



Centurion
UNIVERSITY
*Shaping Lives...
Empowering Communities...*

Lecture – 7

Sex determination, Sex linked, Sex influenced and Sex limited traits

by

Dr. Praveen Kumar

*Asst. Prof. **GPB***

MSSSoA, CUTM, Odisha



Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

Sex Determination in Plant

Three mechanisms

- ❖ Environmental
- ❖ Chromosomal and
- ❖ Genic Mechanism



Centurion
UNIVERSITY
Empowering Communities...

Environmental Sex Determination

Equisetum plants

Under optimum condition- ♀ Under adverse condition- ♂

❖ Sex of flower affected by **temperature, day-length, ethylene, gibberellic acid (GA₃), some ions (Ca⁺⁺, Mg⁺⁺ etc.)**. E.g. Melons, Cucumber, Cannabis etc.

❖ Usually GA₃ promotes female flower

❖ Generally environment has more pronounced effect on males than in females.



Chromosomal Sex determination

❖ In several plant species Sex is determined on the basis of sex chromosome morphology

➤ **Homomorphic**

➤ **Heteromorphic**

Species	Features of Y chromosomes	Mechanism of sex determination
1. Homomorphic sex chromosome		
A. Homogametic (XX) - Female, Heterogametic (XY)- Male		
<i>Asparagus officinalis</i>	Similar to X chromosome	Y- active (?)
<i>Spinacca oleracea</i>	Similar to X chromosome	Y- active (?)
B. Heterogametic (XY)- Female, Homogametic (XX) - Male		
<i>Fragaria elateria</i> (Wild strawberry)	-----	May be genic



Species

Features of Y chromosomes

Mechanism of sex determination

1. Heteromorphic sex chromosome

Centurion

A. Homogametic (XX) - Female, Heterogametic (XY)- Male

Shaping Lives...
Empowering Communities...

<i>Cannabis sativa</i>	Large	X/ autosome balance
<i>Coccinia indica</i>	Large, Heterochromatic	Y- active
<i>Humulus lupulus</i>	Small, euchromatic	X/ autosome balance
<i>Rumex hastatulus</i>	Large, euchromatic	X/ autosome balance
<i>Salina latifolia</i>	Large, euchromatic	Y- active
<i>Salina dioica</i>	Large, euchromatic	Y- active

B. XX- Female, XY₁Y₂ - Male

<i>Humulus japonicus</i>	Large, Heterochromatic	X/ autosome balance
<i>Rumex hastatulus</i>	Large, euchromatic	Active Y and X/ autosome balance

C. X₁X₁X₂X₂- Female, X₁X₂Y₁Y₂ - Male

<i>Humulus lupulus</i>	Moderate, euchromatic	X/ autosome balance
------------------------	-----------------------	---------------------

SEX DETERMINATION IN MELANDRIUM



Sex determination in plants

- Majority flowering plants are monoecious
- Only about 6% of Angiosperms are dioecious
- Studies of sex determination mechanisms were done in very few plants
- Example: *Coccinia*, *Asparagus* and *Melandrium*
- *Melandrium album* or *Silene latifolia* (synonym) is a dioecious plant
- It is model plant in genetics for sex determination studies of plants
- *Melandrium* belongs to the Family Caryophyllaceae.
- Diploid chromosome number of *Melandrium album* is 24 ($n = 12$)

SEX DETERMINATION IN MELANDRIUM



Sex determination in Melandrium album

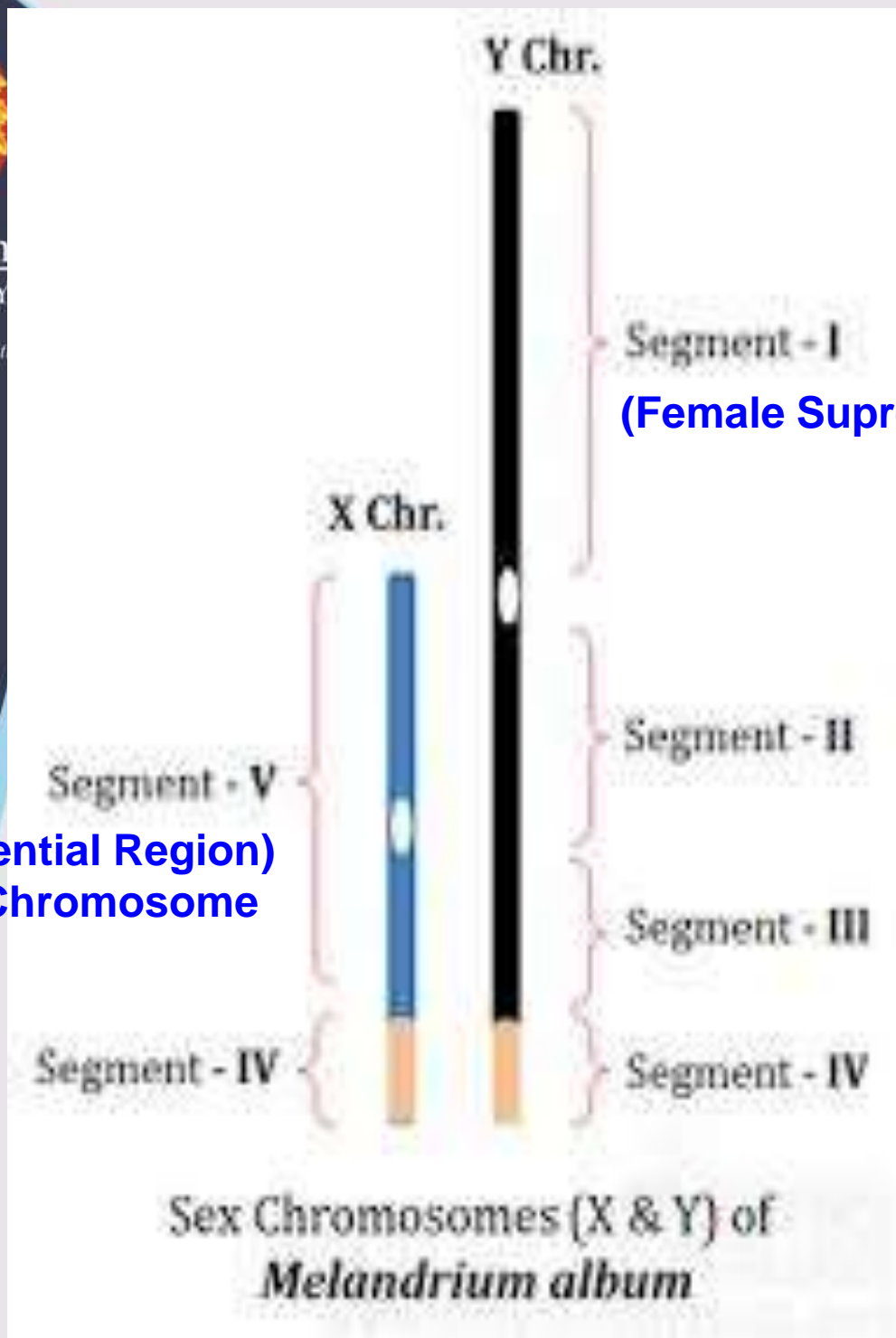
- *Melandrium album* shows sex chromosomal sex determination
- Have X & Y sex chromosomal constitution similar to *Drosophila* and Human
- Mechanism of sex determination is different from the usual XX – XY system
- In *Melandrium album*:
 - AAXX individuals will be females
 - AAXY individuals will be males



