Nucleus

Nucleus as a cell organelle was first described by **Robert Brown** as early as 1831.

Nucleus is a relatively large organelle controlling all the activities of the eukaryotic cells. Some cells have more than one nucleus, *e.g.*, **binucleate** cells have two nuclei per cell (***Paramoecium***), while **multinucleate** ones have many nuclei, *e.g. Opalina*. However, some cells lack nucleus (**anucleate**) at maturity, such as, **mammalian RBCs** and **sieve tube cells.**

Nucleus is a store house of hereditary information was proved by Hammerling (1953) on the basis of his studies on *Acetabularia* (Unicellular green alga).

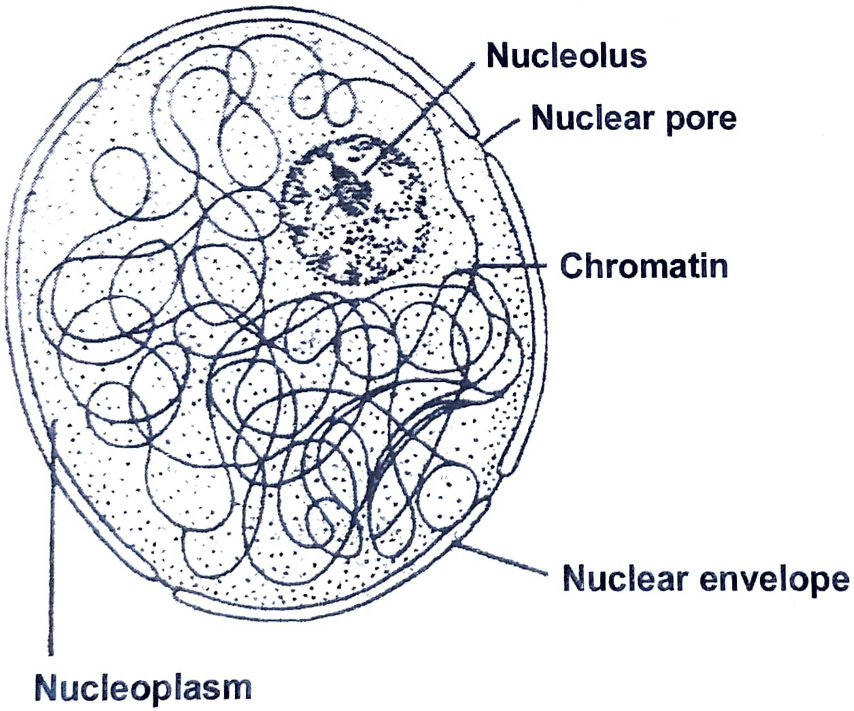

Fig. : Structure of a Nucleus

Structure: A nucleus in non-dividing phase is called interphase nucleus and a typical interphase nucleus is differentiated into nuclear envelope, nucleoplasm or nuclear matrix, nucleolus and chromatin.

(i) **Nuclear Envelope :** It bounds the nucleus on the outside and separates it from the cytoplasm. It is made up of two membranes-outer and inner. The inner membrane is smooth whereas the outer membrane may be smooth or its cytoplasmic surface may bear ribosomes like the RER. The outer membrane is often connected to ER. These two membranes of the nuclear envelope are separated by a space known as **perinuclear space.**

Nuclear envelope contains a large number of complex pores which are formed by the fusion of its two membranes. The nuclear pores control the passage of substances to inside or outside of the nucleus *e.g.*, RNA, ribosomes, proteins.

(ii) **Nucleoplasm :** It is a transparent, semi-fluid and colloidal substance which fills the nucleus. It contains **nucleolus** and highly extended and elaborate nucleoprotein fibres called chromatin.

(iii) **Nucleolus :**

(a) It is a spherical structure found in the nucleoplasm.

(b) It is not separated from rest of the nucleoplasm as it is not bounded by a membrane.

(c) It is the site for ribosomal RNA (rRNA) synthesis. Thus, nucleoli are larger and more numerous in cells that are actively involved in protein synthesis.

