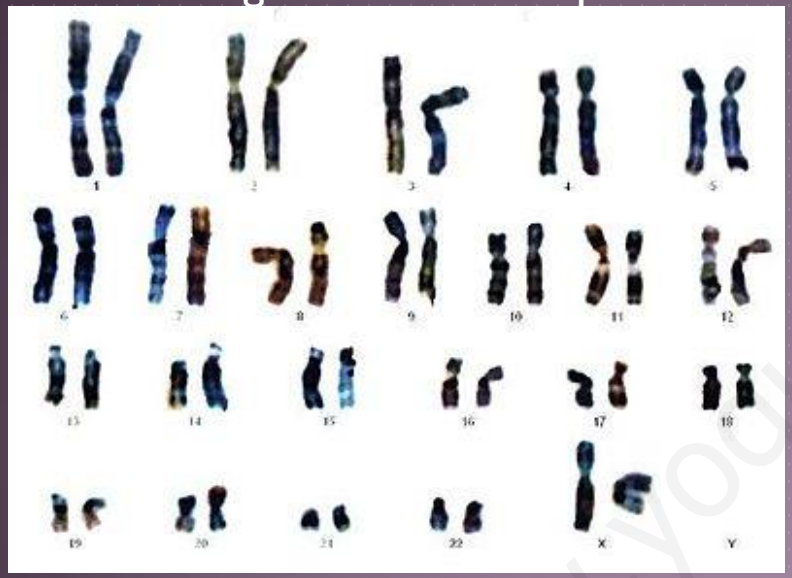
# UNIT 7: HUMAN GENETICS

HUMAN KARYOTYPE
INHERITANCE IN HUMAN SPECIES
GENETIC ALTERATIONS
CONGENICAL ALTERATIONS
DIAGNOSIS OF GENETIC ILLNESES

# 1. HUMAN KARYOTYPE

The **karyotype** is the chromosomal pattern of a species. It shows us the number, type and structure of the chromosomes.

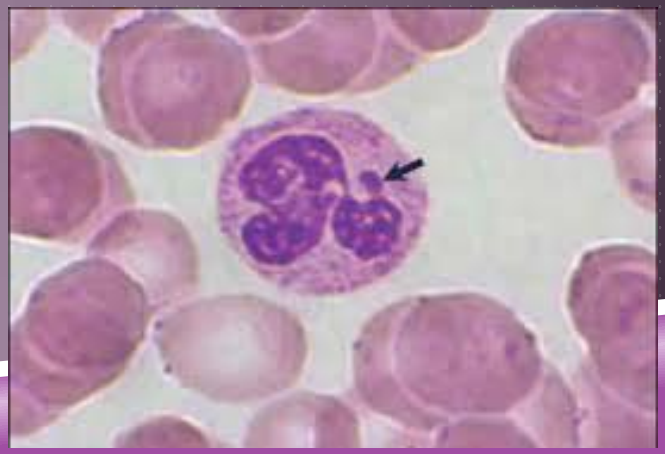
The **karyogram** is the image ordered according to the size and shape of the homologous chromosome pairs of an individual. They are numbered and ordered according to the size and position of the centromere.



Human somatic cells, except alterations, contain 46 chromosomes (23 pairs of homologs)

22 pairs of autosomes,

1 pair of sex chromosomes (XX = female, XY = male)



In the somatic cells of women, one of the X chromosomes is inactivated (randomly) and is "packed" in the cell nucleus in a process called lionization. The chromosome forms a dense spot called the Barr corpuscle. This process was discovered by Mary Lyon.

# 2. INHERITANCE IN HUMAN SPECIES

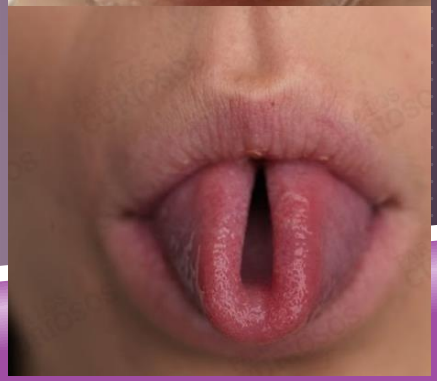
In the human species as in other species, hereditary characters have a genetic and an environmental component. This causes some of them to vary in shape, in a continuous or discontinuous way:

Continuous, in which there is a gradual variation for a character like:
the height,
hair color,
The color of the skin…

Discontinuous, in which there are clearly recognizable varieties, such as:

- Lobe of the ear separated (dominant) or joined (recessive)
- Birth of the dominant "widow's beak" hair
- Bend the tongue as U (dominant)
- Thick lips (dominant) face thin ...





The heritable characters sometimes depend on a single gene with several alleles such as blood groups or they may depend on the accumulation of the same gene. This is the case of quantitative inheritance.

An example is skin color. Suppose there are two alleles A = melanized (dark) and a = light and that for that character there are 2 pairs of genes. So:

If for this character there are three pairs of loci, then the crossing between two hetorozygous (for the trhree loci) individuals, the options would be the ones you see in the picture.

