B.Sc. Botany – 2ND SEM
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Nucleosome Model for Structural Organisation of Chromosomes

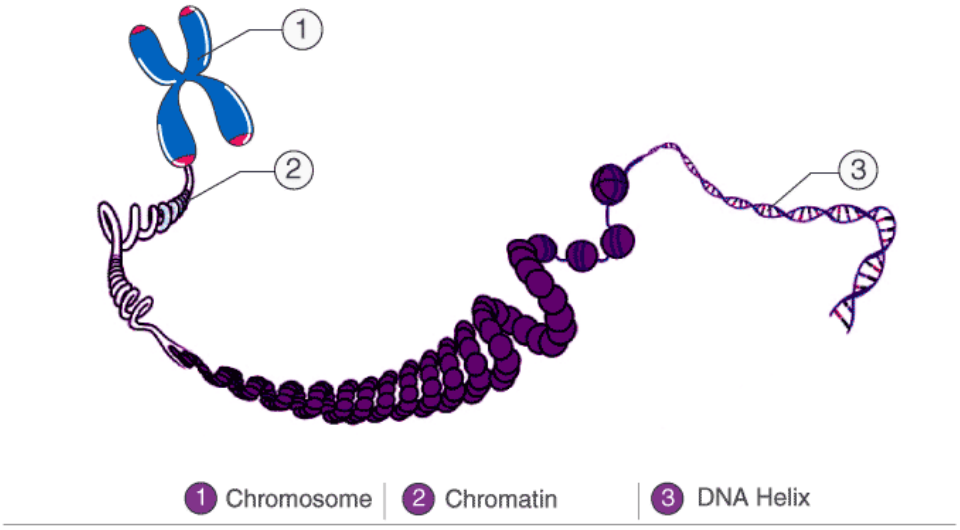
- **R. D. Kornberg** proposed the nucleosome model of basic chromatin material in 1974. Later in 1975, P. Oudet coined the term nucleosome.
- A eukaryotic chromosome's structural unit called a nucleosome is composed of DNA coiled around a core of proteins called histones.
- Chromosome is made up of **chromatin.** Chromatin is made up of DNA, RNA and proteins. At interphase, chromosomes are visible as thin chromatin fibres present in the nucleoplasm. During cell division, the chromatin fibres condense and chromosomes are visible with distinct features.

- The darkly stained, condensed region of chromatin is known as **heterochromatin.** It contains tightly packed DNA, which is **genetically inactive**
- The light stained, diffused region of chromatin is known as **euchromatin.** It contains **genetically active** and loosely packed DNA
- Chromatin consists of DNA and associated proteins. DNA is packaged in a highly organised manner in chromosomes

1. **Nucleosomes** are the basic unit of chromatin. It is 10 nm in the diameter
   - DNA packing is facilitated by proteins called **histones.** DNA is wound around histone proteins to form a nucleosome
   - There are 5 types of histone proteins in the eukaryotic chromosomes, namely **H1, H2A, H2B, H3 and H4**
   - **Histones are positively charged due to the presence of amino acids** with basic side chains and it associates with negatively charged DNA due to the presence of phosphate groups
   - Histone proteins play an important role in **gene regulation**
   - A typical **nucleosome contains 200 bp of DNA helix. The core particle of the nucleosome consists of approximately 146 base pairs (bp) of DNA coiled around a core of eight histone molecules (2 molecules of 4 histone proteins). That is linked by linker DNA of about 80 bp.**

- Nucleosomes prevent DNA from getting tangled

2. Linker DNA and the fifth histone (H1) pack adjacent nucleosomes to a 30 nm **compact chromatin fibre**
3. These fibres form a large coiled loop held together by non-histone proteins (actin, **α** and **β** tubulin, myosin) called **scaffolding proteins** to form **extended chromatin** which is 300 nm in diameter
4. Chromatin further condenses with the help of protein known as **condensin,** it binds to DNA and wraps it into coiled loops and we get the compacted chromosome.



