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## Theme: Genetics

### S4 New Curriculum Biology-Chapter 4– Inheritance



**Inheritance** refers to the process by which genetic information is passed from parents to offspring. It is controlled by genes, which are segments of DNA that determine traits like eye colour, height, and susceptibility to diseases.

#### Terminologies.

1. **A gene** : is the basic unit of heredity and occupies a discrete position on the chromosomes that controls characteristics to be inherited. Genes controlling a particular characteristic always occur in pairs
2. **Alleles (Allelomorphs)**: are alternative forms of a gene controlling a particular characteristic. For example T and t for tall and short respectively

3. **Genotype:** is the genetic constitution of an organism i.e. the particular set alleles, leading to observable characteristics
4. **Phenotype:** is the physical characteristic of an organism determined by the genotype and the environment.
5. **Homozygous:** It is a genotype with identical or similar alleles. For example, TT for tall and tt for short.
6. **Heterozygous:** It is a genotype with two dissimilar genes. For example, Tt for tall
7. **Dominant gene:** It is a gene that expresses itself in a phenotype both in homozygous and heterozygous condition. For example TT and Tt for tall.
8. **Recessive gene:** it a gene that expresses itself only in homozygous condition.
9. **Sex chromosome:** It is one of the two chromosomes that determine an organism's biological sex.
10. **Sex- linked gene** – it one that is located on one of the two sex chromosomes.

### **Monohybrid inheritance**

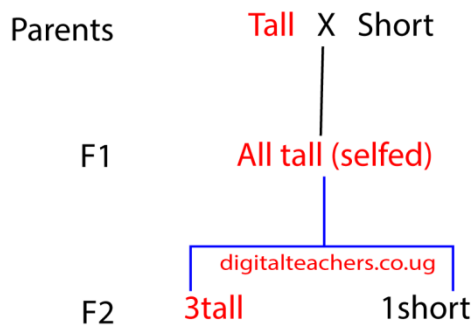
This is an inheritance that deals with a single pair of contrasting characteristics such Tallness and shortness when concerned with height of peas.

In his investigation of a single pair of contrasting characteristics, Mendel observed that, in the first filial (F1) generation one of the characteristic never appeared only to appear in the second filial (F2) generation in small proportion compared to the one that appeared in the first filial (F1) generation.

For example; he crossed peas with long internode, with peas of short internode. He observed that in the F1 generation, all plants had tall internodes. When selfed to produce F2, the peas with short internodes, then appeared in small proportions.



The result of these crosses can be illustrated as follows,



It was concluded from the results that inheritance is a process in which discrete structure or particle (genes) which may or may not show themselves in the outward appearance of the organism are transmitted from parent to off spring.

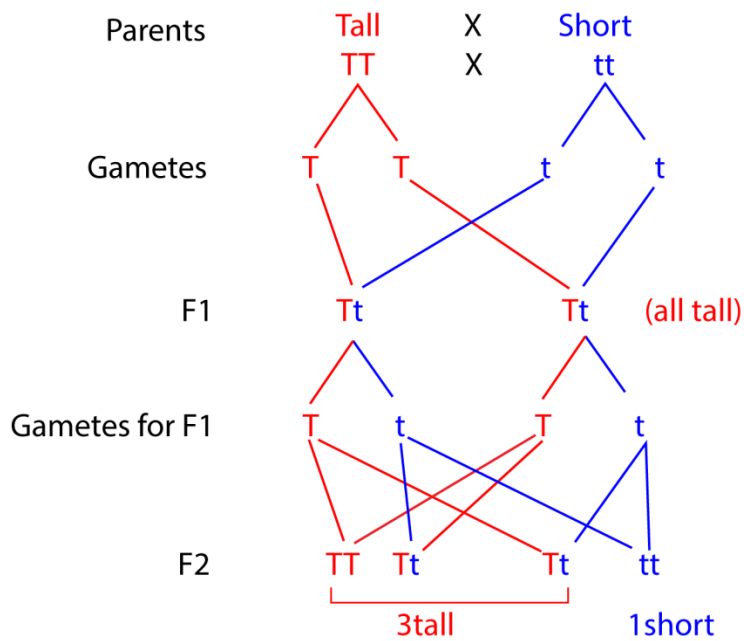
The evidence of existence of inheritable particles is got from the observation that they can be combined in one generation but separate in the next, as in witness by the recovery of the short form in F2 generation despite its absence in the F1 generation,

