MENDEL'S LAWS:

1- **Law of segregation**: States the alleles of any locus segregate in to separate gametes.
2- **Law of dominance**: States that one of the inherited genes will be dominant and the other recessive.
3- **Law of independent assortment: States** that the alleles of each pair is not influenced by any other pair.

Codominant Alleles: Alleles that lack dominant and recessive relationships may be called incompletely dominant, partially dominant. This means that each allele is capable of some degree of expression when in the heterozygous condition. Example:

Genotype	Phenotype
BB	Black Color
bb	White Color
Codominant Bb	Black and White

SINGLE-GENE CROSSES

1. The Six Base Types of Mattings.: There are six type of mating according to parents genotypes as the following examples:

1- **Parent** BB x BB

↓ ↓

Gametes B B

↘ ↙

F1 BB

2- **Parent** BB x Bb

↓ ↓

Gametes B B b

↘ ↙

F1 1/2 BB 1/2 Bb

3- **Parent** BB x bb

Gametes B b

F1 bb

4- **Parent** Bb x Bb

Gametes B b B b

F1 1/4 BB 1/2 Bb 1/4bb

5- **Parent** Bb x bb

Gametes B b b

F1 1/2 Bb 1/2 bb

Matting Summary

No	parents	Gametes	Progeny
1	BB x BB	B & B	ALL BB
2	BB x Bb	B & B b	1/2BB + 1/2Bb
3	BB x bb	B & b	ALL Bb
4	Bb x Bb	B b & B b	1/4BB +1/2Bb + 1/4bb
5	Bb x bb	B b & b	1/2Bb + 1/2 bb
6	bb x bb	b & b	ALL bbS

Lethal Alleles.

The phenotypic of some genes expression is the death of the individual in either the prenatal or postnatal period prior to maturity. A **fully dominant** lethal allele kills in both the homozygous and heterozygous conditions. This gene arises by mutation from a normal allele. The mutant dominant lethal is removed from the population in the same generation in which it arose.

Recessive and incomplete dominance Lethal genes:

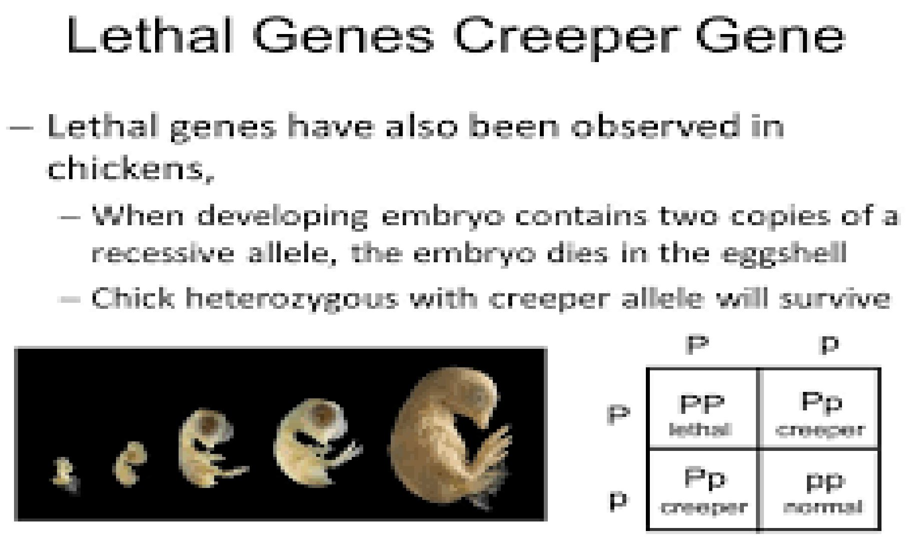
that kill only when homozygous may be of two kinds:

(I) one that has no obvious phenotypic effect in heterozygotes.

(2) one that exhibits a distinctive phenotype when heterozygous.

Example : The amount of chlorophyll in pea is controlled by a pair of codominant alleles, one of which exhibits a lethal effect when homozygous, and a distinctive color phenotype when heterozygous.