Chromatin is a complex of DNA and protein found in eukaryotic cells and it helps in packaging the long DNA molecules inside the cell nucleus.

Types of Chromosomes

A. Autosomes and Sex Chromosomes

Human chromosomes are of two types- autosomes and sex chromosomes. Genetic traits that are linked to the sex of the person are passed on through the sex chromosomes. The rest of the genetic information is present in the autosomes. Humans have 23 pairs of chromosomes in their cells, of which 22 pairs are autosomes and one pair of sex chromosomes, making a total of 46 chromosomes in each cell.

B. On the Basis of Number of Centromeres

1. **Monocentric** with one centromere.

2. **Dicentric** with two centromeres.

3. **Polycentric** with more than two centromeres

4. **Acentric** without centromere. Such chromosomes represent freshly broken segments of chromosomes which do not survive for long.

5. **Diffused or non-located** with indistinct centromere diffused throughout the length of chromosome.

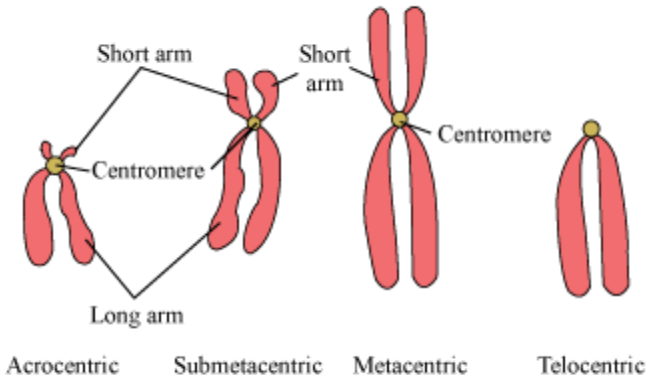
C. On the Basis of Location of Centromere

1. Telocentric are rod-shaped chromosomes with centromere occupying the terminal position, so that the chromosome has just one arm.

2. **Acrocentric** are also rod-shaped chromosomes with centromere occupying a subterminal position. One arm is very long and the other is very short.

3. **Sub-metacentric** chromosomes are with centromere slightly away from the midpoint so that the two arms are unequal.

4. **Metacentric** are V-shaped chromosomes in which centromere lies in the middle of chromosome so that the two arms are almost equal.



Types of chromosomes

Giant Chromosomes

i. Polytene chromosome

a. **Balbiani** first discovered a structure in the nuclei of secretory glands of midges

b. Painter, Heitz and Bauer, rediscovered them in the **salivary gland of Drosophila** and recognised them as a chromosome

c. Also known as **Salivary gland chromosome**

d. These are called polytene by **Kollar** due to the presence of many chromonemata in them

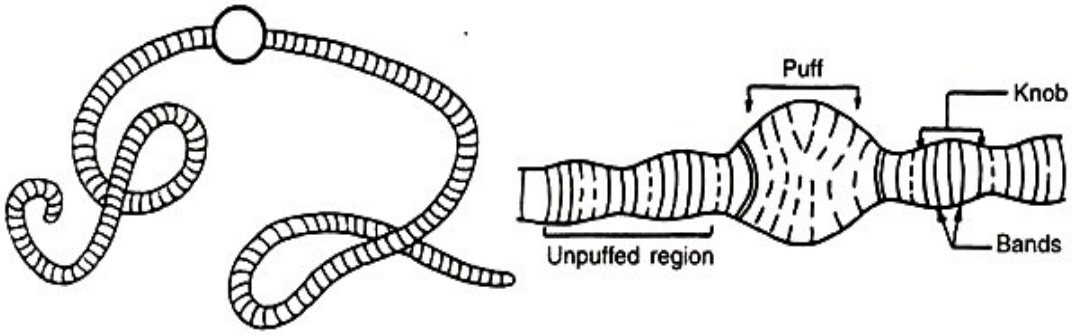
e. These are present in some cells of the larvae of **Dipteran insects**

f. These are very large due to the presence of **high DNA content**

g. The polytene chromosome of **Drosophila's salivary gland has 1000 DNA molecules Chironomus has 1600 DNA molecules** in its each polytene chromosome

h. There is a series of alternating dark and clear bands called interband

i. Chromosome puffs or **Balbiani rings** are present, which are the swelling of bands due to DNA unfolding into open loops. These are the region of the intense transcription or mRNA formation



