SEX DETERMINATION :

The process of figuring out if an individual will become a male or a female early in life is called sex determination. There are different ways this can happen, such as through the environment, certain genetic factors that are not on sex chromosomes, sex chromosomes (allosomic sex determination), and a special case called haplodiploidy.

Sex Determination on the basis of fertilization.

Three types :

- **Progamic :** Sex is determined before fertilization.
  eg. – Drone in honey bee
- **Syngamic –** Sex is determined during fertilization.
  eg. – most of plants & animals
- **Epigamic –** Sex is determined after fertilization.
  eg. – Female in honey bee.

Environmental Determination of Sex

This type of sex determination isn't based on genetics but purely on the surroundings. These organisms have the potential to be both male and female, depending on the environment.

- In the marine worm Bonellia, a larva turns into a female if it settles alone in an isolated place. But if it comes into contact with a mature female, it transforms into a male and lives as a parasite in the female's uterus.
- Crepidula, a marine mollusk, has larvae that become males when in the company of females and females when left alone.
- In crocodiles, low temperatures make them female, while high temperatures make them male.
- Turtles show different sexes based on temperature: below 28ºC induces maleness, above 33ºC induces femaleness, and between 28 - 33ºC, an equal number of males and females are formed.
- In the marine fish Medusa, sex changes with environmental conditions, turning male in cold water and female in warm water.

Allosomic determination of sex

Chromosomes are of two types :

- Autosomes or somatic chromosomes.
  These regulate somatic characters.
- Allosomes or Hetersomes or Sex chromosomes

These chromosomes are associated with sex determination. Term "Allosome" & "Heterosome" were given by Montgomery.
Sex chromosomes first discovered by "Mc Clung" in grass hopper
X - Chromosome discovered by "Henking" and called 'x-body'.
Wilson & Stevens proposed chromosomal theory for sex determination.

XX - XY type or Lygaeus type

This type of sex determination first observed by Wilson & Stevens in Lygaeus insect.

Two types :

XX female and XY male : In this type of sex determination female is Homogametic produces one type of gamete

Male's Gametes and Chromosomes:

Males produce two types of gametes. In a male, the combination is 2A + XY. The gamete with an X-chromosome is called "Gynosperm," and the one with a Y-chromosome is called "Androsperm." This occurs in humans and dioecious plants like Cocinea and Melandrium.

XY or ZW Sex Determination:

Some organisms have XY females and XX males, or ZW females and ZZ males. In this type, females have two types of gametes, while males have only one. This occurs in insects like butterflies and moths, as well as in vertebrates such as birds, fishes, and reptiles. Fragaria elatior, a plant, also follows this type of sex determination.

XX Female and XO Male (Protenor type):

In this type of sex determination, males lack one chromosome. Females are homogametic, producing one type of gamete, while males are heterogametic. This occurs in some insects and is known as the "Protenor type."

Example :

- Grass hopper
- Squash bug Anasa
- Cockroach
- Ascaris and in plants like - Dioscorea sinuta & Vallisneria spiralis

Sex Linkage

When the genes responsible for traits in the body are on the sex chromosomes, it's called a sex-linked gene, and the whole phenomenon is known as sex-linkage. There are two types:

X-linkage:

Genes for body traits are on the X-chromosome. This kind of trait can be inherited through both males and females. Examples include conditions like Hemophilia and Color blindness.

Y-linkage:

The genes for body traits are on the Y-chromosome. This type of trait is only passed down through males and is known as Holandric character. Examples include the gene responsible for forming TDF, Hypertrichosis (excessive hair on ear pinna), and any gene located on the specific region of the Y-chromosome, termed as Holandric gene.

Example of X- linkage :

Eye colour in Drosophila : Eye colour in Drosophila is controlled by a X-linked gene. If a red eyed colour gene is represented as '+' and white eyed colour represented as 'w', then on basis of this different type of genotypes are found in Drosophila.

Gene for red eye domainant (+) and white colour of eye is recessive (w)

Homozygous red eyed female = $X^{+}X^{+}$

Heterozygous red eyed female = $X^{+}X^{w}$

Homozygous white eyed female = $X^{w}X^{w}$

Hemizygous red eyed male = X^{+} Y

Hemizygous white eyed male = $X^{w}Y$

It is clear by above different types of genotype that female either homozygous or heterozygous for eye colour. But, for the male eye colour, it is always hemizygous.

