



Gregor Mendel:
1823-1884

Mendelian Genetics

The study of Heredity

Genetics

- I. Genetics is the Study of heredity (the transmission of traits from generation to generation).

Genetics began with the work of Gregor Mendel.

Mendel developed basic principals of heredity with NO knowledge of genes or chromosomes.

Mendel worked with pea plants.

Why peas ?















Pea plants :

- are inexpensive
- reproduction is easy to control
- Produce many offspring
- Pea plants have contrasting characteristics



Contrasting characteristics include:

- Seeds – round or wrinkled
- Seed Color – **yellow** or **green**
- Height – **TALL** or short
- Flowers – white or **purple**
- pod color – **yellow** or **green**
- Etc.

| Trait | Dominant vs. Recessive | | F ₂ Generation Results | | Ratio |
|-----------------|---|--|-----------------------------------|----------------|--------|
| | | | Dominant Form | Recessive Form | |
| Flower color | Purple  | × White  | 705 | 224 | 3.15:1 |
| Seed color | Yellow  | × Green  | 6,022 | 2,001 | 3.01:1 |
| Seed shape | Round  | × Wrinkled  | 5,474 | 1,850 | 2.96:1 |
| Pod color | Green  | × Yellow  | 428 | 152 | 2.82:1 |
| Pod shape | Round  | × Constricted  | 882 | 299 | 2.95:1 |
| Flower position | Axial  | × Top  | 651 | 207 | 3.14:1 |
| Plant height | Tall  | × Dwarf  | 787 | 277 | 2.84:1 |

Mendel Developed Principles of

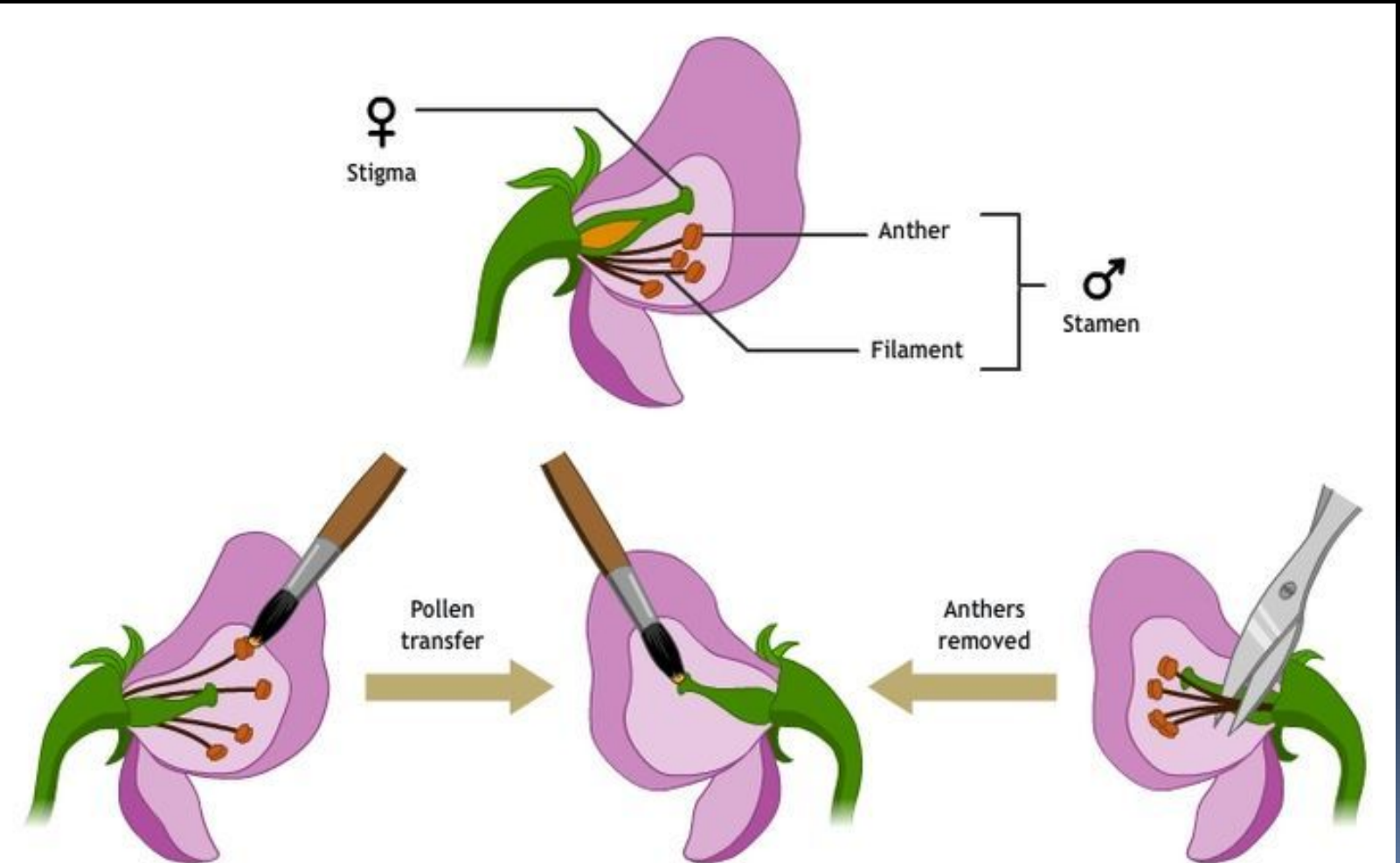
1. **Dominance**: one form of a hereditary trait dominates or prevents the expression of the recessive trait.
2. **Segregation**: Splitting of chromosomes during meiosis
3. **Recombination**: Combining chromosomes from both the sperm and egg (fertilization)
4. **Independent Assortment**: Independent segregation of genes during the formation of gametes.



