

What are Dominant and Recessive?

The terms dominant and recessive describe the inheritance patterns of certain traits. That is, they describe how likely it is for a certain phenotype to pass from parent offspring.

Sexually reproducing species, including people and other animals, have two copies of each gene. The two copies, called alleles, can be slightly different from each other. The differences can cause variations in the protein that's produced, or they can change protein expression: when, where, and how much protein is made. Proteins affect traits, so variations in protein activity or expression can produce different phenotypes.

A dominant allele produces a dominant phenotype in individuals who have one copy of the allele, which can come from just one parent. For a recessive allele to produce a recessive phenotype, the individual must have two copies, one from each parent. An individual with one dominant and one recessive allele for a gene will have the dominant phenotype. They are generally considered “carriers” of the recessive allele: the recessive allele is there, but the recessive phenotype is not.

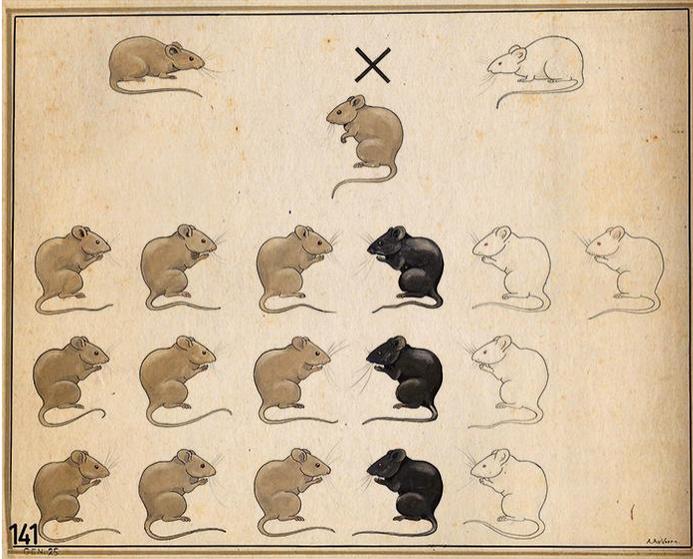
The terms are confusing and often misleading

Dominant and recessive inheritance are useful concepts when it comes to predicting the probability of an individual inheriting certain phenotypes, especially genetic disorders. But the terms can be confusing when it comes to understanding how a gene specifies a trait. This confusion comes about in part because people observed dominant and recessive inheritance patterns before anyone knew anything about DNA and genes, or how genes code for proteins that specify traits.

The critical point to understand is that there is no universal mechanism by which dominant and recessive alleles act. Dominant alleles do not physically “dominate” or “repress” recessive alleles. Whether an allele is dominant or recessive depends on the particulars of the proteins they code for.

The terms can also be subjective, which adds to the confusion. The same allele can be considered dominant or recessive, depending on how you look at it. The sickle-cell allele, described below, is a great example.

Do a simple internet search, and you'll find pages and pages of charts, images, and text explaining dominant and recessive inheritance patterns. However, these patterns apply to few traits.



The sickle-cell allele

Inheritance patterns

Sickle-cell disease is an inherited condition that causes pain and damage to organs and muscles. Instead of having flattened, round red blood cells, people with the disease have stiff, sickle-shaped cells. The long, pointy blood cells get caught in capillaries, where they block blood flow. Muscle and organ cells don't get enough oxygen and nutrients, and they begin to die.

The disease has a recessive pattern of inheritance: only individuals with two copies of the sickle-cell allele have the disease. People with just one copy are healthy.

In addition to causing disease, the sickle-cell allele makes people who carry it resistant to malaria, a serious illness carried by mosquitos. Malaria resistance has a dominant inheritance pattern: just one copy of the sickle cell allele is enough to protect against infection. This is the very same allele that, in a recessive inheritance pattern, causes sickle-cell disease!

Now let's look again at the shape of the blood cells. People with two copies of the sickle-cell allele have many sickled red blood cells. People with two copies of the "normal" allele have disc-shaped red blood cells. People with one sickle-cell allele and one normal allele have a small number of sickled cells, and their cells sickle more easily under certain conditions. So we could say that red blood cell shape has a co-dominant inheritance pattern. That is, individuals with one copy of each allele have an in-between phenotype.

So is the sickle cell allele dominant, recessive, or co-dominant? It depends on how you look at it.

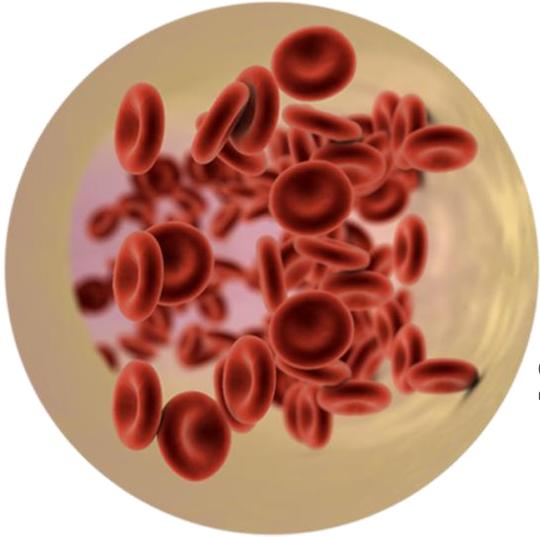
Protein function

If we look at the proteins the two alleles code for, the picture becomes a little more clear. The affected protein is hemoglobin, the oxygen-carrying molecule that fills red blood cells. The sickle-cell allele codes for a slightly modified version of the hemoglobin protein. The modified hemoglobin protein still carries oxygen, but under low-oxygen conditions the proteins stick together.

