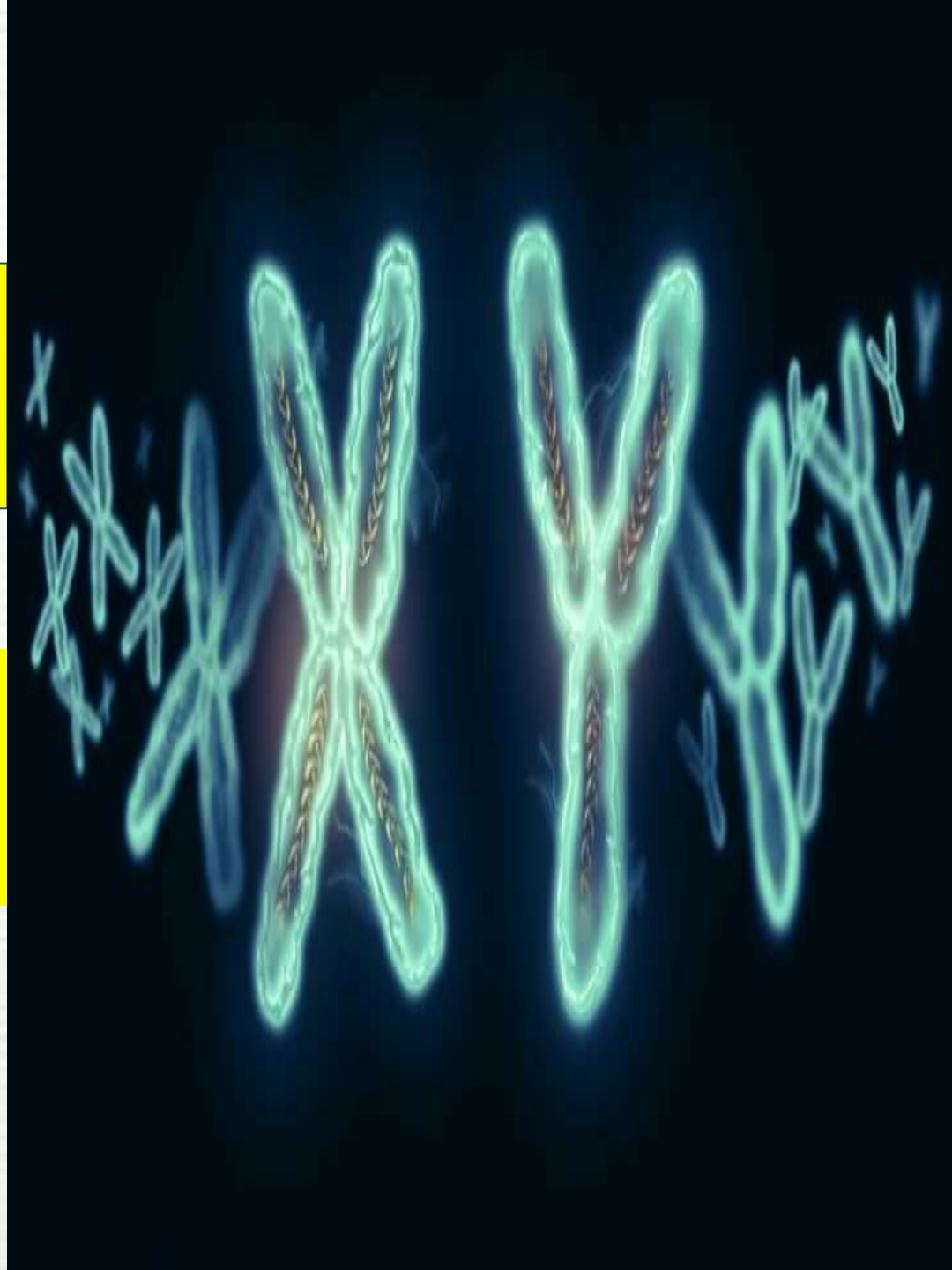
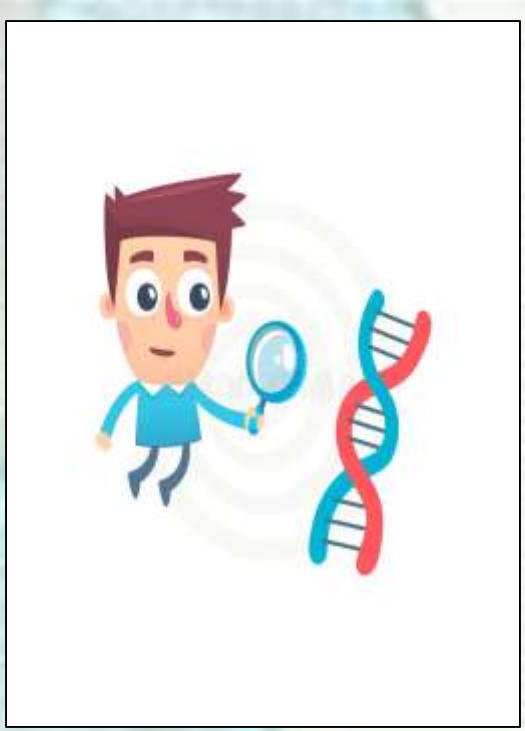
Architecture of Chromosome

Dr. Pratibha Bisen
Dept. Plant Breeding & Genetics
College of Agriculture, Balaghat
JNKVV Jabalpur (M.P.)



Introduction



✓ **Chromosome**, the microscopic threadlike part of the cell that carries hereditary information in the form of genes.

✓**Chromosome= chroma (colour) + some (body)**

✓In 1842, Karl Wilhelm von Nageli, a swiss botanist discovered a structure which later known as chromosomes.

✓Chromosomes were first discovered by **Strasburger** in 1815 .

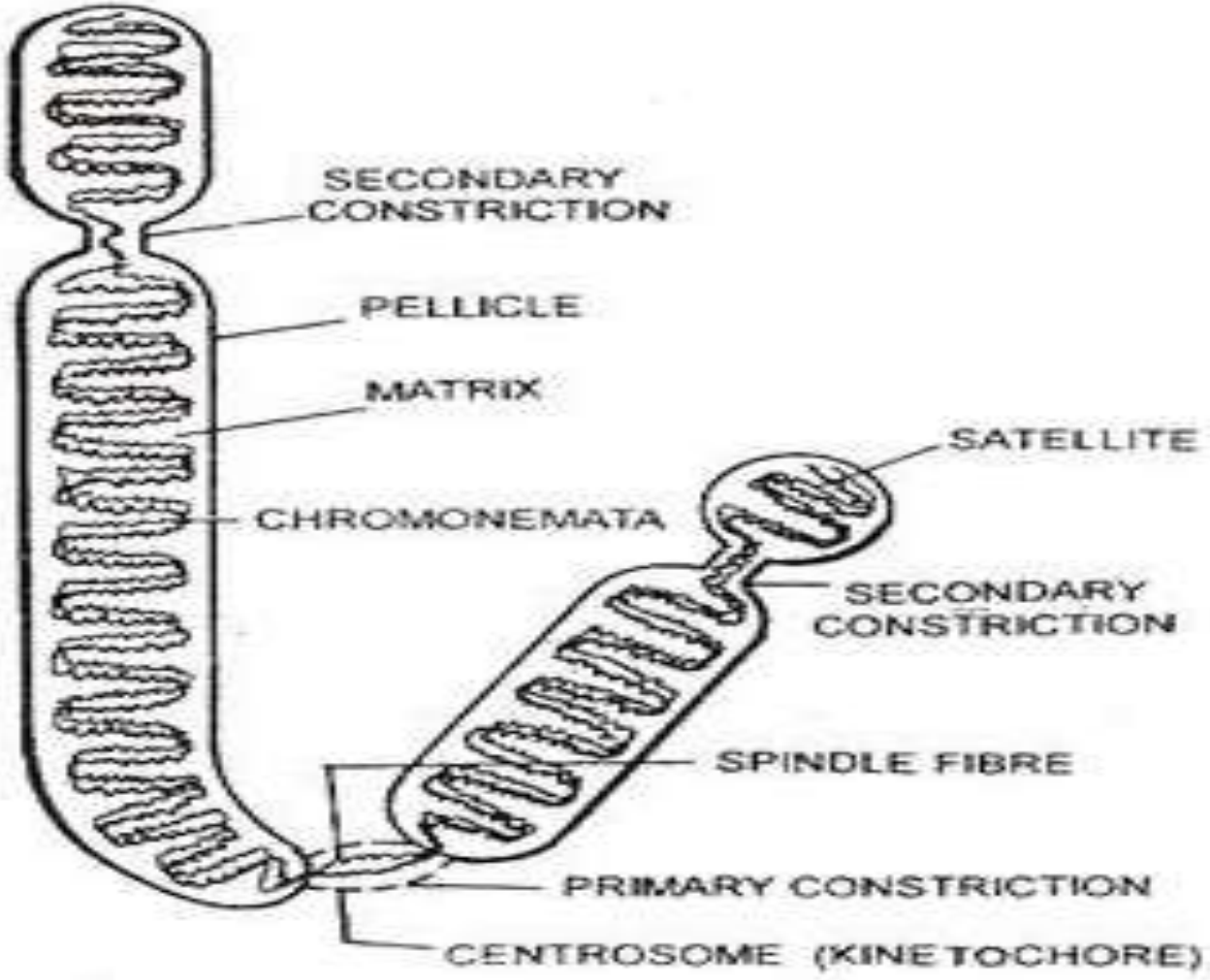
✓Term ‘chromosome’ was first used by **Waldeyer** in 1888.