(iv) **Chromatin :** (Gk. *chroma* – colour) The interphase nucleus contains a loose, extended and diffused network of nucleoprotein fibres called chromatin. These are named so because of their ability to get stained with certain basic dyes by Flemming in 1879. Chromatin fibres condense to form chromosomes.

(a) Chromatin is essentially composed of DNA, basic proteins histones, RNA and some non-histone proteins. The histone proteins are the packaging proteins that are associated with packaging of DNA into compact structures called chromosomes. During different stages of cell division, cells show structured chromosomes in place of the nucleus.

(b) In higher organisms, the well-organised nucleus contains a definite number of chromosomes of definite size and shape. For example, a single human cell has approximately two metre long thread of DNA distributed among its forty six chromosomes (23 pairs of chromosomes).

Structure of a Chromosome

A chromosome consists of two identical halves, the chromatids which are held together at one point called **centromere**. The centromere appears as a narrow region called **primary constriction**, of the chromosome. On the sides of centromere, disc shaped structures are present known as **kinetochores**. Ends of chromosome are called telomeres. They seal the ends of chromosomes and prevent their shortening or chromosome loss.

Depending on the position of centromere, chromosomes can be classified into four types:

(i) **Metacentric chromosome (median centromere):** The centromere is present at the centre and thus during anaphase divides the chromosome into two equal arms (Isobrachial). They appear V-shaped.

(ii) **Sub-metacentric chromosome (submedian centromere):** The centromere is present slightly away from the centre of a chromosome or nearer to one end of the chromosome. As a result, chromosome is divided into one shorter and one longer arm (Heterobrachial). They appear L-shaped during anaphase.

(iii) **Acrocentric chromosome (subterminal centromere):** The centromere is present very close to one end of the chromosome. Thus, it forms one extremely short and one very long arm. They appear J-shaped during anaphase.

(iv) **Telocentric chromosome (terminal centromere):** The centromere is present at the terminal end of the chromosome and thus, chromosome appears to have a single arm. They appear I-shaped during anaphase.

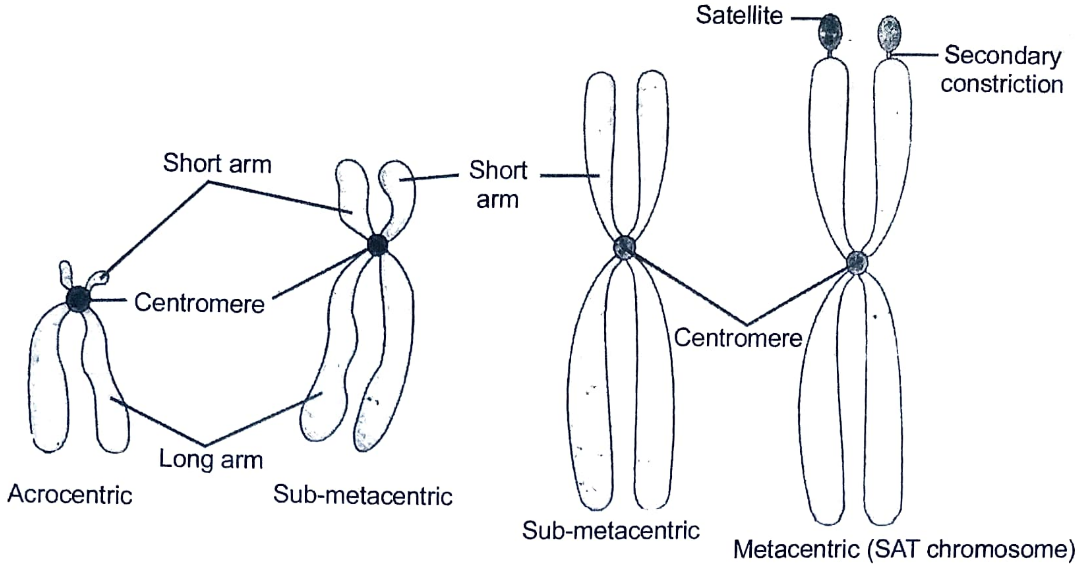

Fig. : Types of Chromosomes based on the Position of Centromere

A few chromosomes may have additional constrictions termed as non-staining **secondary constrictions** or **NOR (nucleolar organiser)** near their ends. The part of the chromosome beyond the secondary constriction is called **satellite**. A chromosome having satellite is called SAT-chromosome and these are considered as **marker chromosome**. In humans, 5 pairs of SAT chromosomes are present.