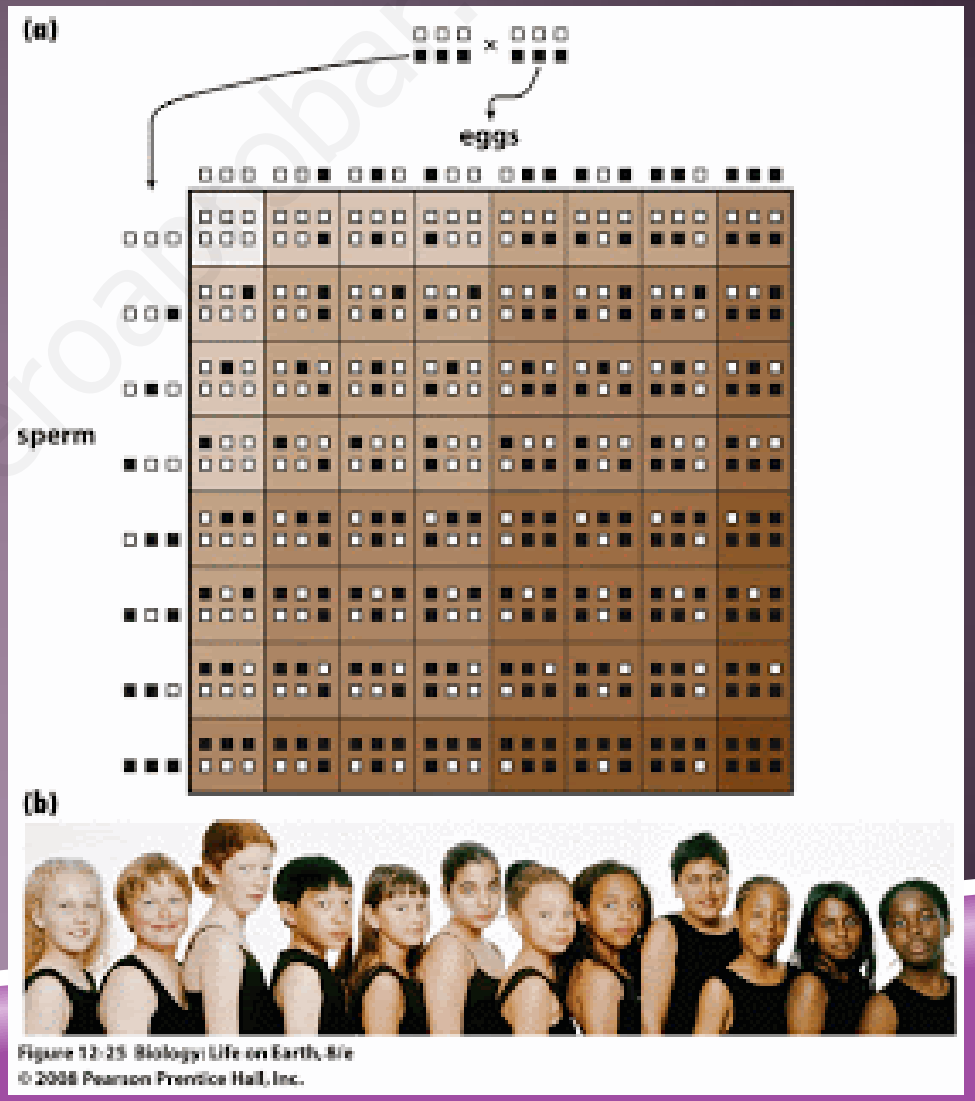


Figure 12-25 Biology: Life on Earth, 8/e

# BLOOD TYPES AND RH FACTOR

ABO blood groups and Rh factor are two characters that are not linked, they are inherited independently because they are on different chromosomes

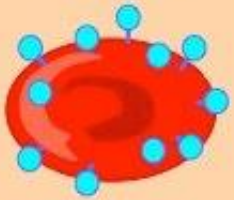
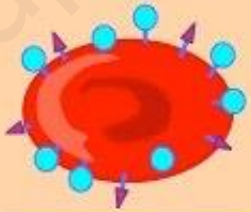
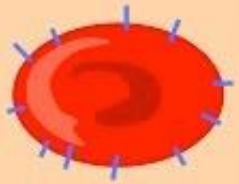
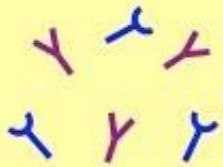
The ABO blood group is inherited controlled by a gene that has multiple allelism (allele A, allele B, and allele 0) with codominance allele A = allele B> allele 0. Alleles A and B control the production of a membrane protein of the red blood cells that can be recognized by the immune system. Allele 0 does not encode any surface protein (see table). The possible genotypes and phenotypes are:

| *Genotipos posibles* |
|---|
| $I^A I^A$ |
| $I^A I^0$ |
| $I^B I^B$ |
| $I^B I^0$ |
| $I^A I^B$ |
| $I^0 I^0$ |

| GENOTIPO | GENOTIPO |
|---|---|
| AA | A |
| AO | |
| BB | B |
| BO | |
| AB | AB |
| OO | O |

A and B alleles control the production of a membrane protein in red blood cells that works as an antigen and can be recognised for the inmune system producing antibodies against it if it is strange.

0 allele doesn´t codify for any membrane protein.

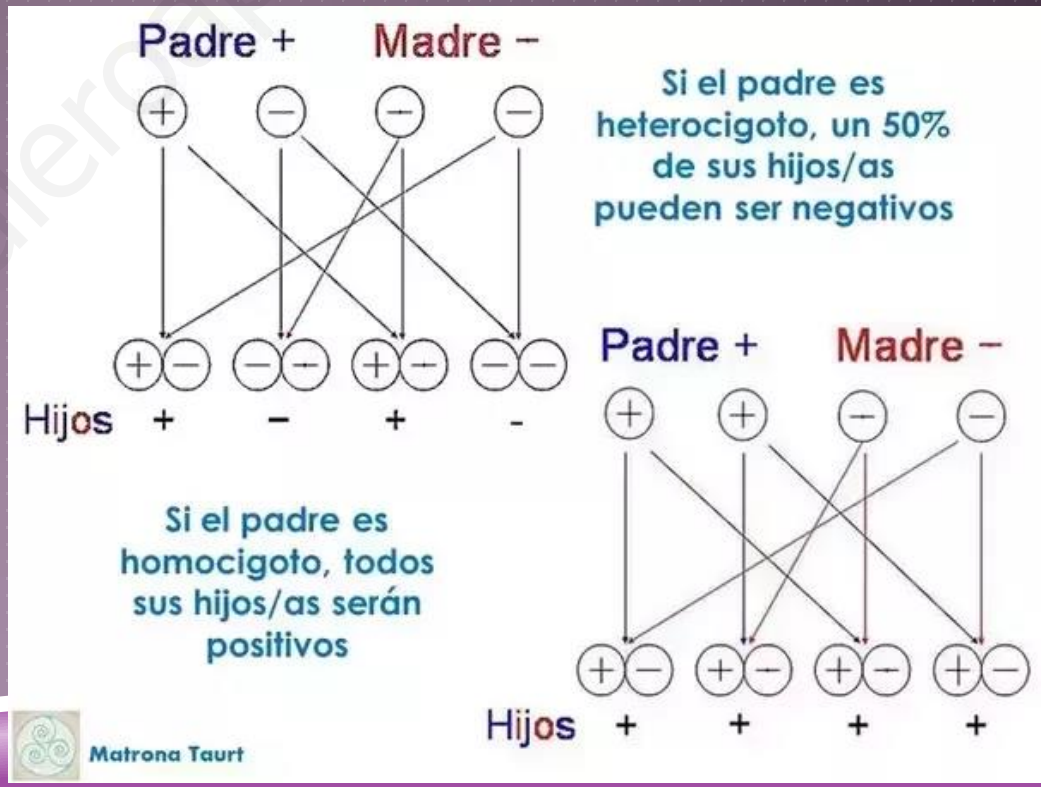
| | Type A | Type B | Type AB | Type O |
|---|---|---|---|---|
| **Antigen** (on RBC) | Antigen A  | Antigen B  | Antigens A + B  | Neither A or B  |
| **Antibody** (in plasma) | Anti-B Antibody  | Anti-A Antibody  | Neither Antibody | Both Antibodies  |
| **Blood Donors** | Cannot have B or AB blood<br>Can have A or O blood | Cannot have A or AB blood<br>Can have B or O blood | Can have any type of blood<br>Is the universal recipient | Can only have O blood<br>Is the universal donor |

The Rh system is inherited by another gene that has two alleles. The + allele produces another surface protein in red blood cells, also recognized by the immune system. The allele - does not generate any surface protein. Therefore, the allele +> -.
The possible genotypes and phenotypes are:

La table with possibles genotypes and phenotypes are:

| GENOTYPE | ++ , +- | -- |
|---|---|---|
| PHENOTYPE Rh FACTOR | Rh (+) | Rh (-) |

See one example about a crossing of a father who is RH+ and a mother who is RH-:

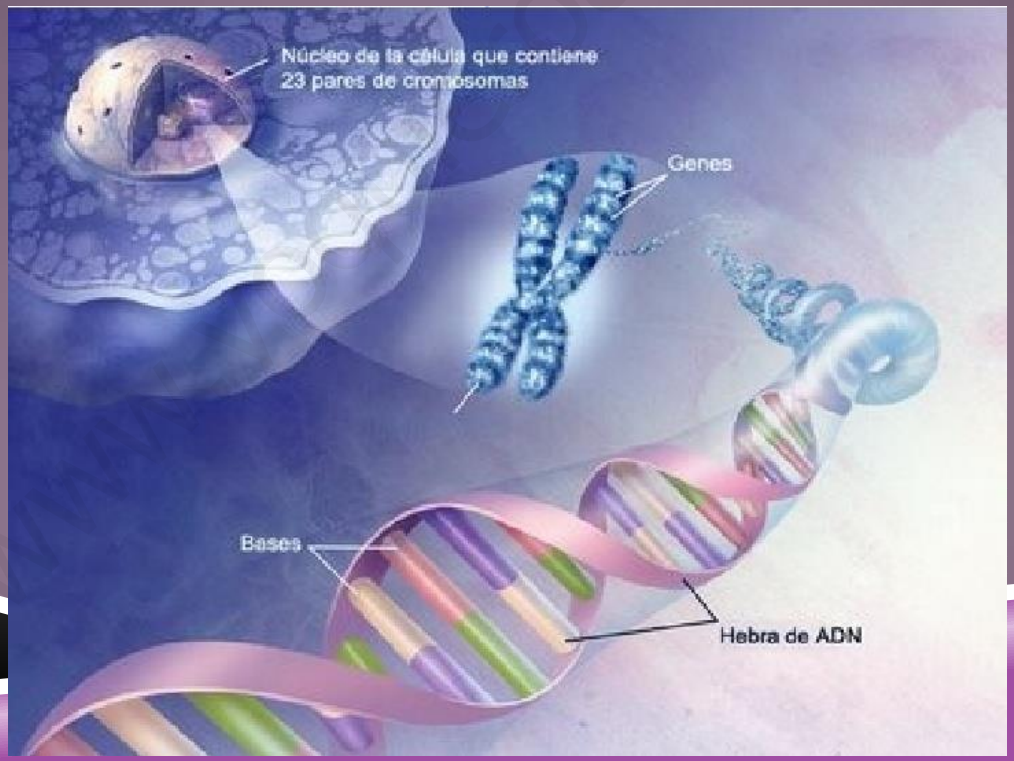


# 3. GENETIC ALTERATIONS IN HUMANS

Genetic alterations (mutations) in humans, as in the rest of the species, can be of one gene, chromosomal or genomic.

- ***GENE ALTERATION***

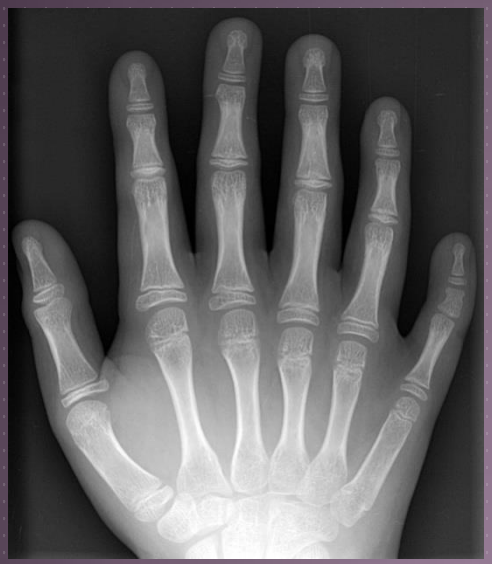
They affect the sequence of a gen. They can be autosomic or linked to sex.



- **AUTOSOMIC**

They are alterations in genes of autosomal chromosomes such as

- Polydactyly: alteration that produces supernumerary fingers. It is a dominant trait.



- Albinism: alteration that results in melanin not being synthesized. This substance is responsible for the coloring of eyes, skin and hair. White hair, very light skin and pink eyes. It is due to alteration of a gene and is recessive compared to normal pigmentation.

- Other disorders are cystic fibrosis, sickle cell anemia caused by recessive alleles.

- **LINKED TO SEX**

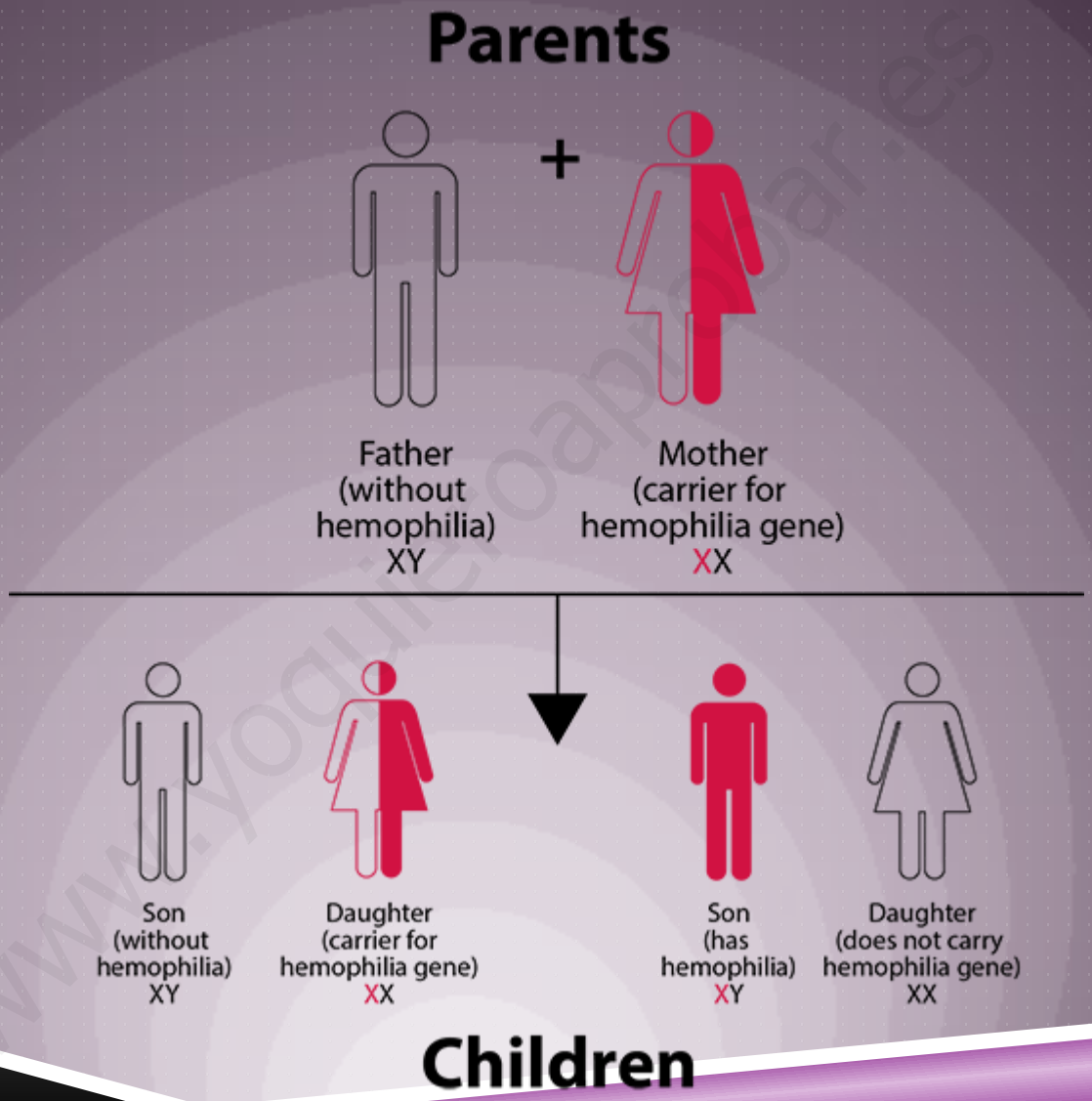
They are alterations that occur in genes found on the X or Y chromosomes. They are said to be linked to the X or Y chromosome. As the X chromosome is greater than the Y, the alterations in this gene on this chromosome are usually more frequent.