Melandrium album
(syn *Silene latifolia*)



Centurion
UNIVERSITY
Shaping Lives...
Empowering Communities

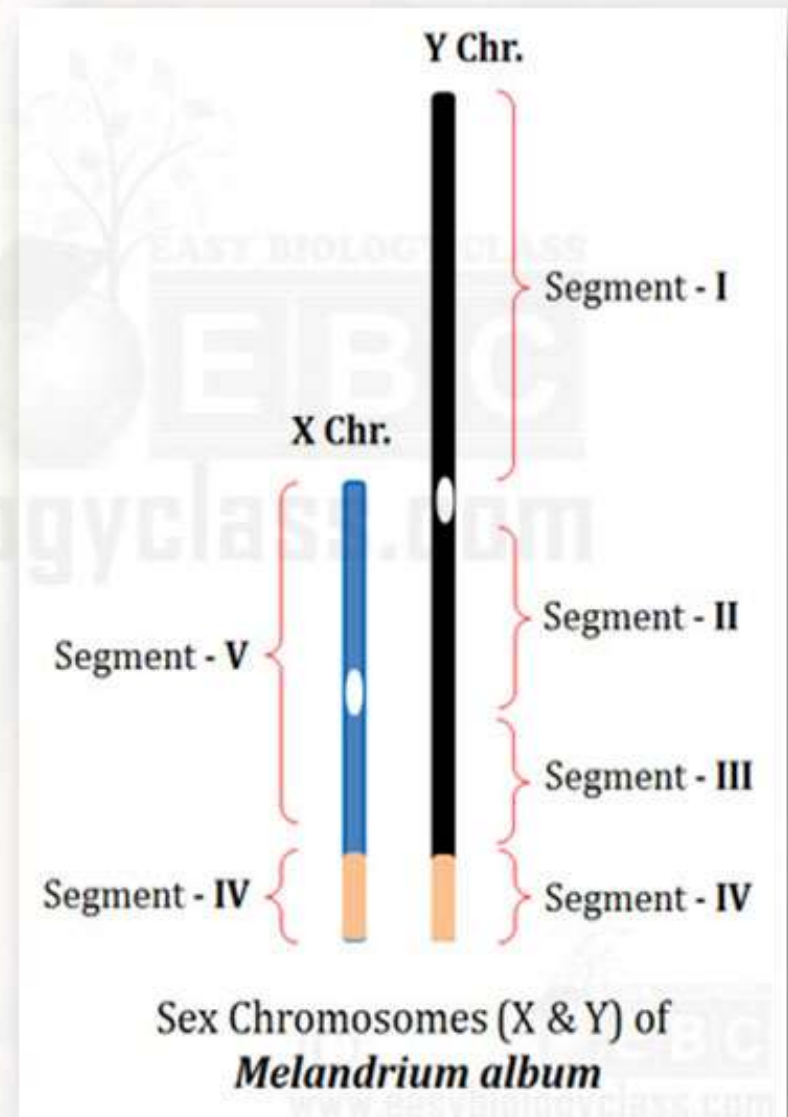


SEX DETERMINATION IN MELANDRIUM



Structure of X and Y chromosomes in Melandrium album

- As in the picture, the X and Y chr. have a common segment (segment - IV)
- This segment is used for homologous pairing during meiosis
- Remaining Y chromosome has three parts
- They are named as segment - I, II and III
- Similarly, the remaining X chromosome has one segment called segment V





Centurion
UNIVERSITY
Shaping Lives...
Empowering Communities...

Deletion in segment of Y chromosome

Outcome

I. Female Suppressor Region	Bisexual Flower
II. Male promoter Region	Asexual Flower
III. Male Fertility Region	Male Sterile Flower
IV. Pairing Region	Irregular separation of X and Y chromosome at AI of meiosis

- ❖ In *S. latifolia* single Y is able to produce fertile male flower even in the presence of 4 X chromosomes (XXXXY)
- ❖ In mammals, where single gene SRY regulates sex determination, at least two genes are necessary for sex determination in plants: one gene suppress carpel development, while other gene is essential for stamen development.



Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

Genic Sex Determination

- ❖ Found in both monoecious and dioecious plants
- ❖ Sex determination may depend on a single or several genes.
- ❖ Eg. Papaya, Vitis, cineria etc.

1. **Single Gene Sex Determination-** eg. In papaya single gene with three alleles.