The characteristic that show in F1 generation (tallness in this case) is described as being **dominant** and while that which masked **F1** generation (shortness) is said to be **recessive**.


### Genes and their transmission

Genes normally occur in pair each of which is obtained from each parent. The cross of a tall plant and short plant is shown diagrammatically by the two methods below.

The allele for tallness (dominant) character is represented by a capital letter **T** while the allele for shortness (recessive character) is represented by small letter **t**. It is assumed that each parent plant contains a pair of identical alleles; **TT** in case of tall plant and **tt** in case of short plant.



Pannet square to show fusion of F1 gametes

|   |                  |                  |
|---|------------------|------------------|
|  | $\frac{1}{2} T$  | $\frac{1}{2} t$  |
| $\frac{1}{2} T$   | $\frac{1}{4} TT$ | $\frac{1}{4} Tt$ |
| $\frac{1}{2} t$   | $\frac{1}{4} Tt$ | $\frac{1}{4} tt$ |

In terms of probability, there are 3 chances out of four for a tall plant to appear in F2 generation; and one chance of four for a short plant to appear.

**Mendel's first law** of segregation states that an organism's characteristics are controlled by two genes (alleles) and only one can be carried by in a gamete.

**Mendel's second law** of Independent Assortment:

During the formation of gametes, alleles in a pair may combine with another allele from another pair randomly.

### Breeding True

Phenotypically TT and Tt are the same i.e. Tall. When an organism contains identical alleles like TT and tt is said to be **homozygous** and with dissimilar allele is **heterozygous**.

Since the homozygous (TT) and heterozygous (Tt) peas are both tall there is no way we can distinguish between the two genotypes from their external appearance.

One way of establishing whether a given tall plant is homozygous or heterozygous is to self-pollinate it. If the resultant offspring are all tall, we can conclude that the parent has the genotype TT. If, however, we get a mixture of Tall and short plants; the parent plant must have the genotype Tt

The point is that when an organism which is homozygous at a particular locus is self-fertilized it produces offspring all of which are identical with parent. Exactly the same results occur if an organism crossed with another organism that is homozygous is said to breed true, The organism is said to belong to a pure line for the characteristics in question.

### Test crosses

This is the crossing of an individual having **homozygous recessive** genotype with an individual showing a dormant trait to determine whether that individual is homozygous or heterozygous for the trait.

The homozygous individual produces all offspring having dominant trait while a heterozygous individual produces a mixture of offspring with dominant and recessive traits.

### Back cross

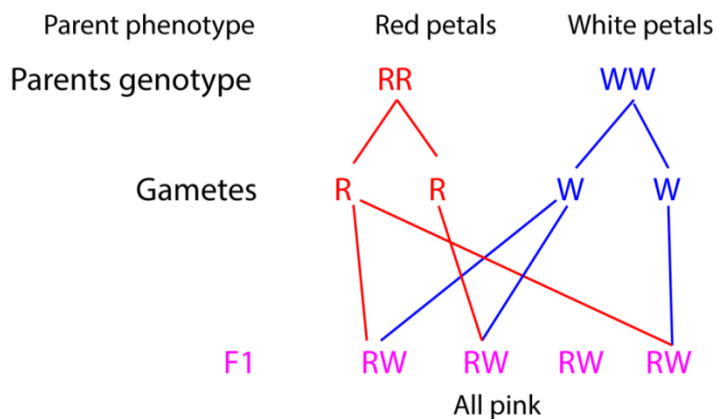
This is a cross between hybrids in F1 generation with one of the parents or an organism genetically equivalent to the parents. Back crossing is mainly aimed at increasing the genetic contribution of one particular parent to the offspring.

