Ministry of Higher Education
& Scientific Research
Al Muthanna University
College of Veterinary Medicine
Division of public health

Subject: Genetics
Grade: 2
Lecture : 12

Sex determination

What is sex determination?

The method by which distinction between male and female is established in an organism under genetic control. The sex chromosomes are responsible for determination of separate sexes. It is a biological system that determines the development of sexual characteristics in an organisms. Traditionally, the symbol ♂ designates male and the symbol ♀ designates female

On the other hand. Sex determination is the process of sex differentiation by which whether a particular individual will develop into male or female sex. Sex expression is governed by chromosomes and genes. In unisexual animals, chromosomes are of two types, viz., autosomes and allosomes.

Autosomes - Chromosomes which do not differ in morphology and number in male and female.

Allosomes or sex chromosomes - Chromosomes which differ in morphology and number in male and female and contain genes that determine sex.

Unisexual diploid individuals have two sex chromosomes and rest are autosomes. In most plants, male and female reproductive organs are found in the same flower is called as Bisexual or Hermaphrodite. In nematodes, earthworm both male and female reproductive organs are found in same individual.

Male and female reproductive organs are found in the different flower of same plant is called as monoecious e.g maize, castor, coconut). In some plant male and female flowers are produced on different plants is called as Dioecious: papaya

Differences between Autosomes and Allosomes

Autosomes	Allosomes or Sex chromosomes
Refer to other than sex chromosomes./ Chromosomes that do not determine the sex of individuals	These are sex chromosomes. / Chromosomes that determine the sex of individuals
Chromosome no. = 2n-1	Chromosome no. = 2
Morphology is similar in male and female	Morphology is different in male and female.
. Number differs from species to species	. Each diploid organism usually has two allosomes
. Do not exhibit sex linkage	Exhibit sex linkage.

Mechanism of Sex determination

Four important mechanisms:

(1) Sex character

(2) Chromosomal sex determination

(3) Monogenic sex determination, and

(4) Environmental sex determination

(1) Sex characters:

- Primary: gametes
- Secondary: all genitalia

(2) Chromosomal sex determination

In a diploid individual, there are 2n - 2 autosomes and two sex-chromosomes.

Three types of chromosomal sex determination:

(a) Sex determination by allosomes

(b) Diploid-haploid system of sex determination

(c) Genic balance system.

(a) Allosomal Sex Determination

Allosomes or sex chromosomes are generally of X and Y types, but in some birds they are of Z and W types. Sex with similar type of sex chromosomes (XX) is known as homogametic sex and with dissimilar type of sex chromosomes (XY) as heterogametic sex.

There are four different systems of allosomal sex determination:

(1) XX-XY female-male system

(2) XX-XO female-male system

(3) XO-XX female-male system

(4) ZW-ZZ female-male system

1. XX-XY [Female-Male] System (Drosophila, man and some other mammals)

 In this system female has two X chromosomes, is homogametic and produces only one type of gamete, i.e., X.

 The male has one X and one Y chromosome, is heterogametic and produces two types of gametes, viz., X and Y.

 Union of X ovum with X sperm leads to development of female (XX) sex. If X ovum units with Y sperm, it produces male (XY) sex.

2- XX-XO [Female-Male] System (Grasshoppers and many orthoptera and hemiptera insects)

 In this system, female has double X chromosomes (XX) and male has single X chromosome (XO).

 Female is homogametic and produces all the eggs with X chromosome.

 The male is heterogametic, which produces sperms half of which have X chromosome and other half have none.

 Union of egg with sperm having X chromosome will give rise to female sex and with sperm having none results in development of male sex.

3- XO-XX [Female-Male] System (Very few species of insects like Fumea)

 In this system, female has only one X chromosome and hence is heterogametic.

 As a result of meiosis, 50% eggs of such female carry an X chromosome and remaining 50% have none.

 On the other hand, male has two X chromosomes and produces all the sperms with one X chromosome. Thus, male sex is homogametic.

 Union of X sperm with ovum having X chromosome gives rise to male sex and union of X sperm with ovum having none leads to development of female.

4. ZW-ZZ [Female-Male] System (Birds, butterflies and moths)

 Female is heterogametic and produces two types of gametes - Z and W types.

 Male is homogametic and produces all the sperms of same type carrying one Z chromosome.

