitten from the above problem has the genotype BbDd. A beige cat has to have the bbdd genotype. The black cat can pass on four possible combinations of alleles: BD, Bd, bD, or bd. The beige cat can only pass on one allele combination: bd. The full-blown Punnett square looks like this:

	BD	Bd	bD	bd
bd	BbDd	Bbdd	bbDd	bbdd
bd	BbDd	Bbdd	bbDd	bbdd
bd	BbDd	Bbdd	bbDd	bbdd
bd	BbDd	Bbdd	bbDd	bbdd

So you get the same answer as problem 7: about equal numbers of black (BbDd), grey (Bbdd), brown (bbDd), and beige (bbdd) cats.

9. Now imagine that you cross a **BbLl** cat with a brown

I forgot to complete this problem. I meant "a brown longhaired cat." Result would be 25% black shorthairs, 25% black longhairs, 25% brown longhairs, 25% brown shorthairs.

10. Imagine you have a cat with the genotype **BbDdLl**. What's its phenotype?

Black and shorthaired.

11. Imagine you crossbreed two cats, each of which has the genotype **BbDdLl**. The resulting Punnett square is 8x8, and is a pain in the neck to work out, but if you can do it you've definitely got Mendelian genetics down. What are the expected ratios of all possible phenotypes in the offspring?

Each parent passes on one of each pair of alleles of each gene. Each parent can pass on BDL, BDl, BdL, bDL, Bdl, bDl, bdL, or bdl —eight possible allele combinations. This gives us an 8x8 Punnett square. . .

	BDL	BDl	BdL	bDL	Bdl	bDl	bdL	bdl
BDL	BBDDLL	BBDDLl	BBDdLL	BbDDLL	BBDdLl	BbDDLl	BbDdLL	BbDdLl
BDl	BBDDLl	BBDDll	BBDdLl	BbDDLl	BBDdll	BbDDll	BbDdLl	BbDdll
BdL	BBDdLL	BBDdLl	BBddLL	BbDdLL	BBddLl	BbDdLl	BbddLL	BbddLl
bDL	BbDDLL	BbDDLl	BbDdLL	bbDDLL	BbDdLl	bbDDLl	bbDdLL	bbDdLl
Bdl	BBDdLl	BBDdll	BBddLl	BbDdLl	BBddll	BbDdll	BbddLl	Bbddll
bDl	BbDDLl	BbDDll	BbDdLl	bbDDLl	BbDdll	bbDDll	bbDdLl	bbDdll
bdL	BbDdLL	BbDdLl	BbddLL	bbDdLL	BbddLl	bbDdLl	bbddLL	bbddLl
bdl	BbDdLl	BbDdll	BbddLl	bbDdLl	Bbddll	bbDdll	bbddLl	bbddll

Rounded off just a bit, this gives you. . .

Black shorthairs: 27/64, or 42%
Black longhairs: 9/64, or 14%
Gray shorthairs: 9/64, or 14%
Brown shorthairs: 9/64, or 14%
Gray longhairs: 3/64, or 4.6%
Brown longhairs: 3/64, or 4.6%
Beige shorthairs: 3/64, or 4.6%
Beige longhairs: 1/64, or 1.5%

Whew. . . No, nothing quite that bad will appear on the final.

12. The dominant allele of yet another gene, called *white*, blocks all color from being shown in the coat, giving a pure white cat. **W** (white coat) is dominant to **w** (non-white coat). No matter what other alleles the cat might have for any coat color, if that cat has a **W** allele it will have pure white fur, because the **W** allele blocks the expression of all other alleles. Draw up the Punnett square for the mating of two cats, each with the genotype **BbWw**. What are the expected ratios of all possible phenotypes in the offspring? (HINT: the answer is *NOT* 9:3:3:1.)

Each cat can pass on the allele combinations BW, Bw, bW, or bw, so this seems like a typical dihybrid cross. . .

