

Lecture 14. Sex linked inheritance – Cris-cross inheritance – reciprocal difference – Holandric genes – sex influenced and sex limited inheritance

Sex limited trait

Trait expressed in only one sex. It may be controlled by sex linked or autosomal loci.

Sex-limited traits- characteristic only appears (or develops) in one of the sexes.

Example: Ovary development in females;
Sperm development in males

Sex-influenced traits- characteristic may appear in both sexes but expression of the phenotype differs.

Example: Early balding (pattern baldness) in humans.

Heterozygous men (b^{+}/b) lose their hair; heterozygous women do not have significant hair loss.

Homozygous men or women (b/b) become bald. The trait is therefore dominant in men, recessive in women.

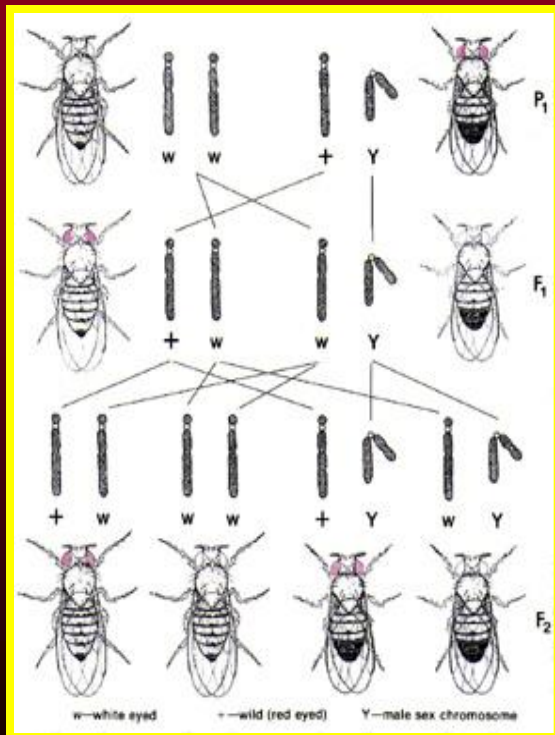
SEX LINKAGE

Characters for which genes are located on sex or X chromosomes are known as **sex linked traits**, such genes are called **sex linked genes** and linkage of such genes is referred to as **sex linkage**.

The location of a gene on a sex chromosome is called sex linkage

Sex – linked inheritance

Any gene located on the *X* chromosome or on the analogous *Z* chromosome is said to be sex linked



Jews had recognized even before 600 A.D. that hemophilia was a hereditary defect and that it was transmitted through females, although ordinarily only males were hemophilic..

But a clear-cut explanation for this phenomenon was presented by Morgan in 1910 for the white eye (w) gene of *Drosophila*

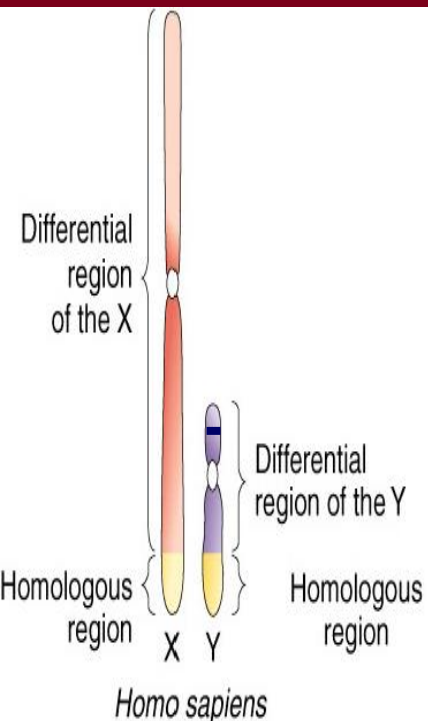
Sex – linked inheritance

Reciprocal crosses are comparable in autosomal traits

But this is not true with sex-linked traits

Crisscross method of inheritance is characteristic of sex-linked genes

Males carry only one allele for sex linked traits; and this one-allelic condition is termed **hemizygous** (females-homozygous/ heterozygous)



Sex – linked inheritance



**Thomas Hunt Morgan
(1866-1945)**

Morgan

Sex – linked inheritance

Inheritance of White eye in *Drosophila*

Parents



$X^R X^R$

Wild (Red)
- female

X



$X^r Y$

White male

F₁

Red eyed
flies



$X^R X^r$
 $X^R Y$



F₂

Monogenic
inheritance

Sex and
eye colour

3 Red

$X^R X^R$
 $X^R X^r$

Females -
all red



$X^R Y$
 $X^r Y$

1 White

Male - $\frac{1}{2}$ red
 $\frac{1}{2}$ white



Sex – linked inheritance

Reciprocal cross

Parents



Gametes



Thus the hypothesis that *r* gene is located in the X chromosome and that it has no allele in the Y chromosome is adequate to explain the peculiar inheritance pattern of the white eye trait in *Drosophila*. This was the first conclusive demonstration that a specific gene was located in a specific chromosome on an organism.

