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Principles of Genetics

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Section no. (4)

Sex Inheritance

- Sex chromosome : chromosomes were discovered in the second half of the nineteenth century by a German cytologist W. Woldeyer , the chromosomes are best seen by applying dyes to dividing cell .
- One pair of the chromosomes called sex-chromosome which responsible of sex determination and sexual traits , the other pairs of chromosomes called autosomal chromosomes .
- In some animal species – for example, grasshopers females have one more chromosome than males , this extra chromosome originally observed in other insects , is called X chromosome or we called sex - chromosome.

Sex Determination

1- Males heterogametic system •

A-The XX – XO system •

B-The XX – XY system •

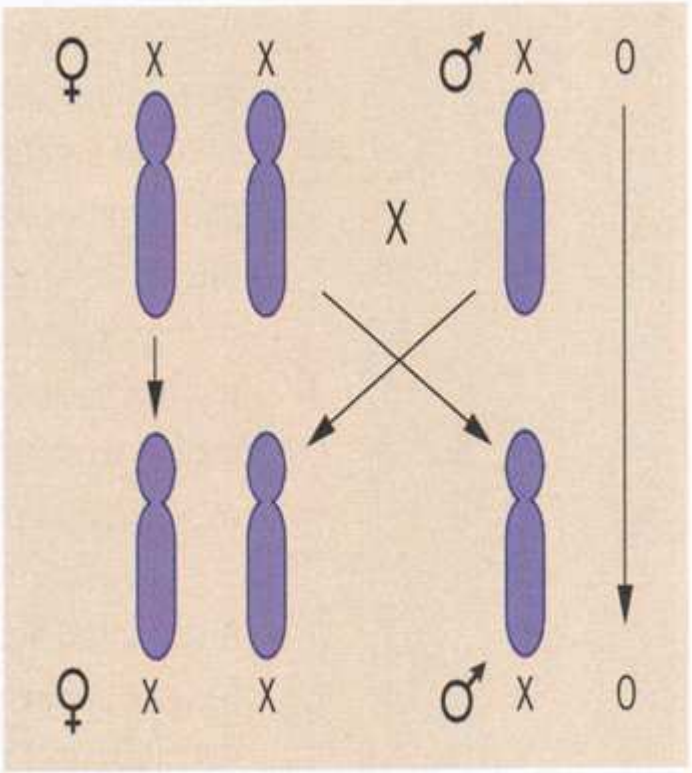
2- Males homogametic system •

A- The ZZ – ZW system •

B- The ZZ – ZO system. •

3- Haploid – Diploid system. •

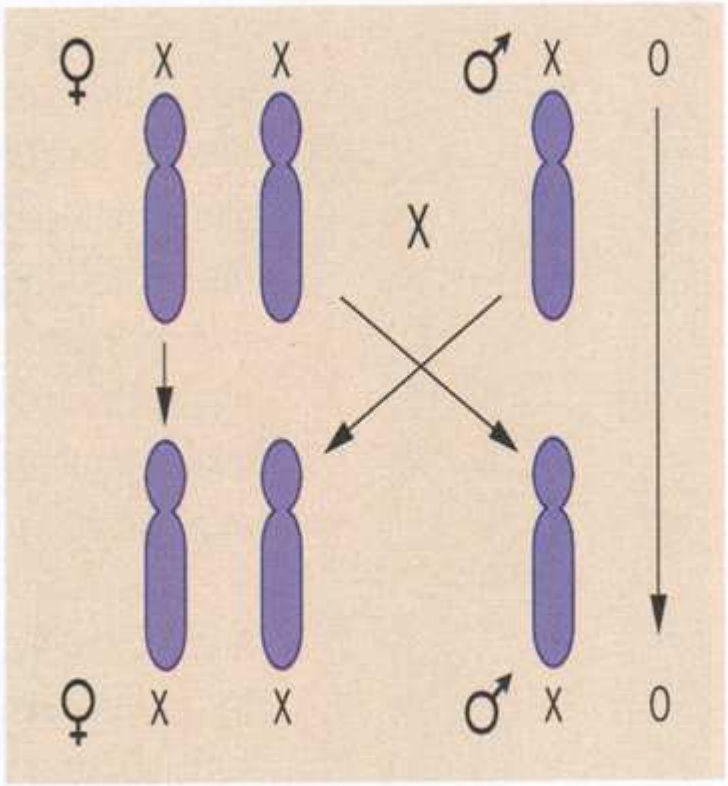
A- The XX – XO system



(a) Inheritance of sex chromosomes in animals with XX females and XO males.

- A- The XX – XO system .
- Females of these species have two X chromosomes and males have only one , thus females are cytologicaly XX and males are XO where the O denotes the absence of a chromosome .
- During meiosis in the female, the two X chromosomes pair and then separate ,producing eggs that contain a single X chromosome.

