

Non-Mendelian Genetics

The Molecular Basis of Dominance

- The terms dominant and recessive have a phenotypic basis
- However, the dominance of one allele over another is determined by the protein product of that allele
- The overall phenotype is the consequence of the activities of the protein products of the alleles of the gene

Non-Mendelian Genetics

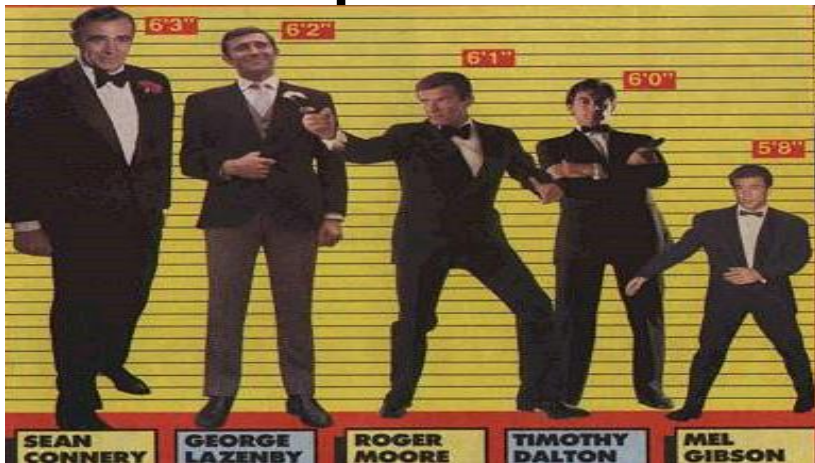
- ❖ Incomplete Dominance
- ❖ Codominance
- ❖ Multiple Alleles
- ❖ Polygenic Traits
- ❖ Penetrance and expressivity

Some exceptions to Mendel's principles: Gene interaction

- Some alleles are neither dominant nor recessive.
- There may be more than two alleles for a given locus (multiple alleles)
- Many traits are controlled by more than one gene (polygenic traits)
- The expression of a trait may depend on the interaction of more than one gene and/or the interaction of genes with nongenetic factors

