SEX - LINKED INHERITANCE

SEX-LINKAGE IN *DROSOPHILA*

- Sex-linkage was first discovered by **Thomas H. Morgan (father of modern genetics),** (1910) in *Drosophila melanogaster.* Morgan observed a few white-eyed mutant males in the population of red-eyed individuals.
- When the white-eyed male is crossed to a normal red-eyed female, in the first generation all the males and females were red-eyed.
- First generation red-eyed female was crossed to a red-eyed male, in the second generation all the females were red-eyed and 50% males were white-eyed.
- **These patterns of inheritance is called crisscross inheritance or skip generation inheritance, in which a character is inherited to the second generation through the carrier of first generation.**
- The white-eyed character from the male is inherited to the male of the 2nd generation through carrier female.
- In a reciprocal cross that involved a second cross of same traits but carried by sexes reversed, the results were different.
- A white-eyed female was crossed to a red-eyed male, in the first generation all the females were red-eyed and males were white-eyed.
- Morgan observed that the difference was due to the inheritance of a recessive gene located on the X-chromosome.
- Males always get the sex-linked recessive characters from females.
- The genes which are located on X-chromosome appear in two doses in female and one dose in males in both of *Drosophila* and humanbeings.
- A recessive gene gives its expression in the male due to a single recessive allele on X-chromosome. In females the same phenotypic expression is due to two recessive genes.

THE GENES ON THE SEX CHROMOSOMES:

- The genes located on the X chromosome, whose alleles are absent on the Y chromosome are called **X-linked genes**.
- These genes are **hemizygous** in males and **holozygous** (homozygous or heterozygous) in females.
- The genes located on the Y chromosome, whose alleles are absent on the X chromosome are **Y-linked genes** or **holandric genes** (also hemizygous).
- X-linked and Y-linked genes do not undergo pairing or crossing-over during meiosis.
- The genes which are located on the homologous segments of the X and Y chromosomes are called **XY-linked genes** and these regions are the **pseudoautosomal regions.**
- These regions undergo pairing and crossing-over during meiosis. XY-linked genes are **incompletely sex linked genes,** as they may undergo crossing over during meiosis like autosomes, but differ from autosomes in their inheritance in reciprocal crosses.

SEX-LINKED CHARACTERS or X-LINKED CHARACTERS IN HUMANS :

- Sex-linked are the X-linked characters (the term sex linked is presently referred to as X-linked).
- Their inheritance is due to X linked genes. The X-linked recessive characters follow **crisscross pattern of inheritance,** or **skip-generation inheritance.**

i. X-linked recessive characters

- Duschenne muscular dystrophy (DMD), haemophilia and color blindness are some of the important sex-linked recessive human traits.
- These are more common in males than females, since males are hemizygous for the X-linked genes.

1. Colour blindness

- Retina of the eye in man contains the cells sensitive to red and green colours. This phenotypic trait is genetically controlled. Its alleles are located on X-chromosome. (Red colour blindness is **protan type** and the green colour blindness is **deutan type).**
- A man having the recessive gene for the colour blindness can't distinguish either red or green colour.
- Men are colour blind, if they have a gene for colour blindness on X chromosome. Their vision is normal, if gene for colour blindness is absent on X chromosome.
- Women have normal vision if gene for colour blindness is absent on both the X chromosomes (homozygous) or if they have only one gene for colour blindness on one of the two X chromosomes (heterozygous, then she is called a **carrier).**
- She will be colour blind, only when she has gene for colour blindness on both the X chromosomes. When a woman with normal vision (homozygous) marries a colour blind man, all the sons and daughters are normal, but the daughters are carriers.
- If a carrier woman marries a man with normal vision, all the daughters and half of the sons have normal vision and another of half of the sons are colour blind**.**

- Colour-blind trait is inherited from male to his grandson through carrier daughter, which is an example of crisscross inheritance.

2. HAEMOPHILIA

- Haemophilia is the X linked recessive genetic disorder. It is more common in men than in women.
- Blood normally clots during injuries with in 5 to 10 minutes, depending on the magnitude of the injury.
- In haemophilia individuals the normal process of blood clotting is delayed or sometimes blood fails to clot.
- So blood bleeds continuously leading to the loss of blood, causing even death. It is also called **bleeder's disease.**
- It follows the characteristic crisscross inheritance like that of colour blindness, **Haemophilia-A** is due to the deficiency of antihaemophilic factor (factor VIII), which accounts for 80% of haemophilia.
- **Haemophilia-B** is due to the deficiency of plasma thromboplastin component (factor IX), which accounts for 20% of haemophila.

ii. X-linked dominant characters

- One important X-linked dominant character is **incontinentia pigmenti**. The affected individuals are characterised by mosaic pigmentation of their skin.
- Mosaic phenotype is due to random loss of melanin from the skin cells. These characters are more common in females**.**

Y-LINKED CHARACTERS :

- The genes of these characters are located only on the nonhomologous region of Y chromosome. These are also called **holandric genes.**
- Their phenotypic expression is observed only in the males. They are inherited from father to son, as son only receives me Y-chromosome from the father.
- Y-linked characters in man are **hypertrichosis** (growth of hair on the rim of pinna) **porcupine man** (straight hair on the body) and **webbing of toes.** Recently two more genes are discovered, testis determining factor (TDF) and minor histocompatibility gene (H-Y).

XY-LINKED CHARACTERS :

- **The genes which are located in the homologous regions of X and Y chromosomes are the XY-linked genes**.
- In *Drosophila,* XY-linked allele for bobbed bristles occurs on both the X chromosomes in females.
- These alleles are present on the X chromosome of male and short arm of Y chromosome. Bobbed condition in Drosophila is a recessive mutation (b). The normal allele is wild (b^+).
- These genes are also called incompletely sex linked genes. Their inheritance is similar to that of autosomes, except in the results of reciprocal cross.

SEX LIMITED CHARACTERS :

- **Sex limited genes are autosomal genes of both males and females, whose phenotypic expression is limited to one sex only.**
- Secondary sexual characters in the humanbeings like development of beard in man, breast in woman are sex limited traits.
- Their expression is limited to one sex due to the internal hormonal environment.

SEX INFLUENCED CHARACTERS

- **Sex influenced genes are the autosomal genes in both males and females, whose phenotypic expression is different in different** sexes, **dominant in one sex, and recessive in the other.**
- *e.g.:* Pattern baldness (premature baldness), one form of white forelock (a patch of white hair) and the absence of upper lateral incisor teeth are some of the sex influenced traits in humanbeings.

Genotype	Phenotype	
	♀	♂
BB	Bald	Bald
Bb	Non-bald	Bald
bb	Non-bald	Non-bald

Sex influenced expression

Baldness in man:

- **Pattern baldness** is a condition in which a fringe of hair is present low on the head in humanbeings. It is a genetically inherited condition. The gene afor baldness B is dominant in males and recessive in females.

- In heterozygous condition males are bald and females are nonbald. Its phenotypic expression in man and woman is given above the Table**.**
- If a heterozygous nonbald woman marries a heterozygous bald man, in the offspring males are bald and nonbald in 3:1 ratio and females are nonbald and bald in 3:1 ratio.