1. **Multigenic Sex Determination-** eg. Annual mercury plant (*Mercurialis annua*), sex is determined by three different genes.



Centurion
UNIVERSITY

Step by Step
Empowering Communities...

Inheritance

- ❖ For a number of traits, gene expression differs in males and females
- ❖ The causes fall under 3 categories:
 - Sex-Linked
 - Sex-Limited
 - Sex-Influenced



Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

SEX LINKED INHERITANCE

- ❖ The characters for which genes are located on sex or 'X' chromosomes which occurs in different numbers in two sexes and the absence of its allele in the 'Y' chromosome are known as **sex linked traits**.
- ❖ Such genes are called **sex linked genes** and linkage of such genes is referred to as **sex linkage**.
- ❖ Inheritance of such genes or characters is known as **sex linked inheritance**.
- ❖ Clear-cut explanation for this phenomenon was presented by T.H. Morgan in *Drosophila* for a recessive gene 'w' responsible for white eye colour.

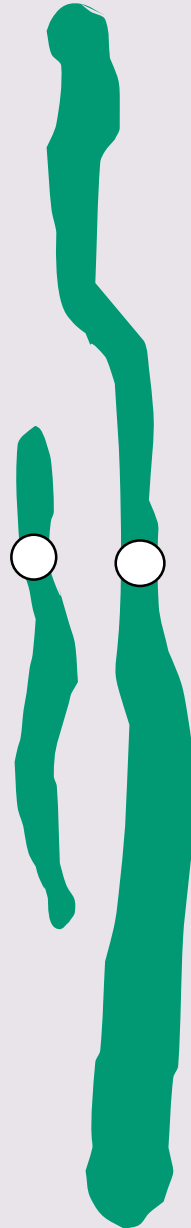


Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

X and Y are homologous chromosomes

- X and Y are an exception to the homology definition.
- Human X-chromosome is larger than Y and has about **2000 genes** compared to about 450.
- X and Y are homologous because they pair up during meiosis I.
- Pairing is due to a small area of homology around the centromere.



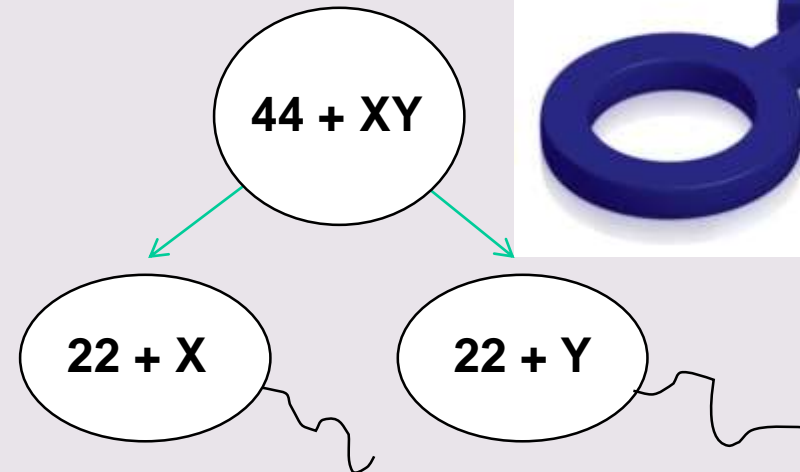
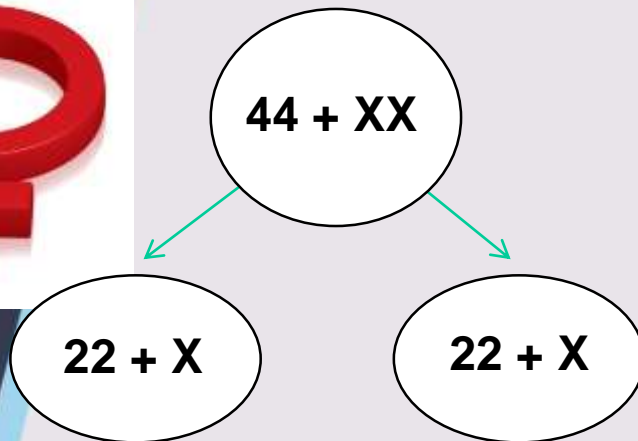
- The Y-chromosome lacks many genes found on its homologous X-chromosome.
- This leads to a pattern of inheritance called **sex linkage**.
- In XX females, a recessive allele on one X can be masked by a dominant allele on the other X.
- In XY males, a recessive allele on the X has no second copy to mask its effects.



Centurion
UNIVERSITY
*Shaping the Future
Empowering Communities...*

Homogametic and heterogametic

- Because they are homologous, the sex chromosomes are separated during meiosis into different gametes.



- Human females produce all gametes with the same combination of chromosomes = **homogametic**.
- Human males produce gametes with two possible combinations of chromosomes = **heterogametic**.



Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

Sex Chromosomes

Y chromosome:

- Contains ~90 genes
- Majority of genes = Male Specific Region (MSR)
- SRY gene – determines “maleness”

• X chromosome:

