21. Inbreeding and Outbreeding

Inbreeding

Mating between closely related individuals is called ***inbreeding.*** ***Self fertilization*** is an ideal inbreeding.

Mendel carried out inbreeding among the F_1 plants in his ***monohybrid*** and ***dihybrid experiments.***

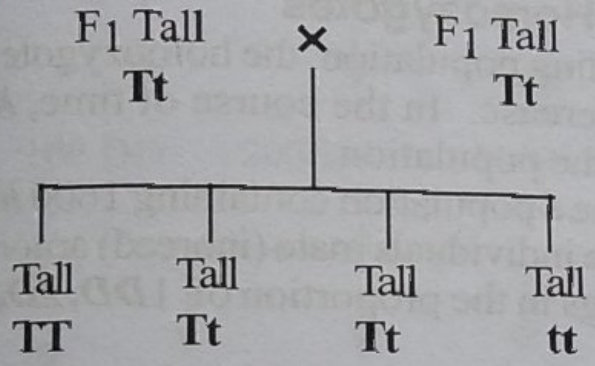

Fig.21.1: Inbreeding in Mendel's experiment.

The marriage between a brother and a sister (not in practice) is an ideal inbreeding.

The Royal family of Egypt including Cleopatra was famous for inbreeding between brothers and sisters.

Cousin marriages are examples of inbreeding.

The mating between a mother cow and an Ox born for the cow is an inbreeding.

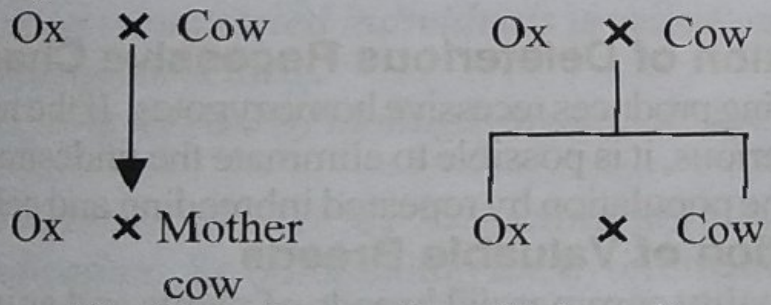

Fig.21.2: Examples of inbreeding.

Significance of Inbreeding

Inbreeding has demerits and merits.

Demerits of Inbreeding

1. Low Yield

Inbreeding results in low yield.

2. Inbreeding Depression

The loss of vigour as a result of inbreeding is called ***inbreeding depression.***

3. Appearance of Deleterious Characters

In human beings, there is a seven-fold increase in phenylketonuric children from cousin marriages than from marriages between unrelated parents.

In corns, inbreeding results in the appearance of deleterious characters such as white seedlings, yellow seedlings and dwarfs.

Merits of Inbreeding

1. Increase of Homozygotes

In an inbreeding population, the homozygotes increase and the heterozygotes decrease. In the course of time, ***heterozygotes*** are ***eliminated*** from the population.

Let us assume a population containing 1600 ***heterozygous*** (Dd) individuals. These individuals mate (inbreed) among themselves and produce offsprings in the proportion of 1***DD:***2***Dd:*** 1***dd*** or 400***DD***: 800***Dd***: 400***dd.***

In the second generation, there will be 600 ***DD***, 400 ***Dd***, 600 ***dd*** and so on.

The heterozygotes will be decreased by half in each generation, with corresponding increase in the frequency of homozygotes.

2. Production of Pure lines

Inbreeding produces ***homozygotes. The homozygotes reproduce only homozygotes by inbreeding***. These homozygotes are ***pure lines*** as they breed pure. Hence inbreeding produces pure lines.

3. Elimination of Deleterious Recessive Characters

Inbreeding produces recessive homozygotes. If the recessive character is deleterious, it is possible to eliminate the undesirable recessive genes from the population by repeated inbreeding and selection.