Genotype	Phenotype
C^1C^1	Green (normal)
C^1C^2	Pale green
C^2C^2	White (lethal)

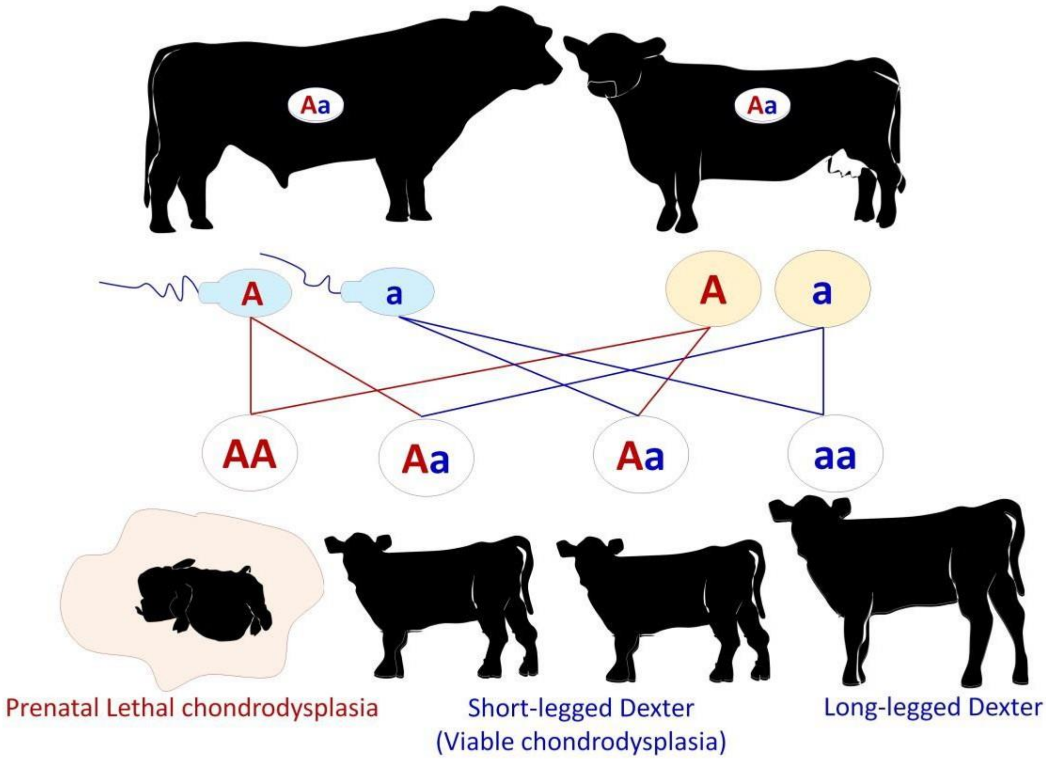

Lethal Genes Creeper Gene
– Lethal genes have also been observed in chickens,
– When developing embryo contains two copies of a recessive allele, the embryo dies in the eggshell
– Chick heterozygous with creeper allele will survive
P p
P PP lethal Pp creeper
p Pp creeper pp normal

Creeper Hen

Interaction 8: Lethal alleles

Alleles implicate with survival of individuals carrying this genes → those carrying homozygous allele die.

Ex. Creeper hen have vestigial wings and legs.
If two creeper hen are crossed, there is a ratio of
2 creepers : 1 normal hen among offsprings (not 3 : 1).
Creeper allele (C) is dominant in its effect on wings and legs length, but recessive on its effect on viability.
CC — lethal, die before hatching
Cc — creeper hen
cc — normal hen, survive after hatching on



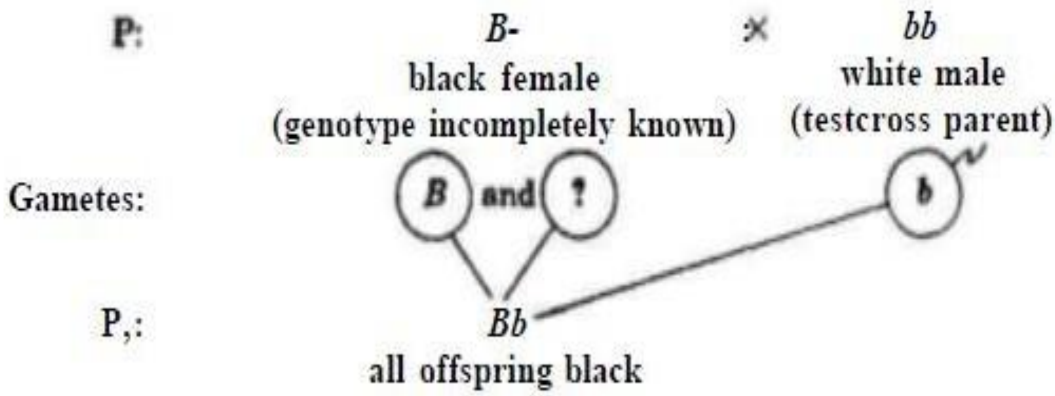
Penetrance and Expressivity.