A- The XX – XO system

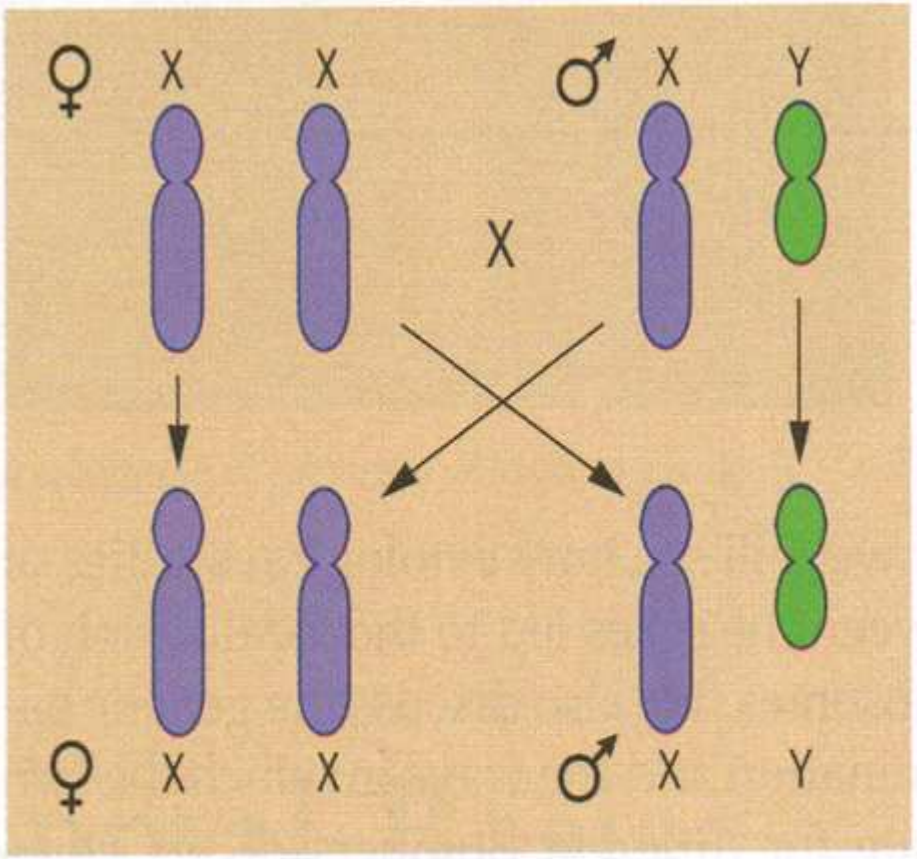


(a) Inheritance of sex chromosomes in animals with XX females and XO males.

- During meiosis in the male , the solitary X chromosome moves independently of all the other chromosomes and appear in half the sperms, the other half receive no X chromosome.
- Thus , when sperms and eggs unite ,two kinds of zygotes are produced . XX which develop into females and XO which develop into males , and the reproduction mechanism produce

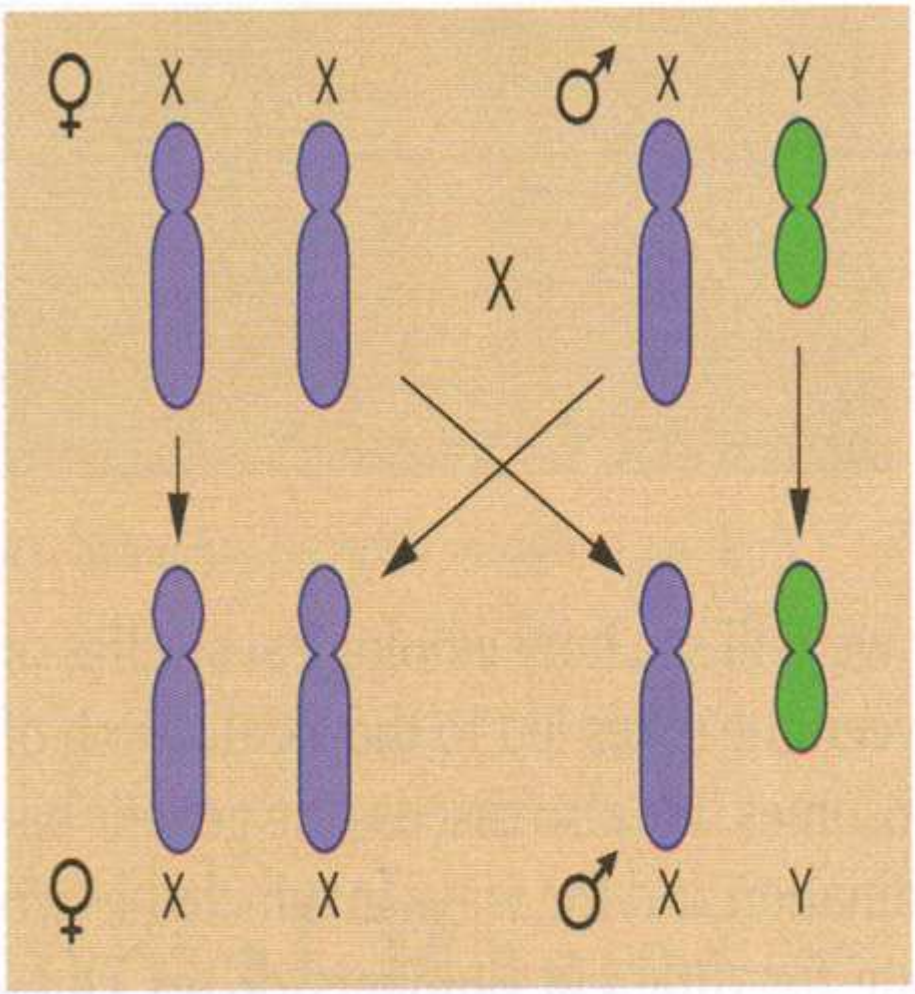
a 1 : 1 ratio of males to females in these species .

B- The XX – XY system



(b) Inheritance of sex chromosomes in animals with XX females and XY males.

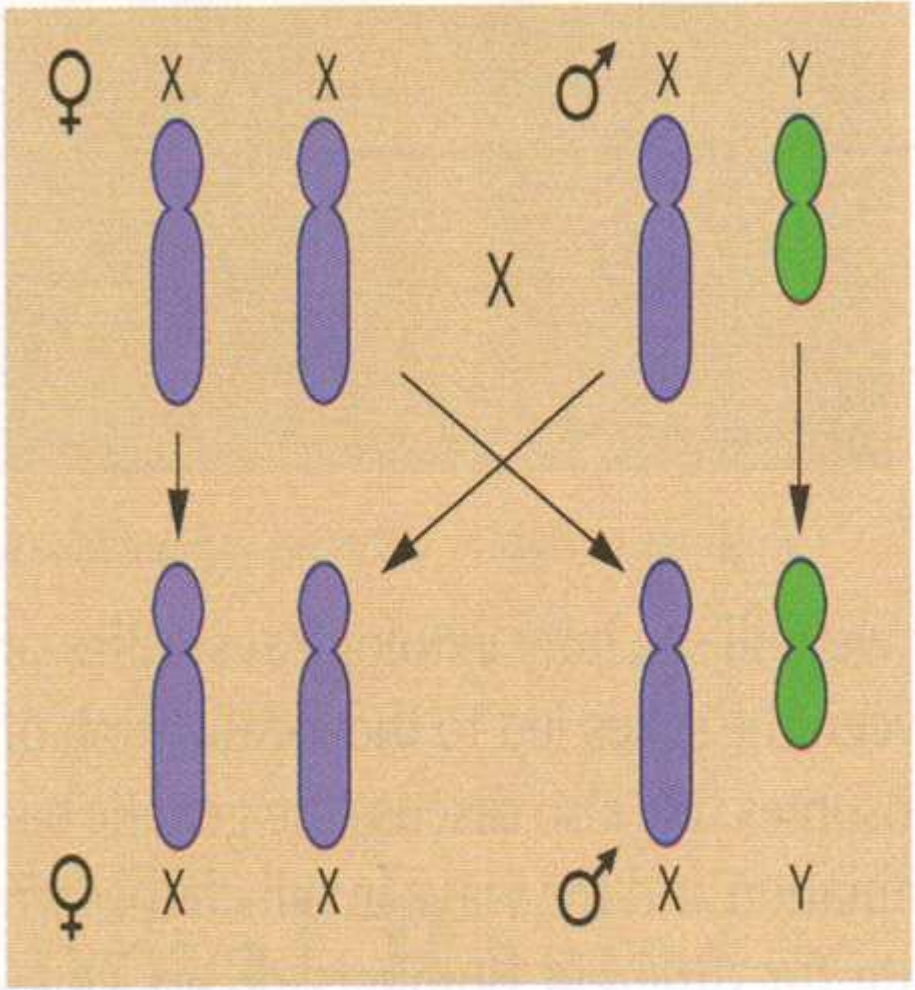
- In many other animals , including human beings ,and Drosophila males and females have the same number of chromosomes , this numerical equality is due to the presence of a chromosome in the male , called the Y chromosome which pairs with the X chromosome during meiosis ..