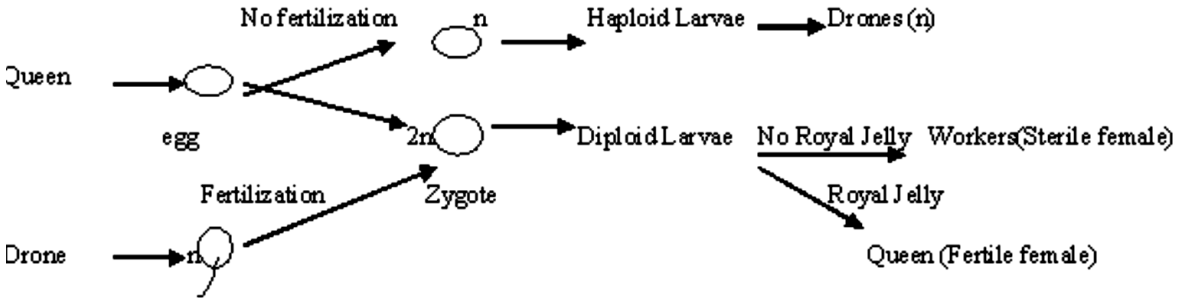
 Union of Z sperm with ovum having Z chromosome gives rise to male and union of Z sperm with ovum carrying W chromosome leads to the development of female sex

(b) Diploid-Haploid (Female-Male) System (Honey bees, ants and termites)

 In honey bees, the females have diploid (2n = 32) chromosomes and drones or males have haploid (n = 16) chromosomes.

 Females are - queen and workers.

 The females which feed on royal jelly develop into queen. The queen is fertile and workers are sterile females. The queen produces haploid eggs. However, haploid male bees produce haploid sperms by mitosis rather than by meiosis. Union of egg with sperm gives rise to diploid larvae which become female.



(c) Genic Balance System

 This system was developed by Bridges (1922) in Drosoplaila., According to this theory “the sex of an individual is determined by a balance between the genes for maleness and those for femaleness present in the individual,” Genic balance theory states that sex determining genes are present on both X chromosome as well as autosomes.

The male sex determining genes are present on autosomes and female sex determining genes on X chromosome. The sex expression is determined by the balance of genes on autosomes and X chromosome.

In other words, the expression of sex depends on the ratio of X chromosomes to that of autosomes. This ratio is represented as X/A ratio. The genic balance is governed by X/A index.

 Individuals with index of 1 develop into female and those with sex index of 0.5 into male.

 If the sex index is between 1 and 0.5, the resulting individual will be neither a female nor a male, but have an intermediate sex expression and is called inter sex.

 The sex index of 1.5, which is higher than the sex index of normal female gives rise to super female.

 A sex index of 0.33, which is lower than the sex index of normal male gives rise to super male.

Sex Index = Number of X chromosomes / Number of Autosomal sets = X/ A

 Individuals with the sex index of 1.0 are normal females (XX: Diploid female, XXX: Triploid fly, XXXX: Tetraploid fly)

 Flies having the sex index of 0.5 are normal males (XO diploid flies, XXOO: Tetraploid fly)

(3) Monogenic Sex Determination

Expression of sex is influenced by a single gene. In Drosophila, a transformer gene (tra) which is present on autosomes plays an important role in sex expression. Transformer gene is recessive and hence does not have any effect in heterozygous condition (Tra/tra) on either sex. In homozygous condition (tra/tra), this gene transforms the normal diploid females into sterile males.

* A similar SRY gene is found in human. The gene is probably present on autosome and transforms the normal male (XY) into female. Such males have feminine (female) characters. They have internal degenerated testes and are sterile. This condition is known as testicular feminization. Similar effects of single recessive gene on expression of sex have been found in some other animals such as goats, pigs, dogs, etc.

(3) Environmental Sex Determination

 Sex determination in some organisms such as sea worm (Bonellia and Dinophilus) and horse tail plant is governed by environmental conditions and also includes some hormonal effects.

 In Bonellia, the larvae which remain free in the sea water and settle on the sea bottom are differentiated into females while those larvae which settle on the proboscis of female develop into tiny males.

Undifferentiate Larvae:

Free living larvae …… Develop into female

Larvae attach to proboscis of female ……Develop into male

Incubation Temperature

In turtle, Alligators and Crocodiles Incubation temperature of egg:

High (30-35ºC): Female

Low (23-28ºC): male

Sex Mosaic in Drosophila

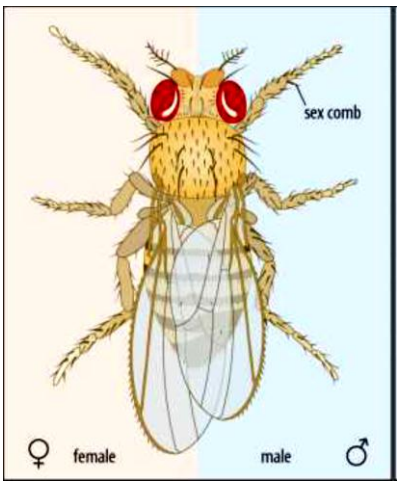
Sex mosaic - Combination of male and female features in the body of an individual. Drosophila flies (1 in 2000) have male tissues in one part of the body and female tissues in other. Individuals with such sex mosaic are known as gynandromorphs or gynanders.

Three patterns of sex mosaic may be found in Drosophila:

1. Bilateral sex mosaic - one side of the fly is male and the other side is female. This is the most common type of sex mosaic.

2. Antero-posterior sex mosaic - the front half of the fly is one sex and the rear half of the other sex.

3. Sex mosaic in Patches - Sometimes, only a quarter of the body is male, and rest is female or just a small patch of tissues may be male and rest of the body is female.



Dr. Naer ALkaabi