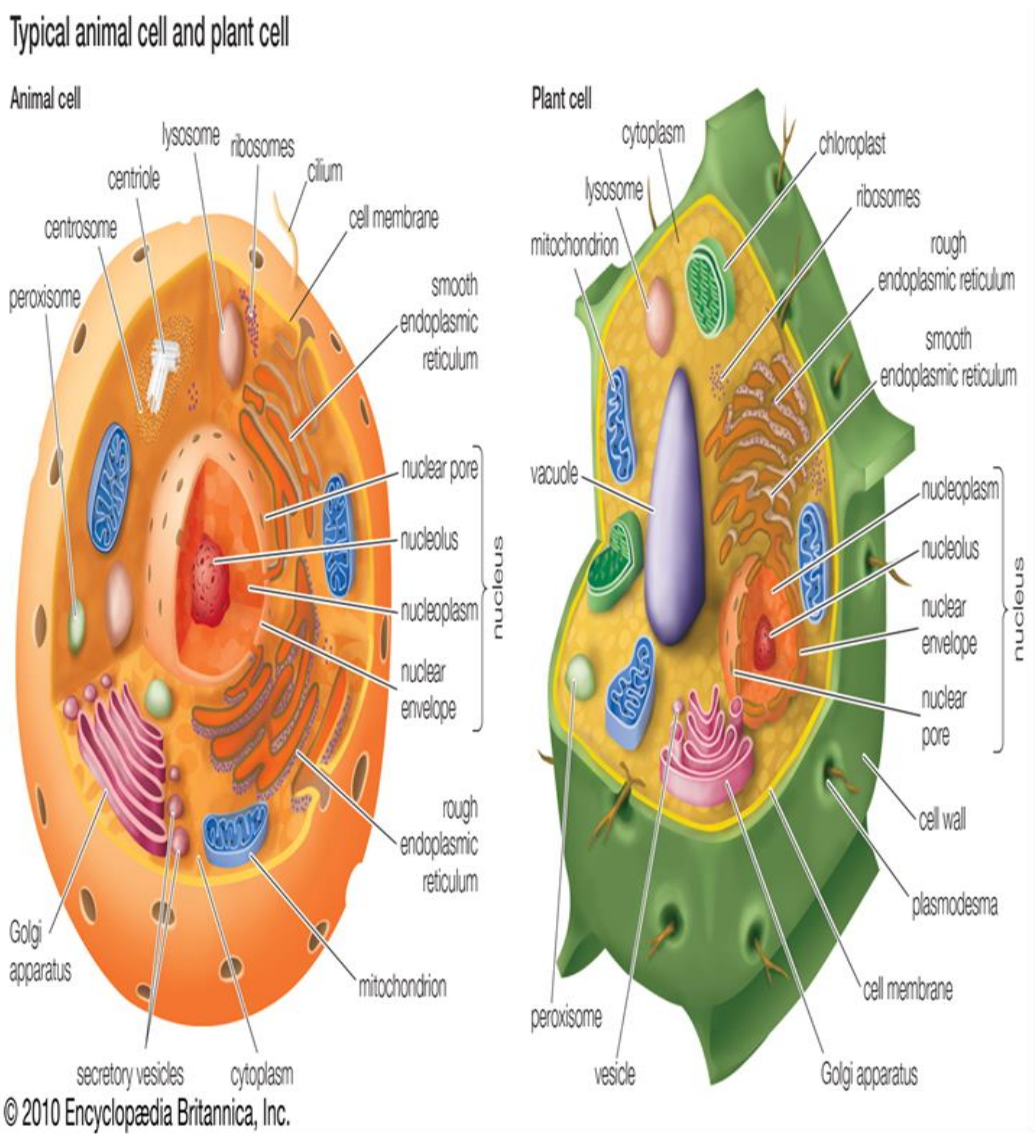
EUKARYOTIC CELL STRUCTURE

Plant and animal cells have several differences and similarities (figure below):

Structurally, plant and animal cells are very similar because they are both eukaryotic cells. They both contain membrane-bound organelles such as the nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes, and peroxisomes. Both also contain similar membranes, cytosol, and cytoskeletal elements. The functions of these organelles are extremely similar between the two classes of cells

The few differences that exist between plant and animals are very significant and reflect a difference in the functions of each cell. Plant cells can be larger than animal cells. The normal range for an animal cell varies from 10 to 30 micrometers while that for a plant cell stretches from 10 to 100 micrometers. Beyond size, animal cells do not have a cell wall or chloroplasts but plant cells do. Animal cells are round and irregular in shape while plant cells have fixed rectangular shapes.

