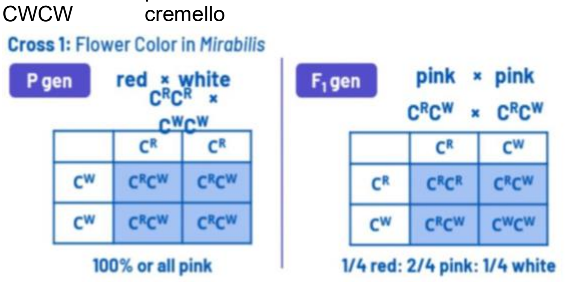
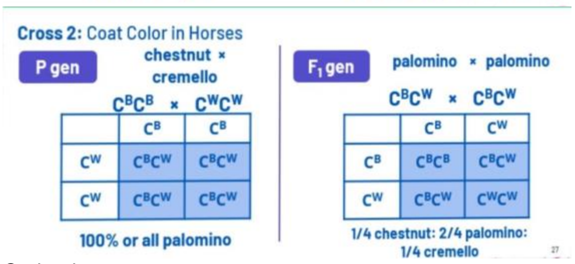
Gene Interaction
+The study of the inheritance of the seven characters in peas laid foundation to the formulation and understanding of the basic laws of inheritance. These laws and all other related assumptions make up the Mendelism.
+ However, many other biological traits in organisms do not follow some of the assumptions of Mendelian inheritance, such as the flower color in snapdragons
How are traits that do not follow Mendel's assumptions inherited?
1. The alleles of a gene separate during gamete formation (Law of Segregation).
2. Alleles from different loci assort Independently (Law of Independent Assortment).
3. In heterozygous individuals, the dominant allele completely masks the expression of the recessive allele (Principle of Dominance).
4. Offspring ratios for the F_2 of monohybrid and dihybrid crosses are 3:1 and 9:3:3:1, respectively.
5. One gene does not interact with another gene to control one trait of an organism.
Extensions of Mendelism
- The expression of the alleles does not follow complete or simple dominance.
- May have greater number of allelic variations for a single gene
- May have greater number of phenotypic variations for a single trait
- Gives offspring ratios that are different from the 3:1 and 9:3:3:1 of Mendel
Incomplete Dominance
- Also called partial dominance
- Two-allele system
- Blending of homozygous phenotypes
- Heterozygote with the intermediate phenotype
- At most three phenotypic classes
Case 1: Flower Color in Mirabilis
Alleles
CR = red flowers
CW = white flowers

Genotypes	Phenotypes
CRCR	red
CRCW	pink
CWCW	white

Case 2: Coat Color in Horses
Alleles
CB = brown fur
CW = white fur

Genotypes	Phenotypes
CBCB	chestnut
CBCW	palomino
CWCW	cremello





Codominance
- Simultaneous expression of two alleles
- Two-allele system
- No blending of homozygous phenotypes
- Heterozygote shows both alleles
- At most three phenotypic classes

Case 1: Coat Color in Cattle
Alleles
FR = red coat
FW = white coat

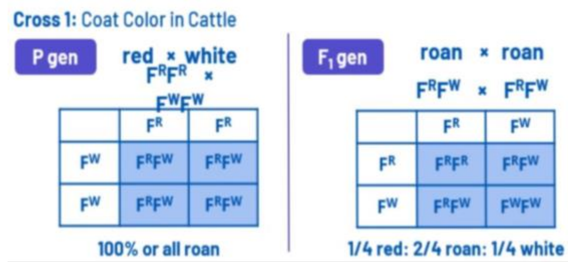
Genotypes	Phenotypes
FRFR	red
FRFW	roan
FWFW	white

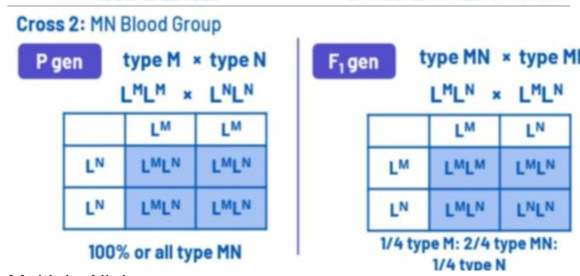
Case 2: MN Blood Group
MN Blood System
- Blood type determined by antigens
- Antigens being membrane glycoprotein
- Antigens detected by the immune system
- Two antigens: M antigen and N antigen
- Presence of an antigen through agglutination

Case 2: MN Blood Group

Corresponding genotypes for L^M and L^N alleles.