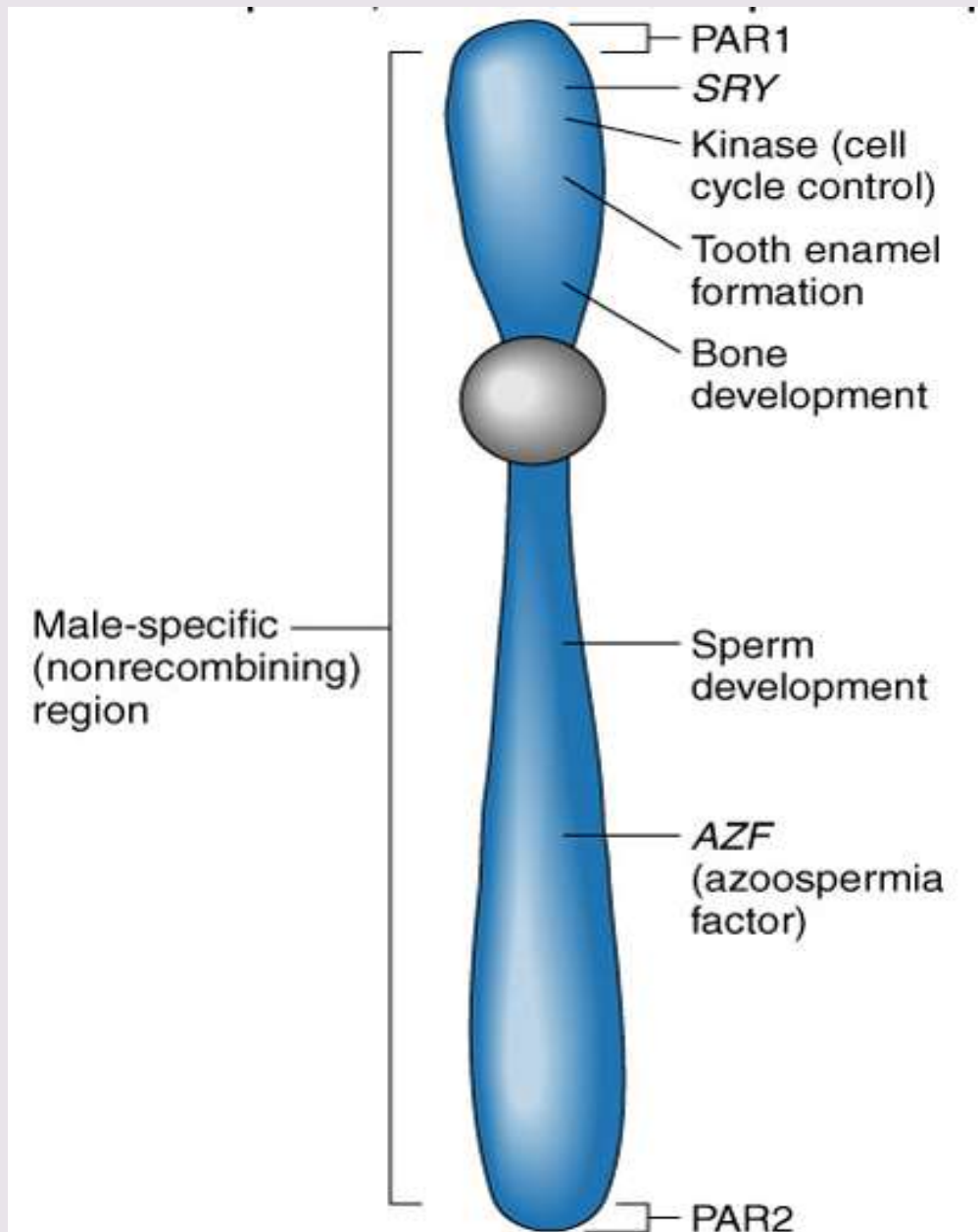
- Contains ~2000 genes
- Some dealing with sexual development
- Most genes encoding proteins that have nothing to do with sex



**Centurion
UNIVERSITY**

*Shaping Lives...
Empowering Communities...*

Y Chromosome





Centurion
UNIVERSITY

Sharing Learning
Empowering Communities...

SRY Gene

❖ **SRY = Sex-determining Region of Y**

- ❖ A transcription factor (TF)
- ❖ TF's are genes that control the expression of other genes (turn on/off)
- ❖ SRY turns on “male” genes
- ❖ “Male” genes activate male hormones (testosterone) end up producing male structures
- ❖ Also, destroy female structures

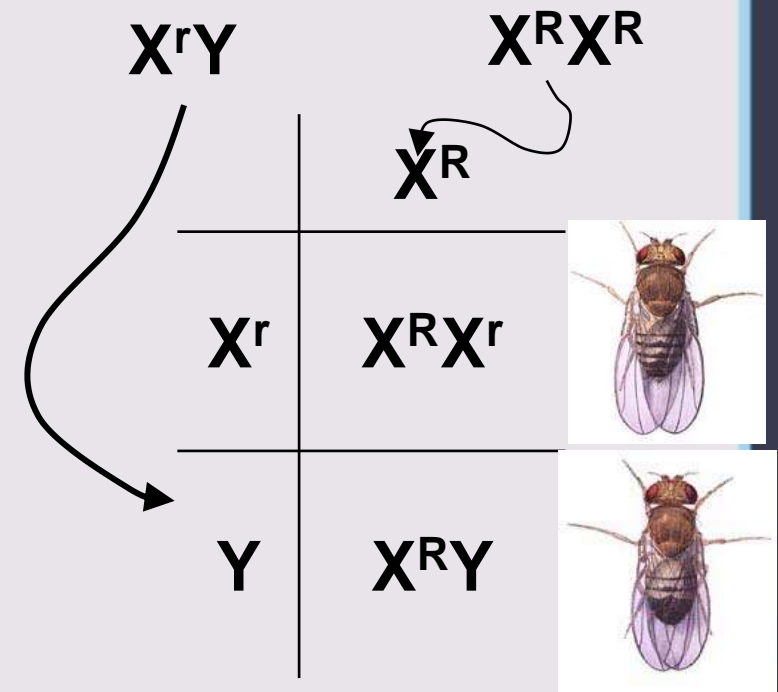
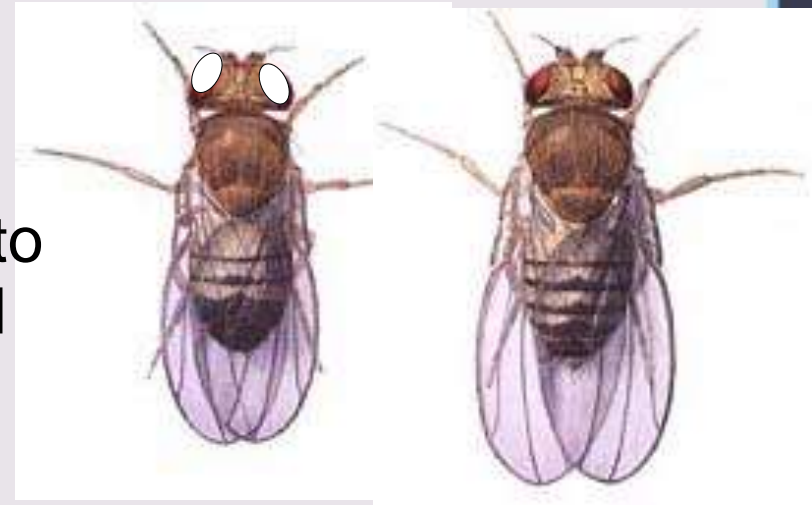