"***An essential element of life- chromosomes are located in the nucleus of a cell on which the entire genomic DNA of an organism is arranged***."

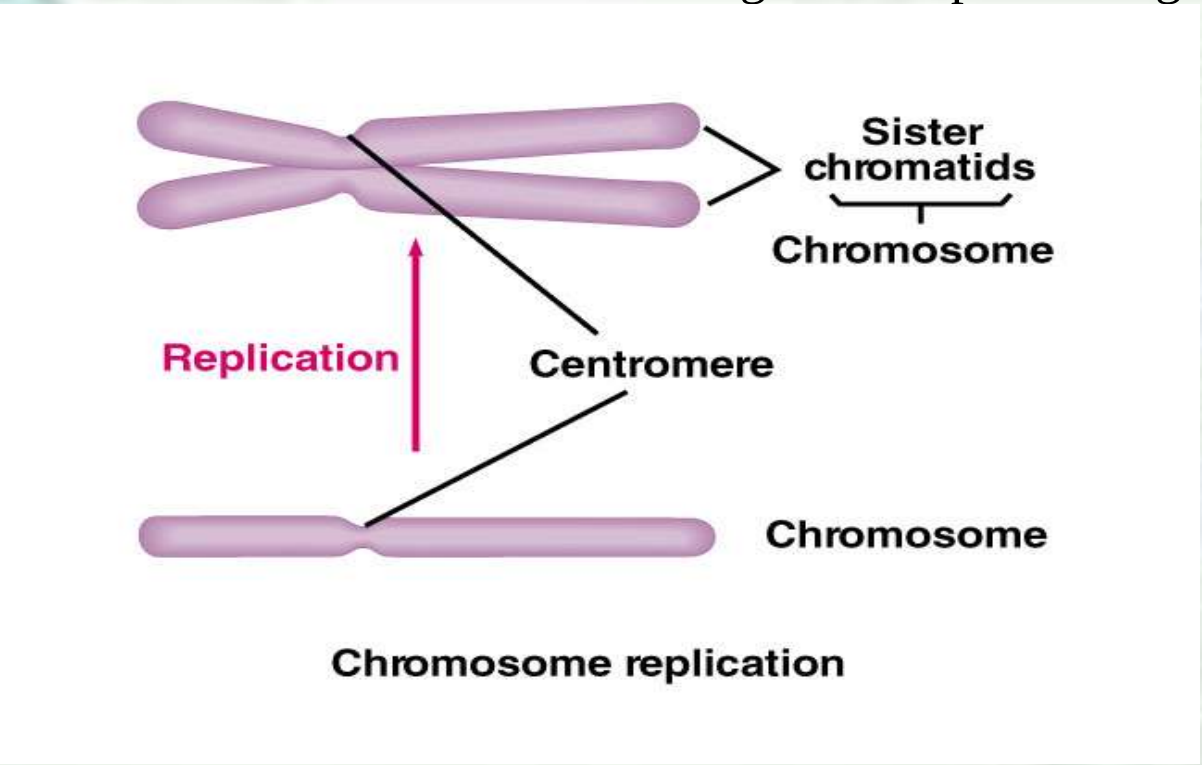
✓Different species have a different number of chromosome based on their genome size.

Organism	**Number of chromosomes (2n)**
Human	46
Potato	48
RIce	24
Monkey	42
Mouse	40

Structure of Chromosome

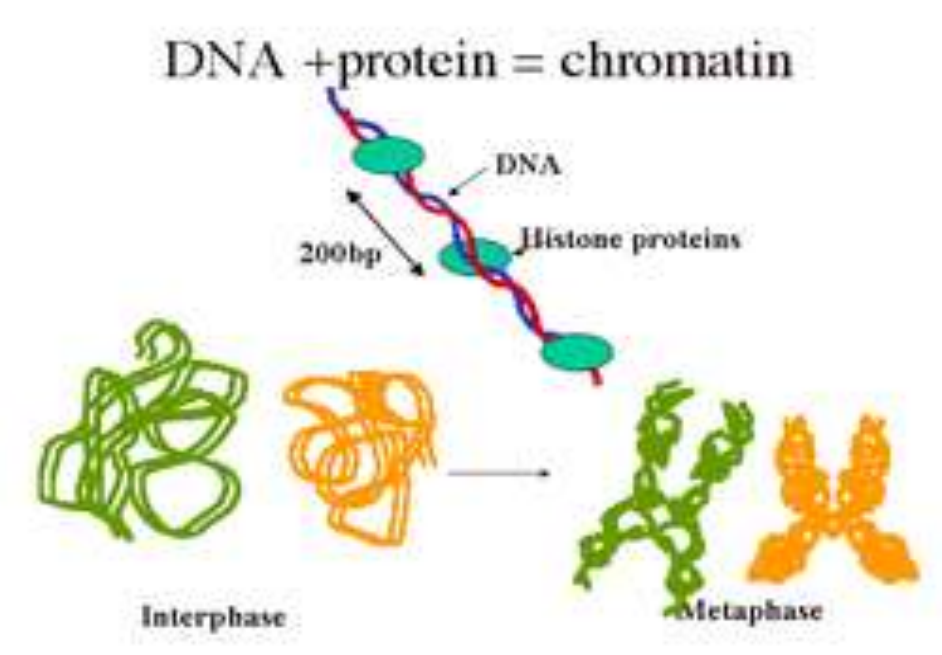


✓**Centromere or Kinetochore**: It is the primary constriction at the center to which the chromatids or spindle fibers are attached. Its function is to enable movement of the chromosome during the anaphase stage of cell division.

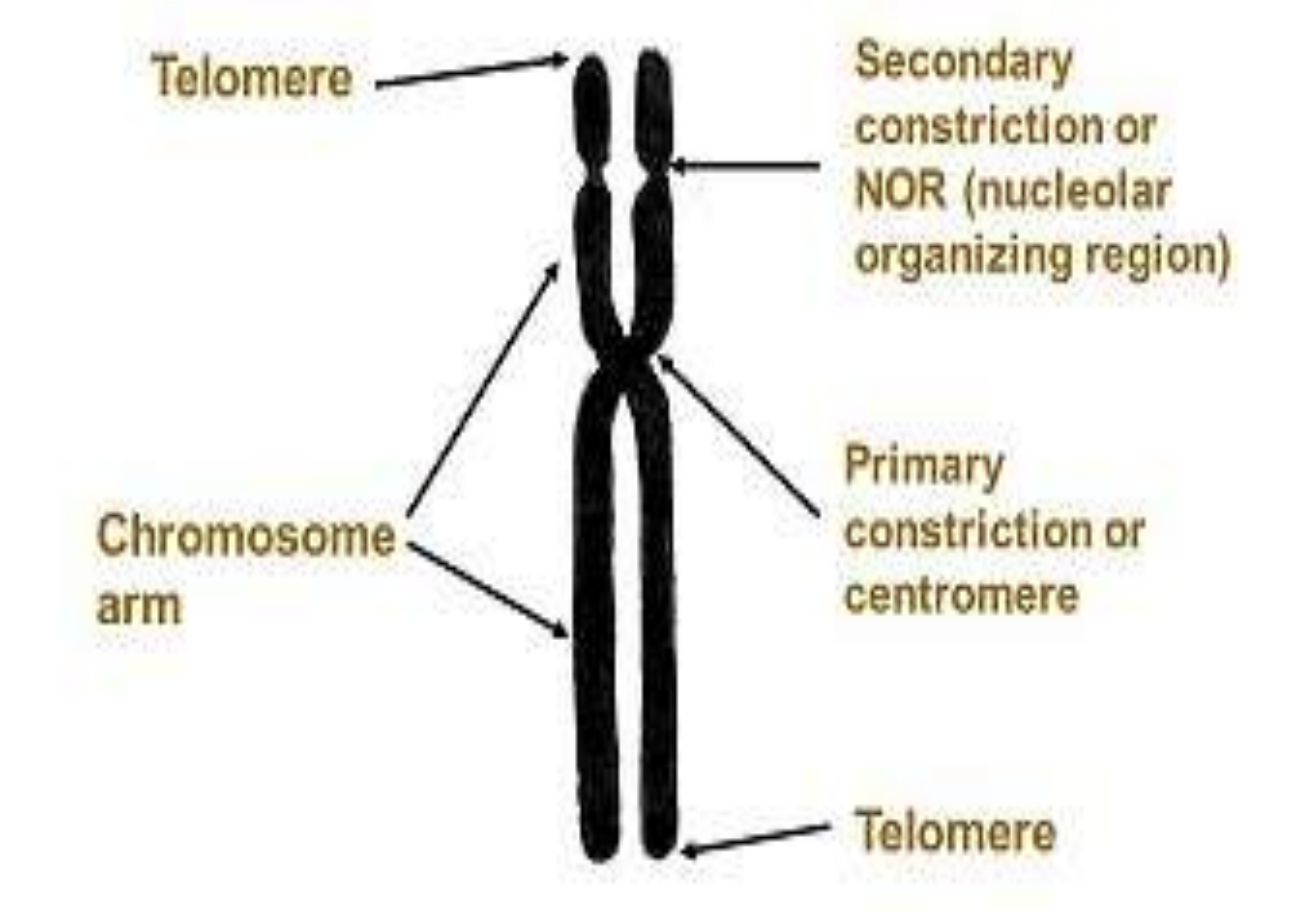


✓**Chromatid:** During cell division, a chromosome is divided into 2 identical half strands joined by a centromere. A chromatid is each half of the chromosome joined. Each chromatid contains DNA and separates at Anaphase to form a separate chromosome. Both chromatids are attached to each other by the centromere.