4. Production of Valuable Breeds

High quality commercial breeds of plants and animals are produced by inbreeding followed by selection. Best races of horses, dogs, bulls and sheep are produced by inbreeding and selection. This kind of inbreeding is also called ***line breeding.***

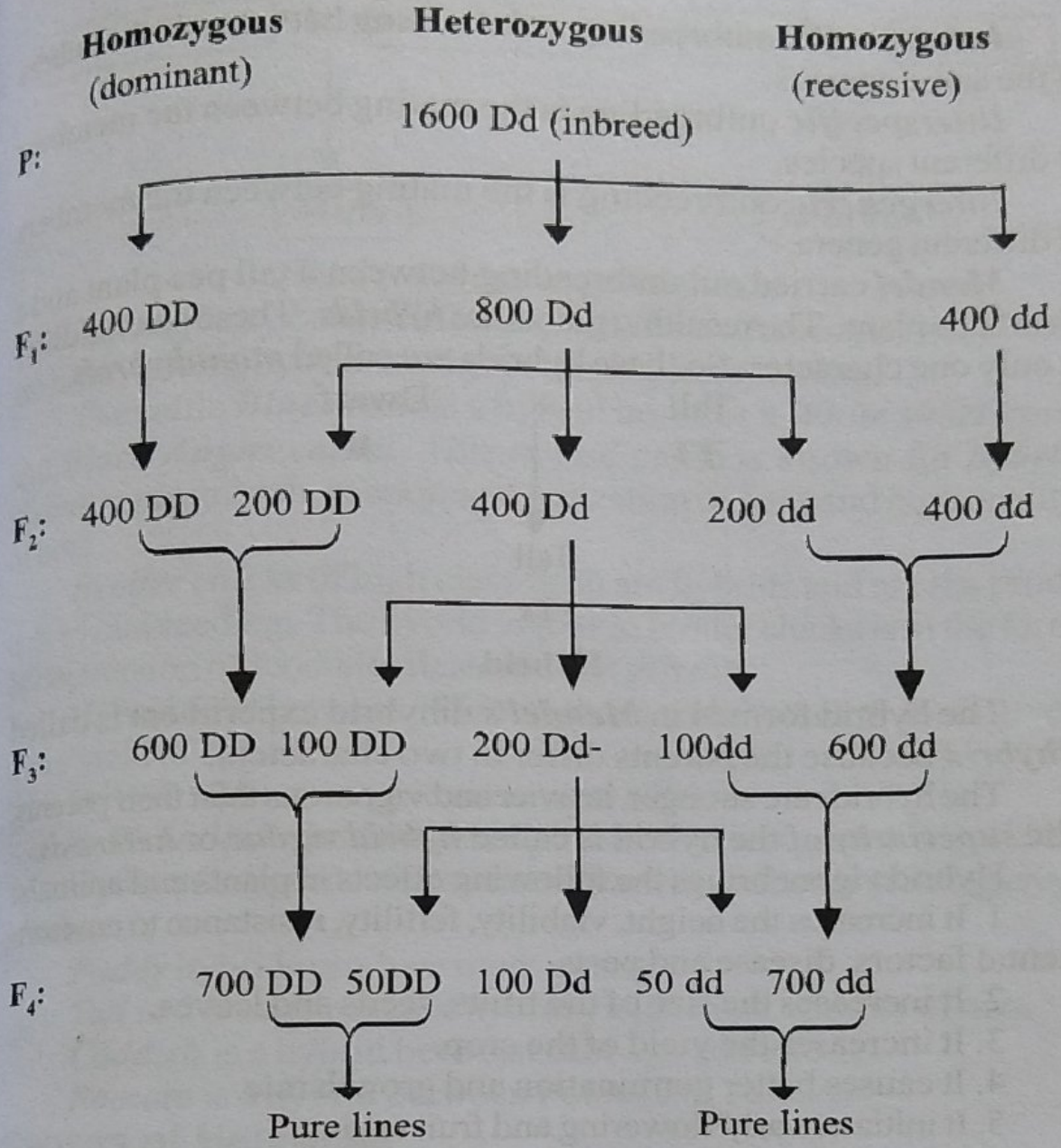

Fig.21.3: Inbreeding.

Outbreeding

The mating of unrelated individuals is called ***outbreeding.*** It is also called ***cross breeding.***

The offspring formed by mating two unrelated parents is called ***hybrids.***

The production of hybrids by mating unrelated parents is called ***hybridization.*** So outbreeding is a hybridization.

Outbreeding is of three types, namely

1. *Intraspecific outbreeding*
2. *Interspecific outbreeding*
3. *Intergeneric outbreeding*

Intraspecific outbreeding is the mating between the members of the same species.

Interspecific outbreeding is the mating between the members of different species.

Intergeneric outbreeding is the mating between the members of different genera.