Some examples are: hemophilia and colour blindness

- ✓ Hemophilia: it is an alteration that makes blood clotting difficult due to the lack of a blood clotting factor. Rotating a blood vessel can cause severe bleeding that is difficult to stop. It is due to a recessive allele found on the X chromosome. That is why its inheritance is said to be linked to sex.

| **ALLELES** | **X* =>hemophilia y X =>normal X > X*** | | | | |
|---|---|---|---|---|---|
| **GENOTYPES** | X*X* | X*X | XX | XY | XY |
| **SEX AND PHENOTYP** | HEMOPHILIC WOMAN | HEALTHY WOMAN (CARRIER) | HEALTHY WOMAN | HEALTHY MAN | HEMOPHILIC MAN |

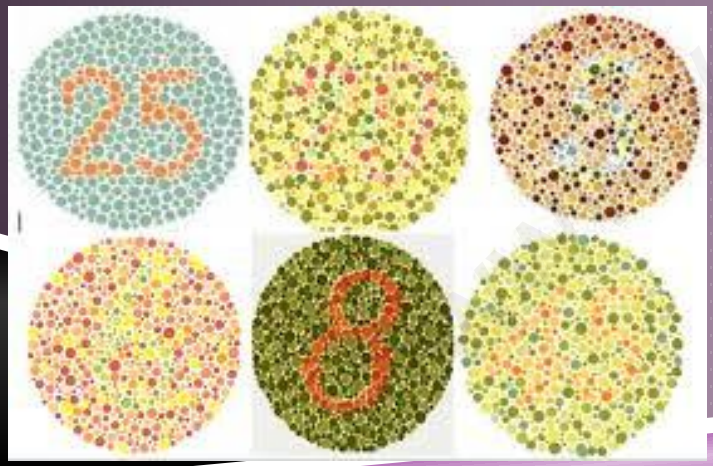
EXAMPLE


Parents
+
Father (without hemophilia) XY
Mother (carrier for hemophilia gene) XX
Son (without hemophilia) XY
Daughter (carrier for hemophilia gene) XX
Son (has hemophilia) XY
Daughter (does not carry hemophilia gene) XX
Children

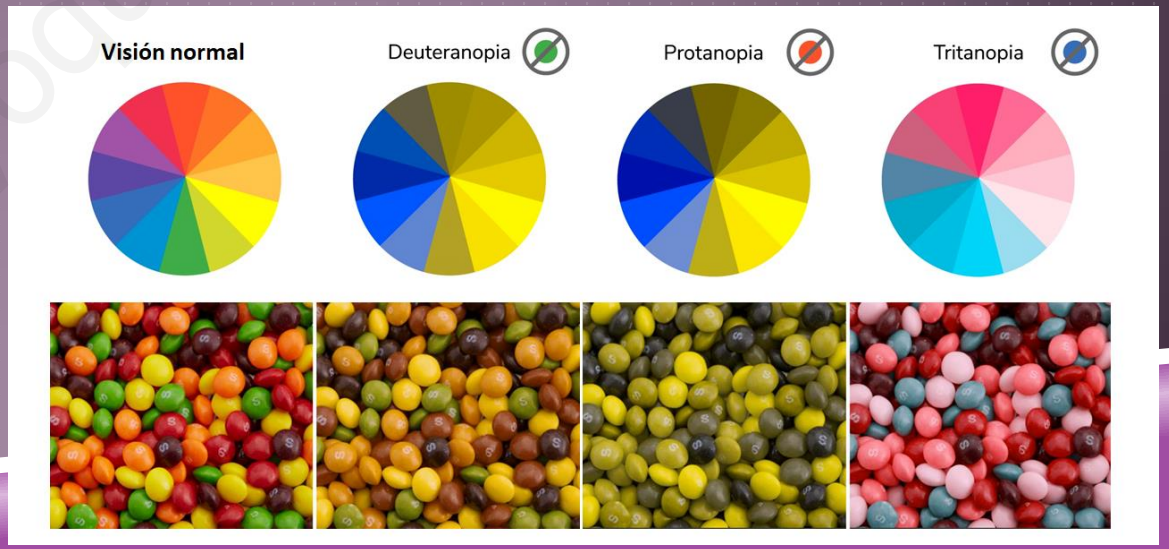
- ✓ Colour blindness is the inability to differentiate some colors (green, red, brown). It is due to the alteration of a gene located on the recessive X chromosome. Therefore, it follows the same hereditary pattern as hemophilia.

| ALLELES | X* =>daltonismo y X => visión normal<br>X > X* | | | | |
|---|---|---|---|---|---|
| GENOTYPES | X*X* | X*X | XX | XY | X*Y |
| SEXO AND PHENOTYPE | COLOUR BLIND WOMAN | NORMAL WOMAN (CARRIER) | NORMAL WOMAN | NORMAL MAN | COLOUR BLIND MAN |

