

SEX LINKED INHERITANCE -

The transmission of genes or traits associated with sex from one generation to another through the sex chromosomes is called sex-linked inheritance. The characters controlled by sex-linked genes are called as sex-linked characters. In organisms having XX-X4 condition of sex chromosomes the sex-linked inheritance is of 3 types

1. X-linked Inheritance - The genes located in the non-homologous region of X chromosome and having no homologous alleles in Y chromosome are called as X-linked genes. The inheritance of these genes is c/o X-linked inheritance.
2. Y-linked Inheritance - The genes located in the non-homologous region of Y chromosome and having no homologous alleles in X chromosomes are called as Y-linked genes. The inheritance of these genes is called as Y-linked inheritance. The Y-linked genes are confined to males only and are also called as holandric genes.
3. X-Y linked Inheritance - The genes located in the homologous region of both X and Y chromosomes are called X-Y linked genes and their inheritance is c/o X-Y linked inheritance.

X-linked Type of Sex-linked Inheritance - It is found in *Drosophila* and human beings. The females are homogametic with two (XX) chromosomes while males are heterogametic with one X and one Y chromosomes. The males can express the sex-linked recessive trait with a single gene but female can express such a trait only if it has two genes for it.

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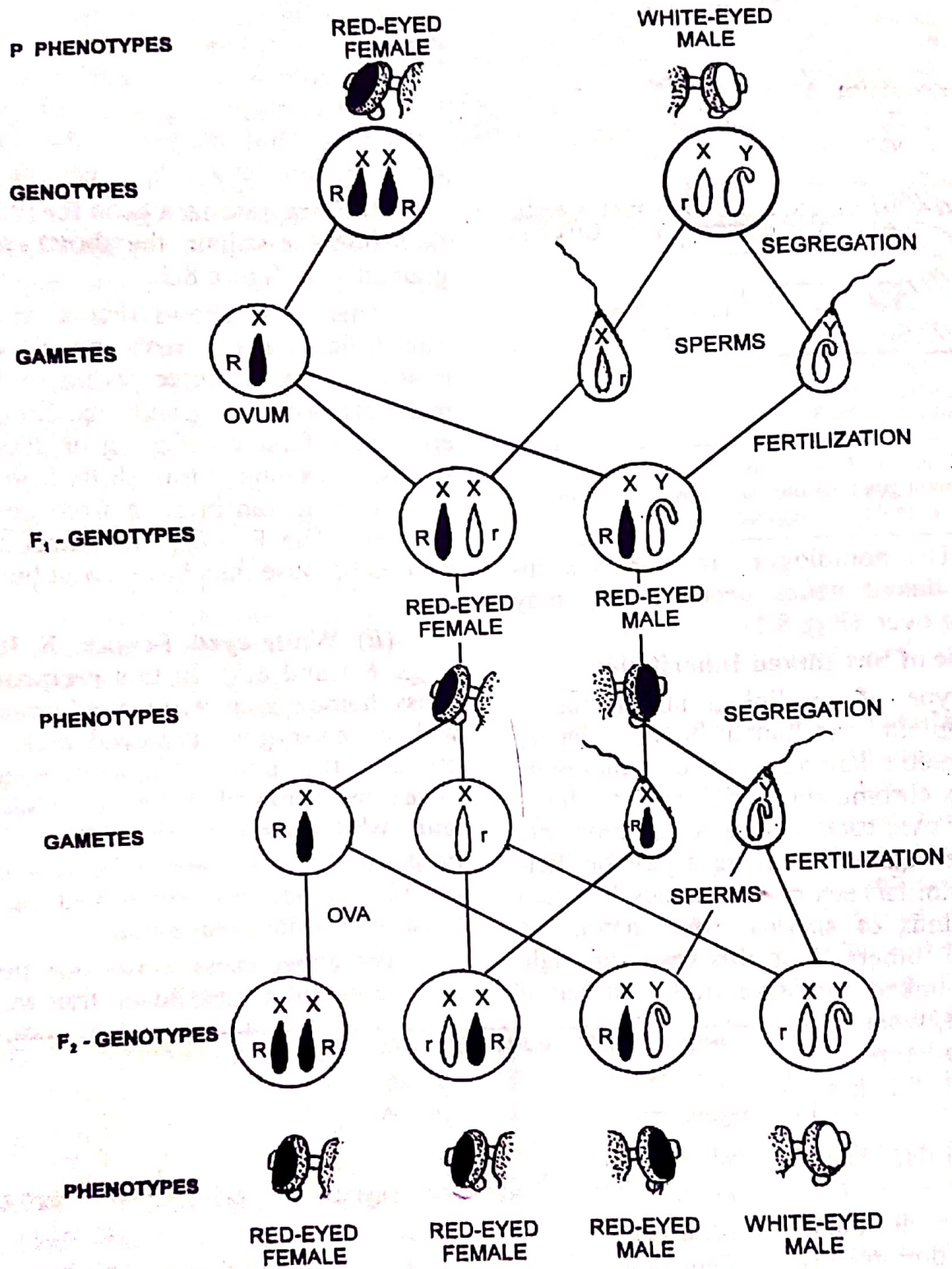
eg. 1. Eye colour in Drosophila is X linked. The normal red eye colour is dominant to the mutant white eye colour.