CHARACTERISTICS OF SEX-LINKED INHERITANCE

Expression of recessive sex-linked trait is higher – in heterogametic sex

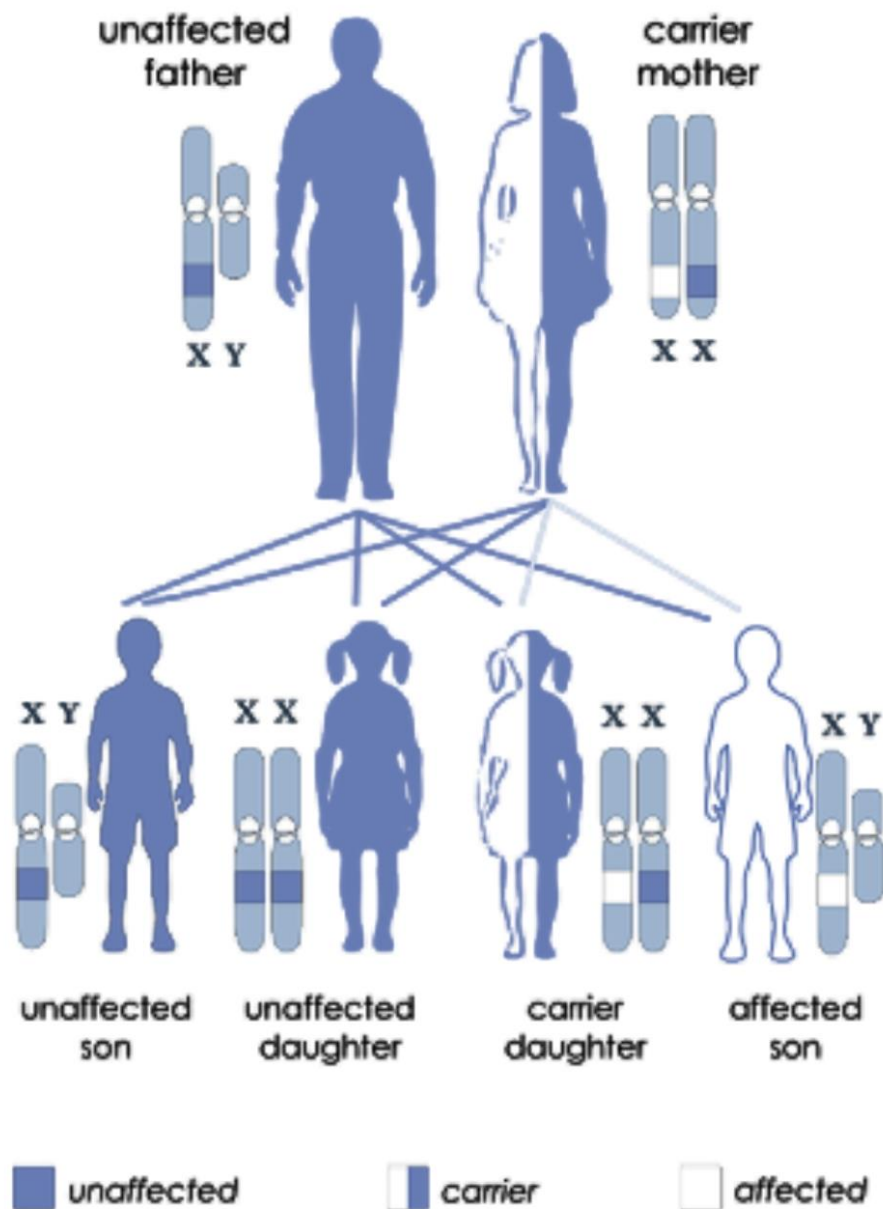
Genes governing sex-linked traits are not transmitted from male parents directly to their male progeny