(b) Inheritance of sex chromosomes in animals with XX females and XY males.

- The Y chromosome morphologically different from the X chromosome , In human (for example) the Y is much shorter than X and its centromer is located closer to one of the ends .
- During the meiosis in the male , the X and Y chromosomes separate from each other , producing two kinds of sperms , X-bearing and Y-bearing , while XX females produce only one kind of eggs which is X-bearing .
- If fertilization were to occur randomly approximately half the zygotes would be XX and the other half would be XY leading to a 1 : 1 sex ratio .

Sex Determination in human beings



(b) Inheritance of sex chromosomes in animals with XX females and XY males.

- The discovery that human females are XX and that human males are XY suggested that sex might be determined by the number of X chromosomes or by the presence or absence of a Y chromosome . As we know , the second hypothesis is correct,

- In human and other placental mammals , maleness is due to a dominant effect of the Y chromosome , The evidence for this fact comes from the study of individuals with an abnormal number of sex chromosomes .
- The XO animals develop as females, and XXY animals develop as males .
- The dominant of the Y chromosome is manifested early in the development, when it directs the primordial gonads to develop in to test, once the testes have formed they secrete testosterone , a hormone that stimulates the development of male secondary sex characters .

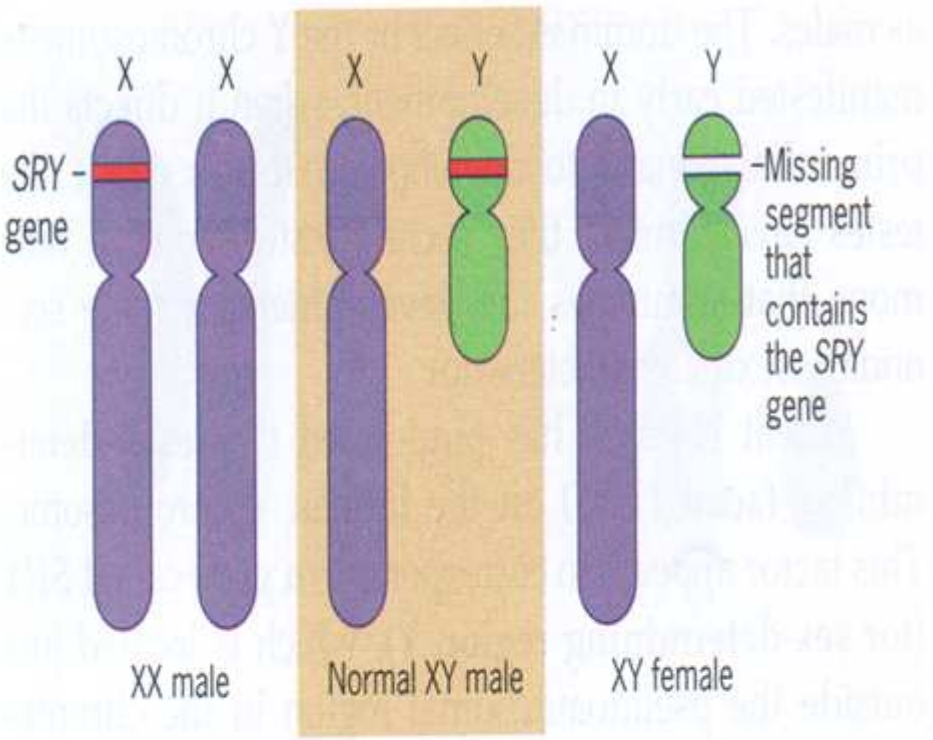
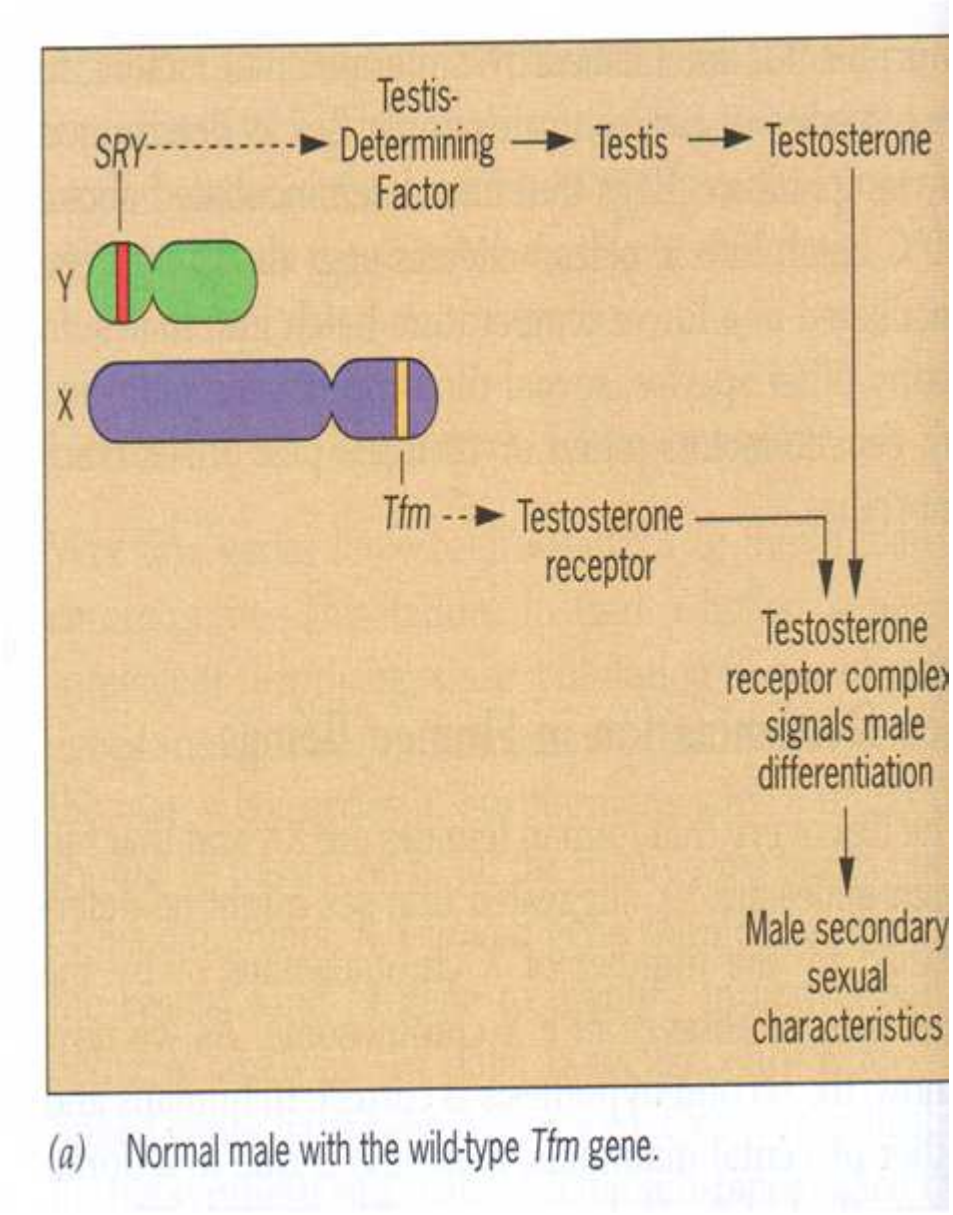