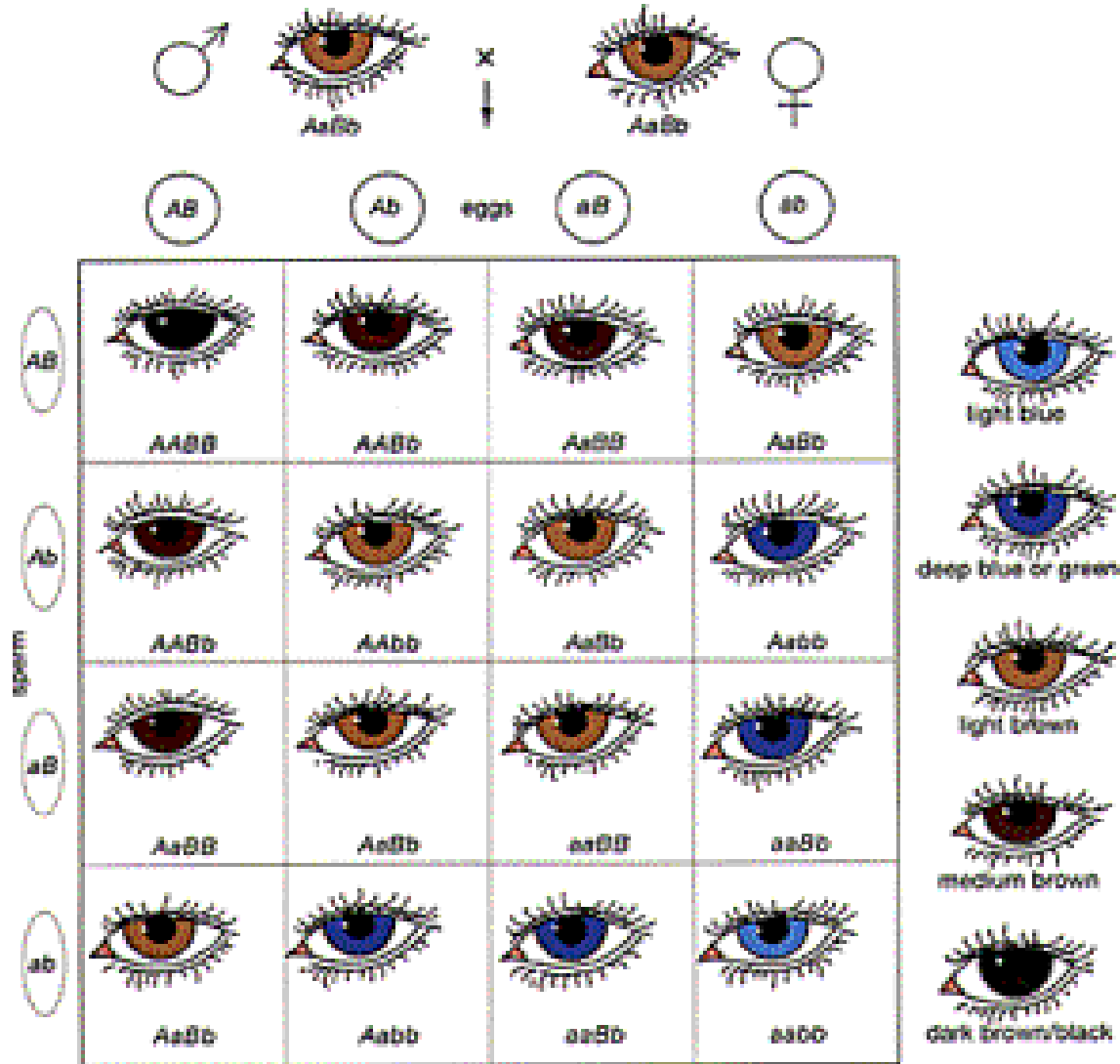
Polygenic traits

- Traits controlled by two or more genes.
- Examples:



Diet and health are strong environmental factors in expressing genetic potential for height