1. Red-eyed Female X White-eyed Male - If a homozygous red-eyed female fly is mated with white-eyed male fly, all the flies of F_1 are red-eyed. When red-eyed male and red-eyed female of F_1 are intercrossed, the F_2 flies are in the ratio of 2 red-eyed females to 1 red-eyed male to 1 white-eyed male. Thus the red-eyed and white-eyed flies are in the ratio of 3:1 in F_2 generation.

	Red eyed Female		X		White eyed Male	
	$X^R X^R$				$X^w Y$	
Gametes	X^R	X^R			X^w	Y
F_1	$X^R X^w$				$X^R Y$	
	(Red eye female)		X.		(Red eyed male)	
Gametes	X^R, X^w				X^R, Y	
F_2	$X^R X^R$	$X^R X^w$	$X^R X^w$	$X^R Y$	$X^w Y$	$X^w Y$
	Red eyed	Red eyed	Red eyed	Red eyed	White eyed	White eyed
	Female	Female	Female	Male	Male	Male
	(Pure)	(Hybrid)				

Ratio Red eyed females : Red eyed males : white eyed males
= 2 : 1 : 1 (2:1:1)

Red eyed flies : white eyed flies = (3:1)



eg 2. Human Beings - Red green colour blindness and Haemophilia are common ^{recessive} X-linked traits in human beings. Other X-linked diseases in humans are juvenile glaucoma, juvenile muscular dystrophy, short sightedness etc. Haemophilia is also called as bleeder's disease. The person who has the recessive gene for haemophilia lacks normal clotting substance (fibrinogen) in blood so minor injuries cause continuous bleeding and ultimate death of person due to haemorrhage. It is more common in men than women. The female are carriers of the disease and would transmit it to some.

recessive.

Red green colour blindness is X-linked trait - The presence of recessive X-linked allele for colour blindness does not allow production of colour sensitive cone, hence homozygous recessive females ($x^c x^c$) and hemizygous recessive males ($x^c y$) are unable to distinguish between two colours. The frequency of colour blind women is much less than colour blind men.

The inheritance can be studied by

- a, Marriage between colour blind man and normal woman.
- b, Marriage between normal visioned male and colour blind female.

2 human X-linked dominant conditions are relatively rare. They are expressed in both men and women. Some examples are - defective tooth enamel (hypoplastic amelogenesis imperfecta) in which tooth enamel is thin.

Parents :	X^+X^h	$\times$	X^+Y
	Normal (Carrier) mother		Normal father
Gametes:	$(X^+)(X^h)$		$(X^+)(Y)$
Progeny :	$1/4 X^+X^+$	=	Normal daughter
	$1/4 X^+X^h$	=	Normal but carrier daughter
	$1/4 X^+Y$	=	Normal son
	$1/4 X^hY$	=	Haemophilic son
			$\left. \begin{array}{l} 3 \text{ Normal : 1} \\ \text{Haemophilic or} \\ 3 : 1 \end{array} \right\}$

Fig. 12.9. Inheritance of haemophilia disease in human beings.

one colour-blind male (1/8)

Parent :	$X^+ X^+$	X	$X^c Y$
	Normal female		Colour-blind male
Gametes :	$(X^+) (X^+)$		$(X^c) (Y)$
F_1 :	$\frac{1}{2} X^+ X^c$		$\frac{1}{2} X^+ Y$
	Normal but carrier female		Normal but hemizygous male

(Marriage between a carrier female and a normal male produces the progeny as follows —)

F_2 :	$\frac{1}{4} X^+ X^+$	= Normal female	} 3 Normal : 1 Colour-blind or 3:1
	$\frac{1}{4} X^+ X^c$	= Normal but carrier female	
	$\frac{1}{4} X^+ Y$	= Normal male	
	$\frac{1}{4} X^c Y$	= Colour-blind male	

and result of the marriage

haemophilia have been recognized :

Parents :	X^cX^c	$\times$	X^+Y
	Colour-blind female		Normal male
Gametes :	$(X^c) (X^c)$		$(X^+) (Y)$
F₁ :	$\frac{1}{2} X^+X^c$		$\frac{1}{2} X^cY$
	Normal but carrier female		Colour-blind but hemizygous male

(Marriage of F₁ carrier female with a colour blind male produces the following progeny—)

F₂ :	$\frac{1}{4} X^+X^c$	= Normal but carrier female	} 2 Normal : 2 Colour-blind 1 : 1
	$\frac{1}{4} X^cX^c$	= Colour-blind female	
	$\frac{1}{4} X^+Y$	= Normal male	
	$\frac{1}{4} X^cY$	= Colour-blind male	

Fig. 12.8. A marriage between a colour-blind female and a normal male and result of the marriage between F₁ carrier female with a colour-blind male.

Y linked Type of Sex-linked Inheritance - The Y linked or holandric genes are transmitted directly from father to son. In man, hypertrichosis or excessive growth of hair on pinna is a Y linked trait. Another Y linked trait is Porcupine or Toad's skin (dry, rough and scaly skin). These genes are directly transmitted from father to son, generation after generation.

X-Y linked Type of Inheritance - The X-Y linked traits have their genes located in homologous regions of X and Y chromosomes as allelic pairs. These genes are inherited like the autosomal genes, although they do not segregate independently of sex as do autosomal genes. In human, total colour blindness, xeroderma pigmentosum, retinitis pigmentosa, spastic paraplegia are X-Y linked traits.