Mendel carried out outbreeding between a tall pea plant and a dwarf pea plant. The resulting plants are ***hybrids***. These parents differ in only one character. So these hybrids are called ***monohybrids.***

Tall × Dwarf

TT **tt**

↓

Tall

Tt

Hybrid

The hybrid formed in ***Mendel's*** dihybrid experiment is called ***dihybrid*** because the parents differ in two characters.

The hybrids are stronger, heavier and vigourous than their parents. The ***superiority*** of the hybrid is called ***hybrid vigour*** or ***heterosis.***

Hybrid vigour brings the following effects in plants and animals:

1. It increases the height, viability, fertility, resistance to environmental factors, disease and pests.
2. It increases the size of the fruits, seeds and leaves.
3. It increases the yield of the crop.
4. It causes better germination and growth rate.
5. It initiates early flowering and fruit setting.
6. It increases milk production.
7. It increases number of eggs in poultry.
8. It produces better beef and pork.
9. It increases in silk production.

Mule is a hybrid. Mule is born for a ***male donkey*** and a ***female horse.*** Mule is superior to a horse in strength, ability to work and resistance to disease. Mule is more intelligent than their parents. Thus mule exhibits ***hybrid vigour.*** However mule is ***sterile*** and it cannot produce another mule.

Everytime mule is produced a new:

Mule is employed in Indian army in Himalayan mountain.

Zebrankey is a hybrid between Zebra and Donkey.

Hybrid cows born between ***Red Sindhe*** and ***Jershey*** give more milk.

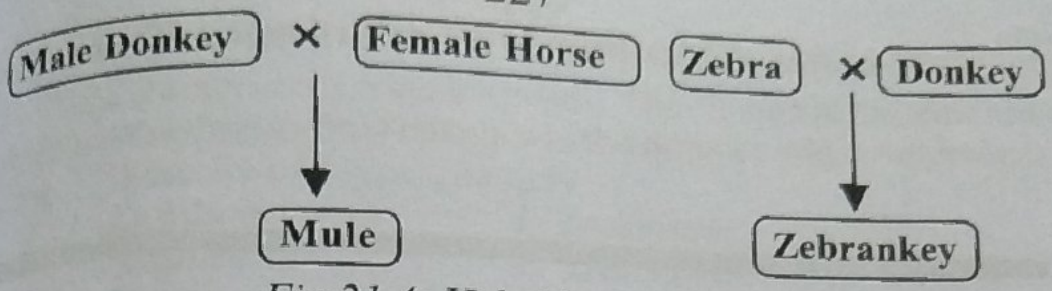

Fig.21.4: Hybrid production.

Among dairy cattle ***Friesian,*** hed ***Dane, Jershey, Sindhi,*** etc. are high yielding hybrid cows produced by outbreeding.

The cattle ***Blue roam*** is a hybrid born for a ***White short horn*** and ***Black Angus cattle.*** This hybrid cattle is known for ***hybrid vigour,*** rapid growth, economical utilization of food and high quality of beef.

Broiler chicks of high class flesh are hybrids and are the products of outbreeding. The hybrid vigour in broiler chicks is in the form of conversion of food into flesh and fast growth.

Hybrid fowl between ***White leghorn*** and ***Plymouth Rock*** gives more yield of eggs.

Hybrid ***silk worm*** produces more silk.

In ***Fisheries,*** hybrid fishes are produced for fast growth. Eg. *Catla.*

Outbreeding produces numerous varieties of better yielding ***crop plants.***

Paddy hybrids produce more grains.

Tall and ***Dwarf*** coconut hybrid yields more number of nuts.

Caddish is a hybrid between cabbage and Radish.

Pomato is a hybrid between Potato and Tomato.

Causes of Heterosis

Heterosis is caused by two main factors, namely

1. *Genetical factors.*
2. *Physiological factors.*

13. Syndromes

Syndromes are caused by non-disjunction. Syndrome is a disease characterized by a group of symptoms.

In man, the following syndromes are produced by non-disjunction:

1. *Klinefelter's syndrome.*
2. *Turner's syndrome.*
3. *Down's syndrome.*

1. Klinefelter's Syndrome (22AA+XXY) = 47

Klinefelter's syndrome is a ***genetical disease*** caused by an additional X chromosome in human ***male.***

It is a sexual abnormality in ***males*** discovered first by ***Harry*** (1942).

It is caused by ***chromosomal aberration.***

It is caused by ***trisomy (aneuploidy)*** where one chromosome is added to a set (2n + 1).