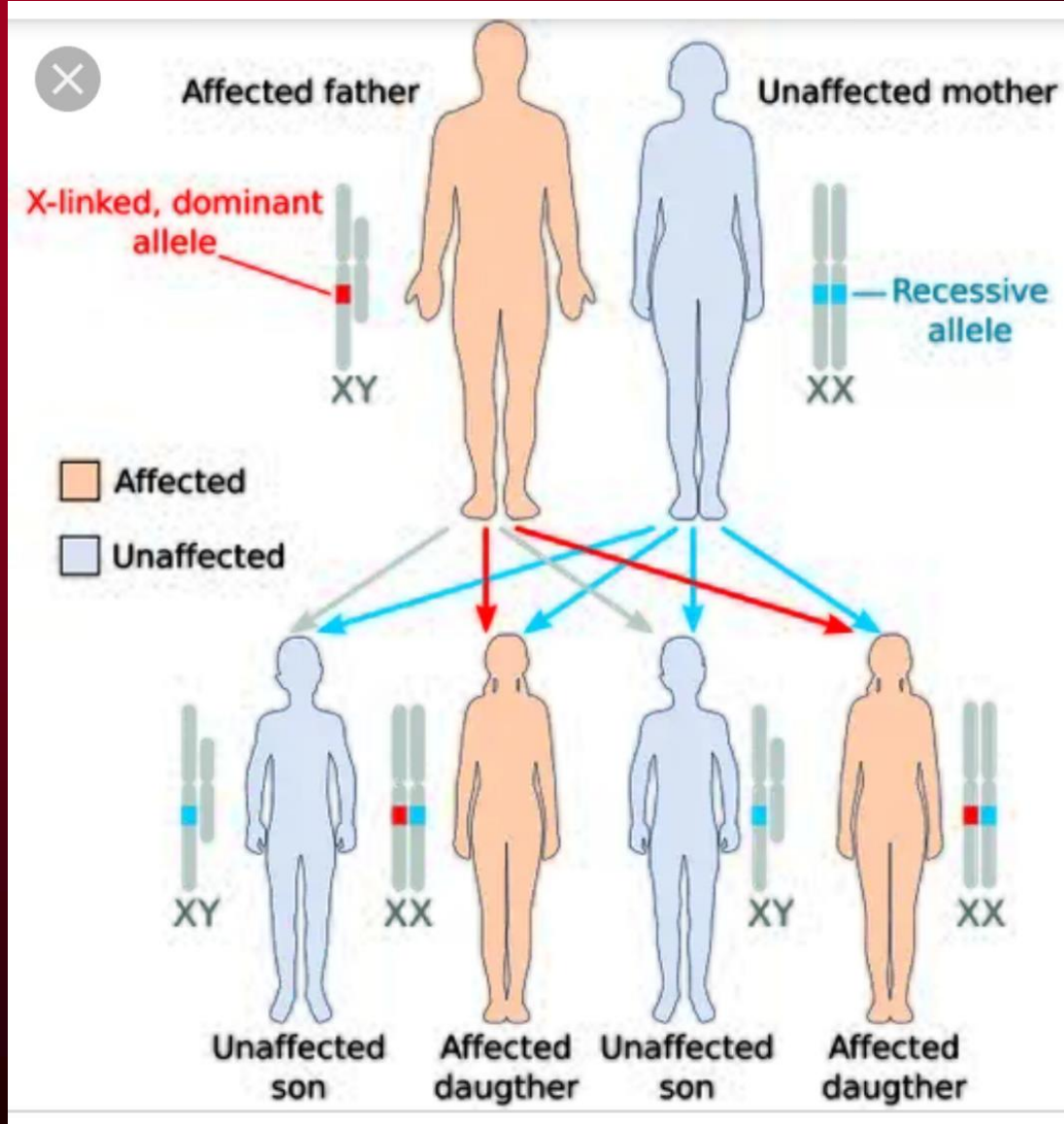
Sex linked gene passes from male to female then back to male; such an inheritance pattern is known as **criss-cross inheritance**.

Homologous region of X and Y chromosome do not show sex linked inheritance and are unusually genetically inactive