Figure 6.13 Evidence localizing the gene for the testis-determining factor (TDF) to the short arm of the Y chromosome in normal males. The TDF is the product of the *SRY* gene. In XX males, a small region containing this gene has been inserted into one of the X chromosomes, and in XY females, it has been deleted from the Y chromosome.

- Recent research has pointed that there is a factor produce from a gene called (SRY) sex determining region Y



(a) Normal male with the wild-type *Tfm* gene.

- .The discovery of SRY in unusual individuals whose sex was in consistent with their chromosome constitution XX males and XY females .

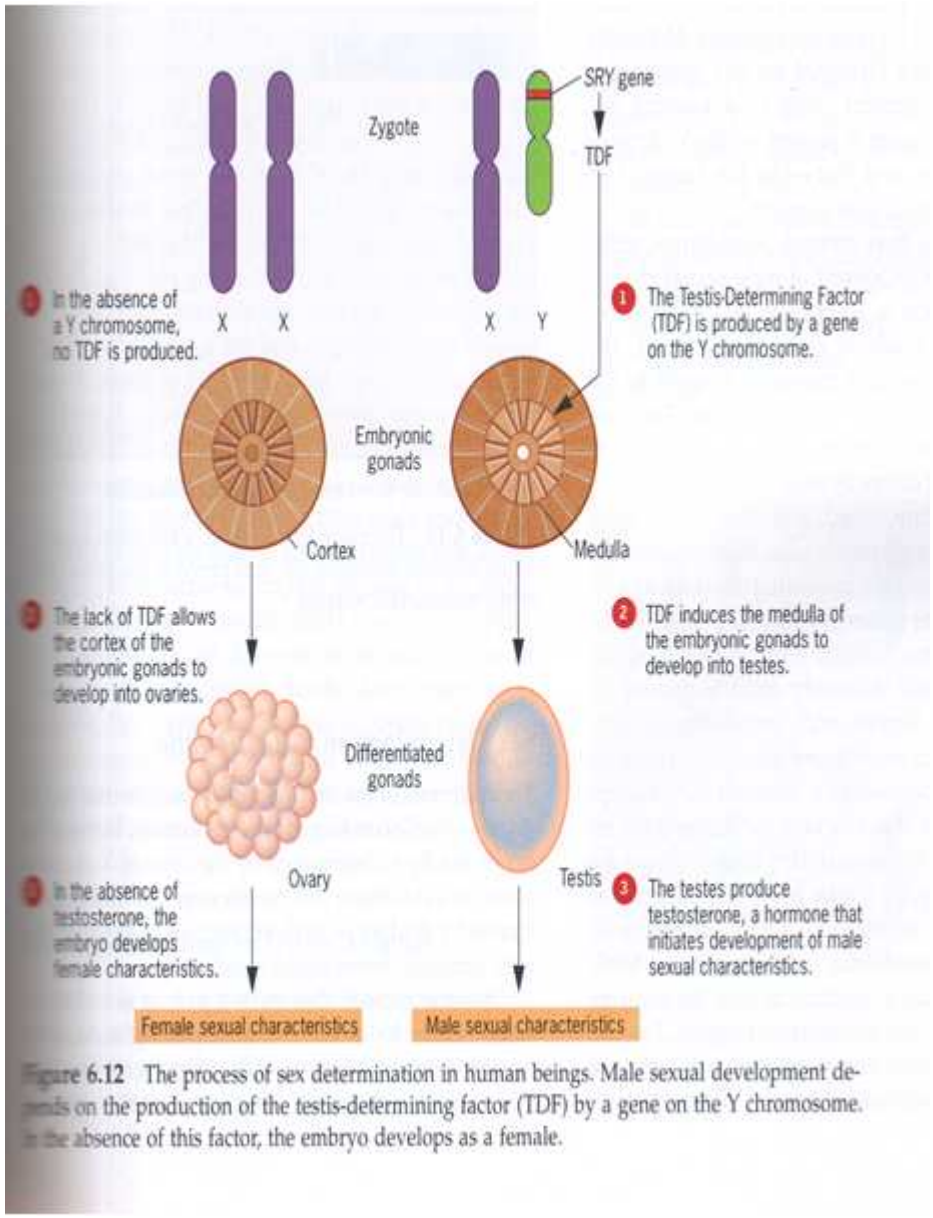
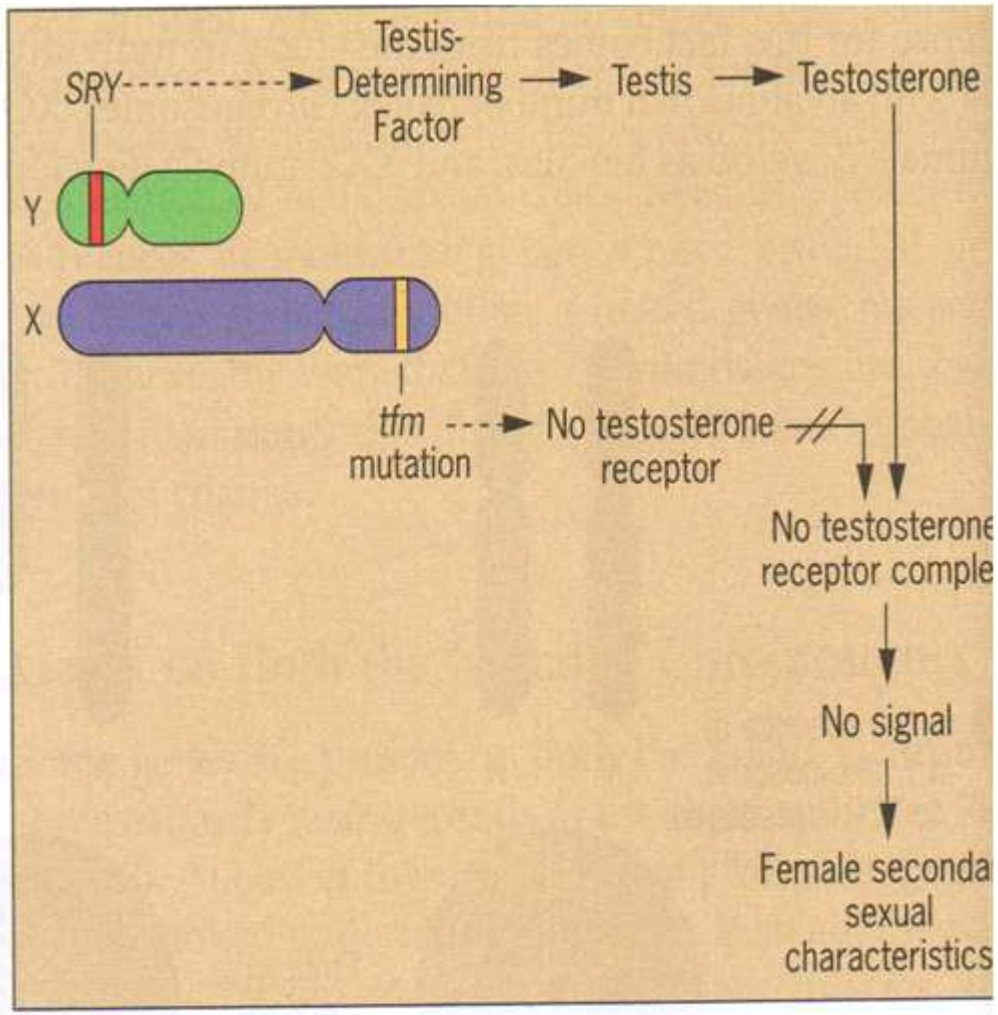


Figure 6.12 The process of sex determination in human beings. Male sexual development depends on the production of the testis-determining factor (TDF) by a gene on the Y chromosome. In the absence of this factor, the embryo develops as a female.