✓**Chromatin:** It is a complex of DNA and proteins that forms chromosomes within the nucleus of eukaryotic cells. Nuclear DNA is highly condensed and wrapped around nuclear proteins in order to fit inside the nucleus. In other words, it is not present as free linear strands. The chromatin consists of DNA, RNA, and protein.



✓**Secondary Constriction:** It is generally present for the nucleolar organization.



✓**Chromonema:** It is a threadlike coiled filamentous structure along which chromomeres are arranged. Chromonema controls the size of the chromosome and it acts as a site of gene bearing.

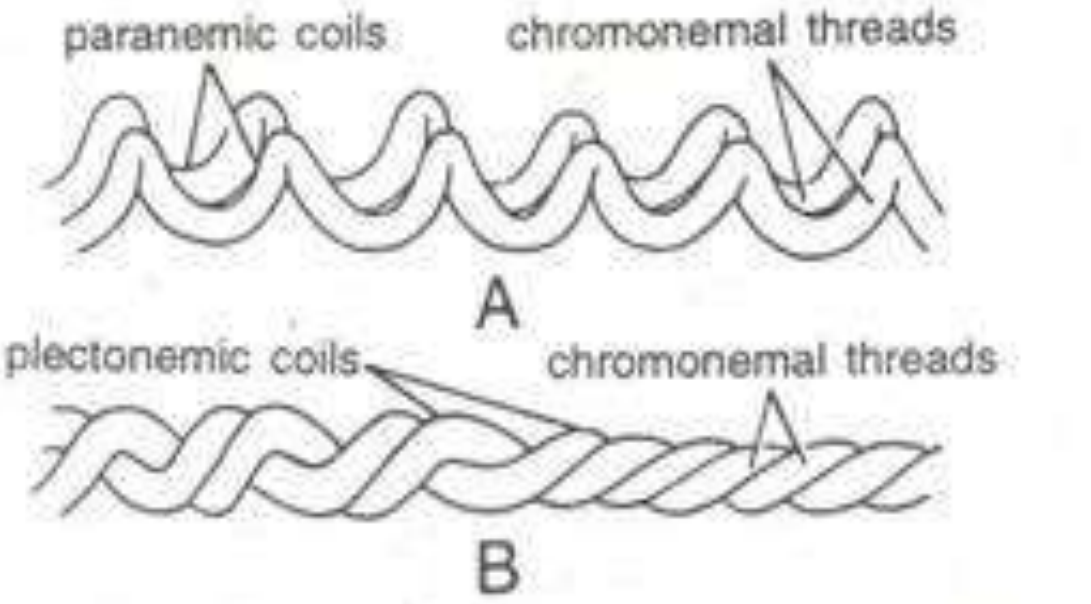
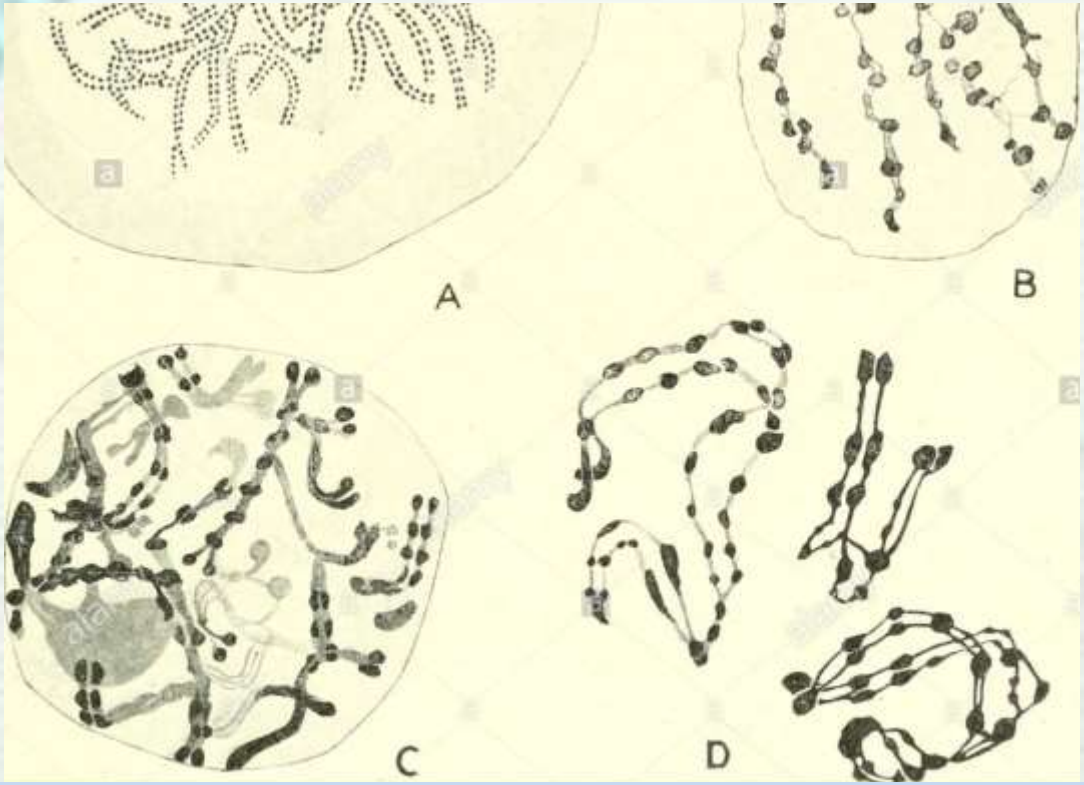


Fig. 3. Two types of coils of chromonemal threads.

✓**Chromomeres:** These are the bead-like structures present on threads or chromonema. These are arranged in a row along the length of chromonema. The number of chromosomes is constant and it is responsible for carrying the genes during cell division to the next generation.

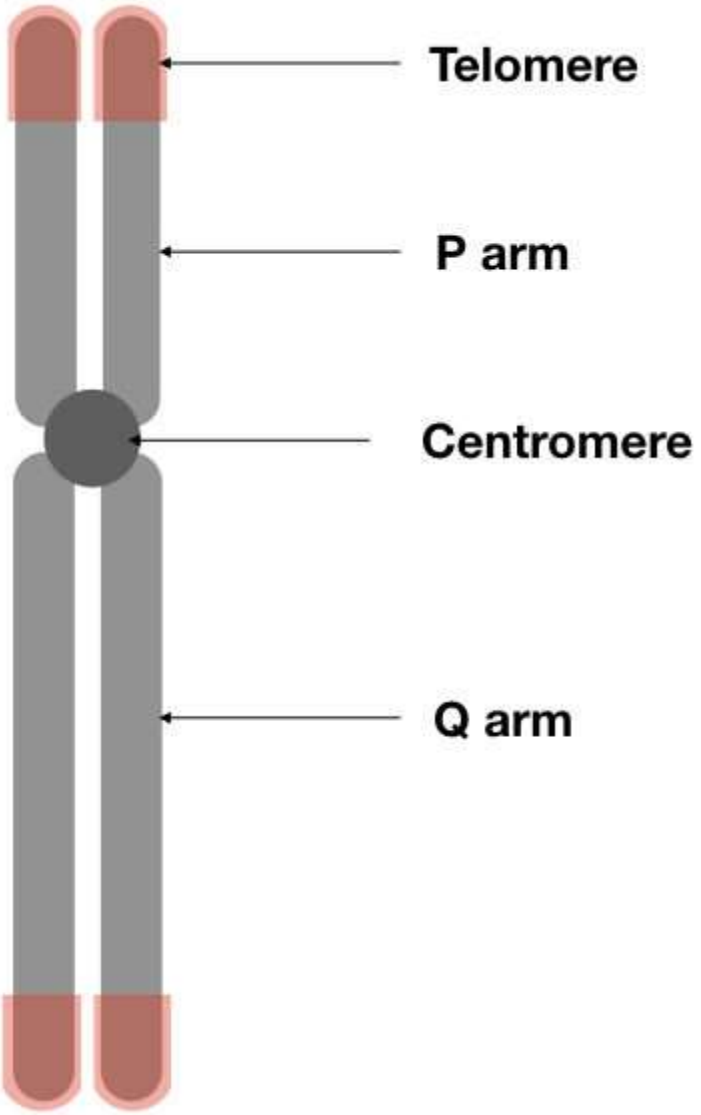
✓**Matrix:** Pellicle is the membrane surrounding each of the chromosomes. Matrix is the jelly-like substance present inside pellicle. It is formed of non-genetic materials

