

Sex-Related Inheritance

Sex-Linked Genes

Genes located on the X chromosomes are called X-linked genes. Genes on the Y chromosomes are called Y-linked genes.

An example of an X-linked trait in humans is hemophilia. A person suffering from hemophilia could die from loss of blood even from a small wound because the blood either clots very slowly or does not clot at all. Another example of an X-linked trait is color blindness. To illustrate the inheritance of an X-linked trait, we will use color blindness in our discussion. Let us study Table 2. The X chromosome with the gene for color blindness is represented as X^C , while the one without is represented as X.

Table 2. Genotypes and phenotypes of color blindness in humans

Genotype	Phenotype
X X	Normal female
X X^C	Normal female, carrier of the gene
$X^C X^C$	Color-blind female
XY	Normal male
$X^C Y$	Color-blind male

Notice that for a female to become color-blind, she must be homozygous ($X^C X^C$) for the color-blind genes. The trait is, therefore, recessive in females. If a female has only one X chromosome with the allele for color blindness, she becomes normal but can pass on the trait to her offspring. She is therefore a carrier of the trait. Since males have only one X chromosome, the gene for color blindness when present in the male, will always be expressed because it does not have an allele to hide or prevent its expression. Thus, the male will be color-blind. This is the reason why color blindness is more common in males than in females.

An example of a Y-linked trait is Hypertrichosis pinnae auris, a genetic disorder in humans that causes hairy ears. Since the trait is found in the Y chromosome, then only males can have the trait. A father who has the condition will pass it on to all his sons, and they, in turn, will pass it on to their own sons.

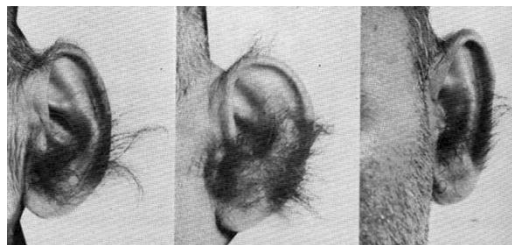


Figure 5. Sex-linked genes

Key Concepts

- Sex-linked traits are inherited through the X chromosomes.
- Males have only one X chromosome. Thus, if they inherit the affected X, they will have the disorder.
- Females have two X chromosomes. Therefore, they can inherit/carry the trait without being affected if it acts in a recessive manner.

Sex-Limited Traits

Sex-limited traits are generally autosomal, which means that they are not found on the X or Y chromosomes. The genes for these traits behave exactly the same way that any autosomal gene behaves. The difference here comes in the expression of the genes in the phenotype of the individual. Sex-limited traits are expressed in only one gender.

In cattle, for instance, lactation is expressed in females but never in males. Both male and female cattle however possess a gene pair for lactation. The gene for lactation (L) is dominant over the non-lactating gene (l). Table 3 shows the genotypes and phenotypes of the gene for lactation. These genes are carried by both males and females, but it is only expressed in females. In female cattle, if they possess at least one gene pair for lactation (L), the female produces milk. In male cattle, it does not matter if they possess one or two genes for lactation. They never produce milk.

Table 3. Expression of lactation in cattle

Female Genotypes	Female Phenotypes
$X^L X^L$	Female lactating
$X^L X^l$	Female lactating
$X^l X^l$	Female not lactating
Male Genotypes	Male Phenotypes
$X^L Y^L$	Male not lactating
$X^L Y^l$	Male not lactating
$X^l Y^l$	Male not lactating

Sex-Influenced Traits

Sex-influenced traits are also autosomal, meaning that their genes are not carried on the sex chromosomes. Again, what makes these traits unusual is the way they are expressed phenotypically. In this case, the difference is in the ways the two genders express the genes. One classic example of a sex-influenced trait is pattern baldness in humans, though the condition is not restricted to males. This gene has two alleles, “bald” and “non-bald”. The behaviors of the products of these genes are highly influenced by the hormones in the individual, particularly testosterone, but males have much higher levels of this hormone than females. The baldness allele behaves

Table 4. Expression of pattern baldness in humans

Male Genotypes	Male Phenotypes
$X^B Y^B$	Male bald
$X^B Y^b$	Male bald
$X^b Y^b$	Male non-bald
Female Genotypes	Female Phenotypes
$X^B X^B$	Female bald
$X^B X^b$	Female non-bald
$X^b X^b$	Female non-bald

If you look at the heterozygous gene pair for baldness (Bb), males express baldness, while females do not. Baldness may be expressed in females but it occurs more frequently in males. Such trait is sex-influenced because of a substance that is not produced equally in males and females.

Key Concepts

- Sex-limited traits are those that are expressed exclusively in one sex.
- Sex-influenced traits are expressed in both sexes but more frequently in one than in the other sex.