- Some of the XX males were found to carry a small piece of the Y chromosome inserted into one of the X chromosomes , this piece evidently carried a gene responsible for maleness .



(b) Male with the *tfm* mutation and testicular feminization.

Figure 6.14 Testicular feminization, a condition caused by an X-linked mutation, *tfm*, that prevents the productio of the testosterone receptor.

- Some of the XY females were found to carry an incomplete Y chromosome that was missing the piece that was present in the XX male .

2- Males homogametic system

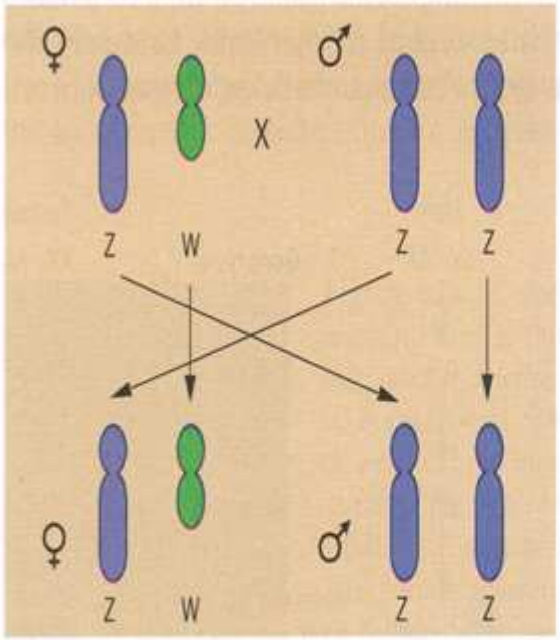


Figure 6.16 Sex determination in birds. The female is heterogametic (ZW), and the male is homogametic (ZZ). The sex of the offspring is determined by which of the sex chromosomes, Z or W, is transmitted by the female.