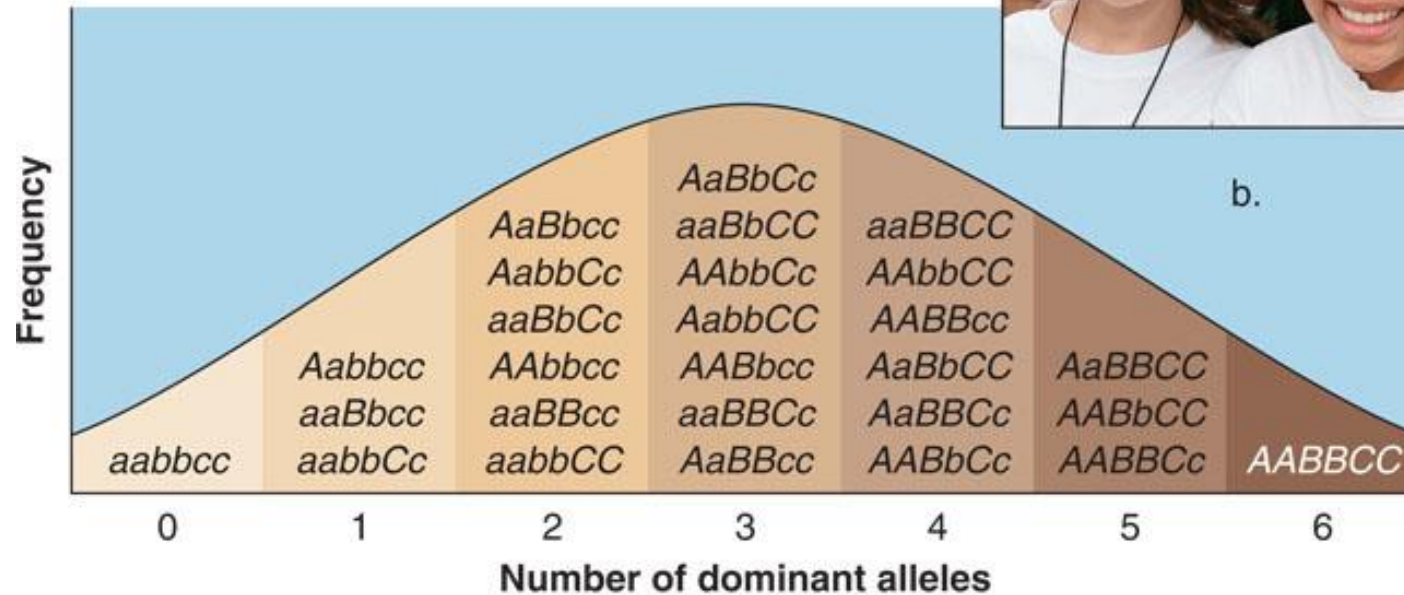
Polygenic inheritance



Polygenic Traits are Continuously Varying: Skin color

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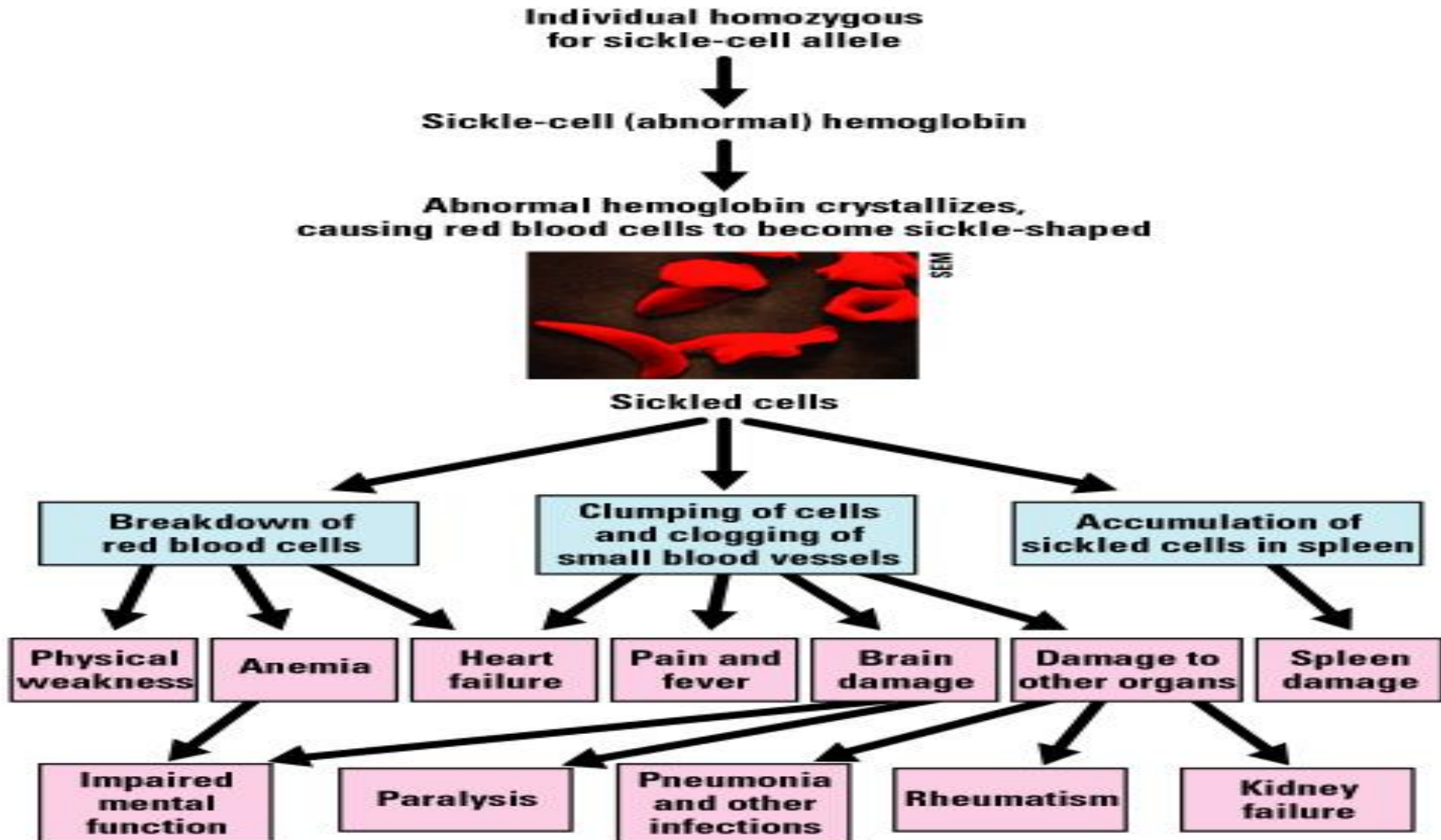
Contribution of many genes create a gradient of colors

