

AP Biology  
Complex Inheritance

**Incomplete dominance:** Pattern of inheritance in which the dominant phenotype is not fully expressed in the heterozygote, resulting in a phenotype intermediate between the homozygous dominant and homozygous recessive.

\*For example when red snapdragons (RR) are crossed with white snapdragons (rr) all F1 hybrids (Rr) have pink flowers. (the heterozygote produces half as much red pigment as the homozygous red-flowered plant.)

\*Incomplete dominance is not support for the blending theory of inheritance, because alleles maintain their integrity in the heterozygote and segregate during gamete formation. Red and white phenotypes reappears in the F2 generation.



**Codominance:** Inheritance characterized by full expression of both alleles in the heterozygote.

\*For example, the MN blood-group locus codes for the production of surface glycoproteins in the red blood cell. In this system there are three blood types, M, N and MN.

Blood type	Genotype
M	MM
N	NN
MN	MN

\* The MN blood type is the result of full phenotypic expression of both alleles in the heterozygote; both molecules, M and N, are produced on the red blood cells.

**Apparent dominance/recessiveness relationships among alleles reflect the level at which the phenotype is studied.**

**For example:**

\*Tay-Sachs disease is a recessive inherited disease in humans; only children who are homozygous recessive for the Tay-Sachs allele have the disease

\*Brain cells of Tay-Sachs babies lack a crucial lipid metabolizing enzyme. Thus lipids accumulate in the brain, causing the disease symptoms and ultimately leading to death.

\* At the organism level, since heterozygotes are symptom free, it appears that the normal allele is completely dominant and the Tay-Sachs allele is recessive.

\* At the biochemical level inheritance of Tay-Sachs seems to be incomplete codominance of the normal allele, since there is an intermediate phenotype. Heterozygotes have an enzyme activity level that is intermediate between individuals homozygous for the normal allele and individuals with Tay-Sachs disease.

\* At the molecular level the normal allele and the Tay-Sachs allele are actually codominant. Heterozygotes produce equal numbers of normal dysfunctional enzymes. They lack disease symptoms, because half the normal amount of functional enzyme is sufficient to prevent lipid accumulation in the brain.

### Multiple alleles:

Some genes may have multiple alleles ( more than just two alternative forms of a gene). The inheritance of the

ABO blood group is an example of a locus with three alleles.

Paired combinations of three alleles produce for possible phenotypes:

\*Blood type A,B, AB or O.

\* A and B refer to tow genetically determined polysaccharides ( A and B antigens) which are found on the surface of red blood cells different from.

There are three alleles for this gene  $I^A$ ,  $I^B$  and  $i$ .

\* The  $I^A$  alleles codes for the production of A antigen the  $I^B$  allele codes for the production of B antigen and the  $i$  allele codes for no antigen production n the red blood cell (neither A or B)

\* Alleles  $I^A$  and  $I^B$  are codominant since both are expressed in heterozygotes.

\* Alleles  $I^A$  and  $I^B$  are dominant to allele  $i$ , which is recessive

\* Even though there are three possible alleles, every person carries only two alleles which specify their ABO blood type; one allele is inherited from each parent.

Since there are three alleles, there are six possible genotypes.

Blood Type	Possible Genotypes	Antigens on the Red Blood Cell	Antibodies in the Serum
A	$I^A I^A$ $I^A i$	A	anti B
B	$I^B I^B$ $I^B i$	B	anti A
AB	$I^A I^B$	A,B	----
O	$ii$	----	anti-A anti-B

Foreign antigens usually cause the immune system to respond by producing antibodies, globular proteins that bind to the foreign molecules causing a reaction that destroys or inactivates it. In the ABO blood system:

\*The antigens are located on the red blood cell and the antibodies are in the serum

\* A person produces antibodies against offering blood antigens (those not possessed by the individual).

These antibodies react with the foreign antigens causing the blood cells to clump or agglutinate, which may be lethal

\* For a blood transfusion to be successful, the red blood cell antigens of the donor must be compatible with the antibodies of the recipient.

### Pleiotropy

*Pleiotropy*: the ability of a single gene to have multiple phenotypic effects.

\* There are may hereditary disease in which a single defective gene cause complex sets of symptoms.

For example: in tigers and Siamese cats, the gene that controls fur pigmentation also influences the connections between a cat's eyes and the brain. AA defective gene cause both abnormal pigmentation and cross-eye condition.

### Epistasis:

Different genes can interact to control the phenotypic expression of a single train. In some cases, a gene at one locus alters the phenotypic expression of a second gene, a condition know as epistasis.

Interaction between two nonallelic genes in which one modifies the phenotypic expression of another, the first gene which one modifies the phenotypic expression of the other.

- \* If one gene suppresses the phenotypic expression of another, the first gene is said to be epistatic to the second
- \* If epistasis occurs between two nonallelic genes the phenotypic ratio resulting from a dihybrid cross will deviate from the 9:3:3:1 Mendelian ratio
- \* For example, in mice and other rodents, the gene for pigment deposition (C) is epistatic to the gene for pigment (melanin) production. In other words, whether the pigment can be deposited in the fur determines whether the coat color can be expressed. Homozygous recessive for pigment deposition (cc) will result in an albino mouse regardless of their genotype at the black/brown locus (BB, Bb, or bb): CC, Cc = Melanin deposition. cc = Albino BB, Bb = Black coat color bb = Brown coat color.

A cross between black mice that are heterozygous for the two genes results in a 9:3:4 phenotypic ratio:

- 9 Black (B\_C\_)
- 3 Brown (bbC\_)
- 4 albino (\_cc)

### **Polygenic inheritance.**

**Quantitative characters:** Characters that vary by degree in a continuous distribution rather than by discrete (either-or) qualitative differences.

- \* Usually continuous variation is determined not by one, but by many segregating loci or polygenic inheritance.

**Polygenic inheritance:** Mode of inheritance in which the additive effect of two or more genes determines a single phenotypic character.

For example, skin pigmentation in humans appears to be controlled by at least three separately inherited genes.

