# Incomplete dominance is a form of inheritance in which one [allele](http://biology.about.com/od/geneticsglossary/g/alleles.htm) for a specific trait is not completely dominant over the other allele. This results in a third, distinct [phenotype](http://biology.about.com/od/geneticsglossary/g/phenotype.htm) in which the physical trait is a blend of the dominant and recessive phenotypes. Study the example that follows before working the practice problems that illustrate incomplete dominance.

Flower color in snapdragons demonstrates incomplete dominance (CR Cw). Genotypes and phenotypes are listed in the table below.

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| **Genotype** | **Phenotype** |
| Cw Cw | White flowers |
| CR CR | Red flowers |
| CR Cw | Pink Flowers |

**PRACTICE PROBLEMS:**

1. What phenotypic ratio of offspring would you expect to be produced when crossing a snapdragon that is homozygous for white flowers and homozygous for red flowers?

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1. In horses, one of the genes that control hair color is incompletely dominant. Genotypes are as follows: brown horses are CB CB, white horses are CW CW and a CB CW genotype creates a yellow-tannish colored horse with a white mane and tail, known as “palomino”. Which two colors of horse would you want to breed if you wanted to produce the maximum numbers of palominos in the shortest amount of time?

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1. Many breed of cattle have three colors: **red coat, white coat, and roan coat (heterozygote condition). A farmer has a roan bull and a red herd of cows. How can he produce a pure breeding (homozygous) white herd without bringing in any outsider bulls/cows.**

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HumanABO blood groups also demonstrate a trait that is controlled by **multiple alleles**. In every trait we have studied so far, each gene has only two distinct forms. In the case of ABO blood groups, there are three forms of the gene (alleles) that exist in the population as a whole: type A blood (IA), type B blood (IB), and type O blood (i). This means that, in some cases, there is more than one genotype that codes for the same phenotype. People with type A and B blood produce either A or B surface antigens on the surface of their red blood cells. Type O blood (the recessive condition) cells do not have any surface antigens.

**Codominance** is a form of inheritance in which two dominant alleles are expressed equally when both are present. For example, in human ABO blood groups, a person who has type AB blood (IA IB) demonstrates this condition. They produce both the A and B surface antigens on their red blood cells. Genotypes and phenotypes are listed in the table below.

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| **Genotype** | **Phenotype** |
| Homozygous | Heterozygous |
| IA IA  | IA i | Type A |
| IB IB | IB i | Type B |
| IA IB | Type AB |
| ii | Type O |

**PRACTICE PROBLEMS:**

1. If a woman is type O and a man is heterozygous for type B, what possible blood types could their children have?

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1. What genotypes must a woman (type A) and man (type B) have to produce a child who is type O?

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1. Two parents think their baby was switched at the hospital. The mother has type O, the father has type AB, and the baby has type B. Has a mistake been made (assume no spontaneous mutations have occurred)? Explain.

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**Sex(X)-linked** traits are traits that are controlled by a gene that is located specifically on one of the two sex chromosomes. There are very few Y-linked disorders, so when you hear “sex-linked” assume we are talking about the X chromosome. Because females are XX and males are XY, this means that a female has more possible genotypes and less chance of expressing a sex-linked trait. A male, on the other hand, only has two potential genotypes. Consider the blood clotting disorder hemophilia (a recessive condition). This disorder prevents normal blood clotting that slows the flow of blood from a wound. Individuals with this disorder can bleed to death even from minor cuts and scrapes if not given immediate medical attention. Genotypes and phenotypes are listed in the table below.

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|  | **Genotype** | **Phenotype** |
| Female | XHXH | Healthy |
| XHXh |
| XhXh | Hemophilia |
| Male | XHY | Healthy |
| XhY | Hemophilia |

**PRACTICE PROBLEMS:**

1. A man who has hemophilia and a woman who does not have the disorder (homozygous dominant) are considering having children.

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1. What is the probability that they will produce a child who is healthy?
2. What is the probability of them producing a child with hemophilia?
3. If they have a boy, what is the probability that he has hemophilia?
4. If they have a girl, what is the probability that she has hemophilia?
5. Red-green colorblindness is a recessive, sex-linked trait. Individuals who have the disorder struggle to differentiate between subtle differences in shades of green and red. A man who is not colorblind wants to have children with a woman who is a carrier (heterozygous).

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1. What percentage of their offspring will be colorblind?
2. What sex are the offspring who will be colorblind?
3. What percentage will have normal vision?
4. Duchene muscular dystrophy (DMD) is a recessive, sex-linked, genetic disorder that causes the progressive deterioration of the skeletal muscles within the body. A man who does not have DMD wants to have a child with a woman who is a carrier.

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1. What are the chances of them having a child who is a carrier for the disorder?
2. What would the couple’s genotype have to be in order to produce a female who is homozygous recessive for DMD?

**Linked Genes** are genes for different traits that are located on the same homologous chromosome. Because of this, alleles for the different traits do not independently assort according to Mendel’s law. Instead, they are inherited together unless crossing over has produced a recombinant chromosome and moved them apart from one another. However, the closer together on the chromosome the genes are located, the less likely it is for crossing over to separate them.

In Siberian foxes, pointy ears are dominant to floppy ears and black coat is dominant to silver coat. You have two hybrid foxes that you want to breed together, both with pointy ears and black coats. You are expecting to get four different phenotypes from this cross, but after several litters of pups are born, you notice that all 54 pups with dark coats have pointy ears and all 48 pups with silver coats have floppy ears. Perform a chi square analysis on this data to determine whether this outcome is significantly different than what you would expect from a normal dihybrid cross.

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| **Phenotype** | **Observed (o)** | **Expected (e)** | **(o-e)** | **(o-e)2/e** |
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