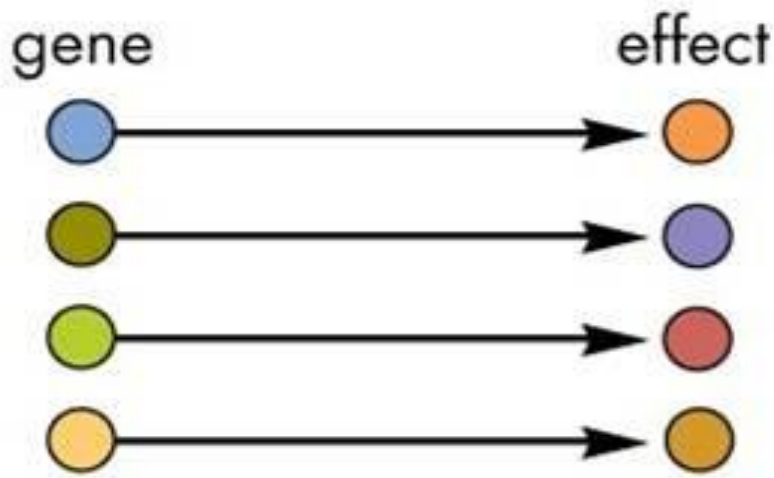


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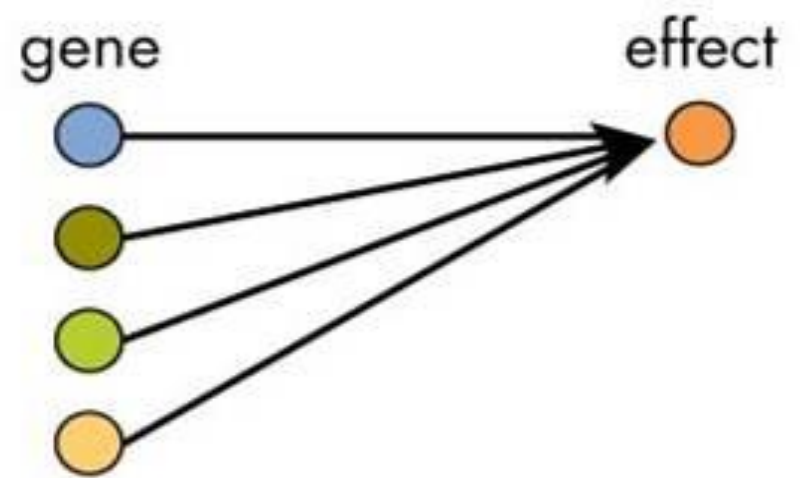
A bell shaped curve