This abnormality is due to the presence of ***47*** chromosomes instead of 46. The victims possess an additional X chromosome with XY. So the chromosomal make up is ***22AA + XXY.***

It is caused by ***non-disjunction*** of XX chromosomes. When an abnormal egg with XX chromosomes, is fertilized with a sperm with Y chromosome, the resulting baby contains ***XXY.***

They are ***sterile males.***

The testes are small; there is no spermatogenesis.

Male sex glands are poorly developed.

The breasts are enlarged.

They are tall.

Amount of male hormone is low.

Genitalia are poorly developed.

They are ***mentally affected.***

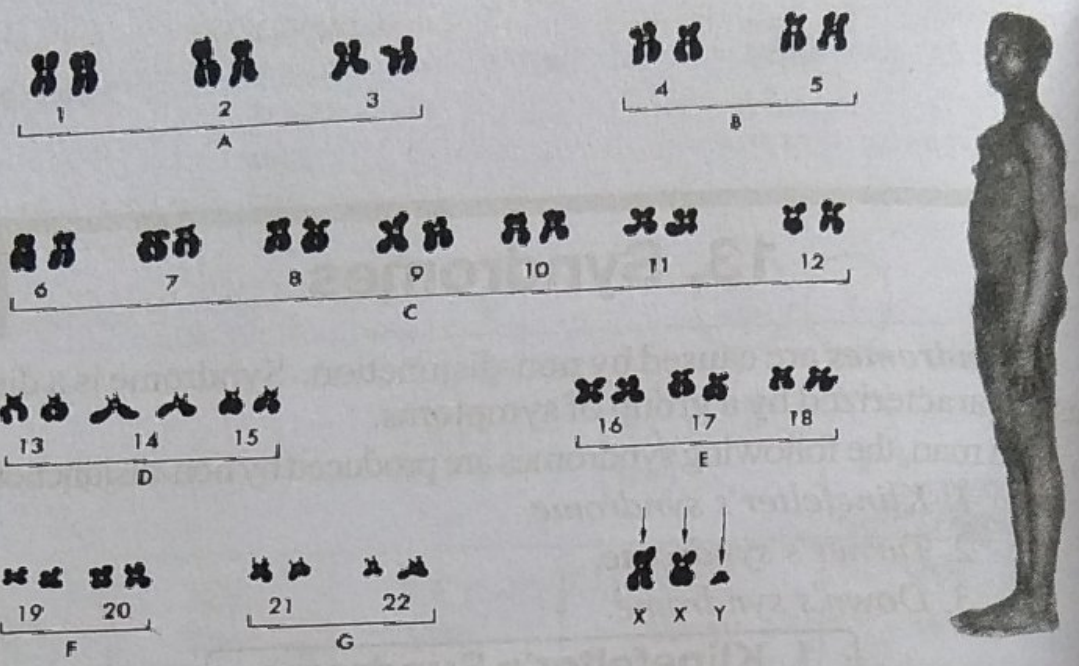

Fig.13.1: The Klinefelter's syndrome in man. Such persons are AAXXY, with 47 chromosomes as shown in the karyotype. External genitalia are male-type, but there is usually some female-like breast development as in this case.

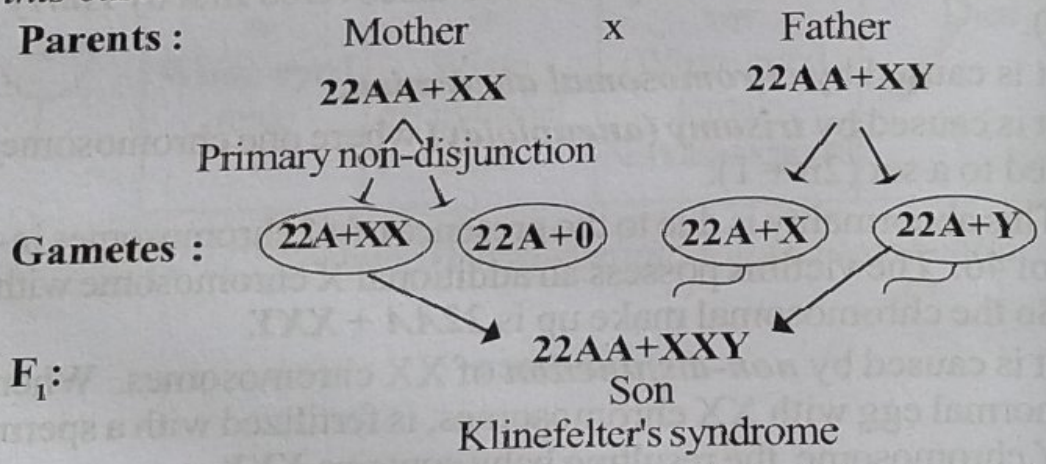

Fig.13.2: Non-disjunction resulting in Klinefelter's syndrome.