Pea Plant Characteristics

- *Mendel determined that since peas reproduce sexually, there must be two “characters” (called alleles) that influence each trait. (one from the egg and one from the sperm).*
- *Alleles are represented by letters.*

Working with Pea Plants – The Next Generation



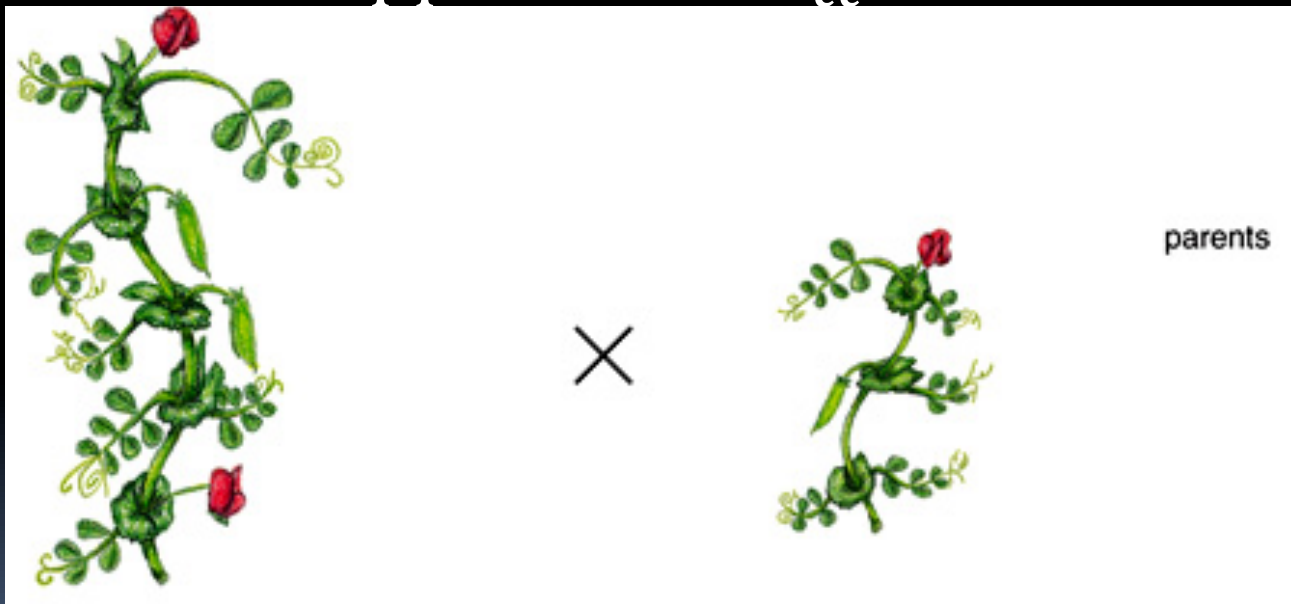
Mendel's Work

Mendel began by cross-pollinating pure plants with contrasting traits.

Ex. pure tall X pure short

TT

tt



Mendel then observed the offspring or 1st filial generation (F1), and noticed only one trait (they were all tall)



×



parents



×



F₁ generation
(all tall)

TT x tt

T

T

t

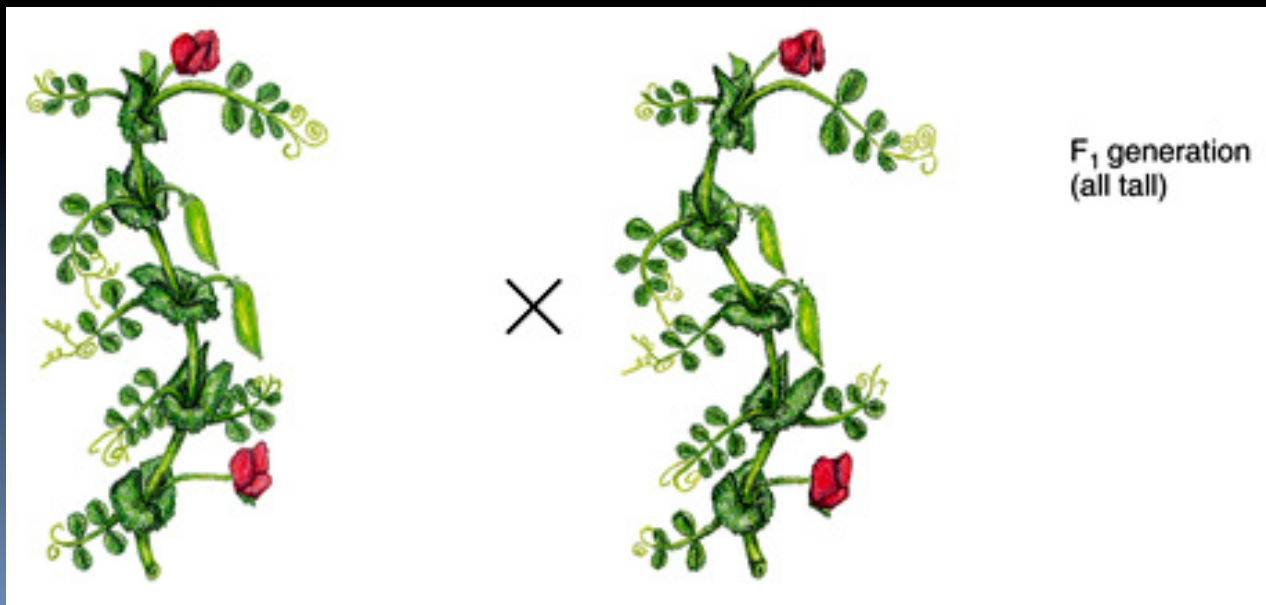
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| | |
|--|--|
| | |
| | |

Mendel's Work

Mendel then used two of these F₁ tall plants and crossed them. (incest)

Ex. F₁ tall x F₁ tall
(Tt) (Tt)



Tt x Tt

T

t

T

t

| | |
|--|--|
| | |
| | |



×



F₁ generation
(all tall)



F₂ generation
(3 tall : 1 dwarf)



From this F1 cross he observed both traits in the offspring (2nd filial generation – F2), but in an unequal proportion

(75% tall and 25% short) or
(3 tall : 1 short)

Mendel determined that one form of the trait is dominant over the other recessive trait (Tall is dominant over short)

Parents pure tall X pure short

F1 all tall

F2 3 tall : 1 short

Law of Dominance – one form of a hereditary trait dominates or prevents the expression of the recessive trait.