- A- The ZZ – ZW system

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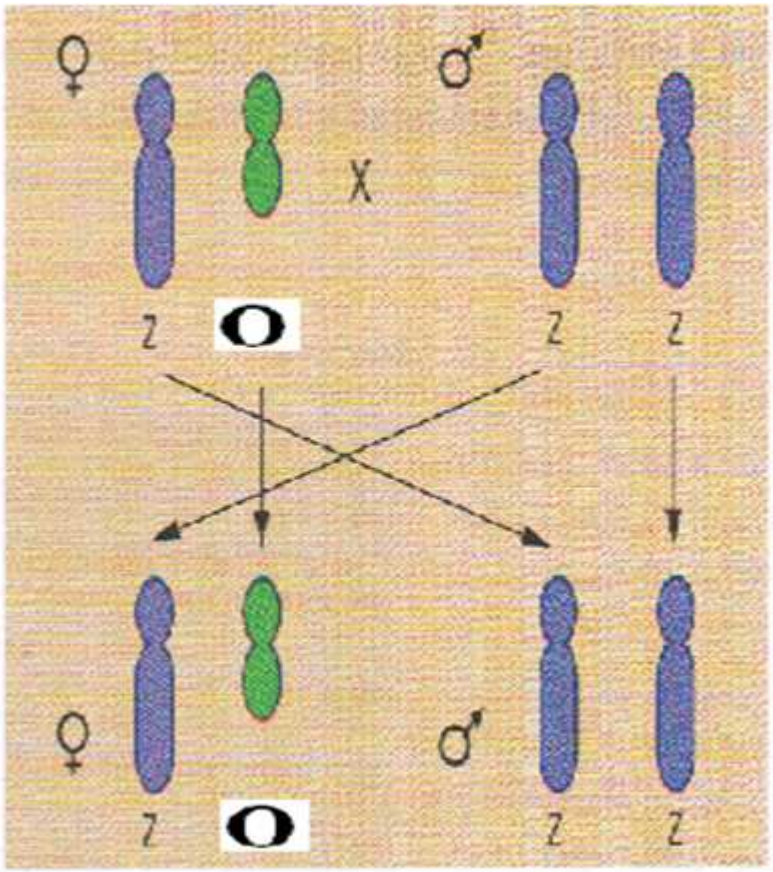
- In bird , butterflies and some reptile , this situation is revered , Males are homogametic (usually denoted ZZ) and females are heterogametic (ZW) .



B- The ZZ – ZO system.

- In chickens there is no evidence about the presence of W chromosome , so we denoted to the females ZO and the males ZZ .

3- Haploid – Diploid system.

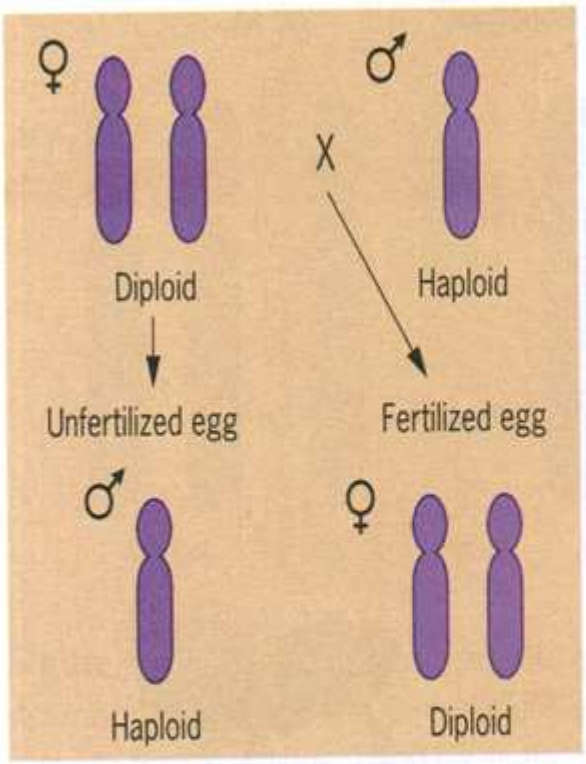


Figure 6.17 Sex determination in honeybees. Females, which are derived from fertilized eggs, are diploid, and males, which are derived from unfertilized eggs, are haploid.

- In honey bees, sex is determined by whether the animal is haploid or diploid .
- Diploid embryos, which develop from fertilized eggs ,become females , haploid embryos , which develop from unfertilized eggs, become males .
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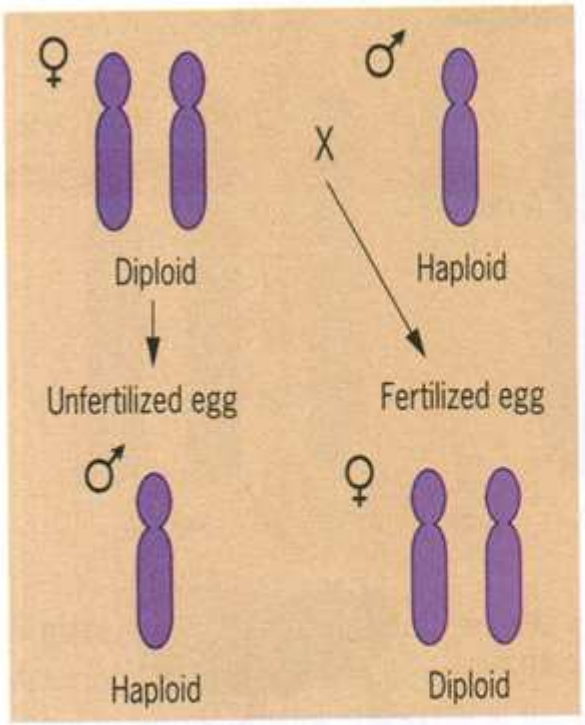


Figure 6.17 Sex determination in honeybees. Females, which are derived from fertilized eggs, are diploid, and males, which are derived from unfertilized eggs, are haploid.