	BW	Bw	bW	bw
BW	BBWW	BBWw	BbWW	BbWw
Bw	BBWw	BBww	BbWw	Bbww
bW	BbWW	BbWw	bbWW	bbWw
bw	BbWw	Bbww	bbWw	bbww

However, if you count, you will note that twelve out of the sixteen possible genotypes include at least one W allele. W blocks all other color genes! This means that 3/4 of all cats will be white—regardless of whether they're carrying BB, Bb, or bb allele combinations! Only if a cat has two w alleles will any other color show up. So the answer is 12:3:1 — you'd expect twelve white cats (__W_) for every three black cats (B_ww) for every one brown cat (bbww).

Questions 13-20 have to do with human ABO blood groups. Recall that there are three alleles of one gene that determine your ABO group: I^A, I^B, and i. I^A and I^B are codominant to each other, and both are dominant to i.

13. In 2003, Mitzi Vanderbeek, who has type O blood, went to a Kid Rock concert, got invited backstage. . . and nine months later gave birth to a bouncing baby boy, who has type A blood. What's the baby's genotype?

If Mitzi has type O blood, she must have the ii genotype, and she could only have passed on an i allele to her baby. Her baby has type A blood, so he must have received the dominant I^A allele from his father, because his mother doesn't have one. So the baby must have the genotype $I^A i$.

14. Mitzi wasn't really sure who the father was, but the men who were, uhh, in the right place at the right time, if you know what I mean, were Kid Rock himself (type B blood), guitarist Jason Krause (type A blood), keyboardist Jimmie Bones (type AB blood) and turntable-ist Uncle Kracker (type O blood). Which of these four could *not* be the father of the baby? Why not?

The father, whoever he was, must have been carrying at least one I^A allele. That immediately rules out Kid Rock (type B) and Uncle Kracker (type O), neither of whom can be carrying the I^A allele.

15. Suppose that Jimmie Bones, the keyboardist, turned out to be the father of Mitzi's baby. What possible blood types could their children have? Draw up the Punnett square showing the genotypes and phenotypes of their offspring.

Jimmie Bones has AB blood, so his genotype must be IAIB. Mitzi must have the ii genotype, because she has type O blood. So their kids' possible blood types are expressed in this Punnett square:

	I^A	I^B
	I^A	I^B
i	$I^A i$	$I^B i$
i	$I^A i$	$I^B i$

So half their kids would have type A blood and the other half would have type B blood. Or to put it another way: each child would have a 50% chance of having A blood and a 50% chance of having B blood.

16. Another groupie, Trixie Kurplowski, has type A blood. She also goes to a Kid Rock concert, gets invited backstage. . . and nine months later gave birth to a bouncing baby boy, who has type O blood. She claims that Kid Rock himself is the father. Is this theoretically possible, so far?

Yes. Kid Rock has type B blood, and Trixie has type A blood. If Kid Rock had the $I^B i$ genotype, and Trixie had the $I^A i$ genotype, then it would be possible for each one to contribute the i allele to their offspring and have a type O (genotype ii) child.

17. Trixie sues Kid Rock for $1,000,000 in child support. However, at the court hearing, Kid Rock's lawyer reveals that both Trixie's parents have type AB blood. What *must* Trixie's blood type be?

I meant to type "What must Trixie's genotype be?" Her blood type, as we know, is type A. But if both her parents are AB, she must have received the I^A allele from each of them. She cannnot have the $I^A i$ genotype, since neither parent has an i allele. She must be $I^A I^A$.

18. Kid Rock's attorney then claims that Trixie's baby isn't really hers—she just borrowed it from a friend so that she could run a scam on Kid Rock. How can you show that he's right?

Trixie has the $I^A I^A$ genotype, but if the baby has type O blood then it must have the ii genotype, and thus received an i allele from each parent. Trixie isn't carrying an i allele to pass on—so the baby cannot be hers.