Dominant allele = capital letter

Recessive allele = lower case letter

Ex. tall = T

short = t

- Parents have 2 alleles (2n) Diploid
- Gametes have 1 allele (1n) Monoploid
 - (half due to meiosis)

Review of dominance :

TT = tall

Tt = tall

tt = short

Genetic Terms

1. **Dominance**- The dominant gene in an allelic pair is expressed (seen). It masks the recessive allele (unseen). Represented by a CAPITAL letter
2. **Recessive**- the trait that is masked by the dominant characteristic. Represented by a lowercase letter.
3. **Allele** – the dominant or recessive form of a gene. You inherit one allele from mom and one from dad

4. **Genotype** – the genetic make up of an individual.

ex. TT, Tt, tt

a. **Homozygous** – (pure) both alleles are the same

ex. TT – tall

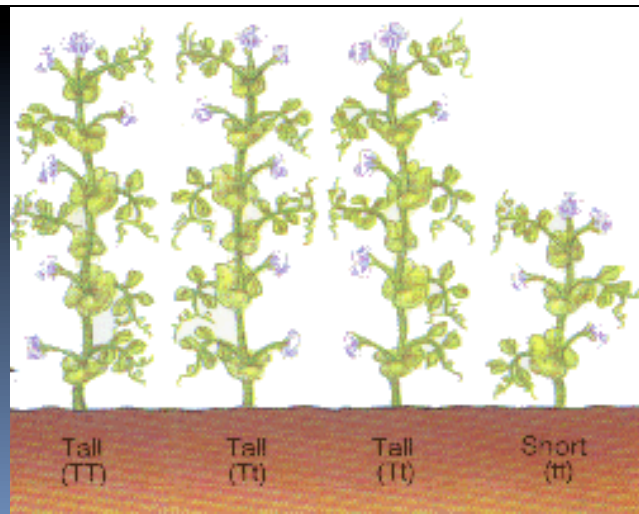
tt – short

b. **Heterozygous**- (hybrid) possessing two different alleles for the same trait

ex. Tt

5. Phenotype – The appearance of the offspring
(you can see the phenotype)

| Genotype | Phenotype |
|-----------------|------------------|
| TT | Tall |
| Tt | Tall |
| tt | Short |