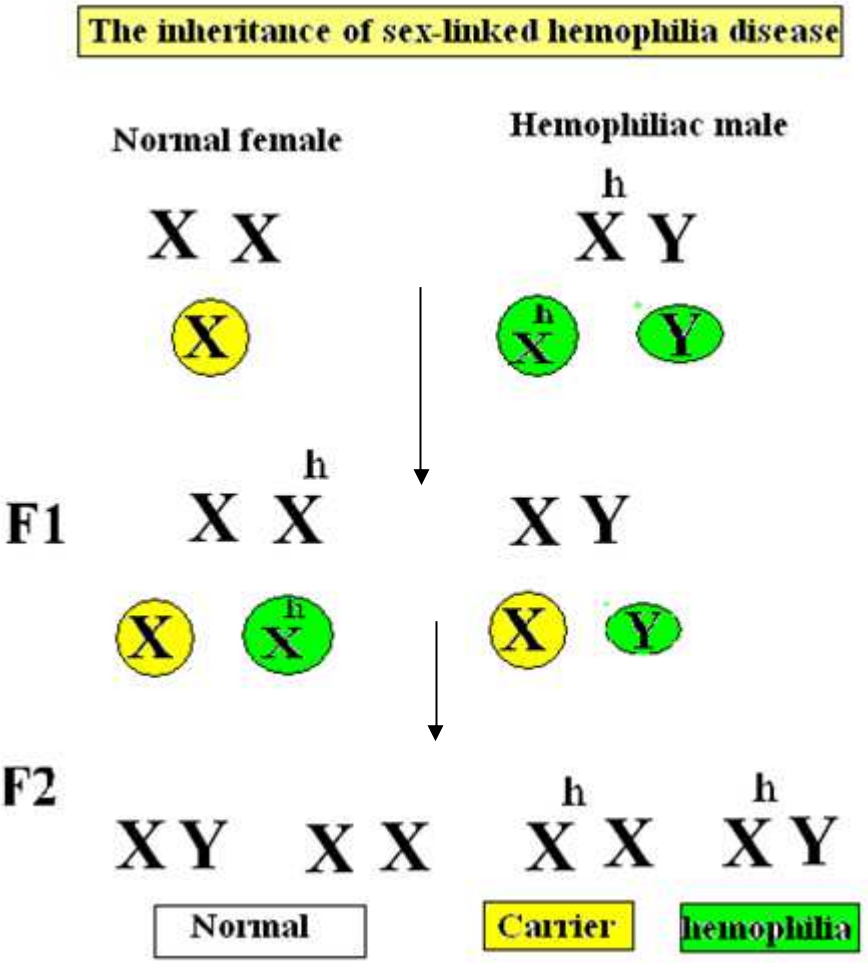
- Whether or not a given female will mature into a reproductive form (queen) depends on how she was nourished as a larva . In this system , a queen can control the ratio of male to females by regulating the proportion of unfertilized eggs that she lays .

Sex –Linked Genes

- Genes which located on X chromosome called sex –linked genes , and the traits influenced with these genes called sex-linked traits .
- In human beings , recessive x-linked traits are much more easy identified than are recessive autosomal traits , a male needs only to inherit one recessive allele to show an x-linked trait . However, a female needs to inherit two recessive allele (one from each of her parents) to show an x-linked trait . Thus , the most appearance of x-linked traits are in the males ..

- The x-linked trait disappear in the first generation and reappear in the second generation .
- Another example for x-linked trait is the color blindness in human beings , a heterozygous female carrier has a chance for transmitting the mutant allele to her children .

Hemophilia , an X-linked disease



- In human beings , a certain type of hemophilia is one of the best known example of an x-linked trait , people with this disease are unable to produce a factor needed for blood clotting(the cut and wounds of hemophiliacs continue to bleed and can cause death)
- Nearly all the individuals affected with x-linked hemophilia are males .

The inheritance of white eye sex-linked mutant in drosophila

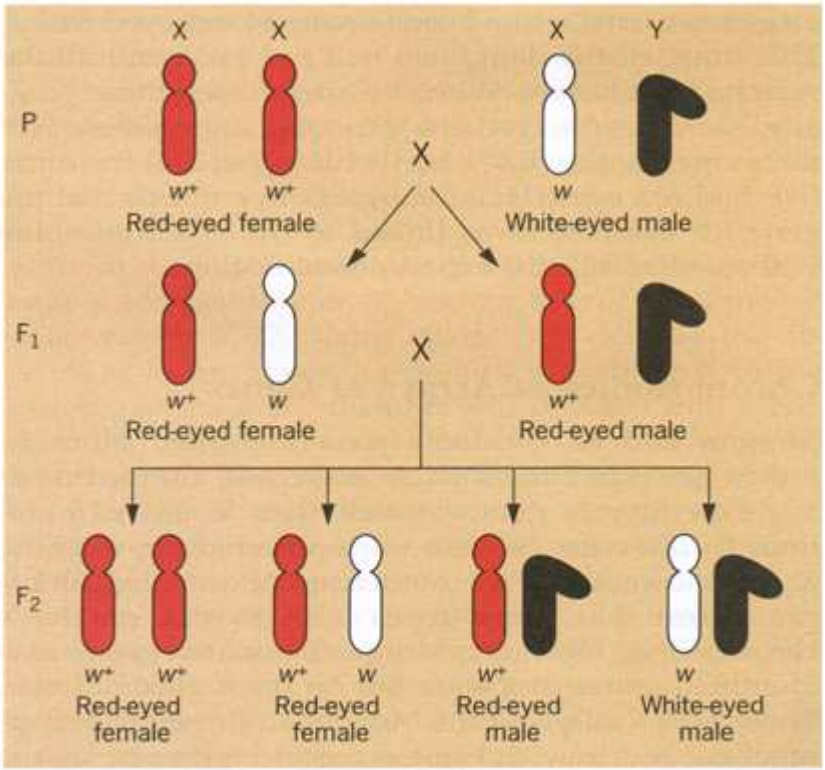
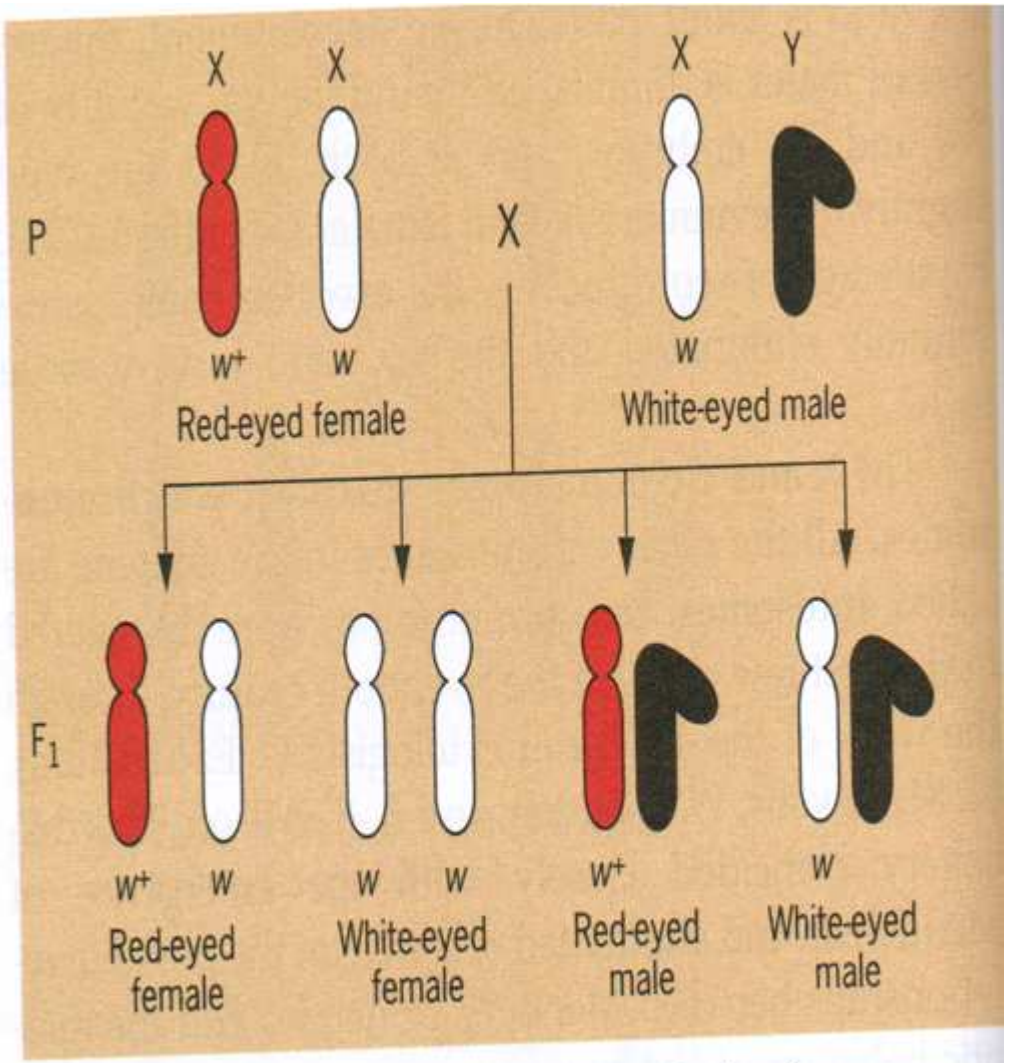