One gene-different phenotype. Pleiotropic inheritance

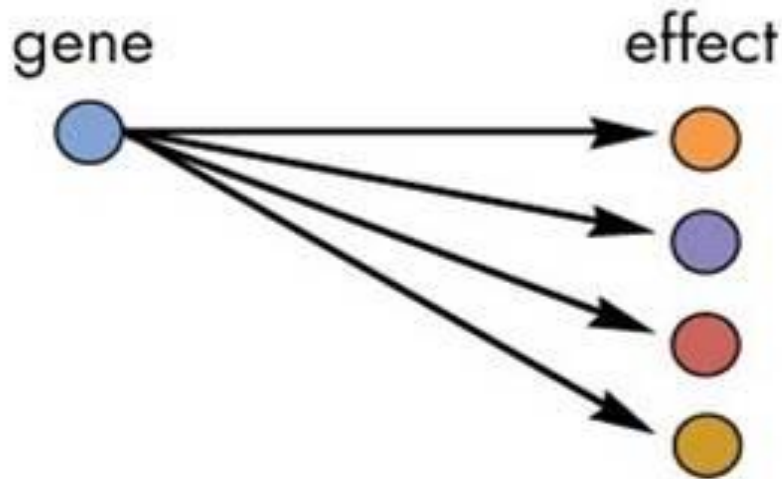




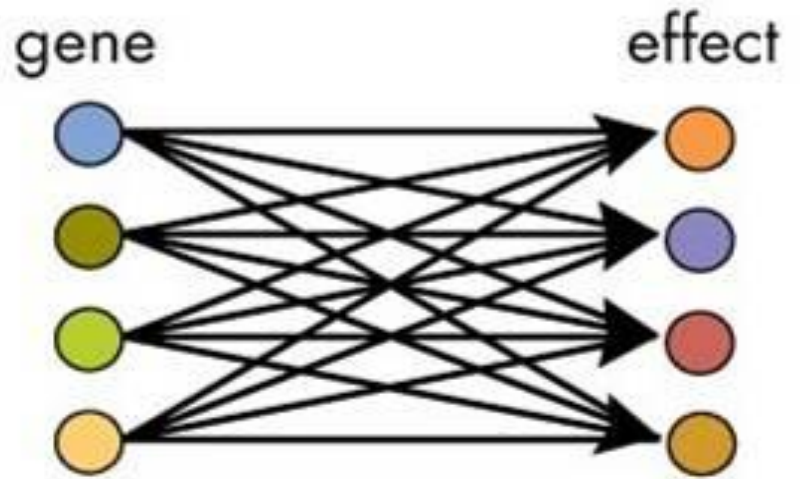
Each gene has a distinct biological effect.



Polygenic trait: Many genes contribute to a single effect.



Pleiotropy: A gene has multiple effects.



Polygenic traits and pleiotropy

Incomplete dominance

- A situation in which neither allele is dominant.
- When both alleles are present a “new” phenotype
- heterozygous individuals display **intermediate phenotypes** between either homozygous type
- Alleles will be represented by big letters only.

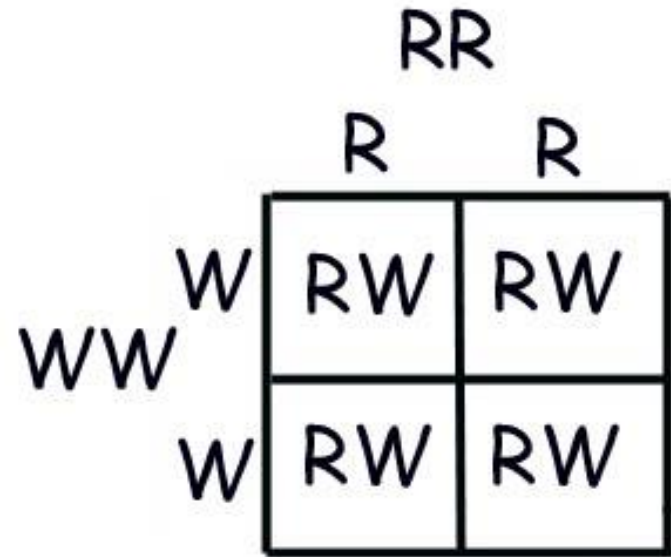
Japanese four-o'clock flowers

- Red flower plant genotype = **RR**
- White flower plant genotype = **WW**
- Pink flower plant genotype = **RW**



What happens when a red flower is crossed with a white flower?