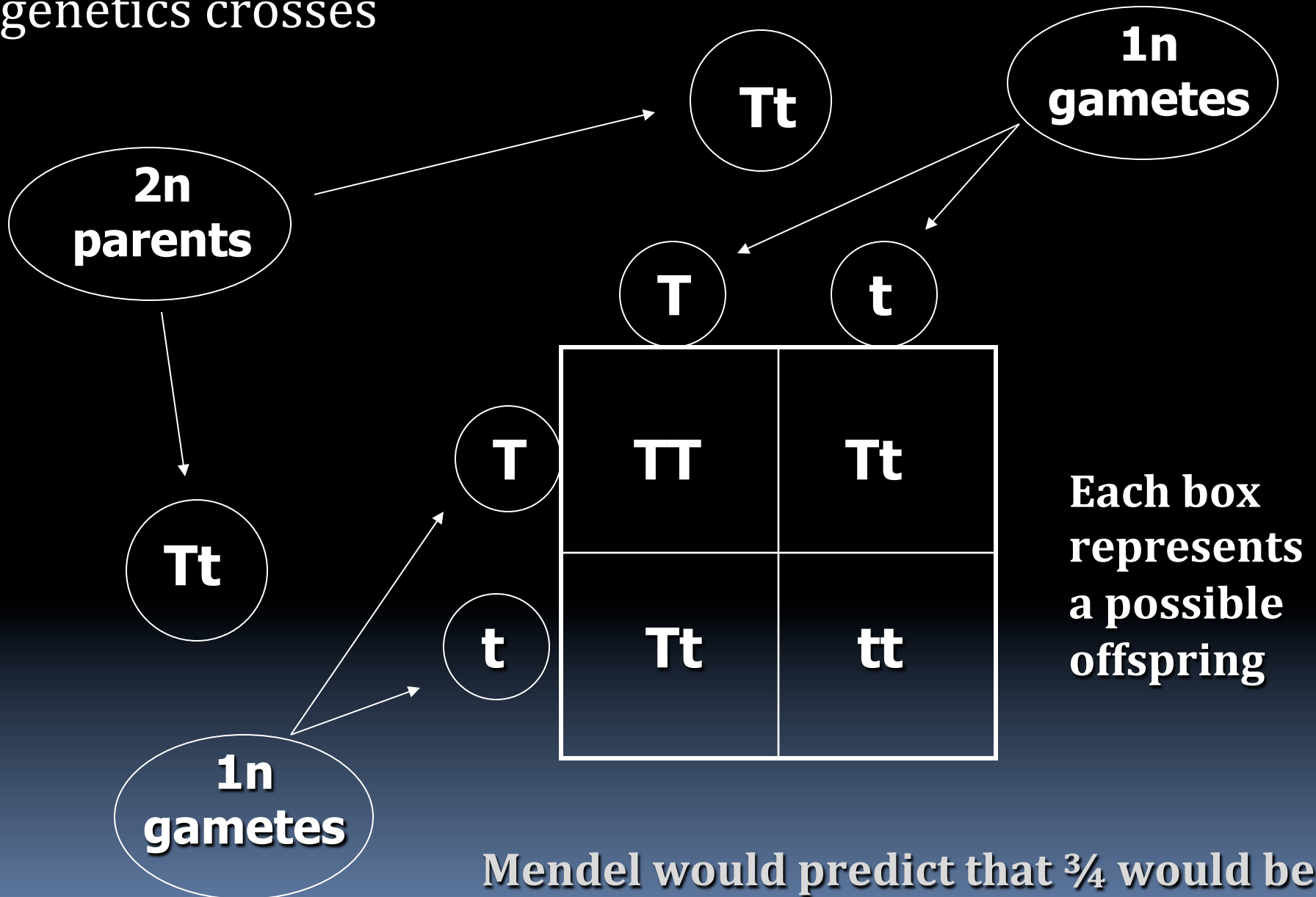


Mendel's 2nd Law: **Segregation and Recombination**

Gametes formed during meiosis separate alleles so that each gamete contains only one gene for each trait. At fertilization the alleles combine to form new combinations.

Mendel tested this hypothesis by predicting the outcome of crosses he never did before

Punnett square – used to predict the outcome of genetics crosses



Mendel would predict that $\frac{3}{4}$ would be tall and $\frac{1}{4}$ would be short

Hybrid Cross – When two heterozygotes are crossed, there are 3 possible genotypes which occur in a 1 : 2 : 1 ratio.

- 1 Homozygous Dominant
- 2 Heterozygous Dominant
- 1 Homozygous Recessive

The phenotypic ratios are 3 : 1
3 Dominant : 1 Recessive

It is not possible to tell the appearance if an individual is showing a dominant trait that is pure (BB) or hybrid (Bb). Therefore you must perform a test cross

Test Cross – To determine the genotype of an organism showing a dominant phenotype, cross the organism with a recessive individual. If any recessive offspring are produced the individual is heterozygous.

Ex. Lets do a test for eye color Bb or BB
B=Brown b=blue

| | |
|--|--|
| | |
| | |

| | |
|--|--|
| | |
| | |

- **$BB \times bb = 100\% \text{ brown}$**
- **$Bb \times bb = 50\% \text{ brown } 50\% \text{ blue}$**

V. Codominance – some traits are controlled by 2 different dominant alleles. Both alleles are dominant, and there are two dominant phenotypes. A heterozygote expresses both phenotypes at the same time.

Ex. coat color in cattle.

$C^R C^R$ = red coat

$C^W C^W$ = white coat

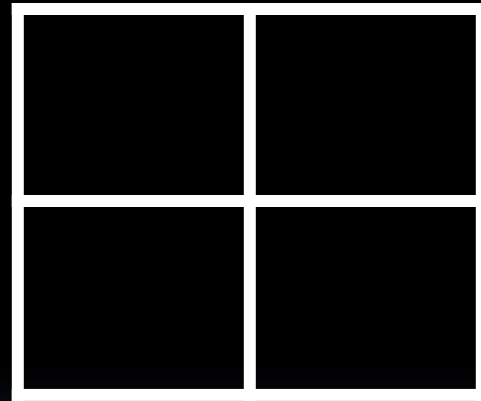
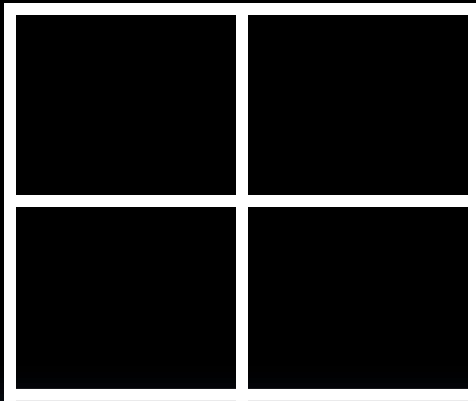
$C^R C^W$ = roan coat



Roan is a mixture of red and white hairs that give a brownish appearance called roan.

Ex. Lets do a test for coat color

R = Red W = White



VI. Incomplete dominance – (blending inheritance) sometimes an allele is only partly dominant over another.

In a heterozygote the dominant allele is only partially expressed and the phenotype is between the two homozygous forms.

Ex. Snap dragons or Japanese 4 o'clock flowers.

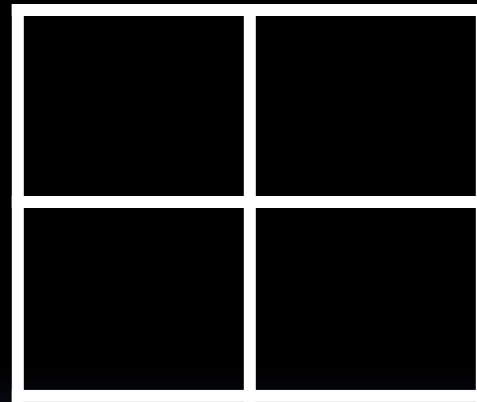
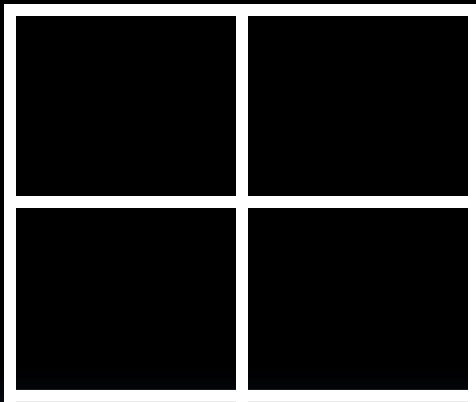
RR = red