Differences in environmental conditions or in genetic backgrounds may cause individuals that are genetically identical at a particular locus to exhibit different phenotypes. The percentage of individuals with a particular gene combination that exhibits the corresponding character to any degree represents the penetrance of the trait. **Expressivity** refers to variation in phenotypic expression when an allele is penetrant. **Example** :In some families, extra fingers and/or toes (polydactyly) in humans produced by a dominant gene *{P)*. The normal condition with five digits on each limb is produced by the recessive genotype (pp). Some individuals of genotype *Pp* are not polydactylous, and therefore the gene has a penetrance of less than 100%.

Testcross: (Finding unknown alleles)

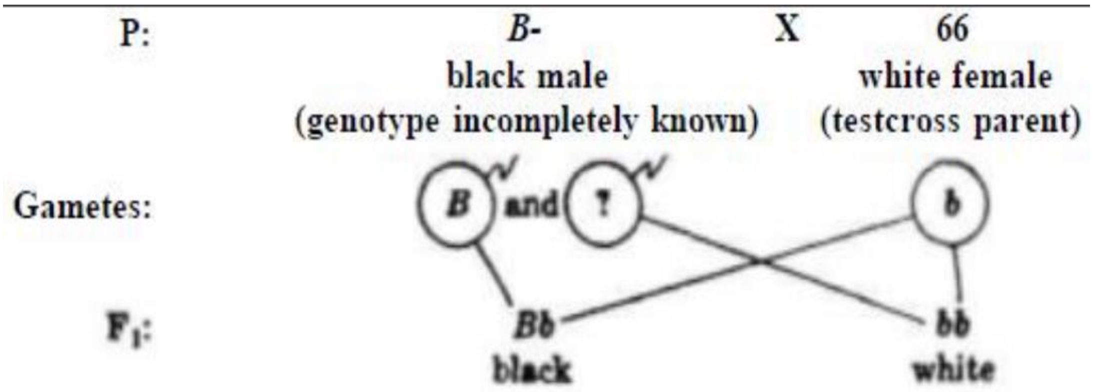
Because a homozygous dominant genotype has the same phenotype as the heterozygous genotype, a **Testcross** is required to distinguish between them. The testcross parent is always homozygous recessive for **all** of the genes under consideration. The purpose of a testcross is to discover how many different kinds of gametes are being produced by the individual. A homozygous dominant individual will produce only one kind of gamete; a heterozygous at one locus produces two kinds of gametes with equal frequency.

Example1 :. Explain the case in which testcrossing a black female produced only black offspring.



Conclusion: The female parent must be producing only one kind of gamete and therefore she is homozygous dominant *BB.*

Example 2: Explain the case in which testcrossing a black male produced black and white offspring in approximately equal numbers.



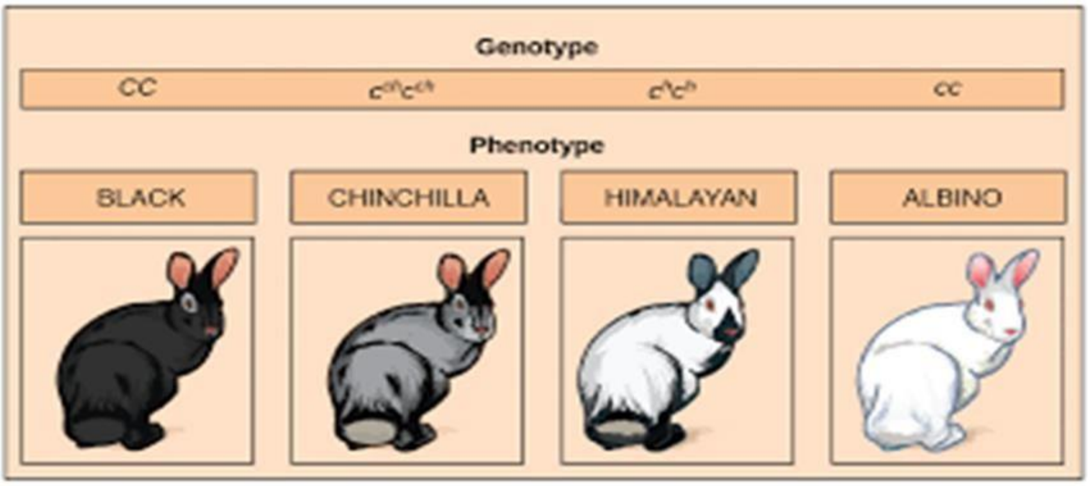
Conclusion: The male parent must be producing 2 kinds of gametes and therefore he is heterozygous *Bb.*