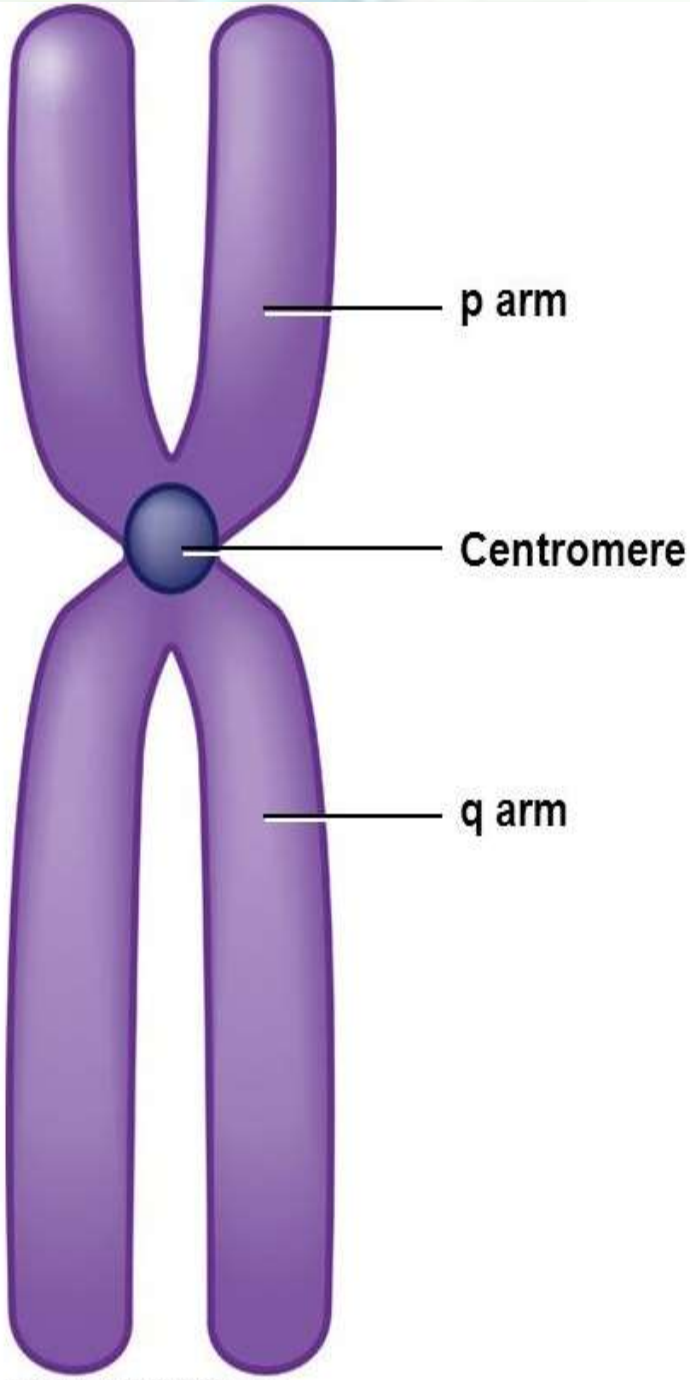


✓**Telomere:** Telomere is the terminal region of each side of the chromosome.

✓Telomeres are the end of chromosomes which protects gene-rich region- and are made up of the repetitive DNA sequence, the non-coding DNA sequences on the telomeres are categorised in microsatellite and minisatellite.

✓The repetitive sequences are highly packed and thus does not encodes any protein however, it protects other genes from the cells own mistake called “end replication problem.”





✓Each chromosome has a constriction point called the centromere, which divides the chromosome into two sections, or "arms."

✓The short arm of the chromosome is labeled the "p arm."

✓The long arm of the chromosome is labeled the "q arm."

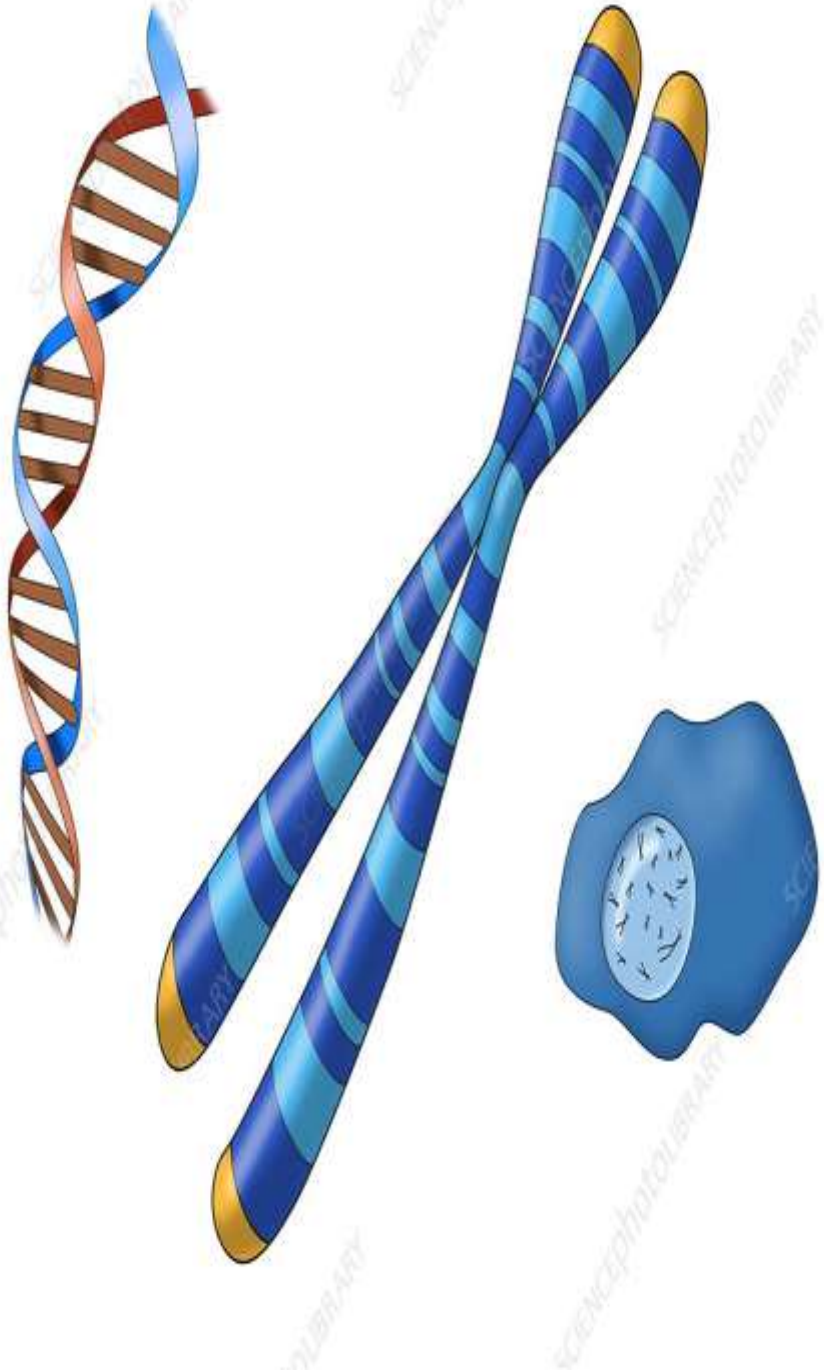
✓The location of the centromere on each chromosome gives the chromosome its characteristic shape, and can be used to help describe the location of specific genes.

✓Arms are the complex network of protein and DNA where genes are located.

✓The densely packed area of arms is called heterochromatin region- a gene less region, rich in non-coding DNA.

✓On the other hand, the loosely packed region is known as euchromatin region- a gene-rich region. The tip of each arm is protected by the structure called telomeres.

✓“Higher the length of arms, more genes it contains.”