(*a*) Entire chromosome (*b*) Enlarged view of a part

ii Lampbrush chromosome

a. First discovered in the **oocytes of salamander**

b. The name is given due to its resemblance with **a brush** that is used for cleaning lamp, glass chimneys, etc.

c. They occur at the **diplotene stage of oocytes** in vertebrates and invertebrates

d. Lampbrush chromosomes are also found in the **spermatocytes of many animals** and also found in the giant nucleus of an algae **Acetabularia**

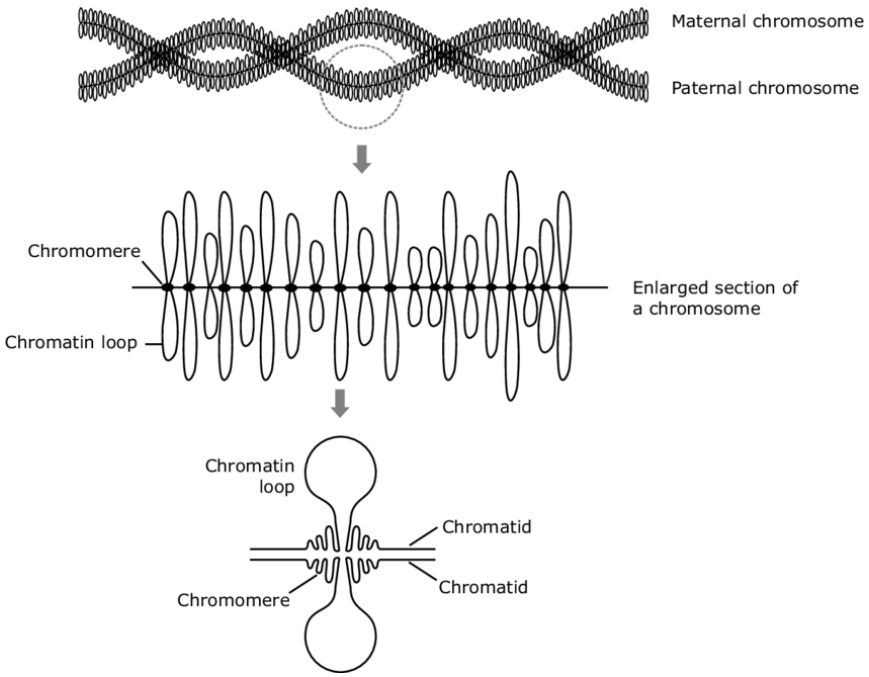
e. They are present as a **bivalent with 4 chromatids**

f. Chromosomal axis is formed from highly condensed chromatin and **lateral loops** extend from the row of chromomeres

g. Lateral loops of DNA are always symmetrical and formed due to intense RNA synthesis

h. In the oocytes of salamander, there are 10,000 loops present per haploid set of chromosomes

i. The centromere doesn't bear any loops



Functions of Chromosomes

- The main function of chromosomes is to **carry the genetic material** from one generation to another
- Chromosomes play an important role and act as a guiding force in the **growth, reproduction, repair and regeneration** process, which is important for their survival
- Chromosomes protect the DNA from getting tangled and damaged
- Histone and non-histone proteins help in the regulation of gene expression
- Spindle fibres attached to the centromere help in the movement of the chromosome during cell division
- Each chromosome contains thousands of genes that precisely code for multiple proteins present in the body