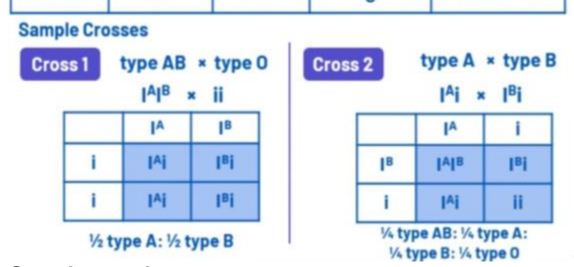
Phenotype	Genotype	Antigens Produced
Type M	L^ML^M	M antigen
Type N	L^NL^N	N antigen
Type MN	L^ML^N	M and N antigens



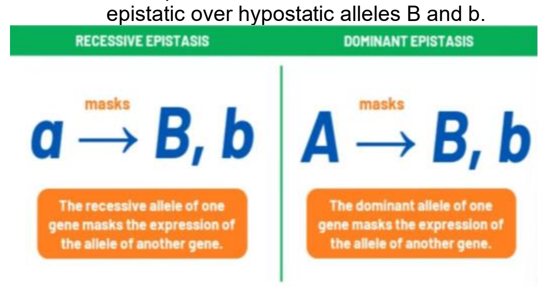


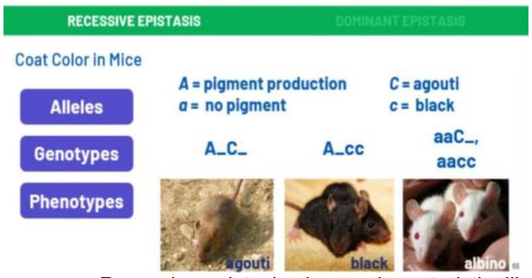
Multiple Alleles
ABO Blood Group
- Determined by the presence of antigens A and B in the surface of RBCs
- Three different alleles: IA (A antigen), IB (B antigen), and I (no antigen)
- IA and IB are codominant; both of them are dominant over i
- Must be determined prior to any procedure related to blood transfusion

Phenotype	Genotype(s)	Antigen(s) Produced	Possible Recipients	Possible Donors
Type A	I^AI^A, I^Ai	A antigen	Types A, AB	Types A, O
Type B	I^BI^B, I^Bi	B antigen	Types B, AB	Types B, O
Type AB	I^AI^B	A and B antigens	Type AB only	Types A, B, AB, O
Type O	ii	None	Types A, B, AB, O	Type O only

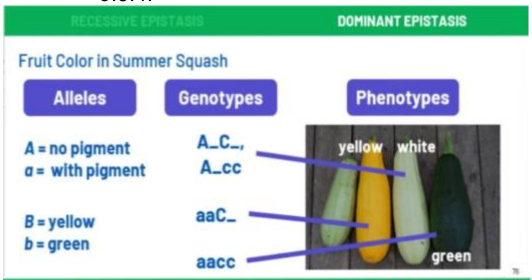


Gene Interaction
- Involves the interaction between two different gene loci
- The interaction controls the expression of only one biological trait
- Epistasis involves masking of the expression of a gene by another gene
- Epistatic gene masks the expression of the hypostatic gene
How do genes from two different loci interact to control the expression of one phenotypic trait?
- The relationship between epistatic and hypostatic genes is like the relationship between dominant and recessive alleles of a locus.
- In complete dominance, the dominant allele completely masks the expression of the recessive allele in a heterozygous individual. In epistatic interaction, two loci are already involved. It may be the recessive allele a that masks the expression of the alleles B and b. In this case, allele a is epistatic over hypostatic alleles B and b.

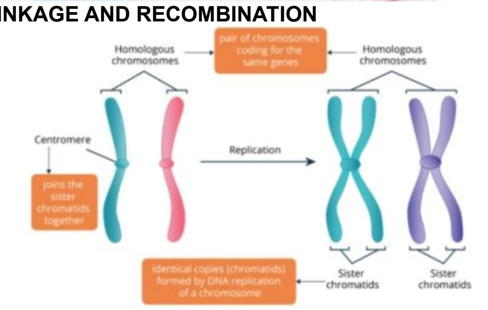




- Recessive epistasis gives a characteristic dihybrid ratio of 9:3:4.