2. Turner's Syndrome (22AA+X) = 45

Turner's syndrome is a genetical disease in human female caused by the absence of one X chromosome.

It is a ***sexual abnormality*** in ***female*** discovered by ***Turner*** in 1938.

It is caused by a ***chromosomal aberration.***

It is caused by ***monosomy (aneuploidy)*** where one chromosome is lost from one pair (2n-1).

This abnormality is due to ***45*** chromosomes instead of 46. The missing chromosome is one X chromosome. Hence the chromosomal make up is ***22AA + X = 45.***

It is caused by ***non-disjunction*** of XX chromosomes. When an abnormal egg without any X chromosome is fertilized by a sperm with X chromosome, the resulting baby contains ***XO*** chromosomes.

The baby develops into a ***sterile female***. She has female phenotypes. But there is ***no menstruation.***

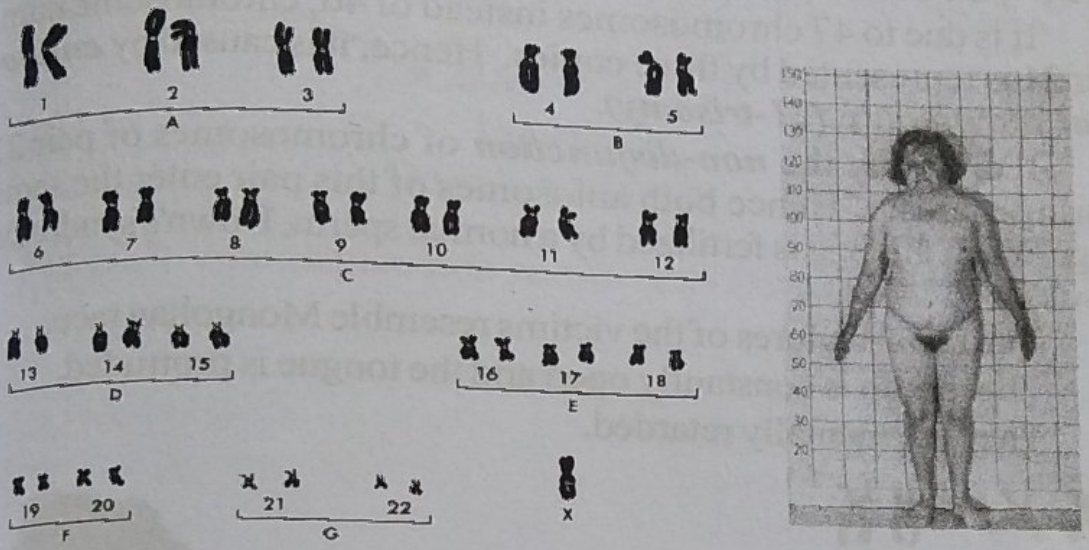

Fig.13.3: The turner's syndrome in woman. Such persons are AAXO, with only 45 chromosomes as shown in the karyotype. Note, external female genitalia, webbed neck, broad chest, underdeveloped breasts and short stature. Turner individuals have a small uterus and vestigial ovaries.

Parents : Mother x Father

22AA+XX **22AA+XY**

Non-disjunction

Gametes : **22A+XX** **22A+O** **22A+X** **22A+Y**

F_1 : **22AA+XO**

Daughter

Turner's syndrome

Fig.13.4: Non-disjunction resulting in Turner's syndrome.

Ovaries are represented by ridge of whitish tissue called ***streak gonad.***

Female hormones are low. The chest is broad. Breasts are poorly developed. They are dwarf. Mentally retarded.

3. Down's Syndrome (Mongolism or Mongoloid idiocy)- 21AA+ A+XX

This abnormality was described by ***Down*** in 1866.

It is caused by ***chromosomal aberration.*** It is due to ***trisomy*** in 21st pair of ***autosome.***

It is due to 47 chromosomes instead of 46; chromosome number 21 is represented by three copies. Hence, it is caused by ***autosomal aneuploidy (21-trisomy).***

It arises by the ***non-disjunction*** of chromosomes of pair 21 during meiosis. Hence both autosomes of this pair enter the same egg. When this egg is fertilized by a normal sperm, Down's syndrome results.