MULTIPLE ALLELES

A gene can mutate several times producing several alternative expressions. When three or more alleles are found for any particular gene, these are called **'**multiple alleles'. These occupy the same locus in homologous chromosomes. All of them control the same character but each of the allele affects that character somewhat differently than the others.

An example of multiple alleles is coat color in rabbits. Here, four alleles exist for the *c* gene. The wild-type version, C^+C^+, is expressed as brown fur. The chinchilla phenotype, $c^{ch}c^{ch}$, is expressed as black-tipped white fur. The Himalayan phenotype, c^hc^h, has black fur on the extremities and white fur elsewhere. Finally, the albino, or "colorless" phenotype, *cc*, is expressed as white fur. In cases of multiple alleles, dominance hierarchies can exist. In this case, the wild-type allele is dominant over all the others, chinchilla is incompletely dominant over Himalayan and albino, and Himalayan is dominant over albino

$$C^+ > c^{ch} > c^h > c$$



Example: . Determine the genotypic and phenotypic ratios expected from mating full-colored Brown males of genotype Cc^{ch} to Himalaya females of genotype $c^{ch}c$

P: Cc^{ch} x $c^{ch}c$

G: C c^{ch} x c^{ch} c

F1: Cc^{ch} Cc $c^{ch}c^{ch}$ $c^{ch}c$ = 1/2 Blak +1/2 chinchilla

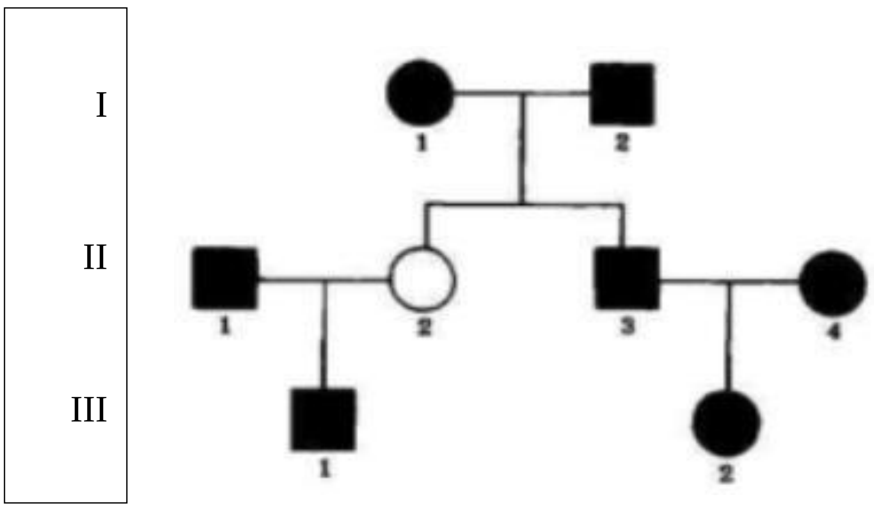
Coat color phenotype	Genotype
Full color	CC or Cc^{ch} or Cc^{h} or Cc
Chinchilla	$c^{ch}c^{ch}$ or $c^{ch}c^{h}$ or $c^{ch}c$
Himalayan	$c^{h}c^{h}$ or $c^{h}c$
Albino	cc

Many others genes have multiple alleles, person or animal can have no more than two alleles. Most of these alleles, even though they differ in one or more nucleotides in the DNA sequence, are able to carry out the normal function of the gene and produce no observable difference in phenotype. For example, the human blood groups designated A, B, O, or AB are determined by three types of alleles denoted I^A, I^B, and I^O or i, and the blood group of any person is determined by the particular pair of alleles present in his or her genotype. (Actually, there are two slightly different variants of the I^A (i).