Classification of Chromosome on the base of centromere location

Metacentric

Classification of Chromosome on the base of centromere location

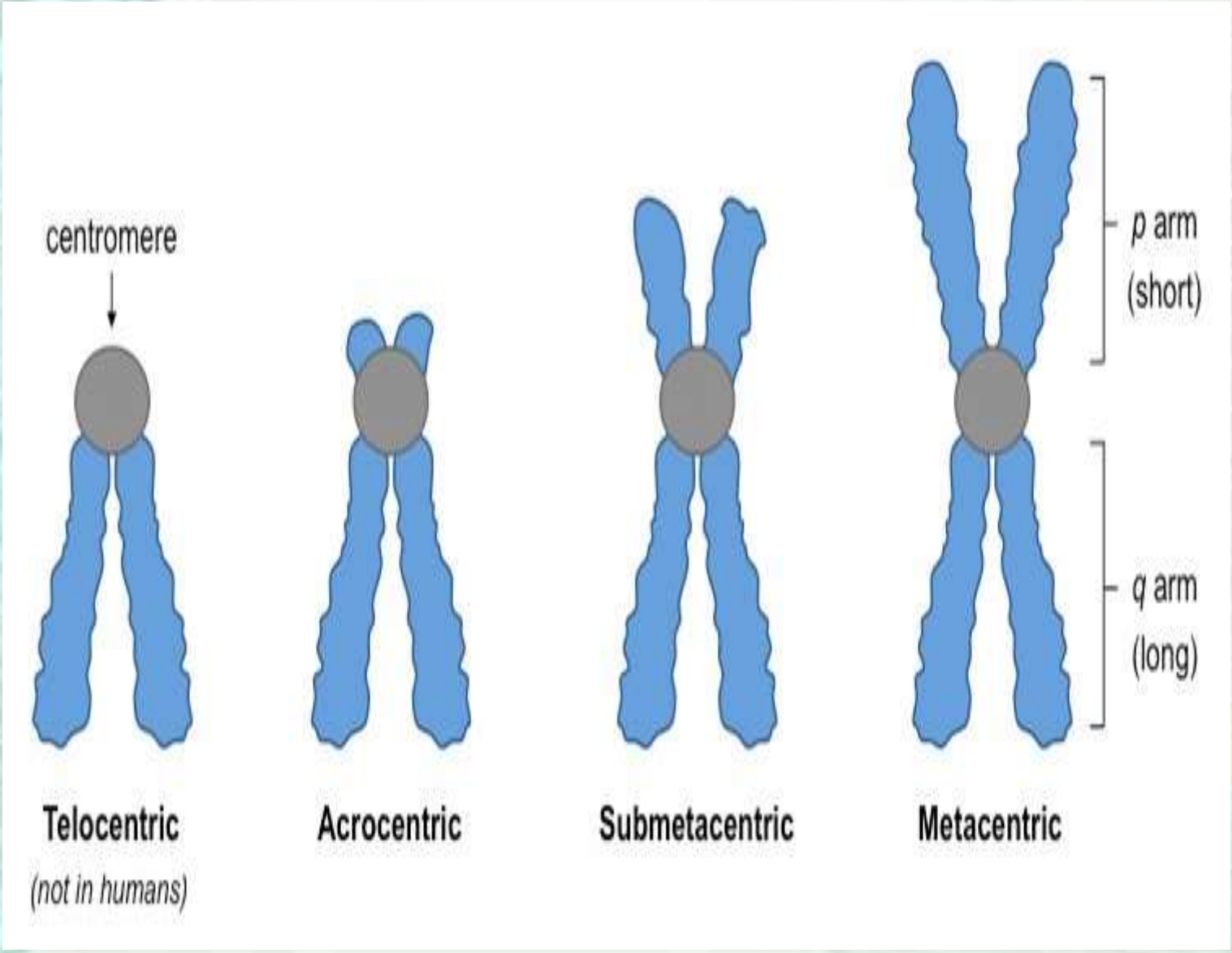
- Metacentric
- Sub Metacentric

Classification of Chromosome on the base of centromere location

- Metacentric
- Sub Metacentric
- Acrocentric

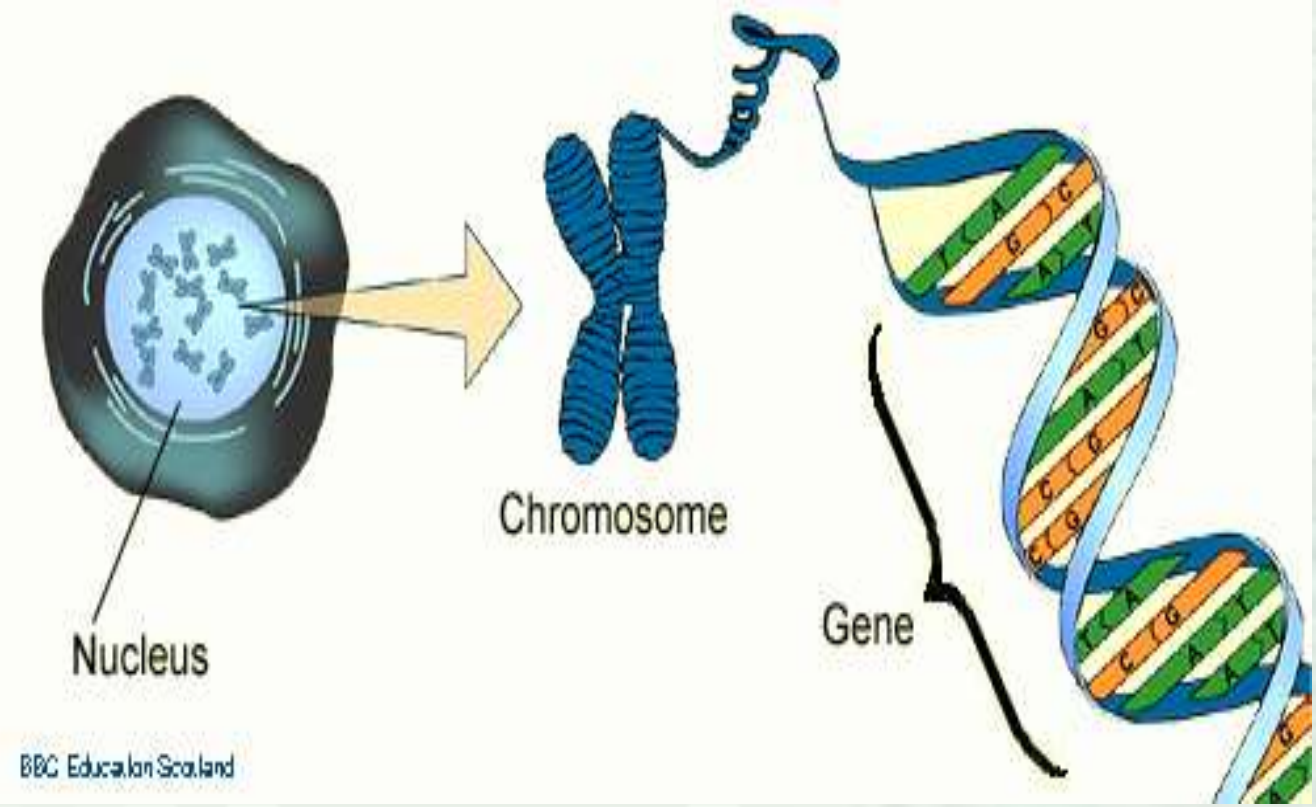
Classification of Chromosome on the base of centromere location

- Metacentric
- Sub Metacentric
- Acrocentric
- Telocentric


centromere
p arm
(short)
q arm
(long)
Telocentric
(not in humans)
Acrocentric
Submetacentric
Metacentric

Function of chromosomes

The *DNA of the chromosomes carry genes*, which are responsible for *transfer of hereditary characters from parents to offspring*. Thus, chromosome is also termed as ***"Thread of Life."***



Function of chromosomes

✓Chromosomes facilitate proper **cell division and replication**.

✓The main function of the chromosome is to **fit the DNA inside the nucleus**. As we all know, that our DNA is too long, if we unwind all the DNA of a cell, it is up to 2 meters in length.

✓Hence it is very important to fit it inside the nucleus which is facilitated by chromosomes. By interacting with proteins DNA forms a coiled structure-chromosome.

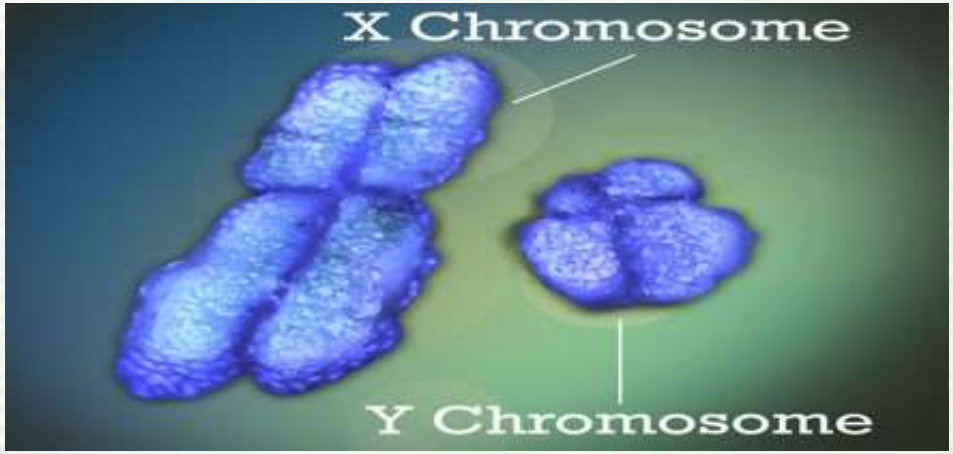
✓Furthermore, sex chromosomes decide the sex of the embryo.

✓The process of sex determination and sex differentiation is governed by genes located on autosomes and sex chromosomes.

Important terms

✓Autosomes:

Autosomes are chromosomes apart from the sex chromosomes in a eukaryotic cell. In humans, the X and Y chromosomes are the sex chromosomes. All the chromosomes other than the sex chromosomes are autosomes.



