Unit

Mechanism of sex determination in Drosophila and Human

Eggs fertilized by sperm containing the X chromosome produced zygotes with two X chromosomes which becomes female. Eggs receiving sperm without an X chromosome produced zygotes with one X which become males. Males are referred to as hemizygous for the X chromosomes or for genes located on the X chromosome. This hemizygosity of males for genes located on the X chromosome is responsible for the altered patterns of inheritance observed for X-linked traits.

XX-XY mechanism of sex determination :

In many species, the cells of males and female have the same numbers of chromosomes, but the cells of female have two X chromosomes (XX) and the cells of males have a single X chromosome and a smaller sex chromosome, the Y chromosome (XY). In humans and many other organisms, the Y chromosome is acrocentric, not Y

shaped as is commonly assumed.

In this type of sex-determining system the male is heterogygotic sex - half of his gametes have an X chromosome and half have a Y chromosome. The female is the homogametic sex - all her eggs cells contain a single X chromosome. Many organisms including some plants, insects and reptiles and all mammals have XX-XY sex determining system. Although the X and Y chromosomes are not generally homologous, they do pair and segregate into different cells in meiosis.

In species with the XX-XY mechanism of sex determination, the female (XX) produce gametes that all have the same chromosome composition; these females are called the homogametic sex. Males of these species produced two different type of gametes, one-half contains one X chromosome plus one set of autosomal chromosomes and other half contains one Y chromo-

s plus one set of autosomes called heterogametic

The Y chromosome and sex-determination in male:

- In both Drosophila and humans, normal females have XX sex chromosome composition and normal males have an XY sex chromosomes composition.
- Thus it might be tempting to assume that in both species the genes for femaleness are on the X chromosomes and the genes for maleness are on the Y chromosomes.
- In mammals, the presence of a Y chromosome is required for the development of a male sex phenotype.
- But details study of genetics reveals that Y chromosome plays no significant role in sex determination in Drosophila:
- X chromosome present in any number (eg. XXX or XXXX) in the absence of a Y chromosome give rise to a female sex phenotype.
- A Y chromosome required for maleness; moreover, the presence of a single Y

chromosomes.

- The Y chromosome induces development of a undifferentiated gonadal medulla into a testis, whereas an XX chromosomal complement induces the undifferentiated gonadal cortex to develop ovaries.
- The gene on the Y chromosome in humans that is responsible for the development of the testis is called TDF (Testis determining factor). The TDF gene has been isolated, characterized structurally and found to encode a protein with features that suggest that it acts by Regulating the expression of other genes.
- The TDF gene is the master Regulator that triggers the expression of a large number of genes that produce the male Sex phenotype.
- In the absence of the TDF gene, the genes that produce the female Sex phenotype would be expressed.
- The TDF gene exhibits a very dominant effect on the development of the Sex phenotype

- Even the presence the three or more X chromosomes, a single Y chromosome is usually sufficient to produced testis and male characters.

Species with Heterogametic females:

- In many species, including most birds, moths and some fish, a chromosomal mechanism of sex determination occurs that is basically identical to the XX-XY ~~mech~~ mechanism but with the females being heterogametic which is denoted by ZW and males being homogametic which is denoted by ZZ.
- The mechanism of sex determination is sometimes called ZZ-ZW.
- Here female is denoted by ZW and males is denoted by ZZ.

Balance concept of Sex determination in Drosophila

The investigations on Drosophila by C.B. Bridges showed that female determiners were located on the X chromosomes and male determiners were on the autosomes.

- Female-determining genes were shown to be carrid on the X chromosomes and male determining genes were shown to be located on the three autosomal chromosomes of Drosophila.

XO and XY chromosomes segregation was interpreted as a means of tipping the balance between maleness and femaleness, whereas more deep-seated processes were involved in the actual process of sex determination.

- Various combination of X chromosomes and autosomes in Drosophila and deduced from comparisions that one X chromosome (X) and two sets of autosomes (A) produce a normal male.

— Normal males had a ratio of X chromosomes to sets of autosomes of 0.5.

- This combinations of one X and two A's resulted in a normal, diploid male, the combination of two X chromosomes and two

sets of autosomes (2X + 2A, 2:2 = 1) produces a normal diploid female.

The first irregular chromosomes arrangement from Bridges exprimentis resulted from non-disjunction the failure of paired chromosomes to separate in anaphase. X chromosomes, which ordinarily come together in pairs during the meiotic prophase of oogenesis and separate to opposite poles during anaphase, remained together and migrated to the same pole. As a result, some female gametes received two X chromosomes and some received no X chromosome.

* Fertilization by sperm from wild-type males (AAXY), all zygotes had 2n autosomes (2A) but some received two X's from the mother and X from the father (3X).

- The ratio of X chromosomes to sets of autosomes of 3:2 resulted in flies called metafemale, that were highly inviable.

⇒ The XXY flies (2X/2A) from the same mating were normal females in appearance XO (1X/2A) males were sterile, and those with a Y chromosome but no X chromosome did not survive.

⇒ These results indicated that, in Drosophila, the Y chromosomes is not involved in sex determination.

⇒ However, the Y chromosome of Drosophila is required for male fertility.

⇒ In XO Drosophila melanogaster sperm developed but are nonmotile.

⇒ Flies produced exprimentally with 4X/3A were also metafemales.

⇒ Those with 4X/4A and also those with 3X/3A both with an X/A = 1 were females.

⇒ The combinations 3X/4A = 0.75 and 2X/3A = 0.67 were intermediate in characteristics between males and female and were called "intersexes".

⇒ Combinations of 2X/2A = 0.5 were males and those of X/3A = 0.33 were metamales.

Sex Chromosome Compliment	Haploid sets of autosomes	X:A Ratio	Sexual phenotype
XX	AA	1	Female
XY	AA	1/2 = 0.5	male
XO	AA	0.5	male
XXY	AA	1	female
XXX	AA	3/2 = 1.5	meta female
XXXY	AA	3/2 = 1.5	Met female
XO	AAA	1/3 = 0.33	meta male
XX	AAA	2/3 = 0.67	Inter sex.

Fig: Balance concept of sex determination in Drosophila.