Genotypes	Phenotypes (Blood types)
$I^A I^A$	A
$I^A I^B$	AB
$I^A i$	A
$I^B I^B$	B
$I^B i$	B
ii	O

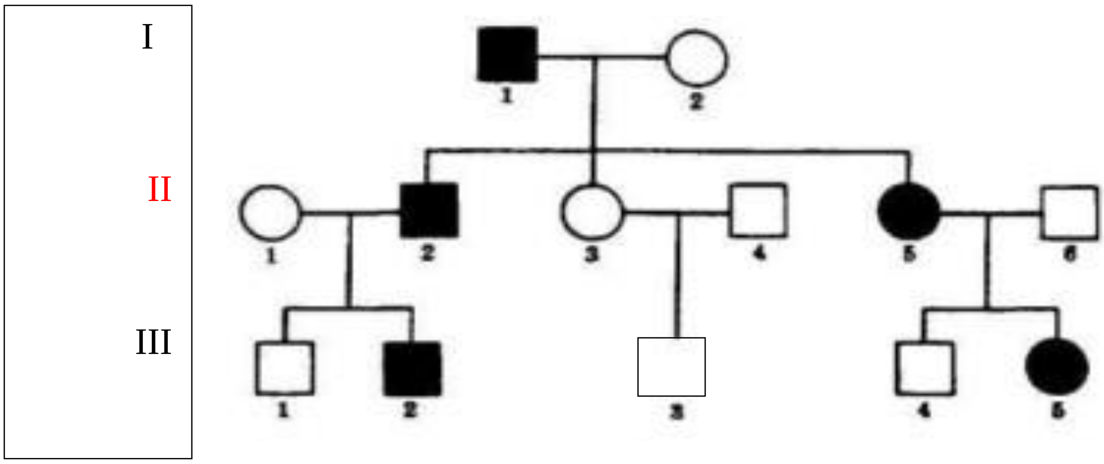
PEDIGREE ANALYSIS:

Example: Mention the expect genotype of the following individuals: 11,12,112,1111,1112 for the gene B which responsible for black color?



Answer: Bb , Bb , bb , Bb , B- .

Example2 :The phenotypic expression of a dominant gene in Ayrshire cattle is a notch in the tips of the ears(N). In the pedigree below, where solid symbols represent notched individuals, determine the probability and genotype of notched progeny being produced from the mating (a) II x12 ,(b) III2xIII3, (c) III3 x III4. (d)IIIl x III5,(e) III2 x III5.



Answer:

(a): **G** Nn x nn , p= 1/2 Nn + 1/2nn

(b): **G** Nn xnn , expected progeny **p**= 1/2 Nn + 1/2nn

(c): **G** nn x nn , expected progeny **p**= All nn

(d): **G** nn x Nn , expected progeny **p**= 1/2 Nn + 1/2nn

(e): **G** Nn x Nn, expected progeny **p**= 1/4NN +1/2 Nn + 1/4nn

Calculating the number of gametes produced from multi allele genotypes:

Suppose we have a genotype of three or more alleles pairs, how we can deduce the number of gametes that produced from these genotypes?

To calculate the number of gametes , **use the formula : 2^n**
Where **n**= number of hybrid alleles in genotype. Notice that 2^2=4, 2^3=8, 2^4=16 and so on.

Example1: What are the number of gamete produced from the following genotypes : **1-** AABbccEe**, 2-**AaBbCcFf **,3-** aabbccff , **4-** AABBCCFf.
The solution:

1- G.No= 2^2 = 4 gametes.

2- G. No= 2^3= 8 gametes.

3- G. No= 2^0 = 1 gamete.

4-G. No= 2^1 = 2 gametes.

Example 2: Write the number and structure of the gametes produced by individuals with the genotypes: AaBbCCEe , AABbCcEe , aabbCcEe.

AaBbCCEe : gamete number= 2^3 =8

Gametes structure:

E ABCE

BC

e ABCe

A E AbCE

bC

e AbCe

E aBCE

BC

e aBCe

a E abCE

bC

e abCe

AaBbCCEe: : gamete number= 2^3 =8

E ABCE

BC

A e ABCe

E AbCE

bC

e AbCe

E aBCE

BC

a e aBCe

E abCE

bC

e abCe

aabbCcEe = 2^2 = 4

E = ABCE

C

ab e = ABCe

E = AbCE

c

e = AbCe

Pleiotropic effect of genes (Gene interaction)

The action of gene at cellular level is unitary i.e., one gene one action. But some genes produce a broad spectrum of phenotypic changes, so that a gene has multiple action. This is called **pleiotropic.**