The facial features of the victims resemble Mongolian race.

The mouth is constantly open and the tongue is protruded.

They are mentally retarded.

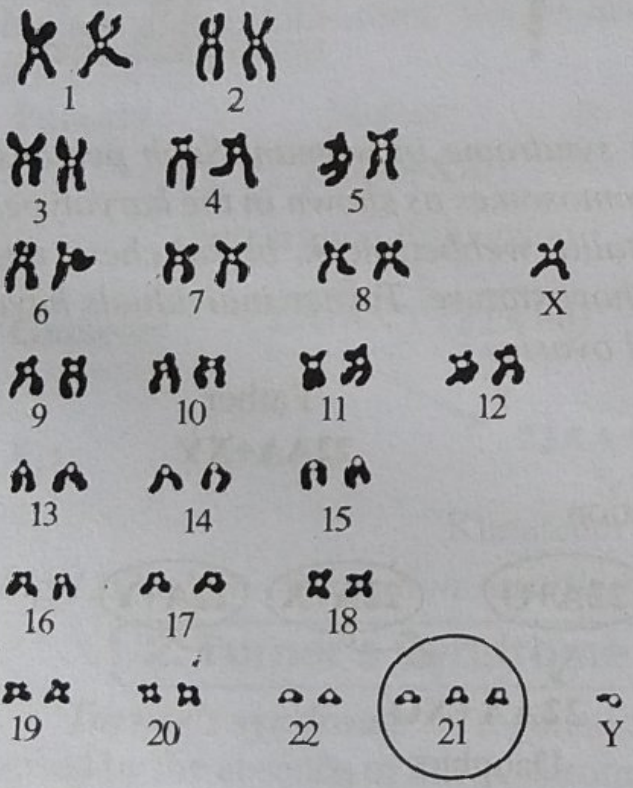

Fig.13.6: Down's syndrome (Mongoloid idiocy) in a child.

Fig.13.5: Karyotype of trisomic mongoloid idiot having 47 chromosomes (triplo-21).

The neck is short and broad. She is dwarf.

The nose is oblique.

The ears are malformed.

This syndrome appears much more frequently in children born to women in the later part of the reproductive life.

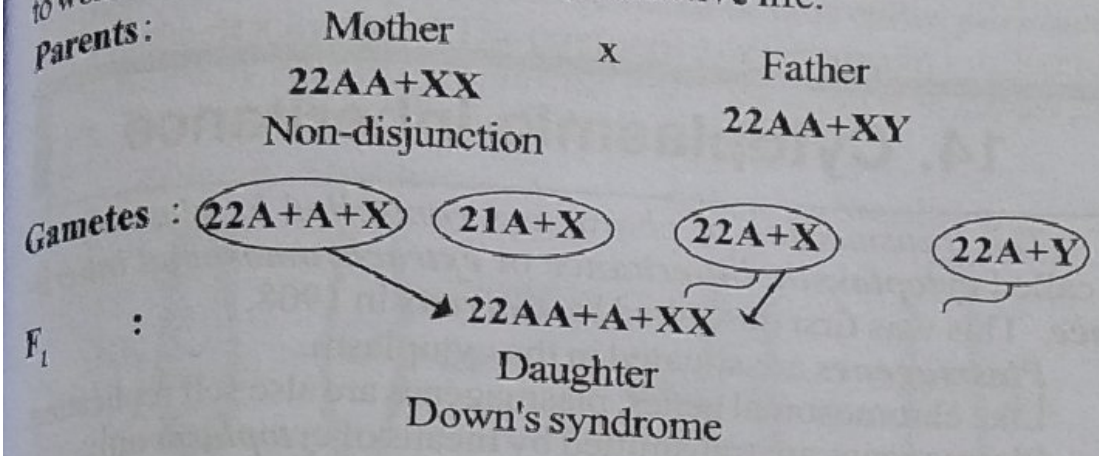

Fig.13.7: Non-disjunction resulting in Down's syndrome.