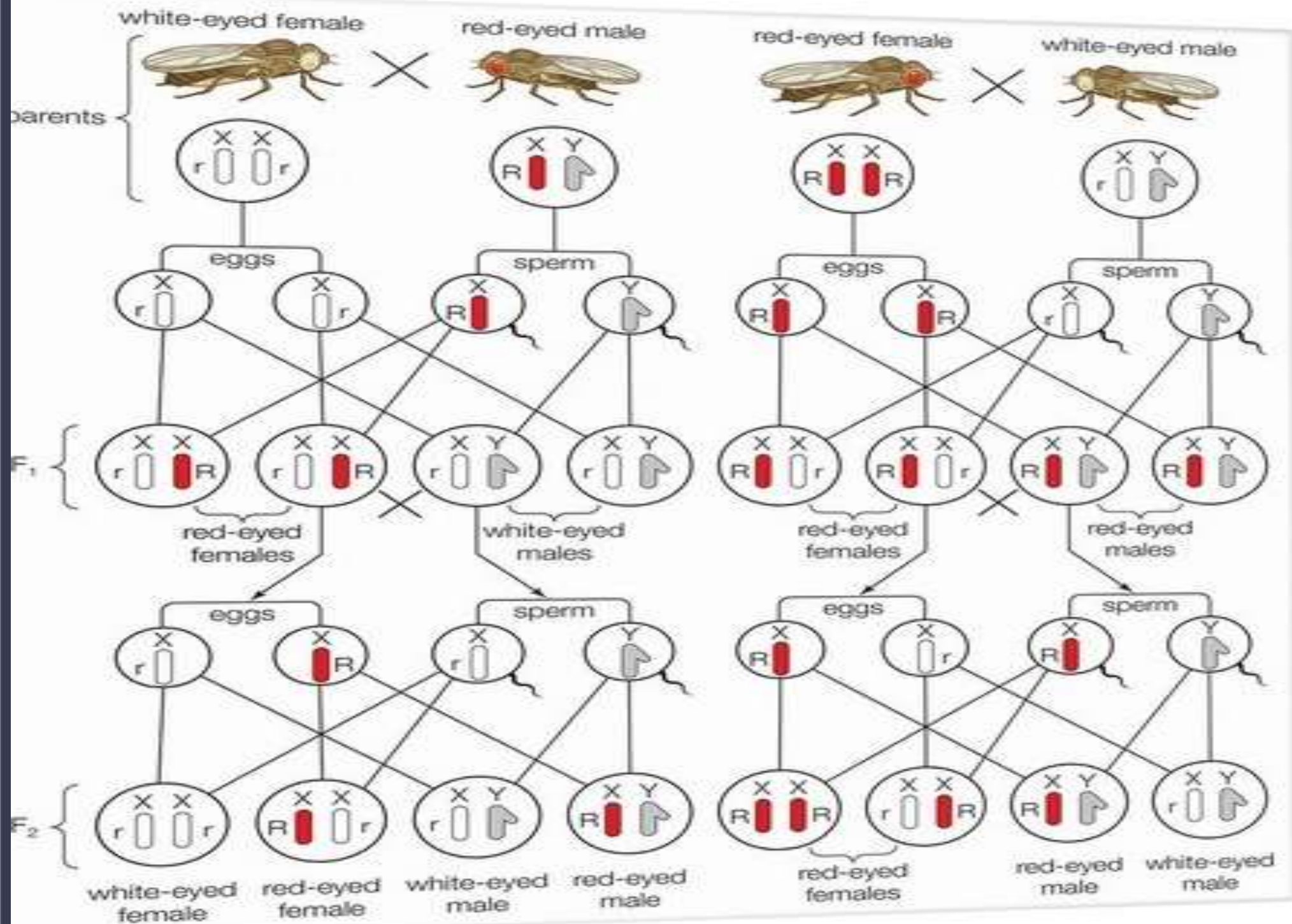
Centurion
UNIVERSITY

Shaping Lives,
Empowering Communities...

Sex linkage- White-eyed males

- In the early 1900s, T. H. Morgan studied inheritance in *Drosophila melanogaster* to try to disprove Mendel's theory of the 3:1 ratio
- It took two years to find any variation in his vast fly breeding programme.
- Eventually a male fly was found which had white eyes. (His wife found it.)
- This white-eyed male was crossed with a normal red-eyed female.
- We will use the notation X^R to show the red eye allele is on the X-chromosome and is dominant to white eye, X^r .







Conclusion

- ❖ White eye gene was located on 'X' chromosome of *Drosophila*
- ❖ Y-chromosome does not carry an allele for this gene.
- ❖ Female flies will have two copies of *w* gene (WW , Ww or ww), while male will have only one copy (W or w) i.e hemizygous for *w*
- ❖ *This was first conclusive evidence demonstrated that a specific gene located in a specific chromosome of an organism*



Sex linkage in human and other organism

➤ **Man**

Mice, Cat, insect, Poultry, Cattle, Guinea pig etc.

Shaping Lives...
Empowering Communities...