WW = white

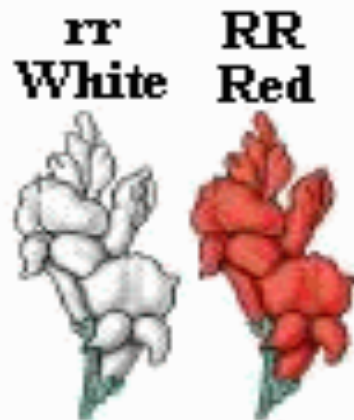
RW = pink



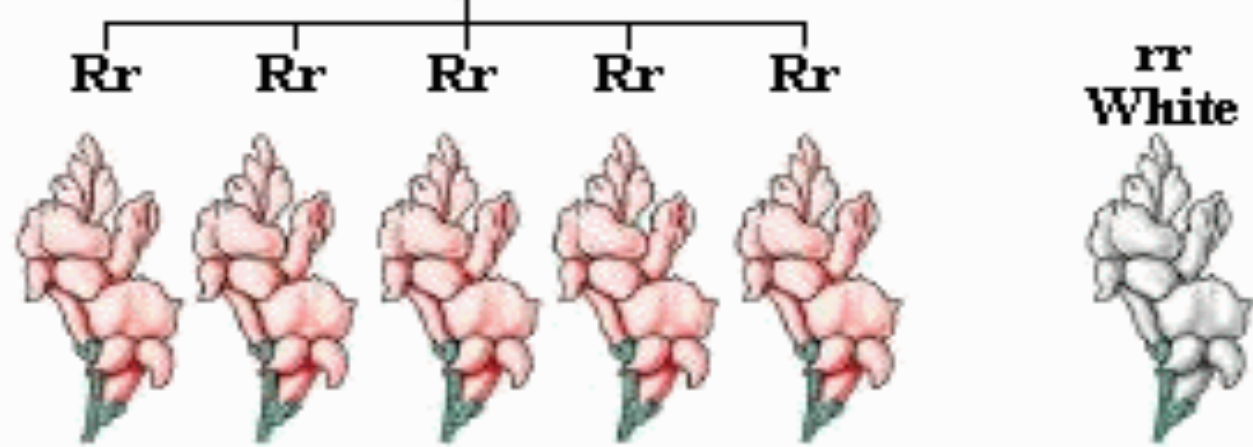
Ex. Lets do a test for flower color
R = Red W = White



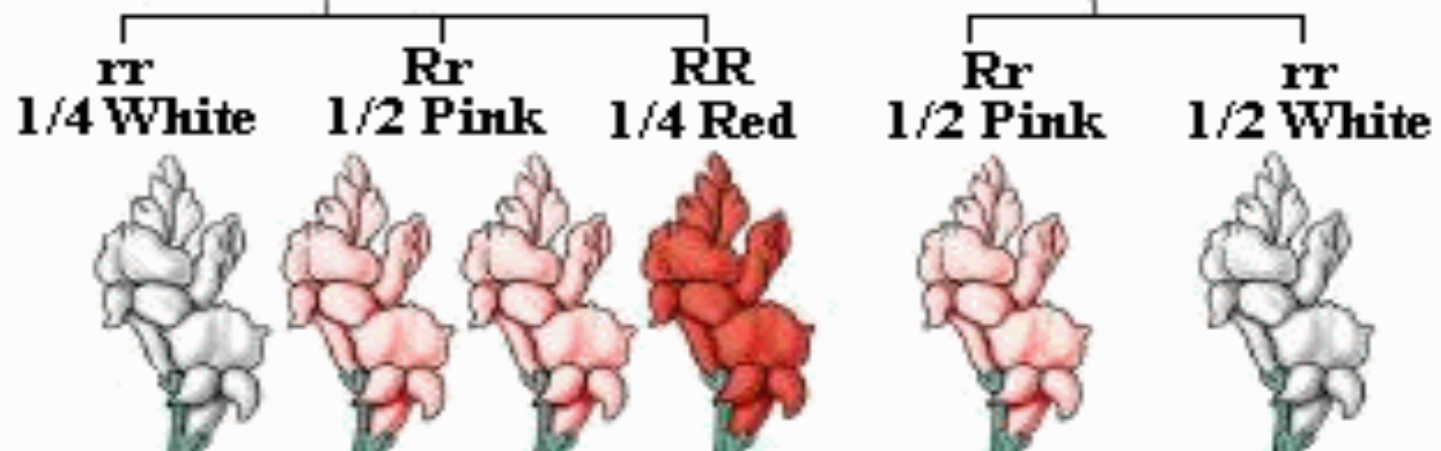
Parental (P) Generation



F1 Generation



F2 Generation



Mendel's Law of Independent Assortment

Two traits will be inherited independently of each other, provided their genes are located on non-homologous chromosomes.

When gametes form, the alleles for different traits segregate independently of each other.

Gene Linkage – If the genes for two different traits are located on the same chromosome pair (homologous chromosomes), they are said to be linked, and are usually inherited together.

Ex. The gene for eye and hair color are on the same chromosome. Blond hair is often inherited with blue eyes.

Crossing over – In the 1st meiotic division the chromatids of homologous chromosomes may exchange segments. This results in the rearrangement of linked genes and increases variability of offspring.

Multiple Alleles – some traits are controlled by more than 2 different alleles types.

Ex. Human blood types – The inheritance of blood types in humans can be explained by a model in which there are 3 alleles for blood type.

I^A = A protein

I^B = B protein

i = no protein

I^A and I^B are both dominant (codominance) over i

Blood Type

Genotypes

| | | |
|----|-----------|---------|
| A | $I^A I^A$ | $I^A i$ |
| B | $I^B I^B$ | $I^B i$ |
| AB | $I^A I^B$ | |
| O | ii | |

Sex determination – Scientists have discovered that chromosomes in cells from males and females were identical except for one pair

Humans have 23 pairs of chromosomes.

- **22 pairs of autosomes**
- **pair of sex chromosomes**

The sex chromosomes are called X and Y

The XX condition produces females, and the XY condition produces males.