Haemophilia

Haemophilia is also called "bleeder's disease" and first discovered by John Otto (1803). The gene of haemophilia is recessive and x-linked lethal gene.

On the basis of x-linked, following types of genotype are found.

X^hX = Carrier female

X^hX^h = Affected female

X^hY = Affected male

But X^hX^h type of female dies during embryo stage because in homozygous condition, this gene is lethal and causes death.

Haemophilia - A – due to lack of factor - VIII (Antihaemophilic globulin AHG)

Haemophilia - B or Christmas disease - due to lack of factor - IX (plasma thromboplastin component)

Haemophilia - C - due to lack of factor XI (plasma thromboplastin anticedent)

Colour Blindness : The inheritance of colour blindness is like as haemophilia, but it is not a lethal disease so it is found in both male and female (discoverd by Horner)

Three types of colour blindness are :

Protanopia : It is for red colour.

Deuteranopia : It is for green colour

Tritanopia : Blue colour blindness. Colour blindness is cheked by Ishihara - chart.

Other examples of X - linkage

- Diabetes insipidus (recessive).
- Duchenne muscular dystrophy (recessive)
- Fragile x syndrome (recessive).
- Pesudoricketes (Dominant)
- Defective enamel of teeth (Dominant)

Types of Inheritance of sex linked characters :

Criss Cross inheritance (Morgan)

In criss-cross inheritance male or famale parent transfer a X-linked character to grandson or grand daughter through the offspring of opposite sex.

- **Diagenic :** Inheritance in which characters are inherited from father to the daughter and from daughter to grandson.
  Father → Daughter → Grand Son
- **Diandric :** Inheritance in which characters are inherited from mother to the son and from son to grand daughter. Mother → Son → Grand Daughter

Non criss-cross inheritance

In this inheritance male or female parent transfer sex linked character to grand son or grand daughter through the offspring of same sex.

- **Hologenic :** Mother → Daughter → Grand-daughter (female to female)
- **Holandric :** Father → Son → Grand-son (male to male)

Sex-Limited Character

These characters are expressed in one sex and unexpressed in another sex. But their genes are present on autosome of both the sexes and their expression is depend on sex hormone.

Example : Secondary sexual characters these genes located on the autosomes and these genes are present in both male and female, but effect of these are depend upon presence or absence of sexhormones. For example - genes of beard & moustache express their effects only in the presence of male hormone - testosterone.

Sex Influenced Characters

Genes of these characters are also present on autosomes but they are influenced differently in male and female. In heterozygous condition their effect is different in both the sexes. Example : Baldness : Gene of baldness is dominant (B).

Genotype	Male (♂)	Female (♀)
BB	Baldness present	Baldness present
bb	Baldness absent	Baldness absent
Bb	Baldness present	Baldness absent

Gene Bb shows partiality in male and female, Baldness is found in male, but baldness is absent in female with this genotype.

Lethal gene :

It was discovered by Cuenot In coat colour of mice Some genes regulate specific characters in the organisms. they cause death of organism if they present in homozygous dominant or homozygous recessive state. If individual dies in embryonic state, it is called Absolute lethality

Ex: coat colour in mice.

Yy (Heterozygous yellow) × Yy (Heterozygous yellow)

♀ \ ♂	Y	y
Y	YY Died	Yy Yellow
y	Yy Yellow	yy Brown

Thus Monohybrid phenotypic ratio is modified 2 : 1 (Yellow : Brown)

Yellow body colour (Y) was dominant over normal brown colour (y) Gene of yellow body colour is lethal in homozygous state so that in nature homozygous Yellow mice are never occured in population

E. Baur discovered lethal gene in Snapdragon (Antirrhinum majus).

Cc (golden or auria) × Cc (golden or auria)

♀ \ ♂	C	c
C	CC died	Cc golden
c	Cc Golden	cc Green

Phenotypic ratio 2 : 1
Golden Green

Homozygous golden are never occured in nature.
If individual dies before reproductive matruity it is called Sublethality Ex: Sickle cell anaemia.
If death of individual takes place after sexual maturity it is called Delayed lethality.

Sex determination in humans

In humans, the process of determining sex involves 22 pairs of body-related chromosomes (autosomes) and one pair specifically dedicated to sex. Females, who produce egg cells (ova), have these cells with a consistent chromosome type (22 + X), making them homogametic. On the other hand, males generate two types of sperm during spermatogenesis. Half of the produced sperm carry an X-chromosome, and the other half carries a Y-chromosome in addition to the autosomes.