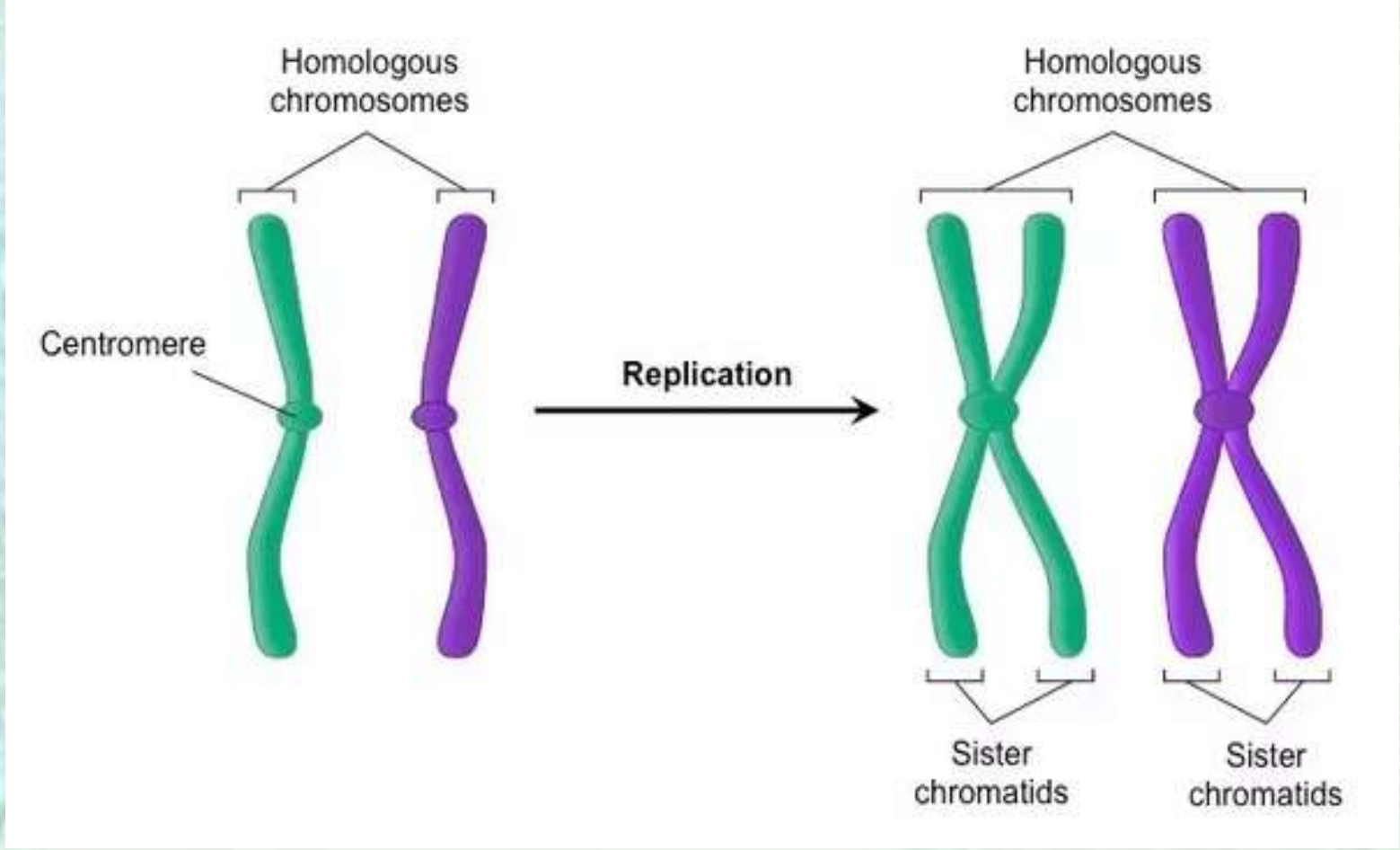
✓Allosomes

An allosome is a sex chromosome that differs in size, form and behaviour from an autosome. Humans have one pair of allosomes These chromosomes contain genes that determine the biological sex of an organism.

These chromosomes form pairs. The X and the Y chromosomes pair together during meiosis and this pair helps in sex determination.

✓Homologous Chromosomes

Homologous chromosomes consist of alleles of the same type of genes in the same loci that are paired during meiosis.



✓Non-homologous chromosomes

✓Non-homologous Chromosomes are chromosomes that do not belong to the same pair. Generally, the shape of the chromosome, that is, the length of the arms and the position of the centromere, is different in non-homologous chromosomes.

✓ Therefore, non-homologous chromosomes do not pair during meiosis. Each chromosome of a particular organism only pairs with its homologue.

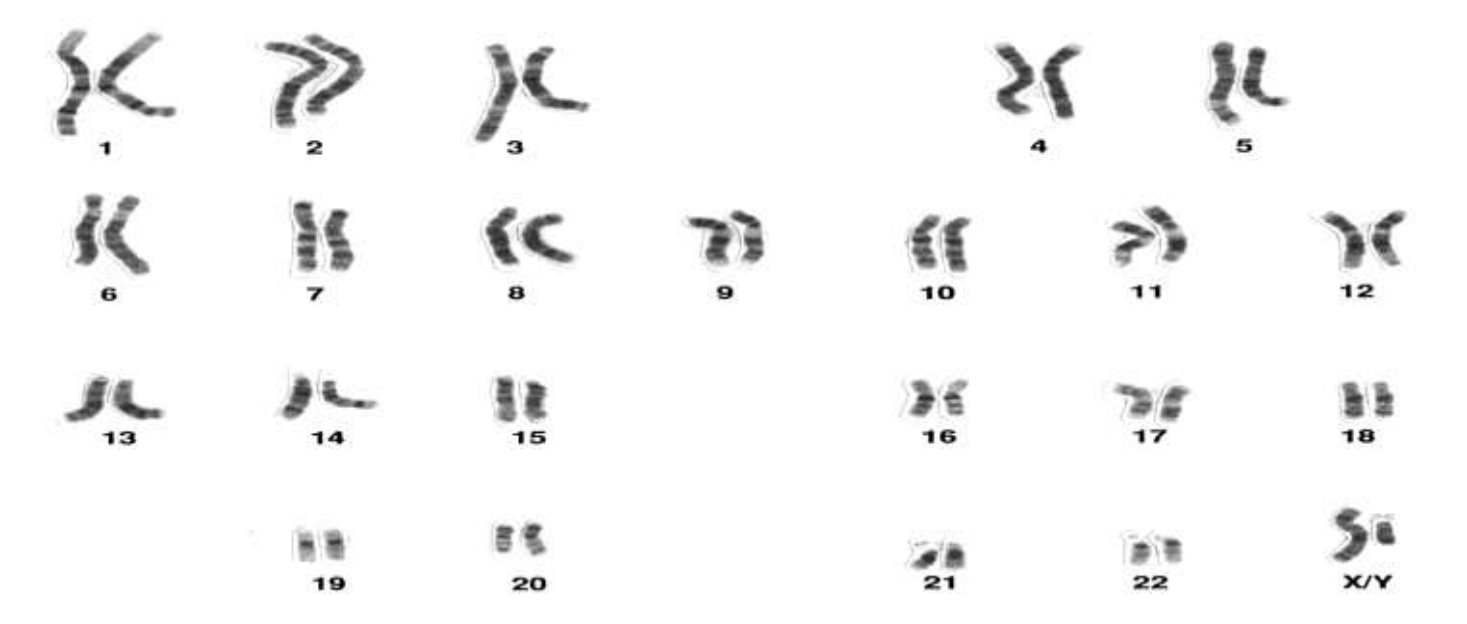
✓This means homologous pairs segregate from other chromosomes of the nucleus as described by the Law of segregation.

✓Karyotype

✓A karyotype is a diagram that shows the chromosomal number and constitution in the cells' nucleus.

✓It consists of a whole set of homologous chromosome pairs, arranged in decreasing series of their size.

✓Moreover, it reveals information regarding the number, size, shape, position of centromeres of each chromosome, length of chromosomal arms, presence of secondary constrictions and satellites, etc.



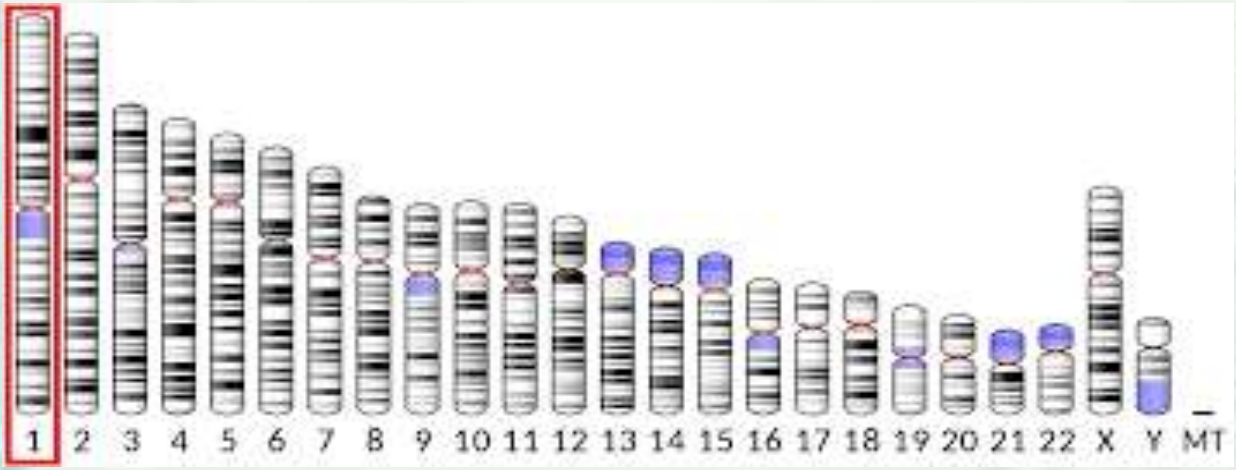
✓Idiogram

•Idiogram is a diagrammatic representation or a schematic diagram of a karyotype of a species.

•Idiogram shows the chromosome maps indicating the locations of genes as bands.