15. Twins

The two babies born at a time for a mother are called ***twins.*** Twins are due to ***multiple pregnancy.*** There are three types of twins. They are the following:

1. *Identical twins*
2. *Fraternal twins* and
3. *Siamese twins*

1. Identical Twins

Identical twins are *extremely similar in their characters.* They are ***developed from a single zygote.*** So they are also called ***monozygotic twins.***

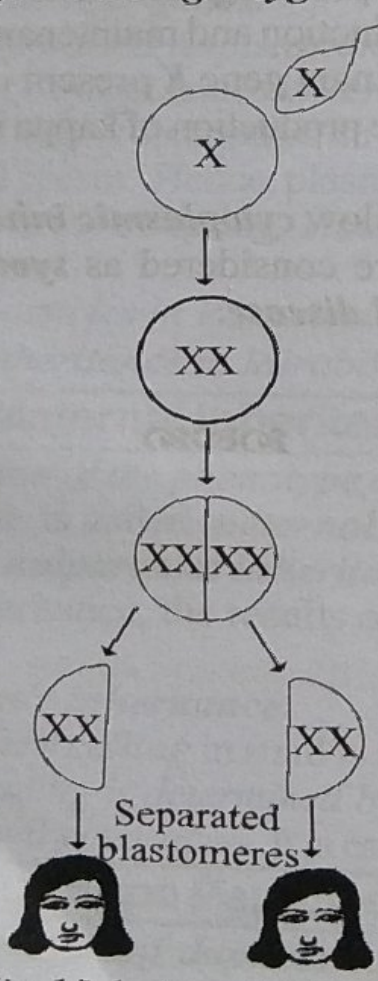

Fig.15.1: Identical twins.

The identical twins develop from a single zygote. During cleavage, the zygote divides into two ***blastomeres.*** These blastomeres separate and each blastomere develops into a baby. Hence the two babies are similar in all respects.

Sometimes, the identical twins are joined together producing ***siamese twins.***

They are of the ***same sex.***

They have the ***same type of genes.***

They have the same type of ***blood group.***

They have very similar temperaments, disposition and mental capacities.

They are generally opposite handed. One of the twin is right handed and the other is left handed.

They show similar whorls of hair on the head but in a reverse order like mirror image.

2. Fraternal Twins

Fraternal twins are like ordinary brothers and sisters born in one birth. They develop from ***two independent zygotes.*** So they are also called ***dizygotic twins.***

They are formed by the fertilization of two eggs by two sperms.

They may be of the same sex or opposite sexes.

They have different genotypes. So they have dissimilar characters. So they are called ***non-identical twins.***

Generally a lady produces only one egg at a time. But some times two eggs are produced simultaneously. The two eggs are fertilized by two sperms producing fraternal twins. If both the eggs are fertilized by sperms containing X chromosomes, female babies are produced. If both the eggs are fertilized by sperms containing Y chromosomes, male babies are produced. If one egg is fertilized by X carrying sperm and another by Y carrying sperm, both male and female babies are produced. (Fig.15.2).

3. Siamese Twins

These twins were born for the first time in ***Siam;*** hence they are called ***siamese twin. Siamese*** twins are similar to ***identical twins.*** They develop from a single egg. So they are ***monozygotic twins.*** They are ***joined together physically.***

The zygote divides into two blastomeres. The blastomeres are partially separated. These blastomeres develop into two babies. They may be attached in the head region or trunk region or hip region.

They may have a double head and a single trunk. Sometimes they are double in the trunk region and single in the head region. On certain occasions, they are double in the head and leg regions and united only in a small area at the hips. They are also called ***double monsters*** or ***abnormal twins.*** They survive very rarely.

The siamese twins are of the same sex. They have the same type of genes.