- In human over 200 genes exhibited sex linkage and most of these causes genetic diseases

Sex linked trait in humen	Effect
1. Hemophilia	Inability of blood to clot
2. Colour blindness	Inability to perceive one or the other colour
3. Optic atrophy	Degeneration of optic nerve
4. Juvenile glaucoma	Hardening of eye ball
5. Myopia	Nearsightedness
6. Mitral stenosis	Abnormality in mitral valve in the heart



Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

Hemophilia

- A blood disorder where the blood does not clot properly.
- A minor cut can cause serious injury and demand medical attention.
- Bleeding into the joints, internal bleeding and deep cuts can be fatal for hemophiliacs.
- Genetic lack of one of the clotting factors produced by the liver.
- There is no cure for hemophilia but treatment options with clotting factor transfusions are available.



Centurio
UNIVERSITY
*Shaping Lives...
Empowering Communities*



Complications from hemophilia include: bruising and bleeding into the muscles, bleeding into the joints, infection, adverse reaction to transfusions and serious bleeding.

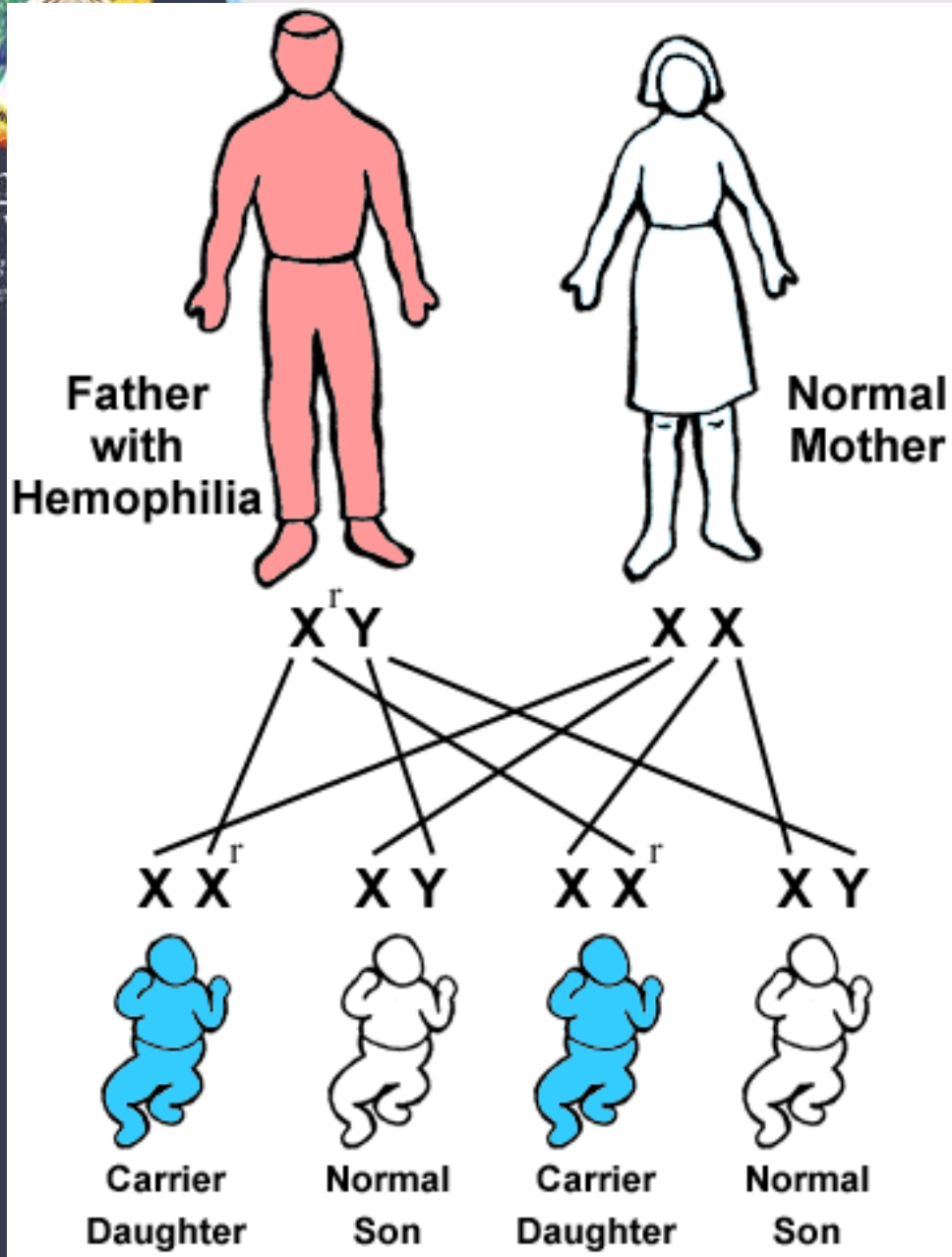


Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

Genetics of Hemophilia

- The gene for hemophilia is found on the X chromosome
- It is a recessive disorder.
- It is referred to as a sex-linked recessive disorder.
- Males are more likely to get hemophilia.
- Females have the possibility of being heterozygous for hemophilia. (This makes them a carrier)



In this example: The father has hemophilia. He cannot give his son hemophilia because he gives his son the Y chromosome.

He can give his daughter the recessive gene, but if her mother does not give her the recessive gene, she will not have hemophilia. She will be a carrier.