Who determines the sex of the child?

Ans. The man. A woman's egg's all have the X chromosome, but due to meiosis 50% of a man's sperm are X and 50% are Y.

Sex Linkage – Thomas Hunt Morgan's work with Drosophila (fruit fly) demonstrated that some genes are located on the X chromosome and do not have a corresponding allele on the Y chromosome.

Since many sex-linked genes are recessive, they are expressed in males more than in females.

Why?

A female must have both recessive alleles, but the male can show the recessive trait with only one allele.

Ex. Hemophilia and colorblindness in humans.

$X^N X^N$ - normal female

$X^N X^n$ - carrier female

$X^n X^n$ - colorblind female

$X^N Y$ - normal male

$X^n Y$ - colorblind male

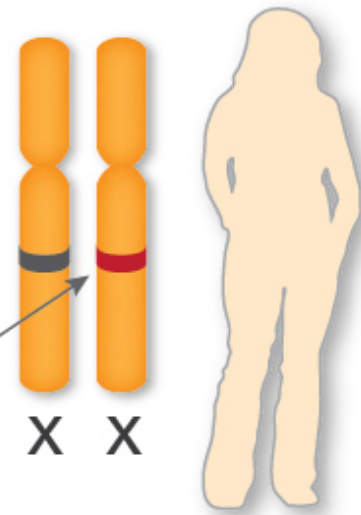
Because a man has only one X chromosome he will show a recessive phenotype with only one allele for that trait.

How do you get a colorblind female?

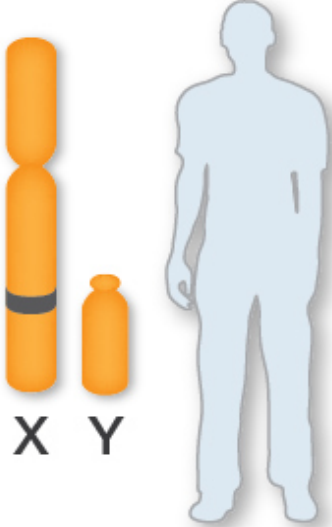
Parents:

Color vision gene

- Normal allele
- Defective allele

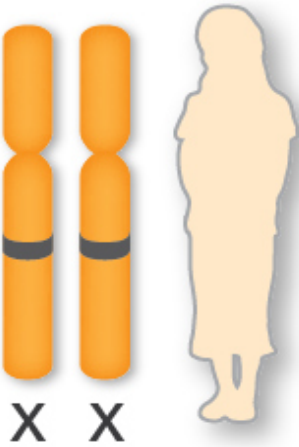


Normal vision
(Corblindness carrier)

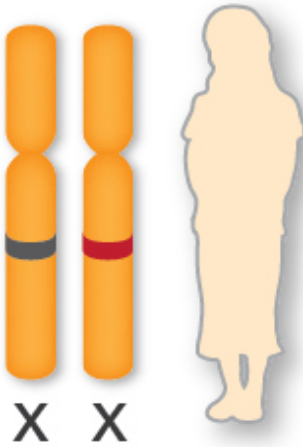


Normal vision

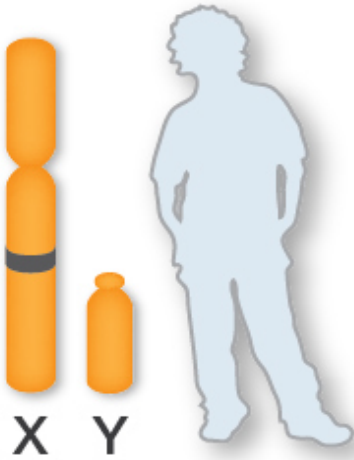
Possible offspring:



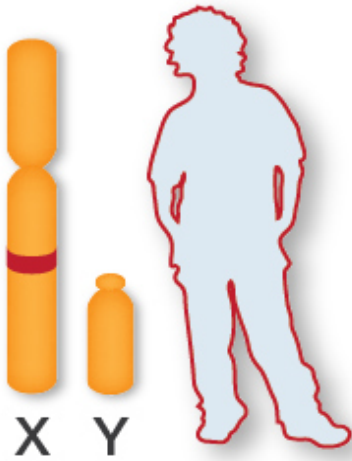
Normal vision



Normal vision
(Corblindness carrier)