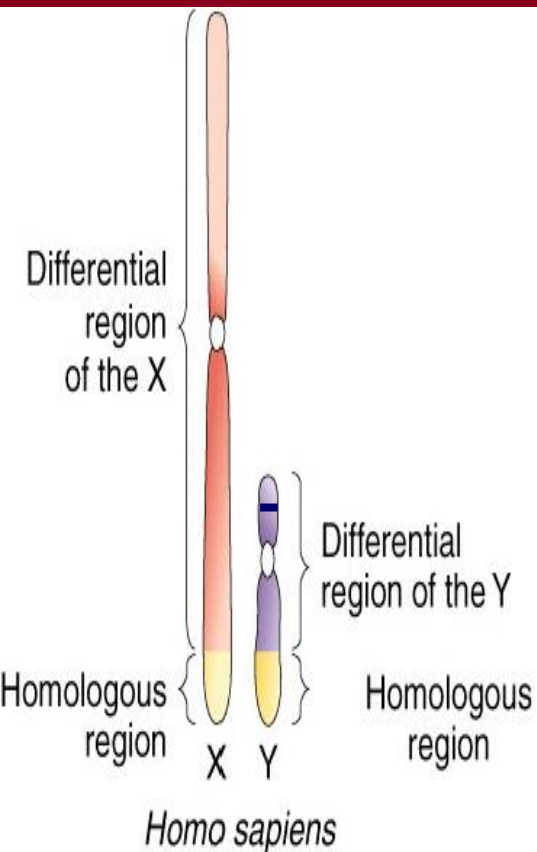
X-linked recessive inheritance





Sex – linked inheritance

Cris cross inhertitance



This is due to the fact that the Y chromosome carries no alleles homologous to those at the X chromosomes

This one-alleleic condition is termed **hemizygous** in contrast to homozygous or hererozygous

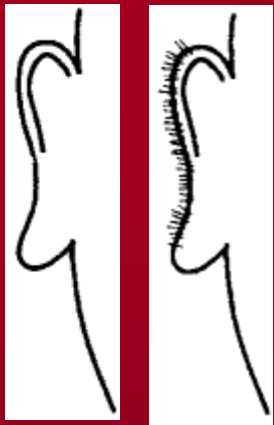
Causes of Sex-Linkage

The peculiar inheritance pattern of sex-linked traits is due to the following two reasons.

- The location of a gene in the X chromosome.
- The absence of its allele in the Y chromosome

Variations of sex linkage

- ❖ Genes on homologous segments of X and Y chromosomes are said to be **incompletely sex-linked or partially sex linked**.
- ❖ They recombine by crossing over
- ❖ Genes on the non homologous segments of the X chromosomes are said to be **completely sex linked**.
- ❖ Few genes known to reside in the nonhomologous portion of the Y chromosome.
- ❖ The traits would be expressed only in males; transmitted from father to son. Such incompletely Y linked genes are called **holandric gene**.



Sex limited traits

When the penetrance of a gene in one sex is zero, the trait will be sex limited.

They express only in one sex

Genes present either in sex chrom. or autosomes

Control the expression of primary and sec. sex

Eg.: Bulls have many genes for milk production –but not expressed – but transmitted to their daughters

Beard in man

Sex limited genes are autosomal genes, whose phenotypic expression is limited to one sex only.

Their phenotypic expression is influenced by the sex hormones.

The sex limited genes are mainly responsible for secondary sex characters in cattle, human beings and fowl.

Eg.: milk production in cattle, beard development in human beings, plumage in male fowls etc.

Sex reversal

In females chickens

Development of cock feathering, spurs and crowing

Development of testes and production of sperms.

Sex influenced genes

Dominant expression of some genes depends on the sex of individual- sex influenced genes; character governed by such genes are sex influenced characters;

located in autosomes

express more frequently in one sex than other
appears to be governed by sex chromosomes

Sex influenced traits Eg.: Pattern baldness in human beings and horns in sheep.

Pattern baldness in human beings is a condition in which a low fringe of hair is present on the head in human beings.

It is a genetically inherited condition, where the allele for baldness B is dominant in males and recessive in females.

In heterozygous condition, males are bald and females are nonbald

If a woman heterozygous for this gene marries a heterozygous bald man, in the offspring, the ratio of bald to non-bald in males is 3 : 1, while in females it is 1 : 3.