•It is not an actual picture of total chromosomes of a cell. However, ideogram provides much information about each chromosome.

• Most importantly, it provides locations of individual genes present in a chromosome.



Special types of Chromosomes

Giant chromosomes

✓Some cells at certain particular stage of their life cycle contain large nuclei with giant or large sized chromosomes.

✓Giant chromosomes were first time observed by **E.G. Balbiani** in the year 1881 in **nuclei of certain secretory cells (salivary glands) of Chironomas larvae (Diptera).**

Special types of Chromosomes

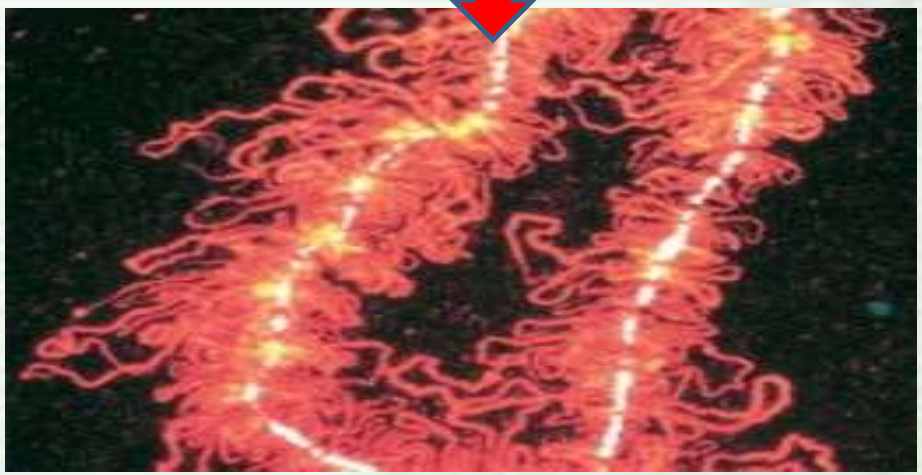
Giant chromosomes

Polytene Chromosome

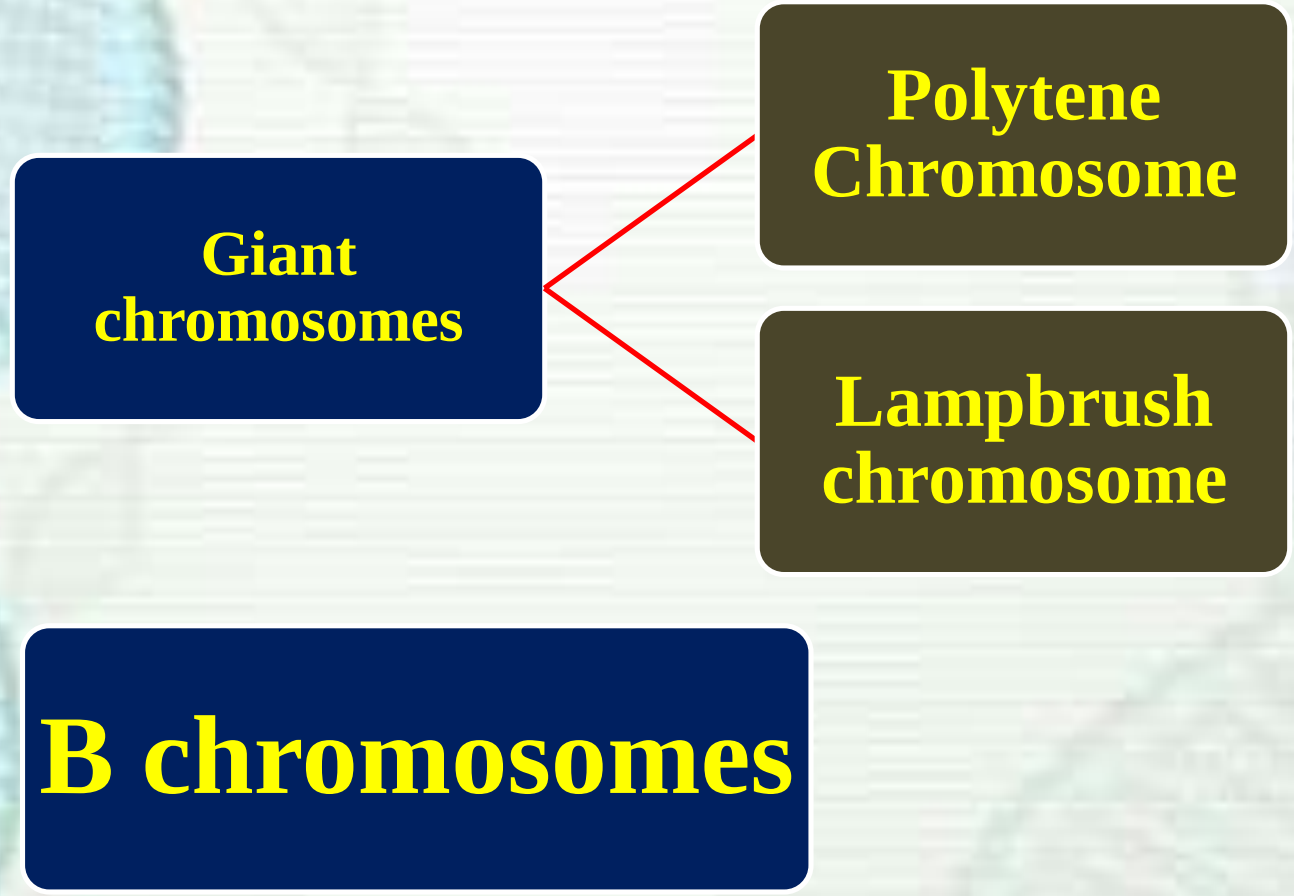
Special types of Chromosomes

Giant chromosomes

- **Polytene Chromosome**
- **Lampbrush chromosome**



Special types of Chromosomes



Polytene Chromosome

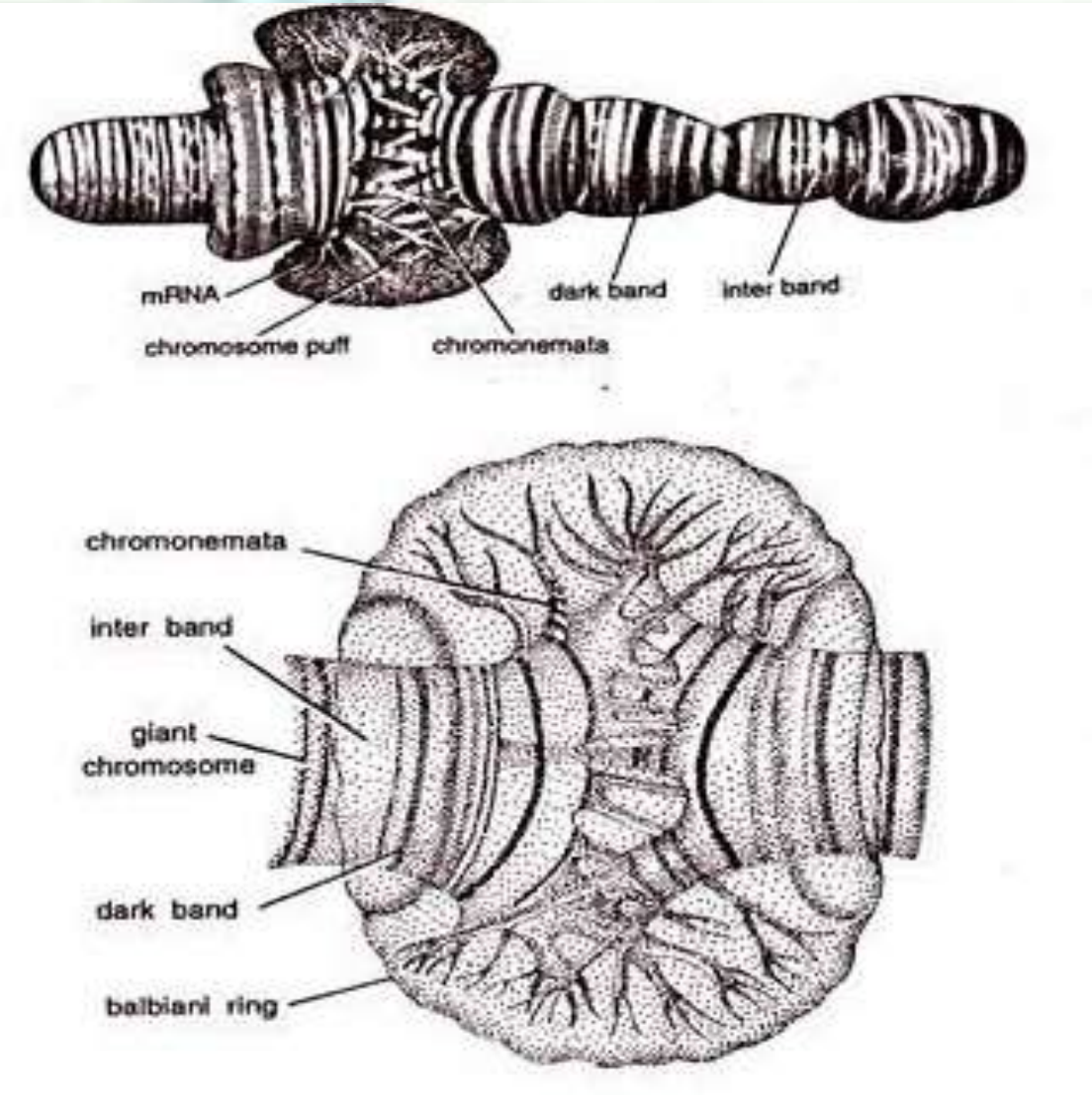
✓The polytene chromosome was proposed by **Kollar** due to the occurrence of many chromonemata (DNA) in them.