Special types of Chromosomes or Giant Chromosomes

In some organisms, the chromosomes assume special structures in some specific tissues, *e.g.,*

1. **Lampbrush chromosomes :** These were described by **Ruckert** (1892). These are present in primary oocyte nuclei of vertebrates as well as invertebrates. These are diplotene bivalent chromosomes joined at certain points called chiasmata.

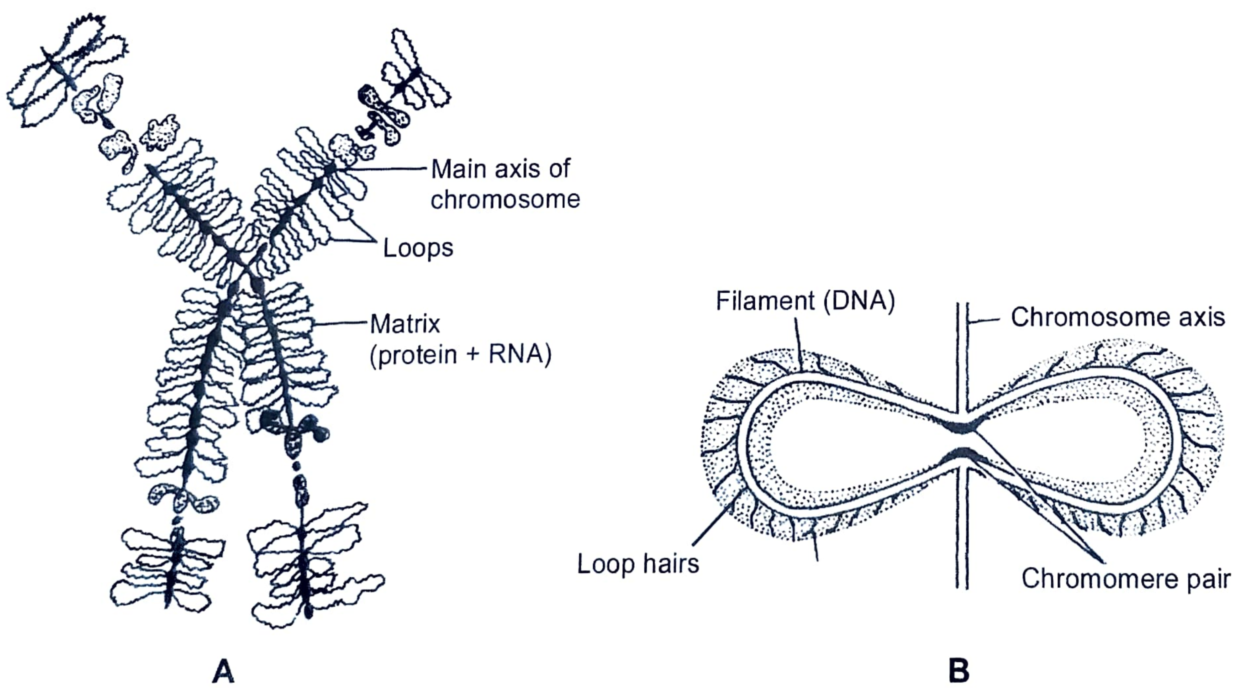

Fig. : Lampbrush chromosome: A. Enlarged view. **B**. One extended loop

Their main axis is formed by DNA. Each of the bivalents bear rows of large number of chromomeres. Many of the chromomeres give out lateral projections or loops.

Loops are extended parts of chromosomes, participating in transcription, the hairs on loops are actually **nascent RNA** molecules. These hairs are bound to proteins, giving it a fibrillar granular appearence. Some of these are stored as **informosomes** (mRNA + proteins) for future use (development of embryo).