- According to Mendel either some white and some red or all offspring either red or white.
- All are pink



When a trait exhibits incomplete dominance, a cross between two heterozygotes produces 1 : 2 : 1 genotypic and phenotypic ratio in the progeny.

Codominance

- Codominance leads to heterozygotes with a different phenotype than that of either homozygote
- In this case, there is detectable expression of both alleles in the heterozygotes

Codominance Example: Roan cattle

❖ cattle can be

red

(RR – all red hairs)

white

(WW – all white hairs)

roan

(RW – red and white hairs
together)



❖ Notice –

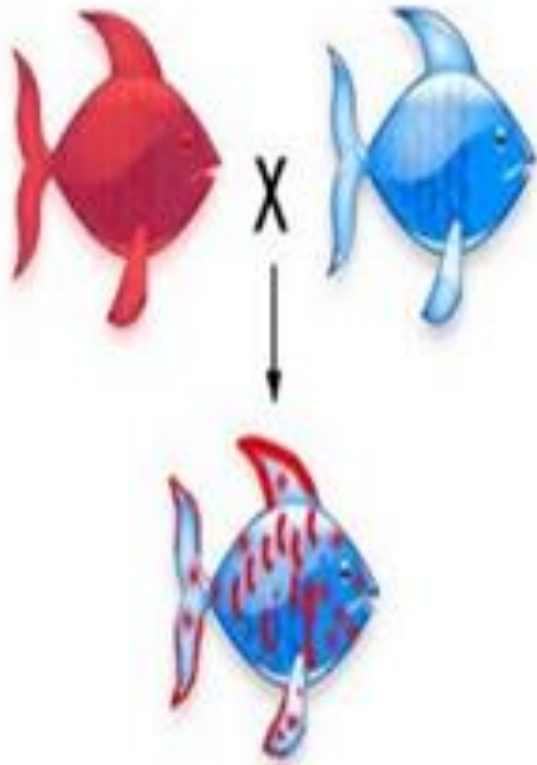
NO PINK!

NO BLEND!