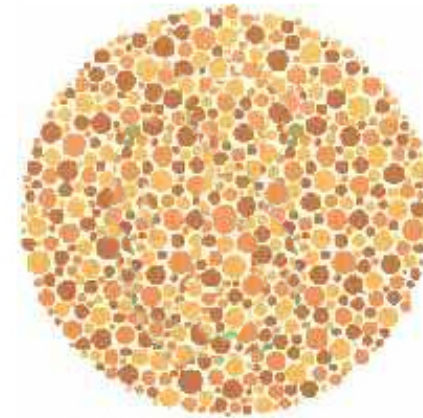
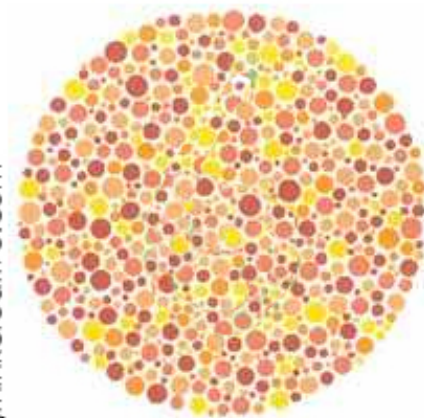
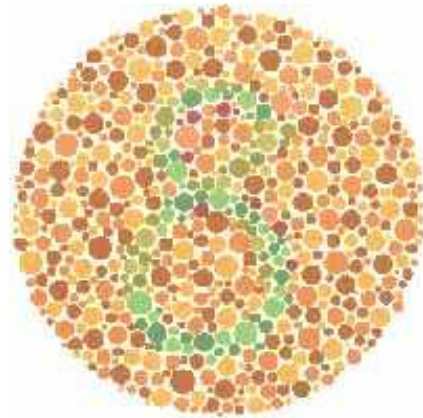
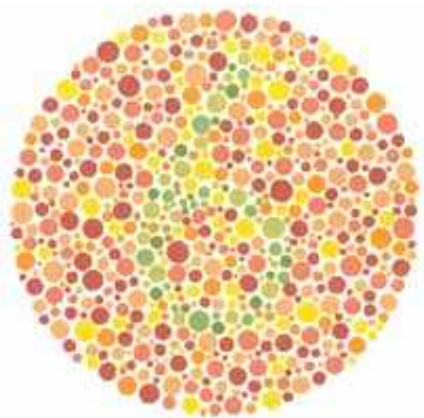
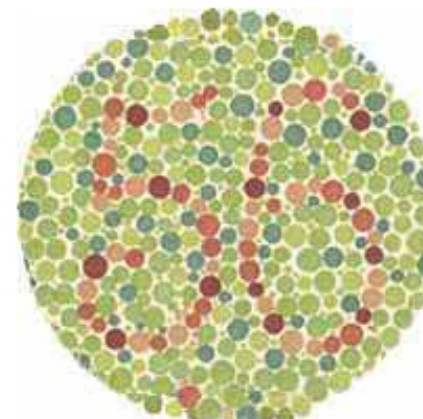
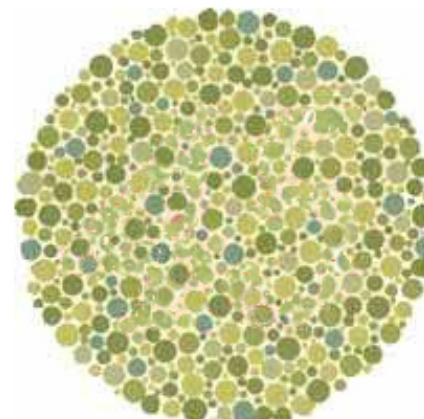
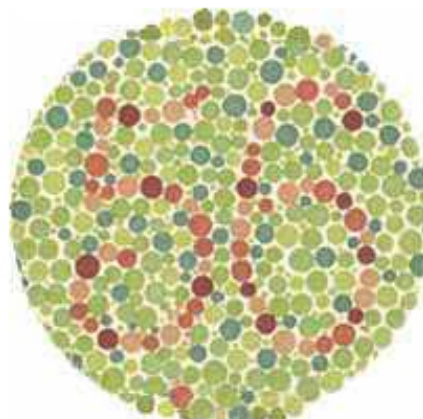
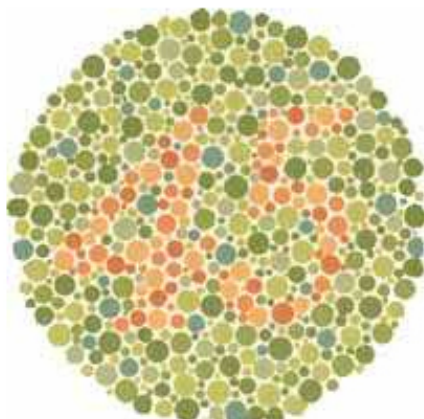
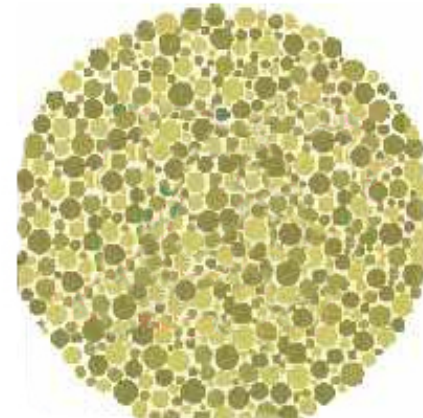
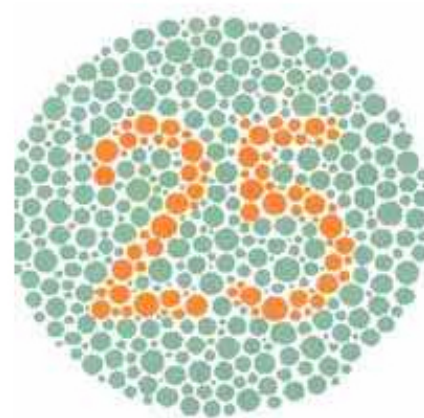
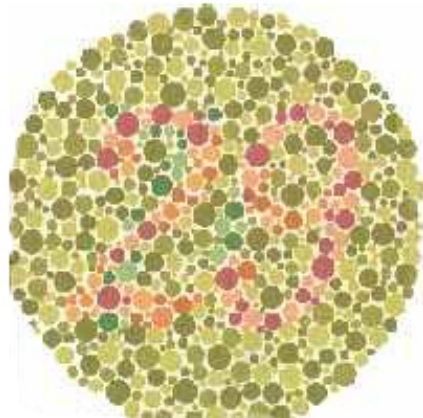
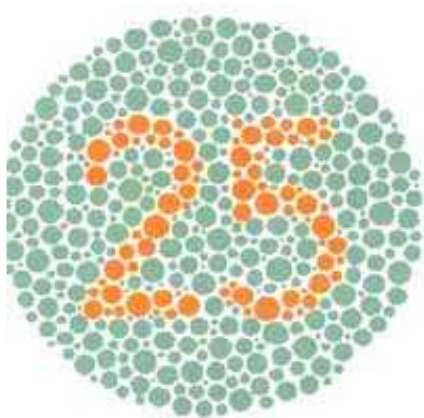
Normal vision



