BIOLOGY OF INHERITANCE

[redacted]

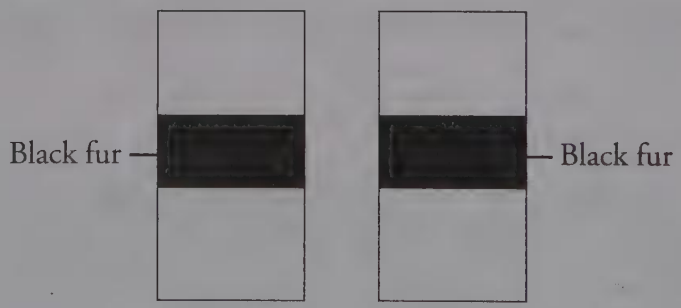
An organism's genes determine its features, its characteristics, its appearance—in other words, its traits.

When talking about an organism's traits, we say **phenotype**. If you're a cat and your fur is gray, then we say that, in terms of fur color, your phenotype is gray. If your fur is white, then we say, in terms of fur color, your phenotype is white. If we meet a person who has diabetes, we say that, in terms of diabetes, his phenotype is diabetic. If we meet another person who does *not* have diabetes, we say that in terms of diabetes, her phenotype is nondiabetic, or we might say that her phenotype is normal. So phenotype just refers to the actual traits that an organism does and does not possess.

PHENOTYPE AND GENES

As you'll remember, we said that, generally speaking, chromosomes are arranged in homologous pairs. Each member of the pair is similar to, but also different from, the other member.

Let's look at one pair of chromosomes, and, in particular, let's focus on one part of each chromosome. We want to make the picture easy to look at, so we won't bother with actually shaping the chromosomes like a double helix/twisted ladder.



Notice that each of these shaded portions is labeled "black fur." This means that the particular part of the chromosome that we've decided to look at codes for fur color. Now, this particular pair of chromosomes codes for enzymes that give rise to black fur. So, when it comes to fur color, what is this organism's phenotype? Simple—it's black.

When we say *pheno*type, we're talking about the organism and its traits. But when we say *geno*type, we're talking about the genes responsible for those traits.

Now, while we're looking at these two chromosomes, let's introduce another word: **genotype**. The genotype is the description of which versions

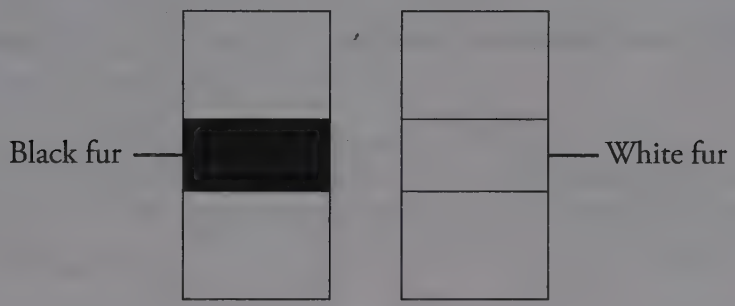
of a gene an organism has on its chromosomes. For the organism that we're now talking about—the one with the black fur—we'd (1) look at the homologous chromosome pair pictured above, (2) see that both homologous chromosomes show a gene for black fur, and (3) say

Fur Color *Geno*type: black/black (or BB)
Fur Color *Pheno*type: black

More About Genotype and Phenotype: Features That Are Dominant and Recessive

Let's consider another organism with black fur. When it comes to fur, what's the organism's phenotype? It's black.

Now let's look at its genotype. Here are the chromosomes that contain the genes responsible for fur color.



Notice, then, that in this example there are two "versions" of the gene for fur color—a black fur version and a white fur version. When the two copies of a gene are different versions, it is called **heterozygous**. If the versions are the same it is called **homozygous**. Versions of a gene are called **alleles**, and we can refer to the black fur allele or the white fur allele.

The two homologous chromosomes don't agree on what color the organism's fur should be. One codes for black fur, and the other codes for white fur. Yet one member of the pair definitely wins the debate, since the organism has black fur. When we want to describe this organism's phenotype and genotype in terms of fur color we say

*Geno*type: black/white (or Bb)
*Pheno*type: black

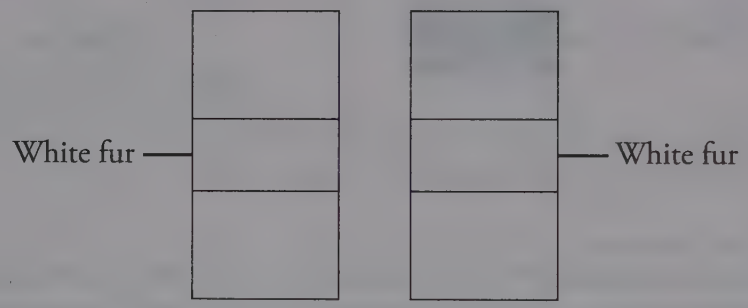
Why does one of the chromosomes get to express itself in the organism's phenotype while the other one has to keep quiet? Here's the answer: for the species to which this organism belongs, black fur is **dominant**, and white fur is **recessive**. That just means that if an organism of this species has one black-fur chromosome and one white-fur chromosome, the organism will have fur that's black. A dominant allele will always give rise to the phenotype. A recessive allele only gives rise to the phenotype when there are no dominant alleles to overshadow it.

Notice that we can use a sort of "shorthand" to indicate genotype. We can use letters to represent the alleles an organism has. For example, in our first organism, the one in which both chromosomes code for black fur, we described the genotype as black/black, or BB. The uppercase B represents the allele for black fur because black is dominant. In our second organism, in which one chromosome codes for black fur and one codes for white fur, we described the genotype as black/white, or Bb. The lowercase b represents the allele for white fur.

> Uppercase letters are used to represent dominant alleles, and lowercase letters are used to represent recessive alleles.

Notice also that the letter chosen to represent the dominant allele is the same letter chosen to represent the recessive allele. In other words, we didn't switch letters and represent the allele for white fur with a lowercase *w*. As long as we're talking about the same trait (in this case, fur color), the letter stays the same; we just use uppercase for dominant and lower case for recessive.

Let's consider a few more organisms of this species. Here's one with fur color genotype: white/white.



Its fur-color phenotype will be white. Even though white is recessive, both chromosomes agree that the fur should be white. There's no black-fur chromosome around to dominate the matter. As a matter of fact, if you see an organism of this species and its fur is white, you know that its genotype is white/white, or bb. Because white is recessive, that's the only genotype that can produce a white phenotype. If a black-fur chromosome were around, the phenotype would have to be black. A white-fur phenotype definitely means a bb genotype because white is recessive.

Codominance and Incomplete Dominance

It is possible, in the case of multiple alleles (i.e., more than two), for two alleles to exhibit **codominance**. This means that a heterozygote expresses both alleles. This is the case, for example, when someone has the blood type AB. Their blood cells have both types of proteins on them at the same time instead of just having protein A or protein B. Neither is dominant.

Another special type of dominance is incomplete dominance. In this type, the dominant and recessive alleles blend together and the phenotype is sort of an in-between version of them. An example would be if a heterozygote has a red allele and a white allele and the flower phenotype turns out pink.