Figure 6.3 Morgan's experiment studying the inheritance of white eyes in *Drosophila*. The transmission of the mutant condition in association with sex suggested that the gene for eye color was present on the X chromosome but not on the Y chromosome.

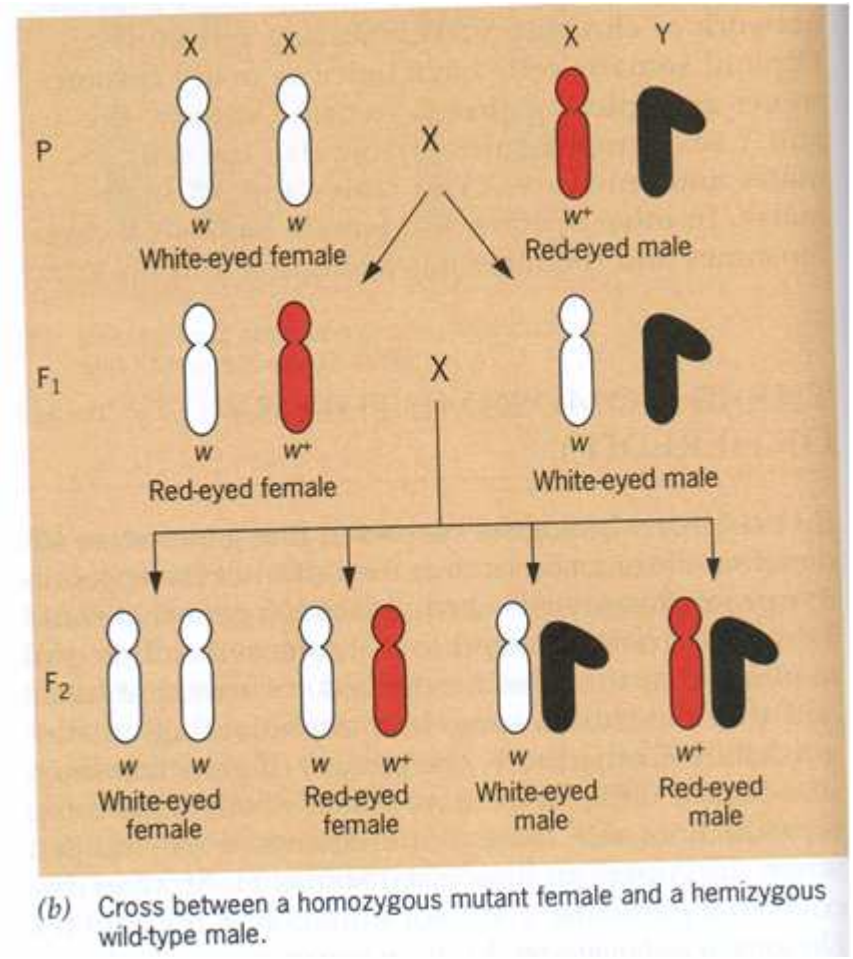
- The development of chromosome theory depended on the discovery of the white eye mutation in Drosophila , this mutation was a recessive allele of an x-linked gene .



(a) Cross between a heterozygous female and a hemizygous mutant male.

- In male one allele can show the phenotype of the trait , while in the female needs two homozygous recessive alleles to appear the trait .

The crisscross inheritance



(b) Cross between a homozygous mutant female and a hemizygous wild-type male.

- With the x-linked trait appear the crisscross inheritance , in this case the female pass her x-linked trait to sons and the male pass his x-linked trait to daughter .The homogamete sex must carry the homozygote recessive x-linked gene to express the phenotype of the trait . As following :

Sex influenced trait

- Some genes not located on the X chromosome or Y chromosome are expressed differently in the two sexes, and therefore they referred to as sex-influenced traits .
- An example for this traits is the index finger length , an index finger equal to or longer than the fourth finger is dominant in females but recessive in males .

Practice problems

- Q1; If a father and son both have color blindness, is it likely that the son inherited the trait from his father ?
- Q2: Both the mother and father of a hemophilic son appear to be normal . From whom did the son inherit the gene for hemophilia ? What is the genotype of the mother, the father, and the son ?
- Q3:Aman is sex linked color blind . If he reproduces with a woman who is homozygous normal, what is the chance that sons will be color blind ? Daughters will be color blind ? Will be carrier ?
- Q4; A normal woman, whose father had hemophilia, marries a normal man . What is the chance that their first child will have hemophilia ?