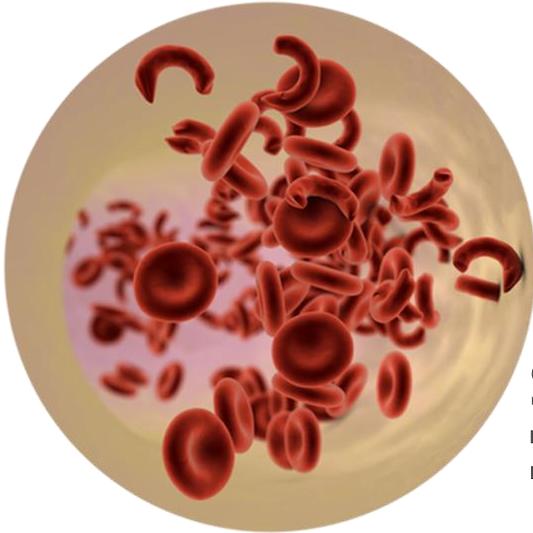
When a person has two sickle cell alleles, all of their hemoglobin is the sticky form, and the proteins form very long, stiff fibers that distort red blood cells. When someone has one sickle-cell allele and one normal allele, only some of the hemoglobin is sticky. Non-sticky hemoglobin is made from the normal allele, and sticky hemoglobin is made from the sickle-cell allele (every cell has a copy of both alleles). The sticking-together effect is diluted, and in most cells, the proteins don't form fibers.

The protist that causes malaria grows and reproduces in red blood cells. Just exactly how the sickle-cell allele leads to malaria resistance is complex and not completely understood. However, it appears that the parasite reproduces more slowly in blood cells that have some modified hemoglobin. And infected cells, because they easily become misshapen, are more quickly removed from circulation and destroyed.

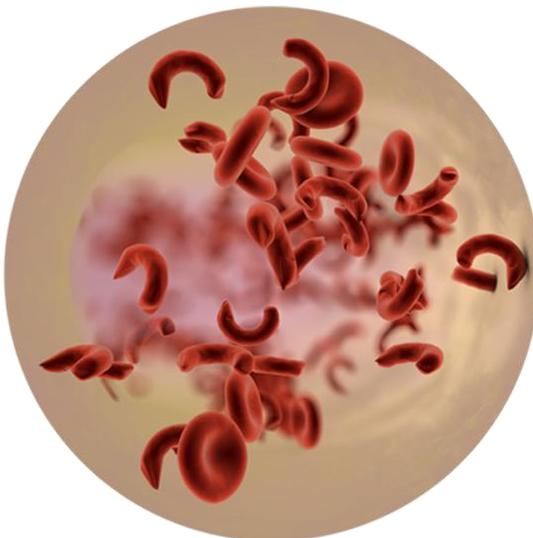
To see more examples of how variations in genes influence traits, visit [The Outcome of Mutation](#).



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Common Myths Explained

Dominant and recessive are important concepts, but they are so often over-emphasized. After all, most traits have complex, unpredictable inheritance patterns. However, at the risk of adding even more over-emphasis, here are some more things you may want to know:

Dominant phenotypes are not always more common than recessive phenotypes

Let's look at a typical (i.e., rare) single-gene trait:

- dominant allele + dominant allele = dominant phenotype
- dominant allele + recessive allele = dominant phenotype
- recessive allele + recessive allele = recessive phenotype

Looking at this, you might conclude that the dominant phenotype is twice as common as the recessive one. But you would probably be wrong.

Recessive alleles can be present in a population at very high frequency. Consider eye color. Eye color is influenced mainly by two genes, with smaller contributions from several others. People with light eyes tend to carry recessive alleles of the major genes; people with dark eyes tend to carry dominant alleles. In Scandinavia, most people have light eyes—the recessive alleles of these genes are much more common here than the dominant ones.

Dominant alleles are not better than recessive alleles

Mode of inheritance has nothing to do with whether an allele benefits an individual or not. Take rock pocket mice, where fur color is controlled mainly by a single gene. The gene codes for a protein that makes dark pigment. Some rock pocket mice have dark fur, and some have light fur. The dark-fur allele is dominant, and the light-fur allele is recessive.

When mice live in a habitat filled with dark rocks, dark fur is “better” because it makes the mice less visible to predators. But when mice live in a habitat filled with light rocks and sand, light fur is “better.” It's the environment that matters, not whether the allele is dominant or recessive.

A “broken” allele can have a dominant inheritance pattern

Many genetic disorders involve “broken” genes that code for a protein that doesn't work properly. Since one “normal” copy of the gene can often provide enough of the protein to mask the effects of the disease allele,

these disorders often have a recessive inheritance pattern. But not all diseases alleles are recessive.

Keratin proteins link together to form strong fibers that strengthen hair, fingernails, skin, and other tissues throughout the body. There are several genetic disorders involving defects in keratin genes, and most of them have dominant inheritance patterns.



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