Sex – linked inheritance

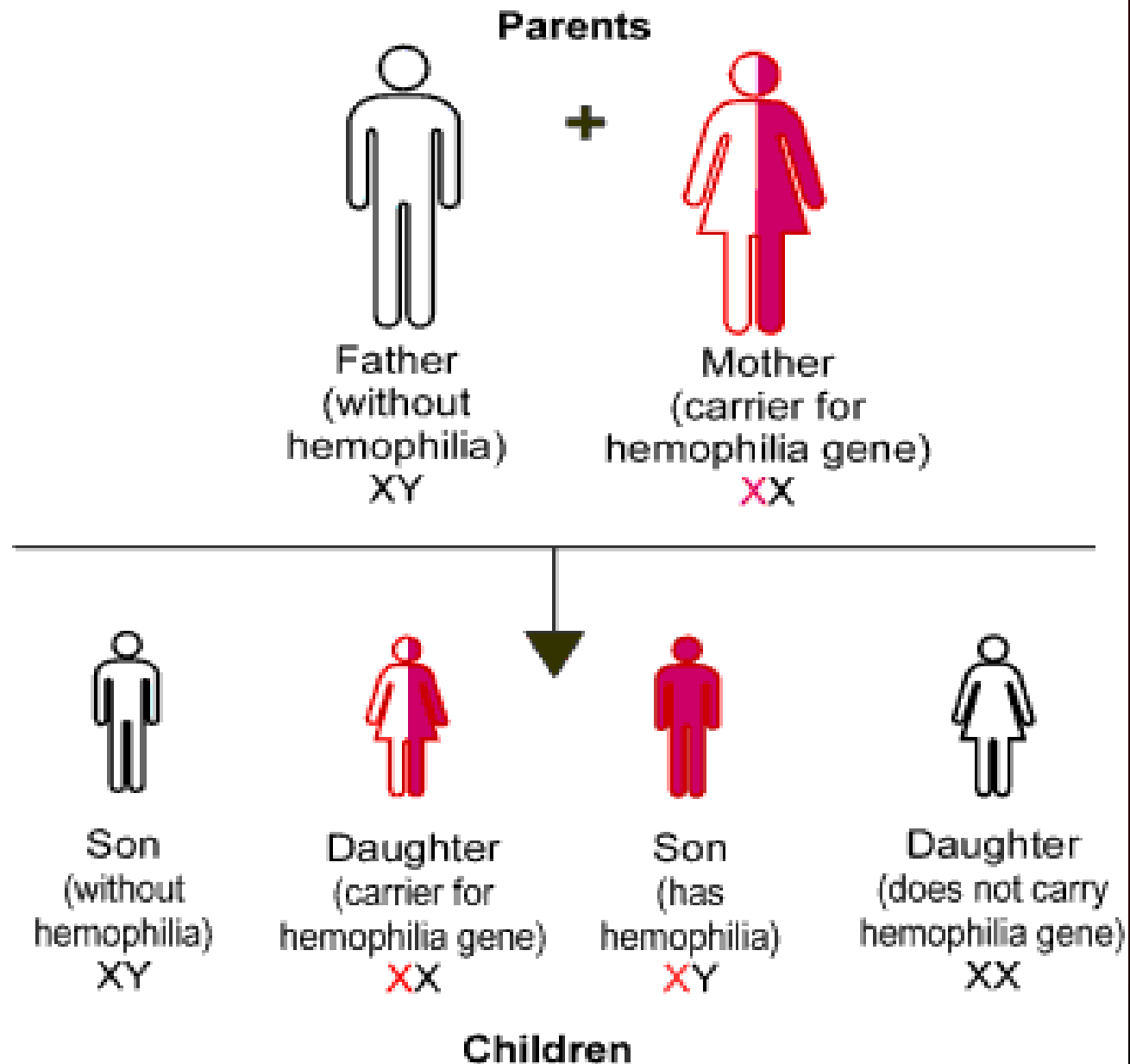
Some of the well-known examples of sex-linked human traits are,

- **Hemophilia** (inability of blood to clot on exposure to air)
- **Colour blindness** (inability to perceive one or the other colour, e.g., green colour)
- **Optic atrophy** (degeneration of the optic nerve)
- **Juvenile glaucoma** (hardening of the eye ball)
- **Myopia** (nearsightedness), defective iris
- **Epidermal cysts**
- **Distichiasis** (double eyelashes)
- **Mitral stenosis** (abnormality of mitral valve in the heart),
- A form of mental retardation,
- **Lesch-Nyhan disease**,
- **Cystic fibrosis** etc.

Inheritance of Hemophilia

"Carrier" Mother and Father Without Hemophilia

Cris- cross inheritance



Differences between sex linked and sex limited characters

Sex Linked characters	Sex Limited characters
1. They are located on sex or X chromosome	They are located on sex chromosomes or autosomes
They can express in both the sexes	They can express in one sex only
Include characters not related to sex	Include characters not related to sex
Examples: White eye in <i>Drosophila</i> , haemophilia and colour blindness in human beings	Examples: milk production in cattle, beard development in human beings, plumage in male fowls etc

Inter sex

In a few rare cases, various mixtures of male and female characteristics may occur in animals, which normally have separate sexes because of various abnormalities of chromosomes or hormonal deficiencies. Such individuals are called inter sex.

These can be of two types.

Two types of inter sexes

1. Pseudo -hermaphrodites: In mammals there are rare cases in which, both sexes are well developed in one body, these are abnormal and hence sterile.

2. Gynandromorphs or gynanders: Among animals and insects that do not have sex hormones, there may be sex intergrades with distinct areas of the body showing male and female tissues.

For example: *Drosophila gynander*, a bilateral sex mosaic, is male on one side and female on the other.