The snake problem (Chapter 7, Problem 26)

In corn snakes, the wild-type color is brown. One autosomal recessive mutation causes the snake to be orange, and another causes the snake to be black. An orange snake was crossed to a black one, and the F_1 offspring were all brown. Assume that all relevant genes are unlinked.

a. Indicate what phenotypes and ratios you would expect in the F_2 generation of this cross if there is one pigment pathway, with orange and black being different intermediates on the way to brown.
b. Indicate what phenotypes and ratios you would expect in the F_2 generation if orange pigment is a product of one pathway, black pigment is the product of another pathway, and brown is the effect of mixing the two pigments in the skin of the snake.

Comments:

I picked this problem because it illustrates a very important concept: that the way that different genes interact in a biochemical pathway will lead to different predictions regarding the outcomes of crosses and epistasis analysis.

The main problem I had in going through this in class had to do with the poor choices I made in the notation I used to write out the different possibilities. This was embarrassing for me, but on the other hand it's a useful demonstration of why it's important to have a clear, logically consistent system for expressing genotypes and phenotypes. This is particularly challenging with phenotypes like color, which can result from the *absence* (rather than the presence) of pigments.

So, let's try it again...

The two possible pathways described in parts a. and b. are diagrammed below:

a.

Orange $\xrightarrow{A}$ Black $\xrightarrow{B}$ Brown

Here, genes A and B are in the same pathway. *aa* snakes are orange (because they can't turn substance Orange into substance Black, and *bb* snakes are black because they can't convert substance Black to substance Brown.

b.

$\xrightarrow{A}$ Black
$\xrightarrow{B}$ Orange
} Brown

Here, gene *A* is a gene required in the pathway to make Black. *aa* snakes are thus orange because they don't make substance Black. Conversely, *B* is a gene required in the pathway to make Orange. *bb* snakes are thus black, because they don't make substance Orange.

I've changed the notation slightly to avoid making the error I made in class by failing to distinguish clearly between pigments and phenotypes. Here, pigments are capitalized and phenotypes are underlined. Note that in both cases, the phenotypes of *aaBB* and AA*bb* snakes are the same.

a.

Orange $\xrightarrow{A}$ Black $\xrightarrow{B}$ Brown

b.

$\xrightarrow{A}$ Black
$\xrightarrow{B}$ Orange
} Brown

In either case, the initial cross is *aaBB* X *AAbb*, the F_1 progeny are *AaBb*, and there are 4 genotypic classes of F_2 progeny expected in a 9 : 3 : 3 : 1 ratio *(A-B- : A-bb : aaB- : aabb)*. The difference is in the phenotypes.

	pathway:	a.	b.
9	*A-B-*	brown	brown
3	*A-bb*	black	black
3	*aaB-*	orange	orange
1	*aabb*	orange	white*

*or some color other than brown, black, or orange.
It's this case that differs in phenotype depending on the pathway.