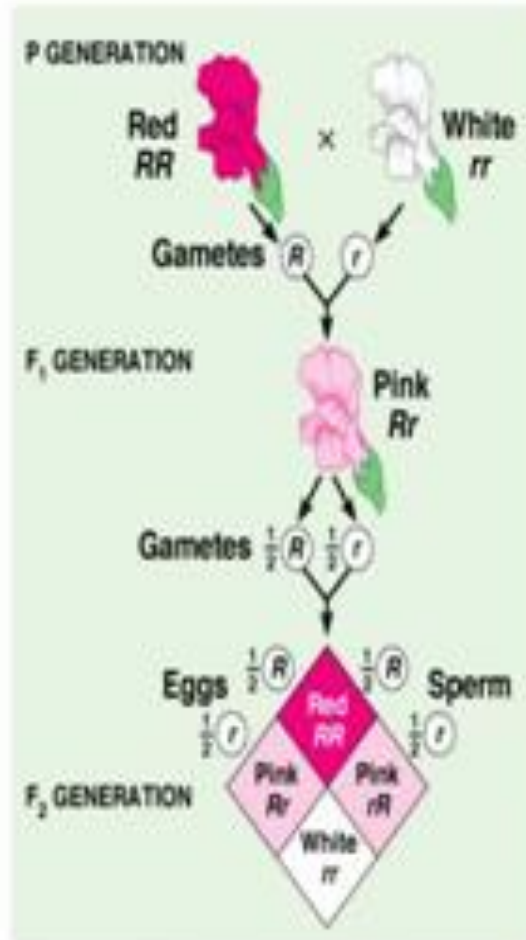
Each hair is

either red or white

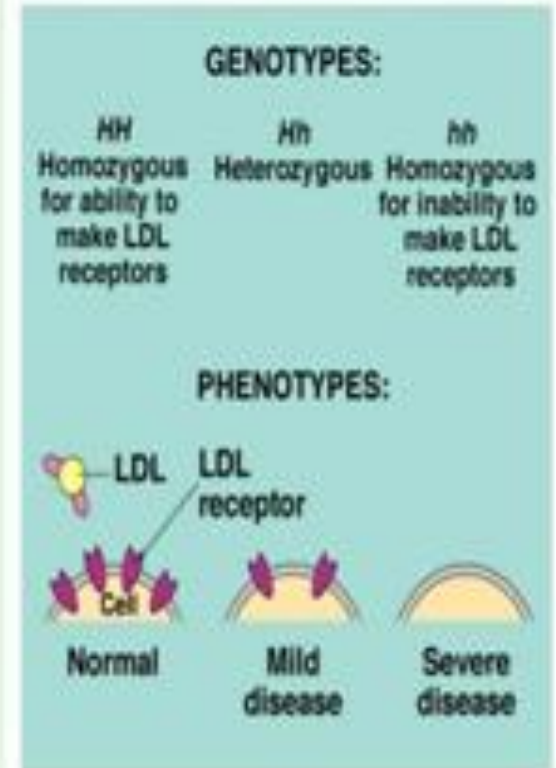
Explain.....



Codominance



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Incomplete dominance

Multiple allele inheritance

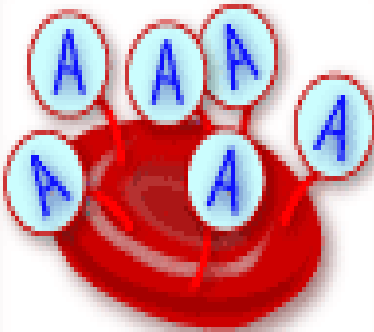
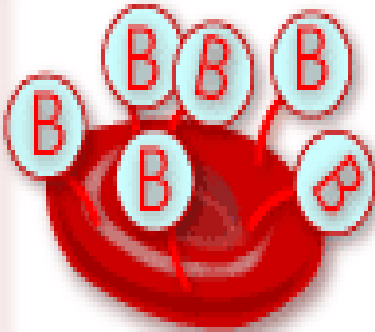


- When two or more alleles contribute to the phenotype.
- Human blood types: A,B,O and AB
- A and B are codominant to each other.
- Both A and B are dominant over O.

Dominance Relationships of ABO Alleles

- The ABO blood type has 4 different types, resulting from different combinations of 3 alleles
- The alleles are: I^A , I^B and i ; the I^A and I^B alleles are completely dominant over the i allele but codominant with each other
- The A blood type involves the presence of one antigen on the blood cell surfaces; type B the presence of a different antigen
- Type AB people have both antigens and type O people have neither

Multiple Alleles: Blood Types (A, B, AB, O)

The ABO Blood System

Blood Type (genotype)	Type A (AA, AO)	Type B (BB, BO)	Type AB (AB)	Type O (OO)
Red Blood Cell Surface Proteins (phenotype)	 <p>A agglutinogens only</p>	 <p>B agglutinogens only</p>	 <p>A and B agglutinogens</p>	 <p>No agglutinogens</p>

Blood Types (A, B, AB, O)

6 different genotypes

How many genotypes are present at a locus with five alleles?
=15

$$[n(n+1)]/2$$

n= number of alleles at a locus

Sample Problem:

- A man with type AB blood marries a woman with type B blood whose father has type O blood. What are the chances that they have a child with type A blood? Type AB?