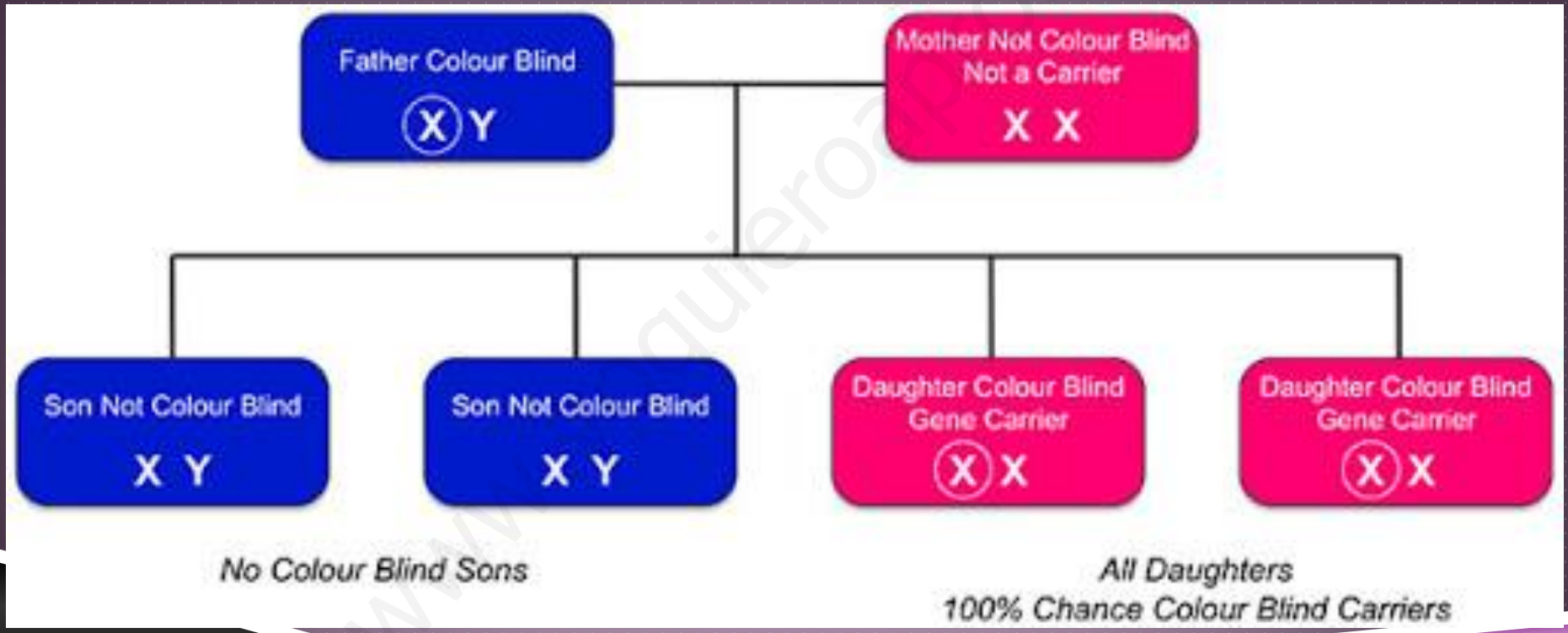
- *Which numbers do you see?*




*This is how colour blind people see*



# EXAMPLE OF A CROSSING

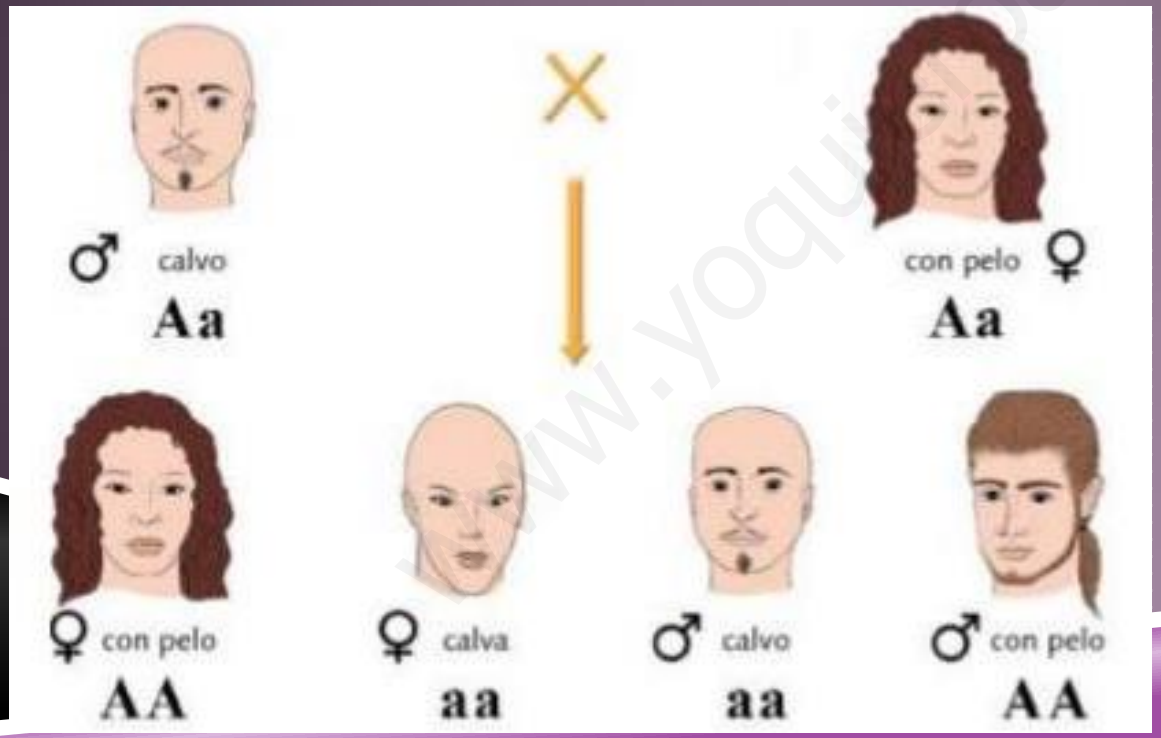


- **INFLUENCED BY SEX**

***Some alterations are due to the alteration of an autosomal gene but its phenotypic expression is influenced by sex. it is the case of:***

- Baldness: dominant in men and recessive in women
  a (baldness) A (hair).

- WAADENBURG SYNDROME: STREAK OF WHITE HAIR DOMINANT IN MEN AND RECESSIVE IN WOMEN.



## ➢ CHROMOSOMIC ALTERATIONS

Chromosomal alterations affect the structure of a chromosome. They can be for many causes such as:

- Deletions of a chromosome fragment
- Duplications: a fragment of chromosome that repeats
- Inversions: a fragment of a chromosome inverts its position. This is the case of Ambras syndrome, the congenital universal hypertrichosis. People who suffer from it have very thick hair that covers the entire body "werewolf syndrome"
- Translocations: a chromosome fragment moves to another chromosome.