### Incomplete or partial dominance

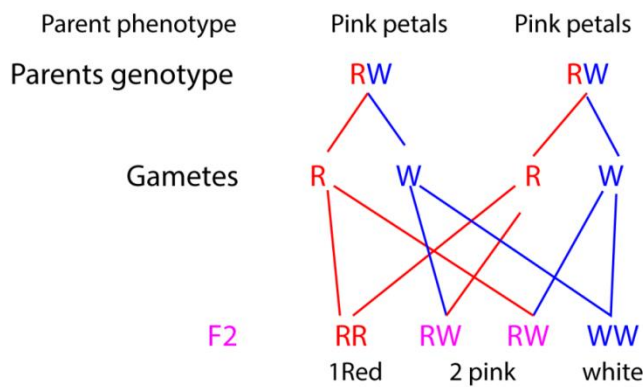
This is a condition in which two alleles express themselves partially in the phenotype when they occur together. No allele is completely dominant or recessive. This term is commonly applied to plants. For example, when a white flowered plant is crossed with a red flowered plant the F1 generation plants have pink flowers.

Let R represent the allele for red petal colour.

Let W represent the allele for white flowers



**Then Selfing F1 (Cross between offspring in F1)**



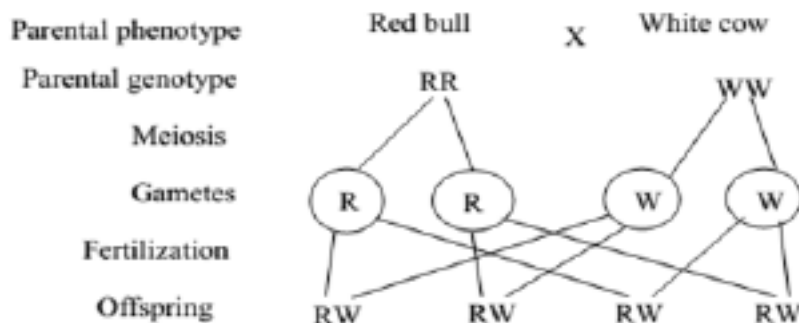
F2 Phenotypic ratio: 1 red: 2 pink: 1 white. (1:2:1)

**Codominance**

This is a condition (usually in animals) in which both alleles express themselves equally in the phenotype. That is the alleles are equally dominant. For instance, when a red bull is crossed with white cow, the all F1 generation are roan.

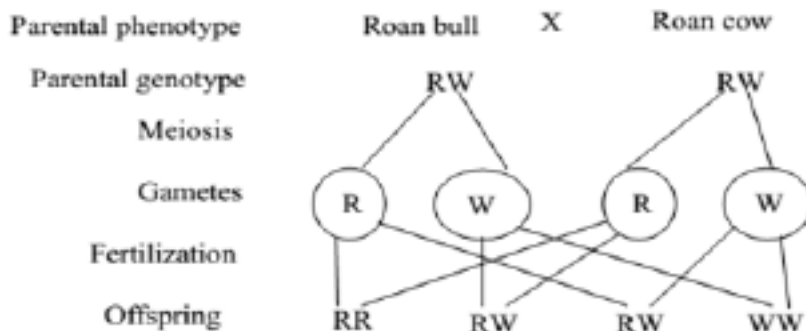
Let R represent the allele for red bull

Let W represent the allele for white cow



F1 generation are all roan

**Selfing F1 generation**



F2 generation 1red, 2 roan, 1 white

## **Monohybrid inheritance human**

A number of human conditions are known to be associated with a single pair of alleles which are inherited in Mendelian fashion.

### **1. Albinism**

This is a condition in human beings where the individual fail to produce skin pigments called melanin.