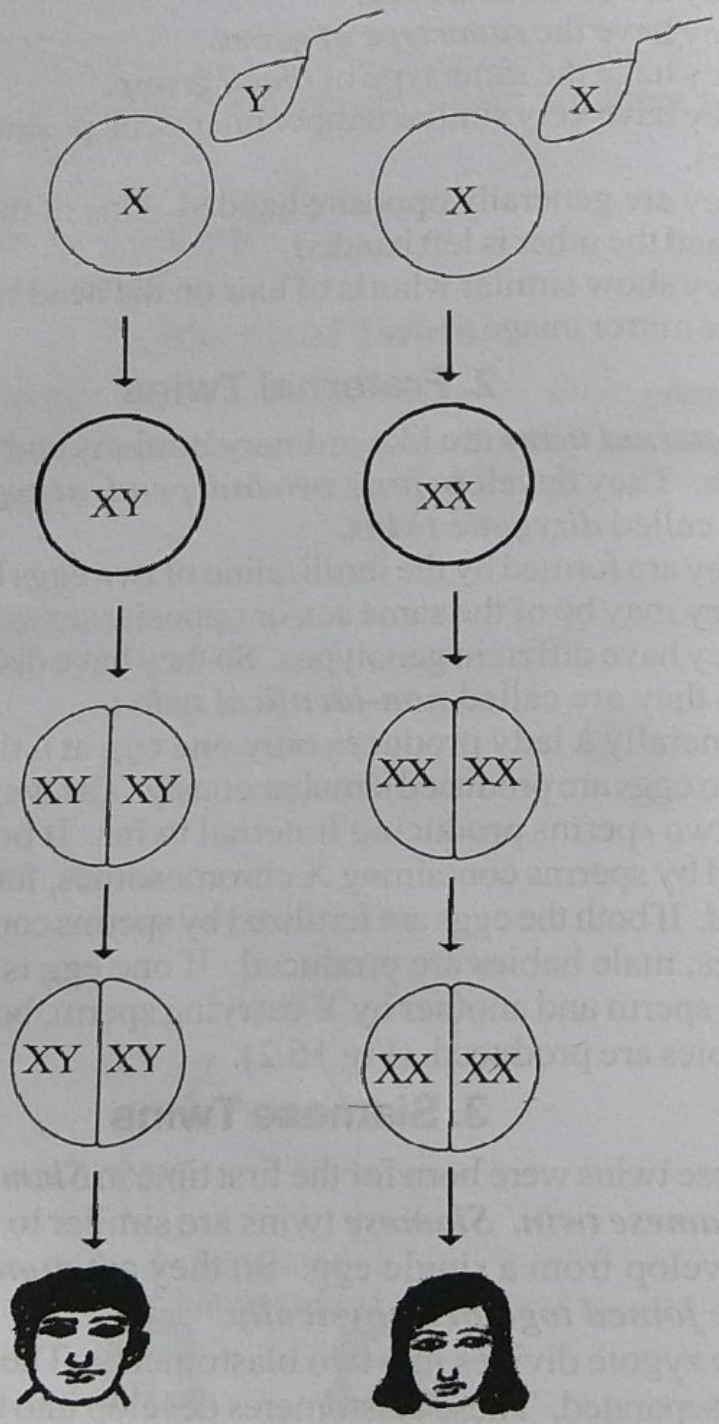

Fig.15.2: Fraternal twins.

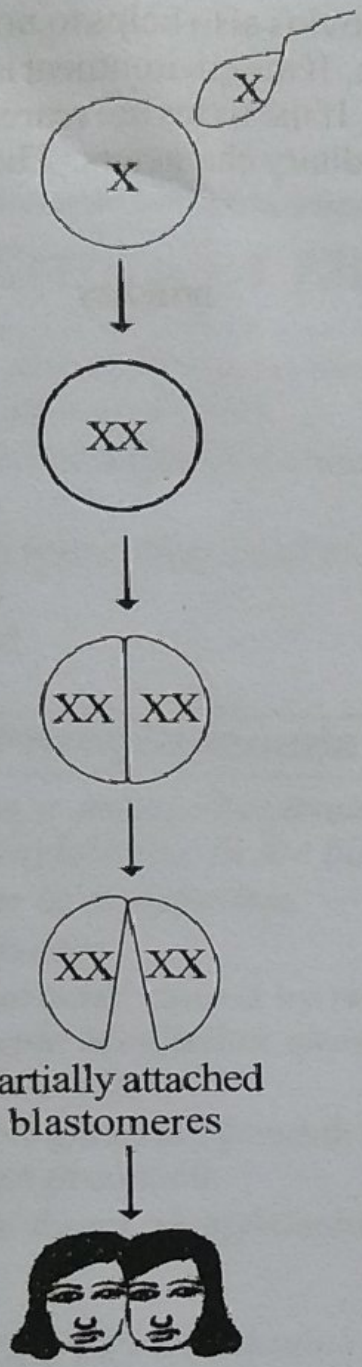

Fig.15.3: Siamese twins.

Importance of Twin Study

1. The study of the heredity of twins helps to understand the hereditary and environmental characters. The identical twins contain the same type of genes because they develop from one egg. So all the characters which are similar are hereditary characters. The character which is present in one of the twin and absent from the other is produced by the environment. Observation of this shows that intelligence, diabetes, feeble mindedness, etc. are hereditary characters.

2. The study of twins also helps to understand the influence of environment on twins. If the environment is similar, twins show practically no difference. If the twins are reared apart, there is definitely difference in the hereditary characters. These differences are caused by the environment.