Colorblind

What People With Regular Vision See

What Red-Green Color Blind People See



Unaffected father

Carrier mother

X Y

X X

X



X X

Unaffected daughter



X X

Carrier daughter



X Y

Unaffected son



X Y

Affected son

Hemophilia B

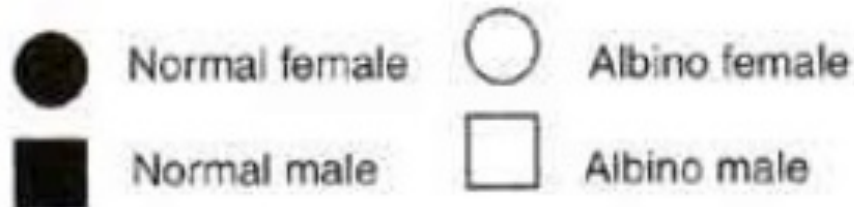
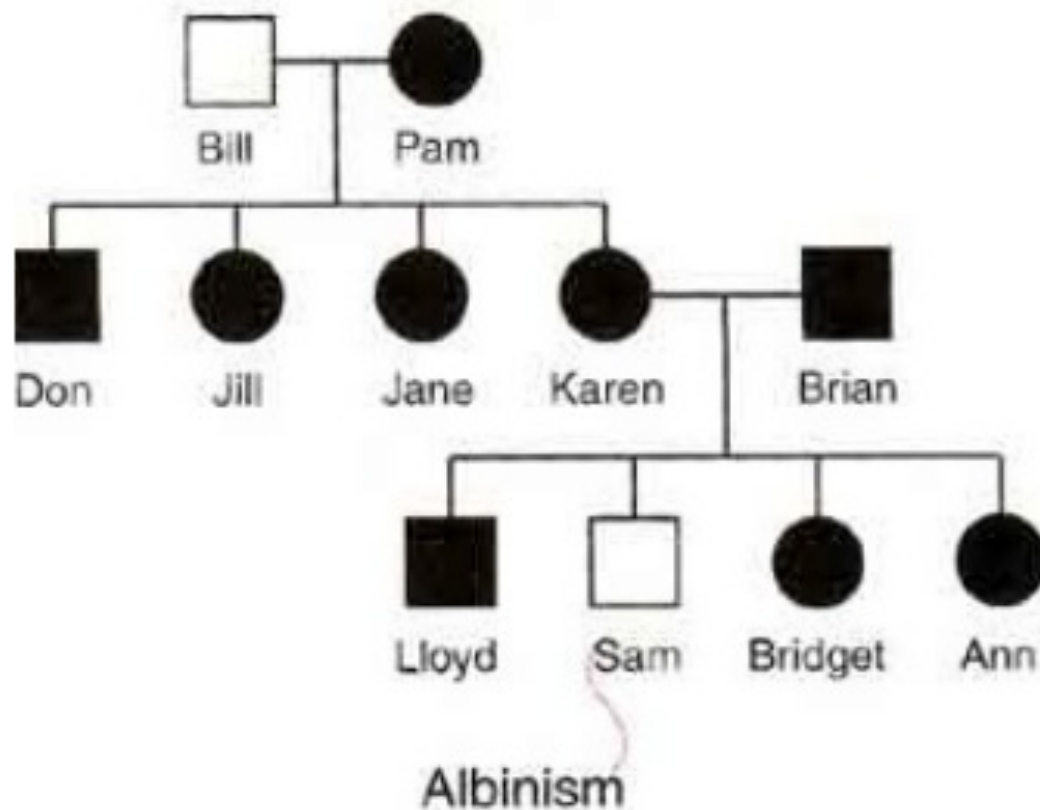
Hemophilia A



Chromosome X

Pedigree charts

Pedigree showing albinism



XII. Heredity and the Environment – The environment interacts with genes in the development and expression of inherited traits

Ex. Effect of light on chlorophyll production

Plant grown in dark – white

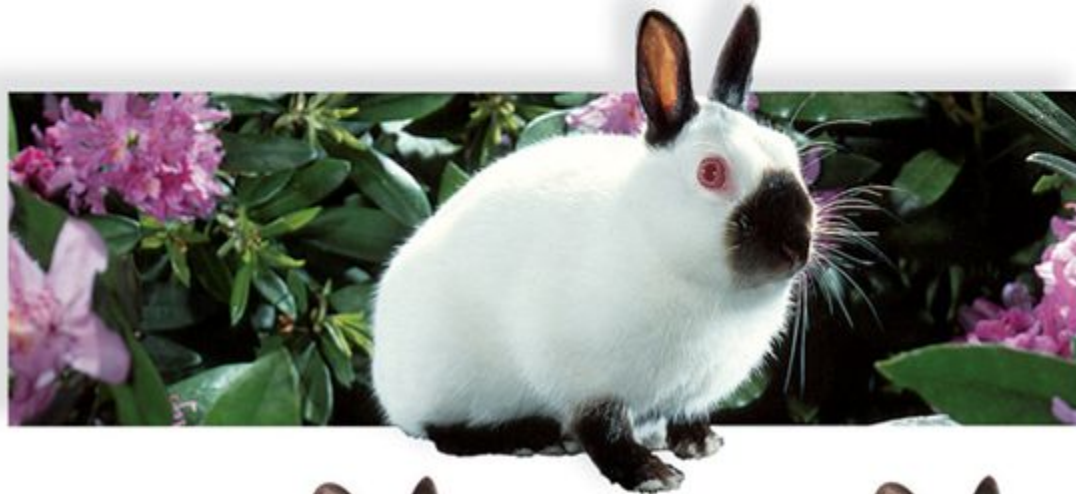
Plant grown in light – green



Ex. Effect of temp. on color of the Himalayan rabbit. Usually the rabbit has white fur with black ears and paws. If you shave the rabbit and place an ice pack on the shaved area it will grow black hair in that area.

Coat Color in Himalayan Rabbits

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