2. **Salivary gland chromosomes or Polytene chromosomes :** In salivary gland cells of insects of order Diptera (dipteran insects), some special chromosomes were reported by **E.G. Balbiani** (1881). It is due to the presence of these giant chromosomes that maximum cytological studies have been made in *Drosophila.* Another example is *Chironomus.*

   In *Drosophila*, salivary gland chromosomes upto **2000 µm** (2 mm) have been observed. The name polytene chromosome has been given to them as there occurs polyteny *i.e.,* number of chromonemata or fibrils increases upto 2000 or more per chromosome. A characteristic feature of these chromosomes is that **somatic pairing** occurs in them and hence, their number appears half of normal somatic cells.

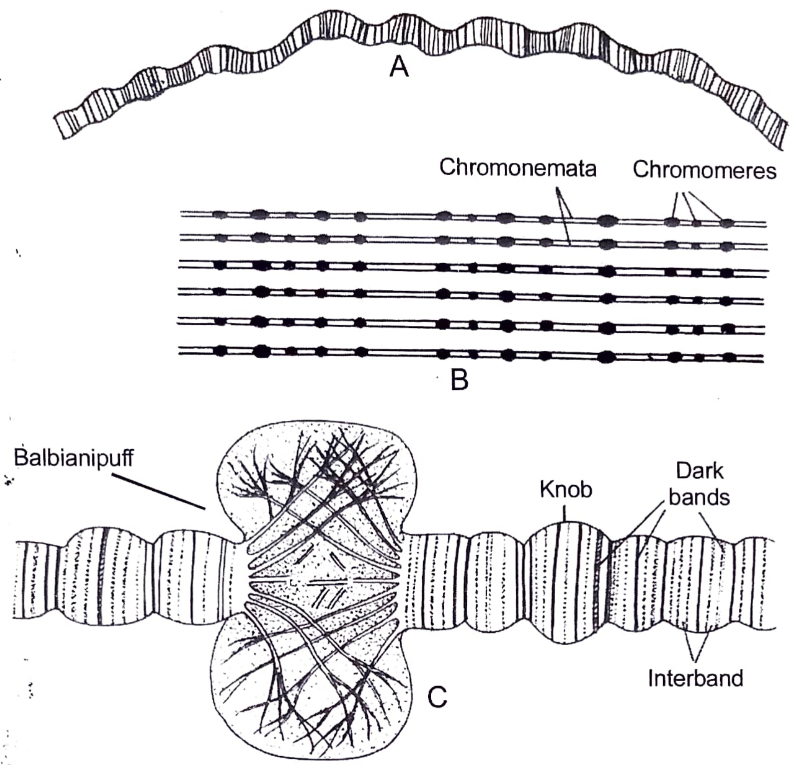

Fig. : Polytene chromosome: A. A typical polytene chromosome. **B**. Schematic representation of formation of a polytene chromosome and its dark bands by coming together of a number of chromonemata and their chromomeres. **C**. An enlarged portion of polytene chromosome showing a puff.

Microbodies

Many single membrane-bound minute vesicles called microbodies that contain various enzymes are present in both plant and animal cells. They are associated with oxidation reactions other than those of respiration. These include :

1. **Peroxisomes:** They have enzymes for peroxide biosynthesis. These occur in most of the animals and plants, but are quite common in photosynthetic cells where these perform **photorespiration**. For this, they are associated with chloroplasts and mitochondria. They possess peroxide producing (glycolate oxidase), as well as peroxide destroying enzymes (catalase).

2. **Sphaerosomes :** These are actually unit membrane bound, spherical, refractile bodies which take part in storage and synthesis of fats. These are in abundance in endosperm cells of oil seeds. These contain hydrolytic enzymes. These are believed to be plant lysosomes. They are produced from SER.

3. **Glyoxysomes :** Glyoxysomes were discovered by **Tolbert and Beevers.** These originate from **ER** and are bounded by a **single membrane**. These contain enzymes for the **glyoxylate cycle** through which fats are converted into carbohydrates **(gluconeogenesis).** These are found in germinating seeds, especially in **germinating fatty seeds (such as castor seed, ground nut seed, etc.)**, where insoluble lipid food reserves must be turned into soluble sugars for the growing tip. Animals cannot execute this conversion because they do not possess glyoxylate enzymes.