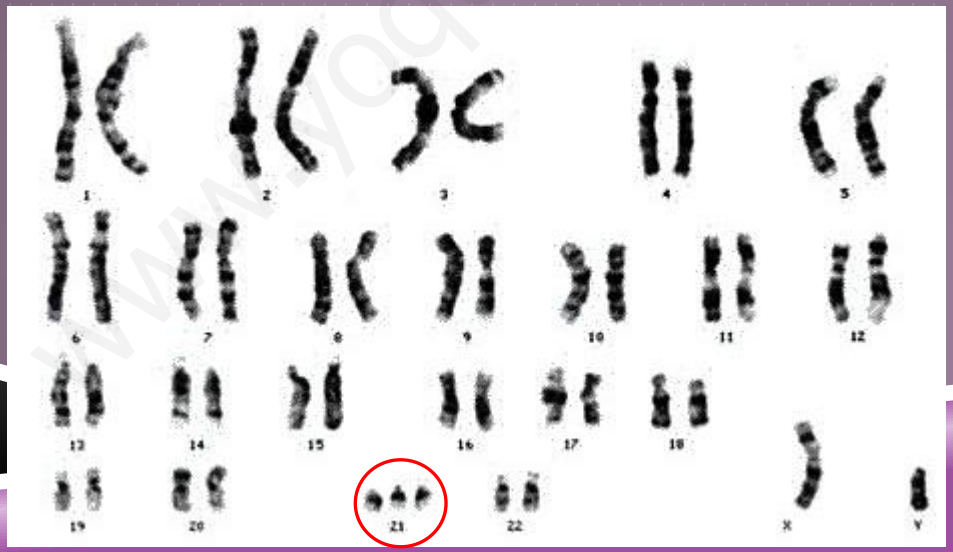
*Petrus Gonsalvus, a ¿"werewolf" ?*

## ➢ GENOMIC ALTERATIONS

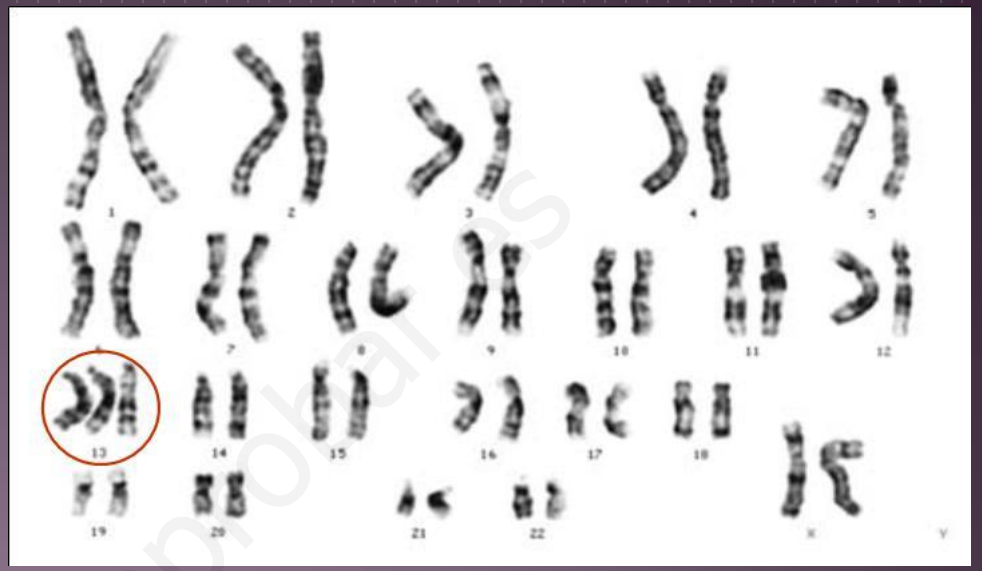
They are alterations that affect the total number of chromosomes of an individual. They can affect the number of autosomes or the number of sexual chromosomes.

### I. ANOMALIES THAT APPEAR IN THE AUTOSOMES

- **Trisomy in pair 21:** Down syndrome. Described by J. Langdon Down and its cause discovered by Lejeune et al (1958). They have three chromosomes in pair 21. It appears with a frequency of 1 in 700 live births, increasing the odds with the age of the parents. Individuals may have mild or profound mental retardation and characteristic facial features.

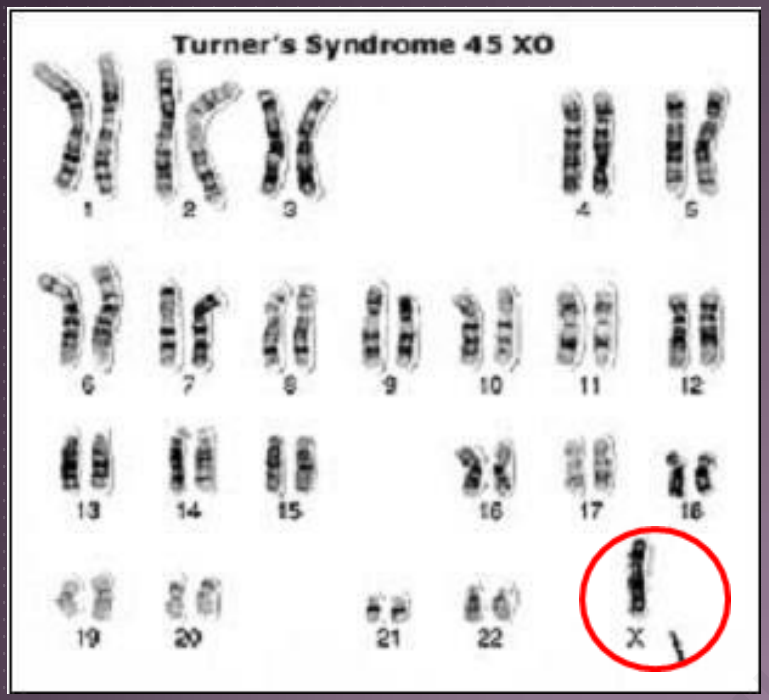


- . **Trisomy in par 13**: Patau syndrome. It appears in 1 in 12,000 live births. They present multiple deformations and very deep mental retardation. The half-life is about 130 days.



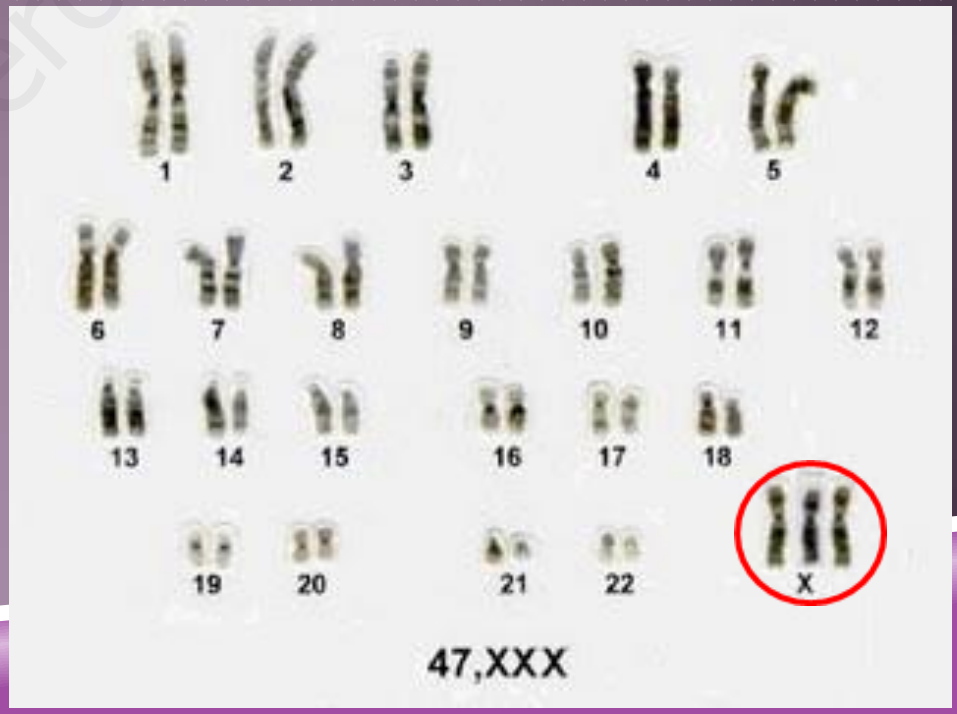
- **Trisomy in par 18:** Edwars syndrome. 1 out of every 6000 live births appears. Individuals suffer severe microcephaly, kidney and cardiac malformations, short neck and sternum ...