✓Cells in the larval salivary gland of Drosophila, mosquito and Chironema contain chromosomes with high DNA content.

✓They may also occur in malphigian tubules, rectum, gut, foot pads, fat bodies, ovarian nurse cells etc.

✓Polyteney of giant chromosomes happens by replication of the chromosomal DNA several times without nuclear division (**endomitosis)** and the resulting daughter chromatids do not separate but remain aligned side by side.

✓The polytene chromosomes are visible during **interphase** and **prophase** of mitosis.



✓These chromosomes are not inert cellular objects but dynamic structures in which certain regions become “puffed out” due to active DNA transcription at particular stages of development.

✓These chromosome puffs are also termed **Balbiani rings**.

✓Puffs may appear and disappear depending on the production of specific proteins which needs to be secreted in large amounts in the larval saliva.

Polytene chromosome with puff

Lampbrush chromosome

✓Lampbrush chromosomes were first observed by **Flemming** in 1882 in sections of Salamander oocytes and later described by Ruckert in the year 1892.

✓Observed during the diplotene stage of prophase I in meiosis in the oocytes of all animal species both vertebrates and invertebrates.

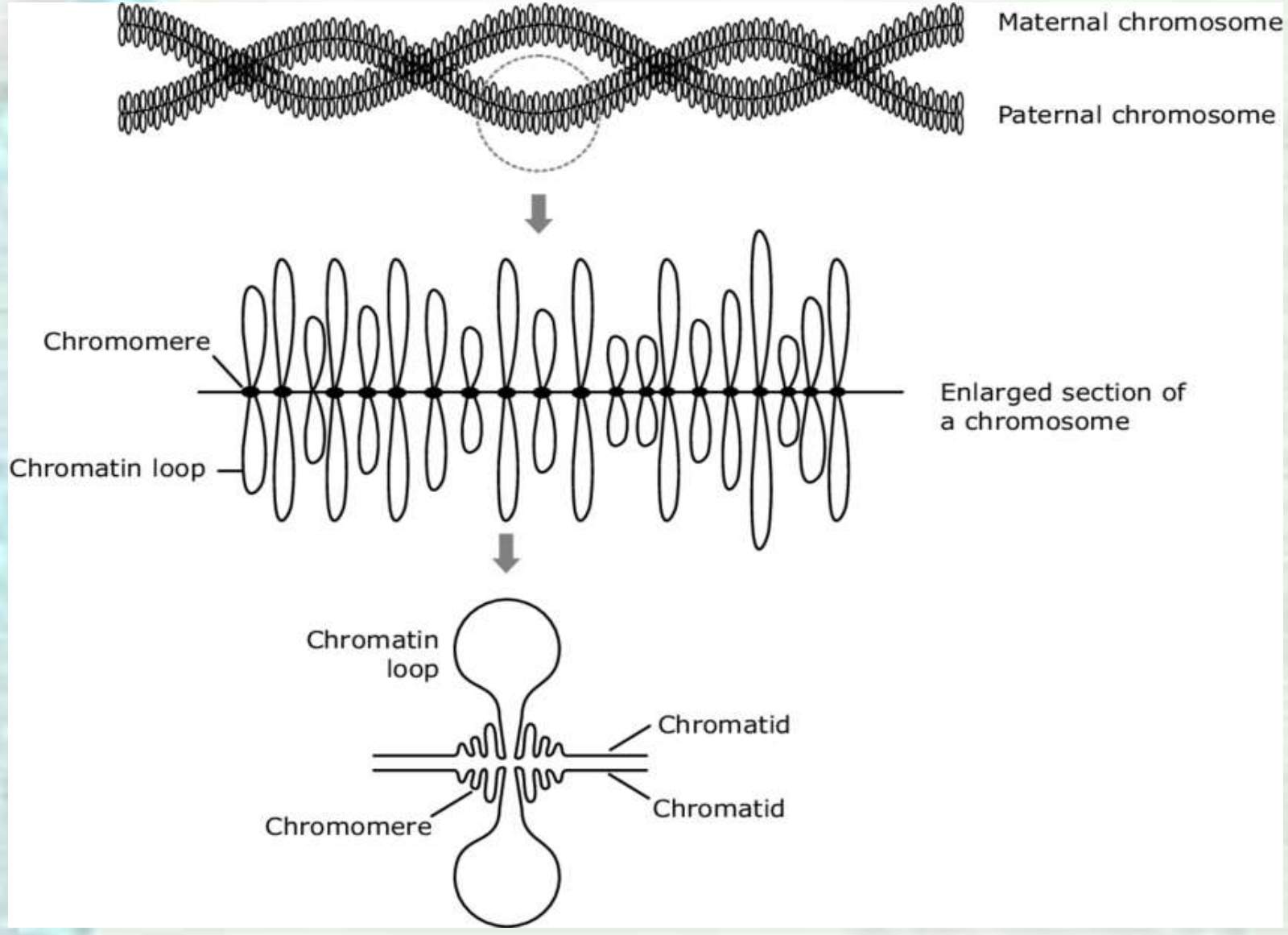
✓Generally they are smaller in invertebrates than vertebrates.

✓They appeared like brushes used for cleaning lamps, hence the name lampbrush chromosome.

✓They are formed due to the active synthesis of mRNA molecules.

✓Lampbrush chromosomes are clearly visible in the light microscope they are organized into a series of chromomeres with large chromatin symmetrical loops extending laterally.

✓Each loop appears at a constant position in the chromosome (10,000 loops per chromosome set or haploid set).



Lampbrush chromosome

B chromosomes

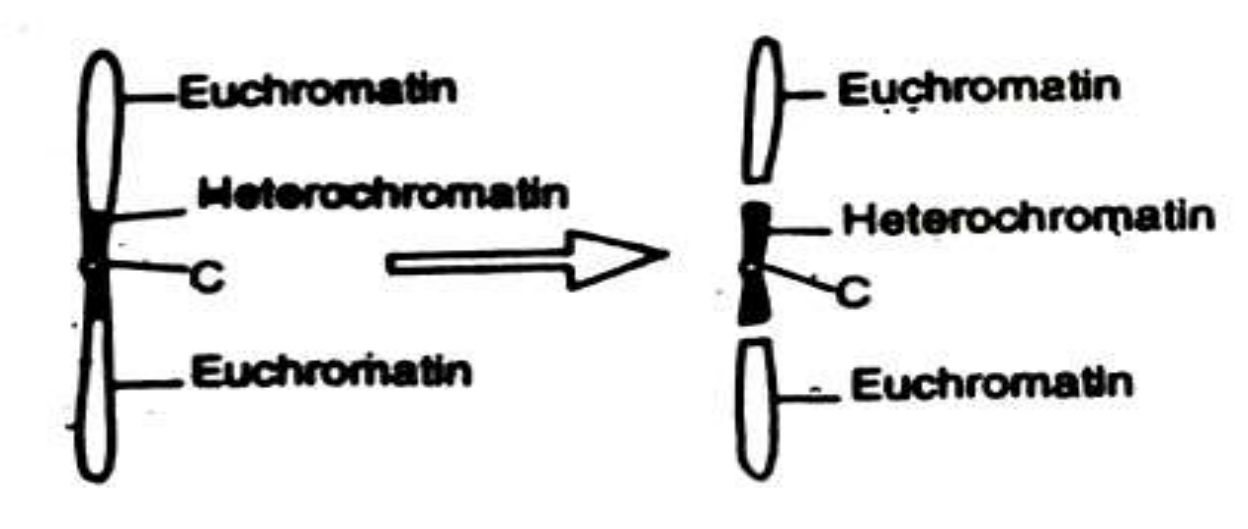
✓Many plant (maize, etc.) and animal (such as insects and small mammals) species, besides having autosomes (A-chromosomes) and sex-chromosomes possess a special category of chromosomes called B-chromosomes without obvious genetic function.

✓These B-chromosomes (also called supernumerary chromosomes, accessory chromosomes, accessory fragments, etc.) usually have a normal structure, are somewhat smaller than the autosomes and can be predominantly, heterochromatic (many insects, maize, etc.) or pro-dominantly euchromatic (rye).

✓In maize, their number per cell can vary from 0 to 30 and they adversely affect, development and fertility only when occur, in large amount.

✓ In animals, the B-chromosomes disappear from the non-reproductive (somatic) tissue and are maintained only in the cell-lines that lead to the reproductive organs.

✓B-chromosomes have negative consequences for the organism, as they have deleterious effect because of abnormal crossing over during the meiosis of animals and abnormal nucleus divisions of the gametoophyte plants.
✓The origin of the B-chromosomes is uncertain. In some animals they may be derivatives of sex chromosomes, but this is not the rule.
✓They generally do not show any pairing affinity with the' A-chromosomes.



THANK YOU