Lethal Alleles

- Some single-gene mutations are so detrimental that they cause death in the organism
- These are caused by **lethal mutations**, which are inherited as recessive alleles (only the homozygotes die)

Penetrance and expressivity

- **Penetrance -**
 - ❖ **Percent individuals with a given allele that show the phenotype of the allele**
 - ❖ **<100% penetrance a result of epistasis, suppressors, environmental conditions**
- **Expressivity**
 - ❖ **Extent to which allele is expressed at phenotypic level**
 - ❖ **Affected by genetic background and environment**
- **These phenomena make pedigree analysis and genetic counseling more difficult**
- **Epistasis:** the alleles of one gene modify or prevent expression of alleles of another gene

Incomplete Penetrance: Polydactyly

- Polydactyly is an autosomal dominant condition, in which affected individuals have more than 5 fingers and toes
- The dominant allele is nonpenetrant in about 25 – 30% of individuals carrying it

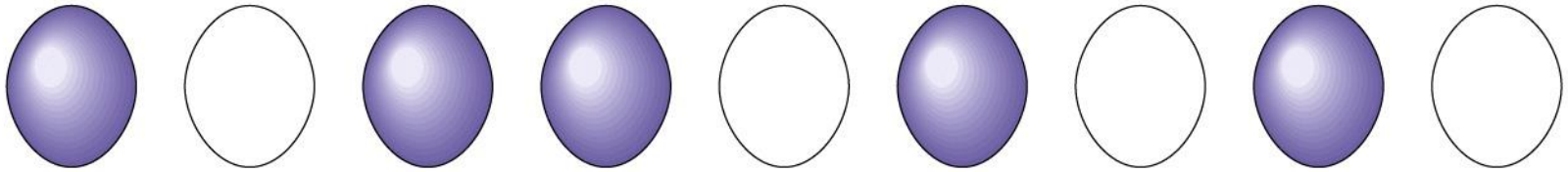


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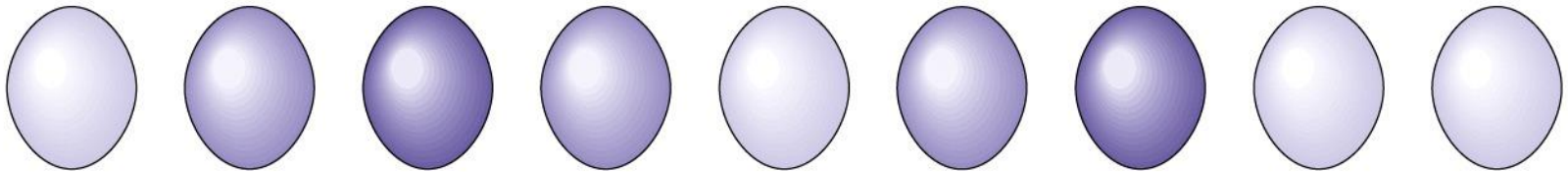


Penetrance and expressivity

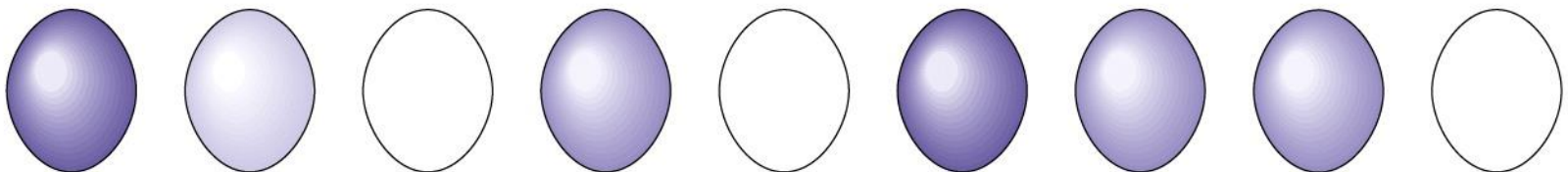
Phenotypic expression
(each oval represents an individual)



Variable penetrance



Variable expressivity



Variable penetrance and expressivity

Glossary

Table 5.1 Differences between dominance, incomplete dominance, and codominance

Type of Dominance	Definition
Dominance	Phenotype of the heterozygote is the same as the phenotype of one of the homozygotes.
Incomplete dominance	Phenotype of the heterozygote is intermediate (falls within the range) between the phenotypes of the two homozygotes.
Codominance	Phenotype of the heterozygote includes the phenotypes of both homozygotes.