# II ANOMALIES THAT APPEAR IN SEXUAL CHROMOSOMES IN WOMAN



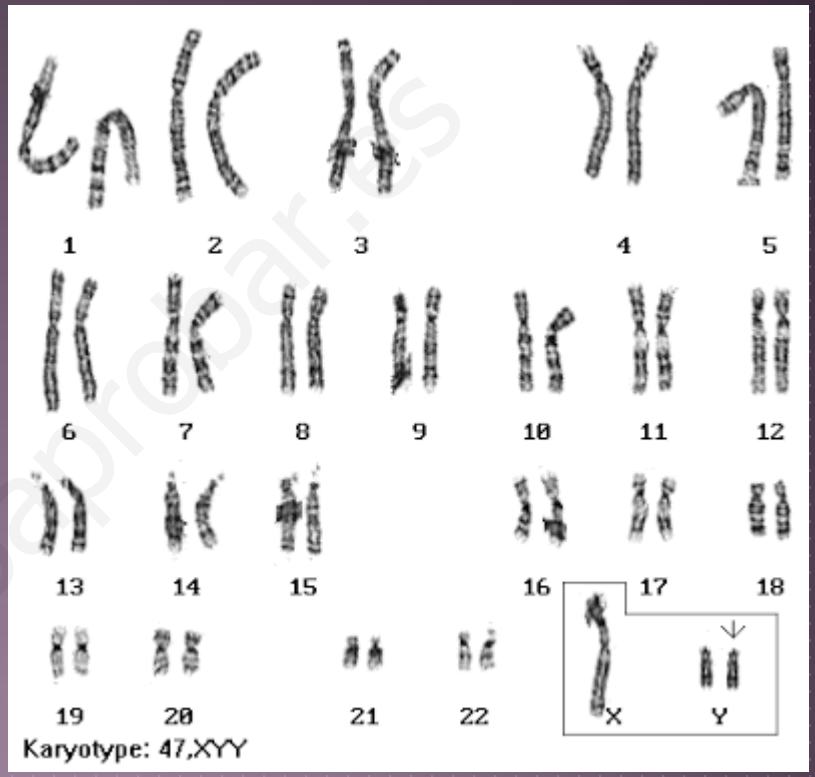

- **Constitution X0**: Turner Syndrome. It is the lack of an X chromosome. It has a frequency of 1/2500 girls, childlike women almost always sterile. Short stature, low ear implantation and cardiovascular deficiencies.

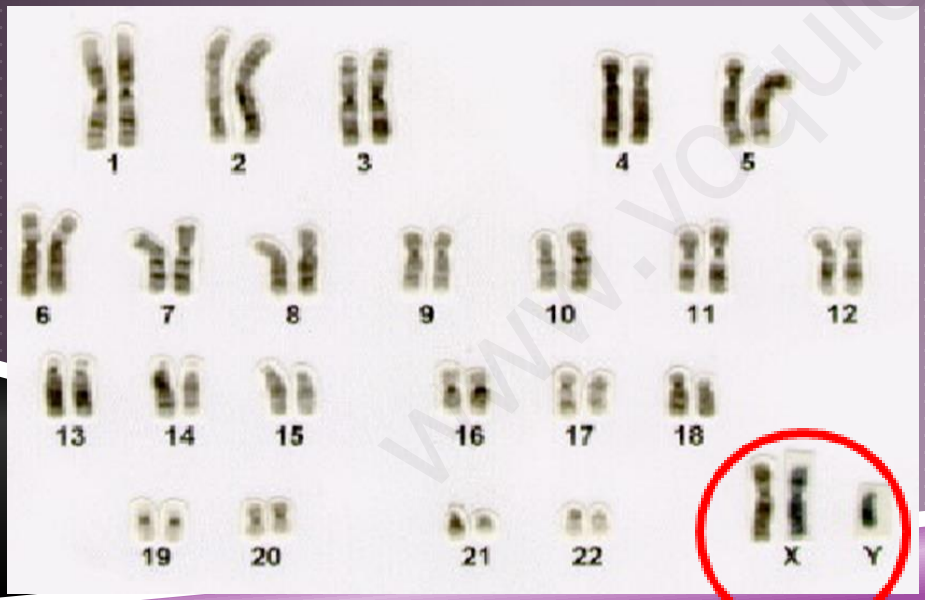
- **Triple XXX syndrome**. They have an extra X chromosome. They are female individuals with atrophic sexual organs and limited fertility, high probability of stopping speech and language problems. Appears on 1/1500 girls.



# II ANOMALIES THAT APPEAR IN SEXUAL CHROMOSOMES IN MALES

- **XYY duplo syndrome**: Corresponds to men of high stature (from 1.80 m), intelligence somewhat lower than normal. It has been linked to aggressive and antisocial behavior, but there is no evidence to show it.



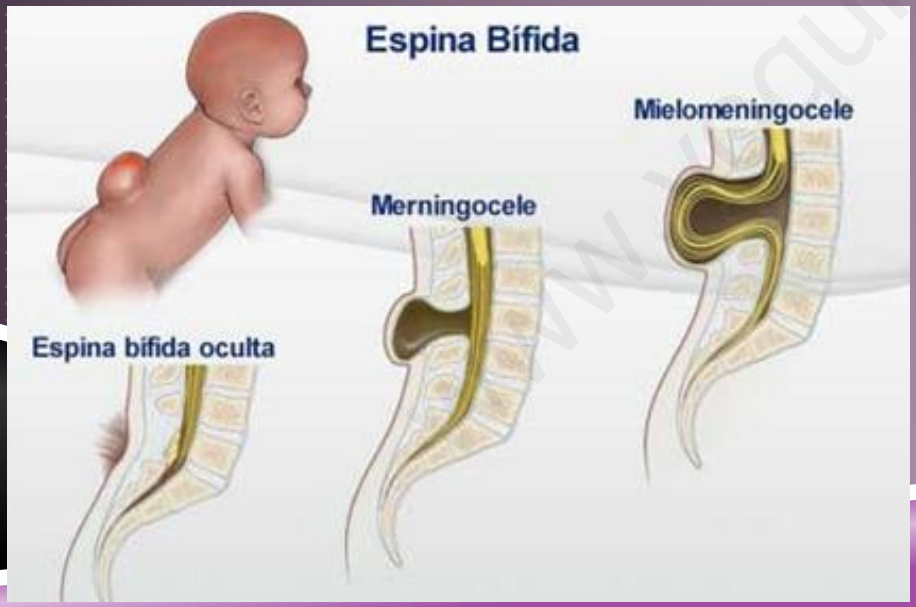

- **XXY Constitution:** Klinefelter Syndrome. Frequency of 1 in 400 live births. Eunucoids, low hairiness, gynecomastia. 25% with mental retardation. They are sterile, since they lack spermatogenesis.

# 4. CONGENITAL ALTERATIONS

Congenital disorders are those changes in the shape, structure, or size of organs during fetal development. They are produced by genetic alterations or environmental factors.