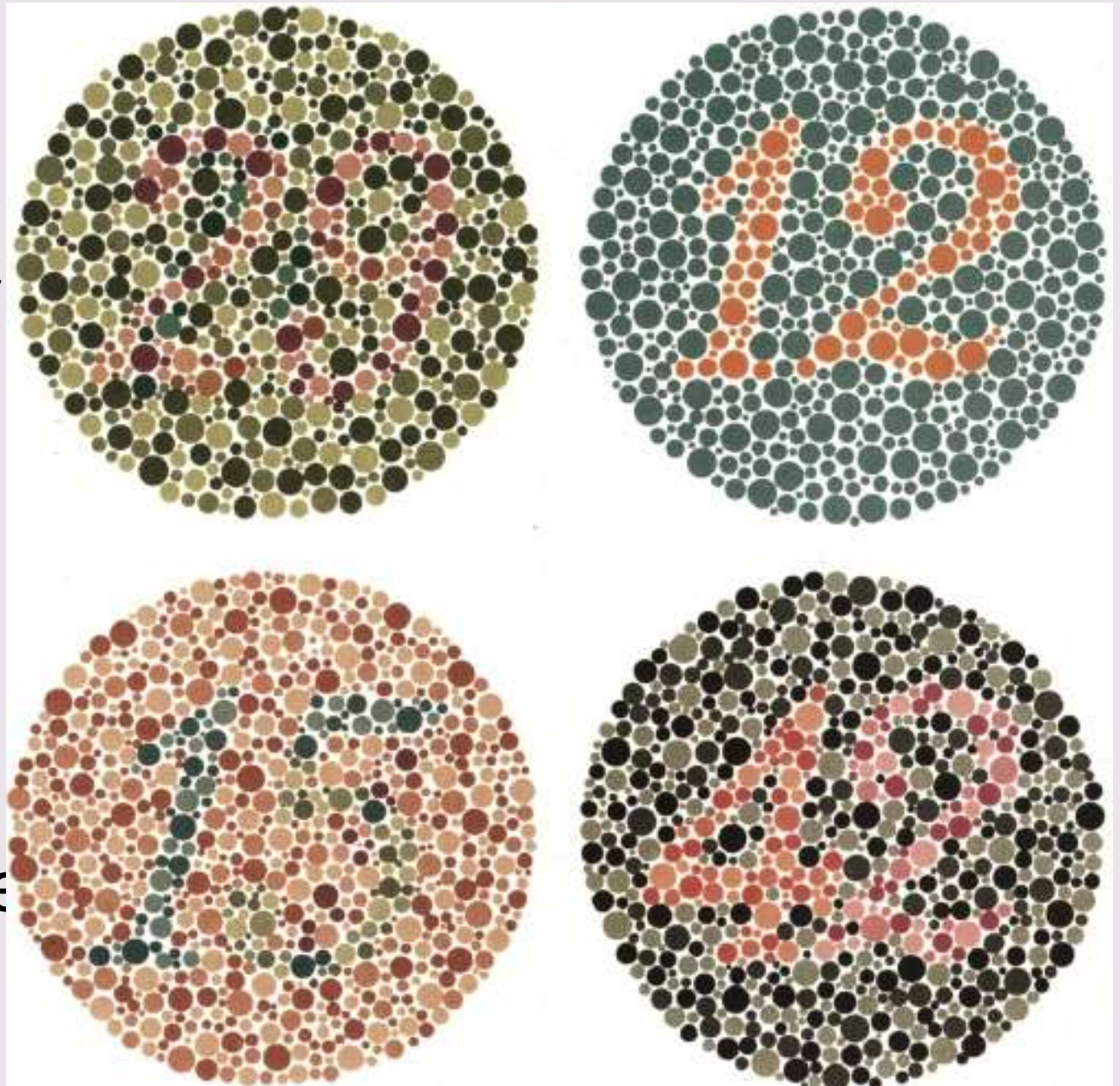


Centurion
UNIVERSITY

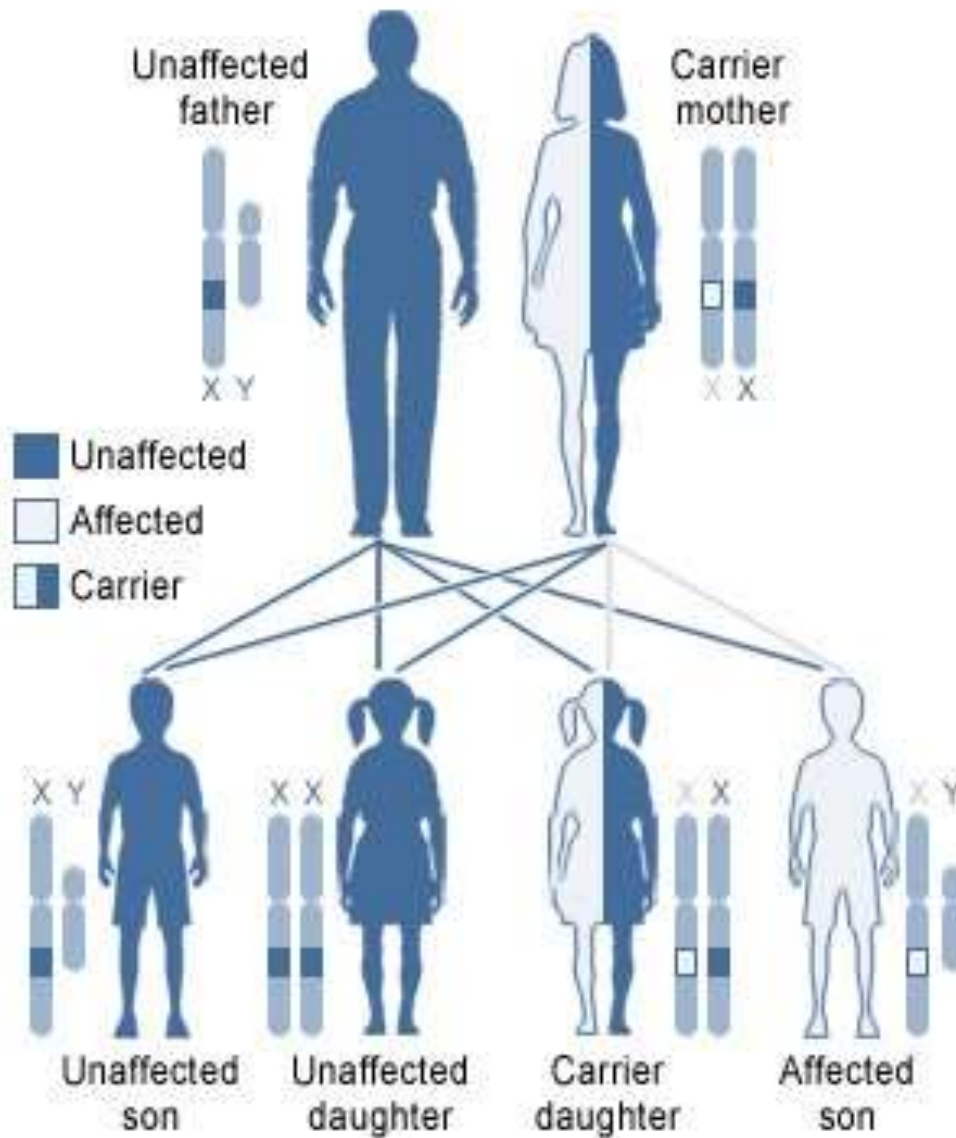
Shaping Lives...
Empowering Communities...