When an egg (ova) fertilizes with a sperm carrying an X-chromosome, the resulting zygote develops into a female (44 + XX). Conversely, if the egg fertilizes with a sperm carrying a Y-chromosome, the zygote develops into a male individual (44 + XY). Hence, the genetic makeup of the sperm determines the gender of the child. Notably, in each pregnancy, there is an equal 50% probability of having either a male or a female child.

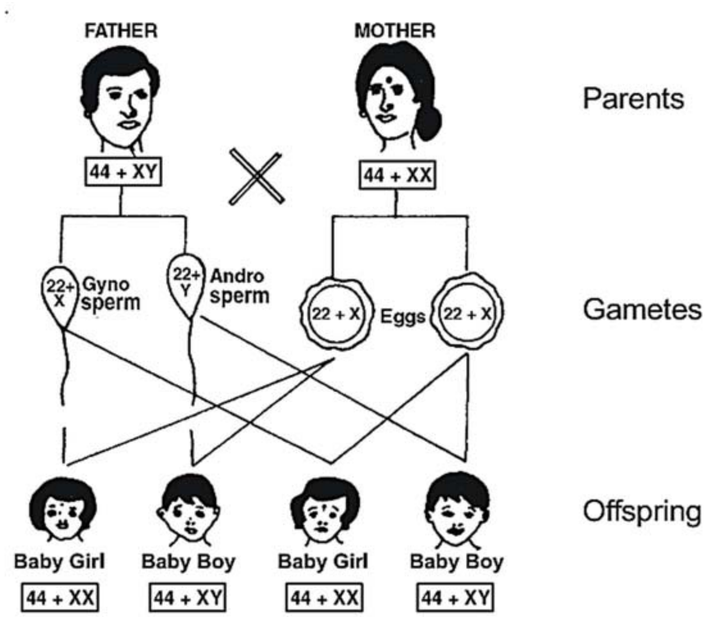

Fig.: Sex-determination in man. Note that all the eggs carry X-chromosome but one-half of the sperms carry an X-chromosome and one-half carry a Y-chromosome.

Sex determination in honey bee:

In honey bees, the way they determine sex is based on the number of sets of chromosomes an individual gets. When a sperm and an egg come together, the resulting offspring becomes a female, which can be a queen or a worker. On the other hand, if the egg is not fertilized, it turns into a male bee called a drone through a process called parthenogenesis.

Here's an interesting twist: male bees have only half the number of chromosomes compared to females. Females are diploid, with 32 chromosomes, while males are haploid, meaning they have 16 chromosomes. This unique system of sex determination is called haplodiploid.

What's even more fascinating is that male bees produce sperm through a process called mitosis, and they don't have fathers or sons. Instead, they have grandfathers and can have grandsons. It's a special characteristic of the haplodiploid sex determination system in honey bees.

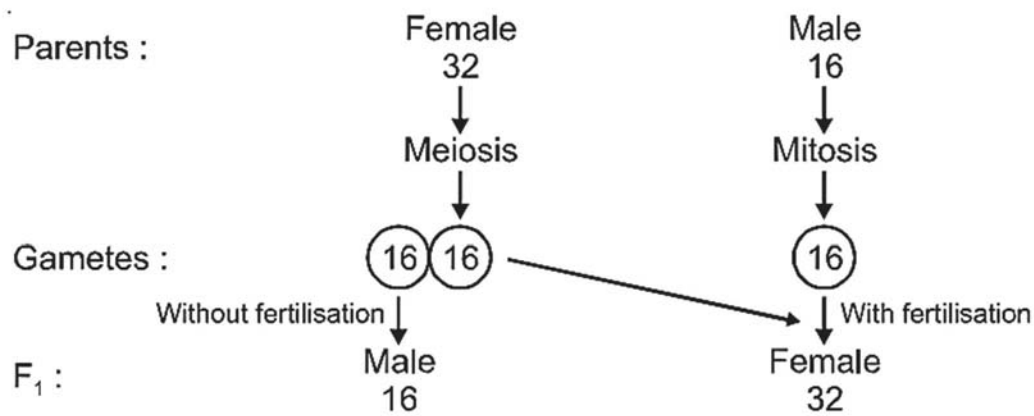

Fig.: Sex-determination in honey bee