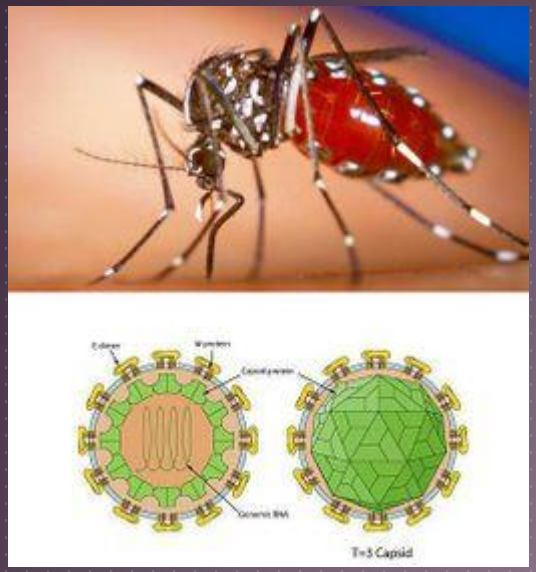
Cleft lip: is the presence of a cleft or separation in the upper lip, accompanied by a cleft palate (without welding the bones)


Labio leporino y paladar hendido



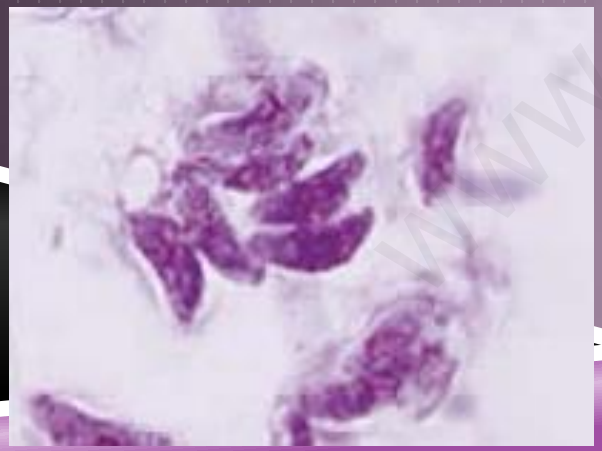

- Spina bifida: congenital malformation of the neural tube and is due to incorrect closure of the spine. It is due to a deficit of folic acid during pregnancy.

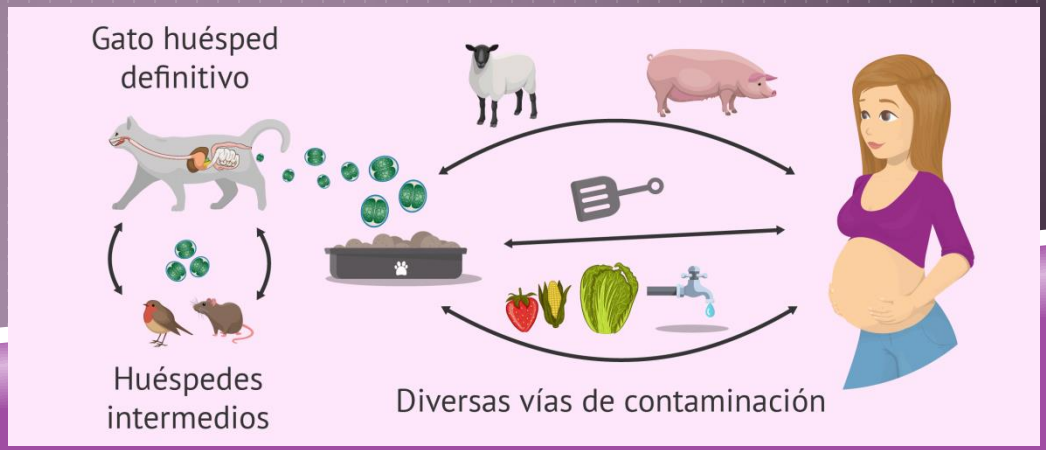
- Due to infections:




Zika virus during pregnancy can cause microcephaly in the fetus

- maternal infection during pregnancy by the protozoan Toxoplasma (toxoplasmosis) produces injuries to the fetus in the brain, eyes and other organs.





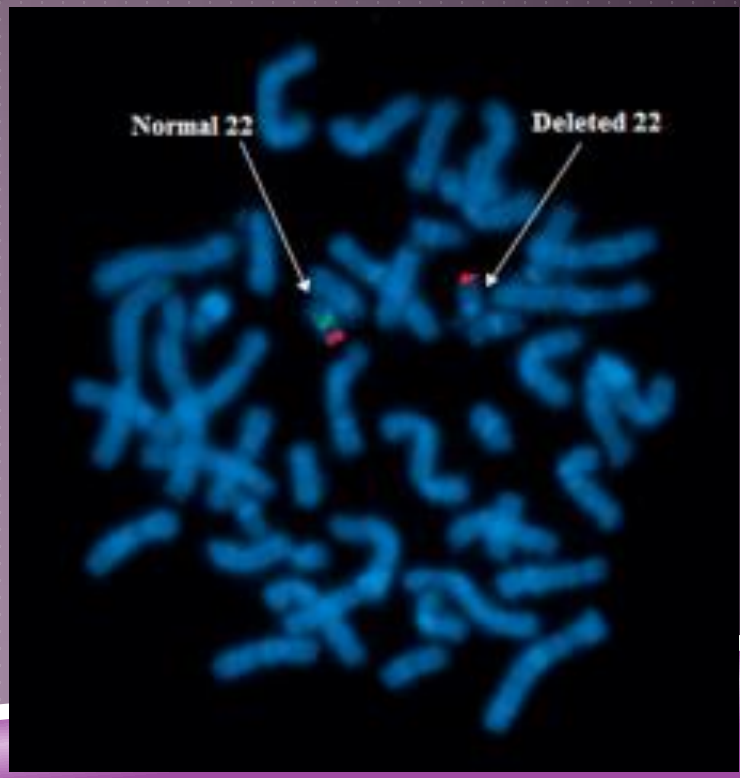
Due to chemical agents:


This is the case of thalidomide, medication that was administered to pregnant women to decrease nausea and generated serious malformations in the fetus.

# 5. DIAGNOSIS OF GENETIC DISEAES

Early diagnosis tests allow early detection of the development of a disease in order to apply treatments or interventions that prevent the disease from manifesting itself or doing so less seriously. In the case of genetic diseases there are types of tests:

- **Cytogenetics:** by obtaining and studying the karyogram.
- **Biochemical:** they investigate the presence of certain molecules in the cells of body fluids that indicate a disease.
- **Genetics:** they allow the study and comparison of DNA molecules to detect mutations related to certain diseases



## These tests are performed:

In the study of the predisposition to suffer certain types of disease (as in the case of certain types of cancer)

Studies of whether future parents are carriers of a disease (in this case, embryonic selection can be made to prevent the newborn from having the disease)

Neonatal diagnosis, detecting the presence of diseases in the newborn (neonate). A blood test is done.

Prenatal diagnosis, that is, detecting the presence of diseases in the embryo / fetus before birth. If they carry abnormalities, a therapeutic abortion could be performed. To perform prenatal diagnosis, fetal cells must be obtained. Two techniques are used: amniocentesis and chorionic biopsy.

## ➢ AMNIOCENTESIS

It is a prenatal diagnostic technique in which a sample of amniotic fluid containing fetal cells, is removed in order to study them. It is done between 14 and 20 weeks of pregnancy by abdominal puncture

It is a technique with a certain risk of abortion, so it is only recommended when there is a risk of having a fetus with abnormalities and it is planned to perform a therapeutic abortion if it is positive. It is practiced in the following cases:

- Parents with a history of chromosomal abnormalities, genetic diseases or spina bifida.
- Parents with pregnancies older than 35 years (higher probability of Down syndrome)