Albinos have;

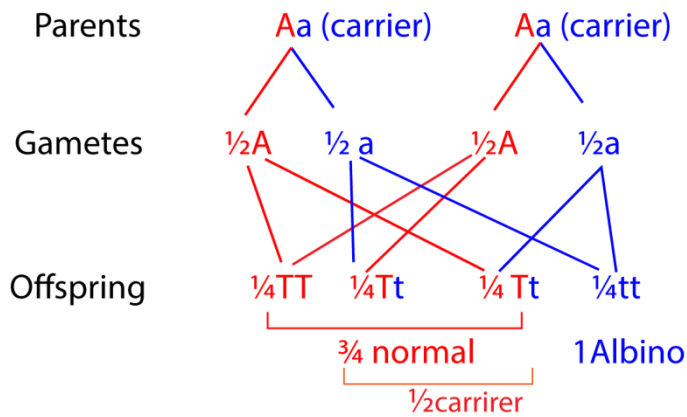
- ✓ Light skin
- ✓ White hair
- ✓ Pink eyes
- ✓ They are sensitive to bright light



## **Albino**

The allele for albinism is caused by recessive [a] and so only exert its effect in the homozygous state [aa]. The allele for melanin production [A] is dominant.

Suppose a couple each with normal pigmentation have an albino child. For this to happen the child must have [aa]. Therefore, unless for rare mutation, the parents must both be heterozygous [Aa] so each produces A and a gametes in about equal number. Therefore, randomly to produce three types of genotype AA, Aa, aa.



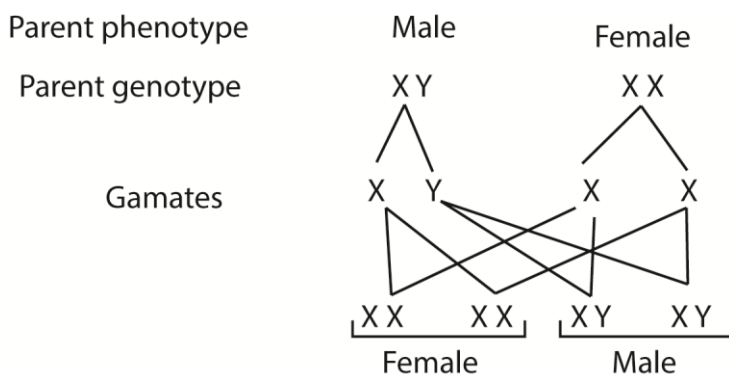
1. Congenital disease such as cystic fibrosis in which the connective tissue develops in glands of the body.
2. Chondrodystrophic dwarfs are characterized by shortened and deformed legs and arms. It is caused by a dominant gene and hence affects in homozygous and heterozygous state.

### Sex determination.

The medium size chromosome in *Drosophila melanogaster* determines the individual's sex for which reason they are called the **sex chromosome**. In the female the two sex-chromosomes, both rod-shaped in appearance, are identical and are known as **X-chromosomes**. In the male, however, the two sex-chromosomes differ from each other; one is rod-shaped X-chromosome, the other is hook-shaped and is called **Y-chromosome**.

The sex chromosomes are an exception to the rule that homologous chromosomes are identical in appearance. Being different they are described as **heterosomes**; all the other chromosomes, which are identical in appearance, are called **autosomes**.

Despite this difference, the sex chromosomes are transmitted in a normal Mendelian manner as shown below.



Generally, a female produces only one kind of gamete as the chromosomes are concerned; all her eggs contain an X chromosome. For this reason, in human and many other species, the female is said to be homogametic (same gametes). A male on the other produces two

kinds of gametes as far as chromosome are concerned: half of the sperm contain an X chromosome, the other half a Y. The male is therefore heterogametic (different gametes) on fusing randomly, approximately half the zygotes receive two X chromosome and develop into female, the rest receive Y chromosomes and give rise to males. In some insects, females are XX and male XO

### **Sex linkage**

Sex linked characters are those whose genes that are carried on sex chromosomes usually X-chromosomes and is inherited along with sex for examples: red-green colour blindness and haemophilia

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