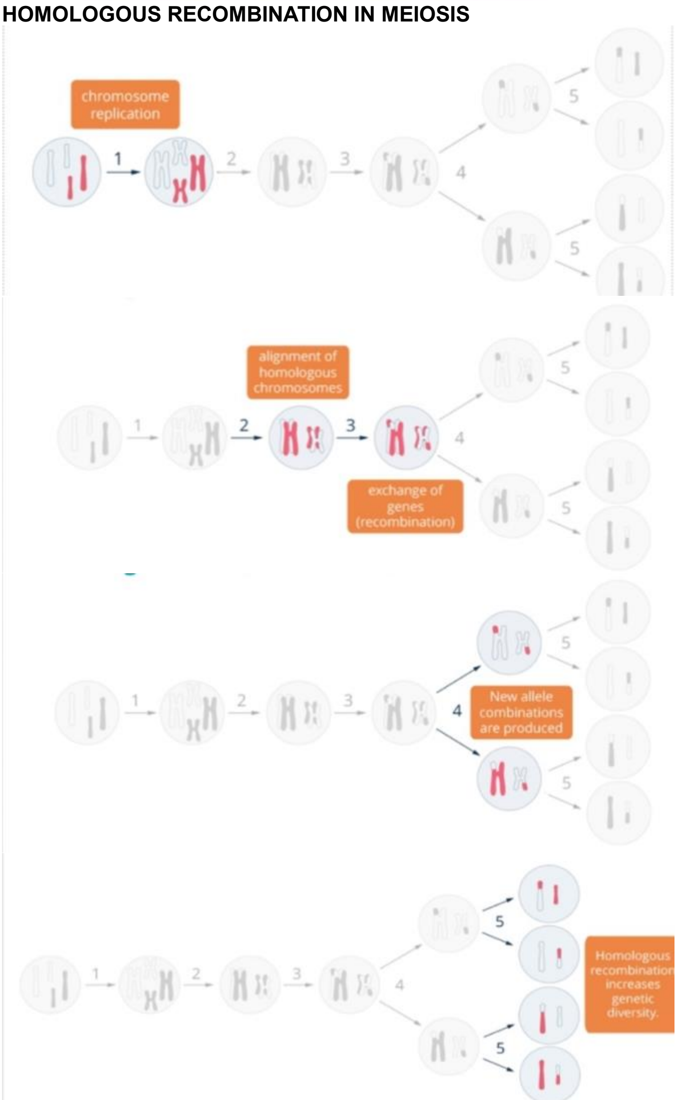


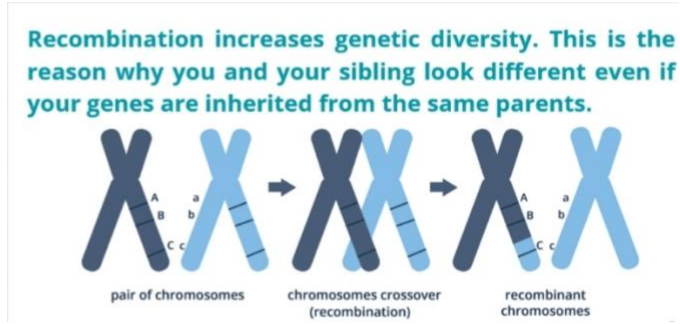
SEX LINKAGE AND RECOMBINATION



Replication produces another copy of chromosomes.

HOMOLOGOUS RECOMBINATION IN MEIOSIS





HOW ARE SEX LINKED TRAITS INHERITED?

Human Chromosomes

- The 1st to 22nd pairs are called the autosomes, and the 23rd pair is termed as the sex chromosome.
- Genes that go along with either sex chromosome are said to be sex-linked.
- When the trait is linked to the X chromosome, it is called an X-linked trait.
- If the trait is linked to the Y chromosome, it is called a Y-linked trait.

Your female friend does not exhibit a sex-linked trait, but her brother does. What can possibly account for this?

X-linked Trait

- The X-linked trait is more common in males than in females.
- Even if the mother is just a carrier of the trait and the father is normal, there is still a possibility that they will have an offspring with an X-linked trait.
- Generally, males have a ½ or 50% chance (50% chance of being normal or 50% chance of possessing the X- linked trait) to express the trait.
- Females only have 1/3 or 33.3% chance (33.3% chance of being normal, 33.3% chance of being a carrier, and 33.3% chance of manifesting the X-linked trait) of acquiring the trait.

Color Blindness Is an X- linked Trait

- Colorblindness is the inability to distinguish certain colors.
- The Ishihara chart is used as a test for color blindness.

Sex Linkage

Y-linked Trait

- The Y-linked trait is only common in males since only males have the Y chromosome.
- An example is the *hypertrichosis pinnae auris* trait, which is characterized by having a hairy ear.

Why is sex-related inheritance not following Mendel's laws?

Possible color blindness genotypes and phenotypes of males and females

Female	
Genotypes	Phenotypes
XX	Normal female
X^cX	Carrier female
X^cX^c	Color-blind female

Male	
Genotypes	Phenotypes
XY	Normal male
X^cY	Color-blind male

Sex-Related Inheritance

- As opposed to Mendelian inheritance wherein the heterozygous genotype expresses the dominant trait, the heterozygous genotype of an X-linked trait in females will result in a carrier female.

Sex-influenced Trait

- Sex-influenced traits are controlled by autosomal genes.
- The genes are found on both sexes, but one expresses it more than the other.

Sex Linkage

Possible baldness genotypes and phenotypes of males and females.

Female		Male	
Genotypes	Phenotypes	Genotypes	Phenotypes
BB	Bald	BB	Bald
Bb	Non-bald	Bb	Bald
bb	Non-bald	bb	Non-bald

Sex-limited Trait

- Sex-limited traits are also controlled by autosomal genes.
- The genes are also found on both sexes, but only one sex expresses it.
    - Lactation is a female-limited trait.

Possible lactation trait genotypes and phenotypes of males and females.

Female		Male	
Genotypes	Phenotypes	Genotypes	Phenotypes
RR	Lactating	RR	Not lactating
Rr	Lactating	Rr	Not lactating
rr	Not lactating	rr	Not lactating