Color Blindness

- Males are more likely to be color blind due to the fact they only have one X chromosome.
- Color Blindness is a sex-linked trait found on the X chromosome.



X-linked recessive, carrier mother



U.S. National Library of Medicine

In this example:
the mother is a
carrier of the
colorblind gene.

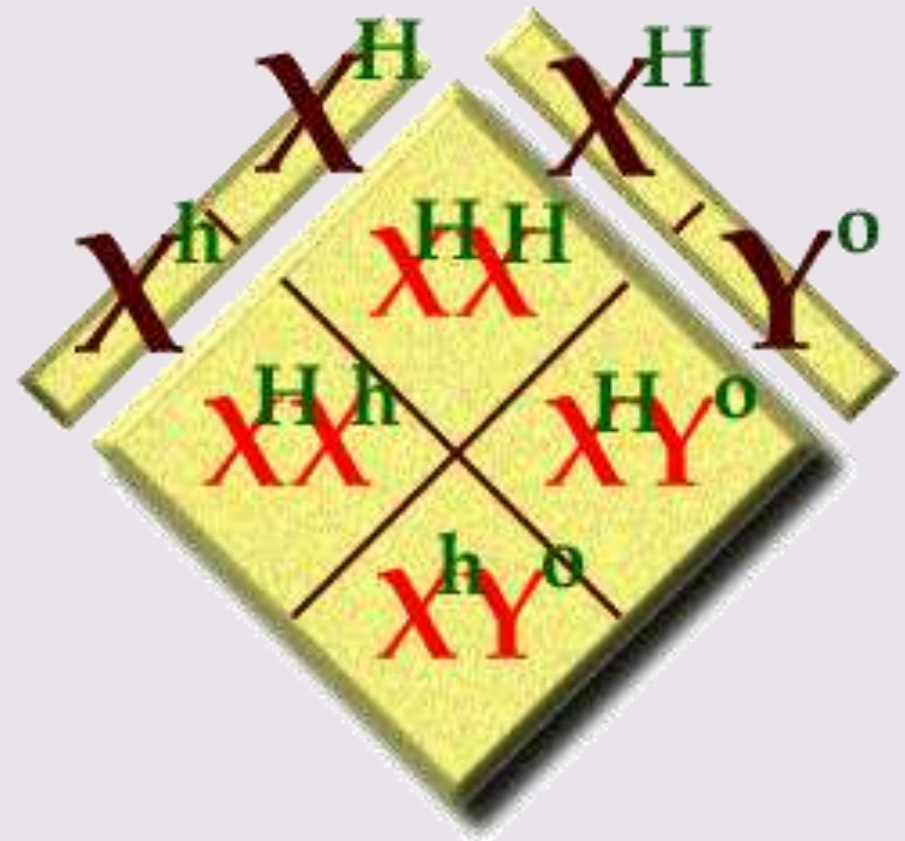
There is a 50%
chance her son will
be colorblind but
unless the father is
colorblind the
daughter cannot
end up colorblind.



Centurion
UNIVERSITY
Shaping Lives...
Empowering Communities...

Sex-Linked Inheritance- Punnett Square

- In the punnett square the mother is a carrier and the father is normal.
- Male offspring:
50% normal &
50% hemophiliac
- Female offspring:
50% normal
50% carrier





- Cross a normal mother with a hemophiliac father.

Results:

Genotypes: 50% 50%

Phenotypes: 50% 50%




Sex- Influence Inheritance

Centurion
UNIVERSITY

Shaping Lives...
Empowering Communities...

- ❖ Genes are inherited from both parents
- ❖ Either autosomal or X chromosome
- ❖ Modes of gene expression differ between males & females
- ❖ **An allele may be expressed as a dominant in one sex and a recessive in the other**
- ❖ **Male pattern baldness**
- ❖ **Scurs** (degrowing of horn after disbudding operation) on **cattle** is a sex-influenced inheritance
- ❖ The allele for scurs is dominant in males and recessive in females
- ❖ A male with one copy will be scurred, but a female must have 2 copies

	Males	Females
PP SS	Polled	Polled
PP Ss	Polled	Polled
PP ss	Polled	Polled
Pp SS	Scurs	Scurs
Pp Ss	Scurs	Polled
Pp ss	Polled	Polled
pp SS	Horned	Horned
pp Ss	Horned	Horned





Centurion

UNIVERSITY

Shaping Lives...

Empowering Communities...

Sex-Limited inheritance

- ❖ Genes are inherited from both parents
- ❖ Either autosomal or X chromosome
- ❖ Yet, affect a structure that is only present in one sex, therefore phenotype shows a sex “difference”
 - ✓ Horns
 - ✓ Milk production
 - ✓ Genitalia anatomy/function
- ❖ These genes are not necessarily on the sex chromosomes but are only expressed in the male or female
- ❖ Thought to be hormonally conditioned



Centurion
UNIVERSITY

*Shaping Lives...
Empowering Communities...*

THANK YOU