In contrast to animal cells, plant cells often contain large central vacuoles occupying up to 90% of the total cell volume, pushing the nucleus against the cell wall.



TRANSMISSION AND INHERITANCE OF CHROMOSOMES

We have two types of gene transmission and inheritance:

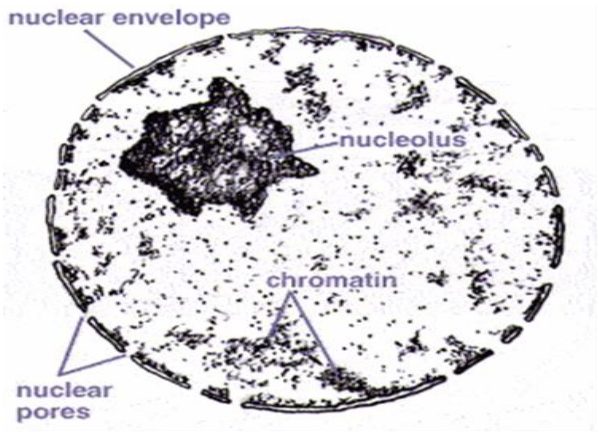
nuclear (happen in nucleus) and cytoplasmic (happen in plastids and mitochondria). Both plastids and mitochondria undergo self-replication.

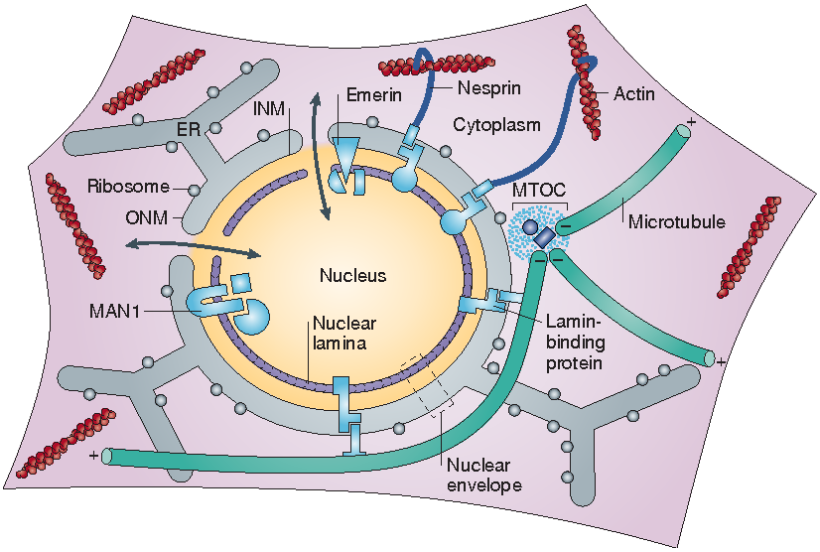
We will focus in this lecture on **the nucleus, nuclear transmission and inheritance**.

I. Nucleus:

The nucleus in the cell is analogous to the brain in the body. It is a control center for a cell by maintaining the integrity of the genes and to control the activities of the cell by regulating gene expression. The nucleus stores all the information the cell needs to grow, reproduce, and function. This information is contained in long but thin molecules of deoxyribonucleic acid, or DNA. One of the functions of the nucleus is to protect the cell's DNA from damage, but that is not all that it does. It is spherical membrane-bound organelle that contains the genetic information of eukaryotic cell. It controls cellular, developmental and genetic activities.

It consists of nuclear envelope, sap, pores, lamina, chromatin and nucleolus.





1. Nuclear envelope:

   It consists of 2 thin membranes separated by a perinuclear space (10 - 50 nm). The outer membrane is continuous with rough endoplasmic reticulum (rER).

2. Nuclear lamina:

   It is a dense network of fibrous protein (lamins=intermediate filaments) lining in the inner surface of the inner nuclear membrane to support the nuclear envelope.

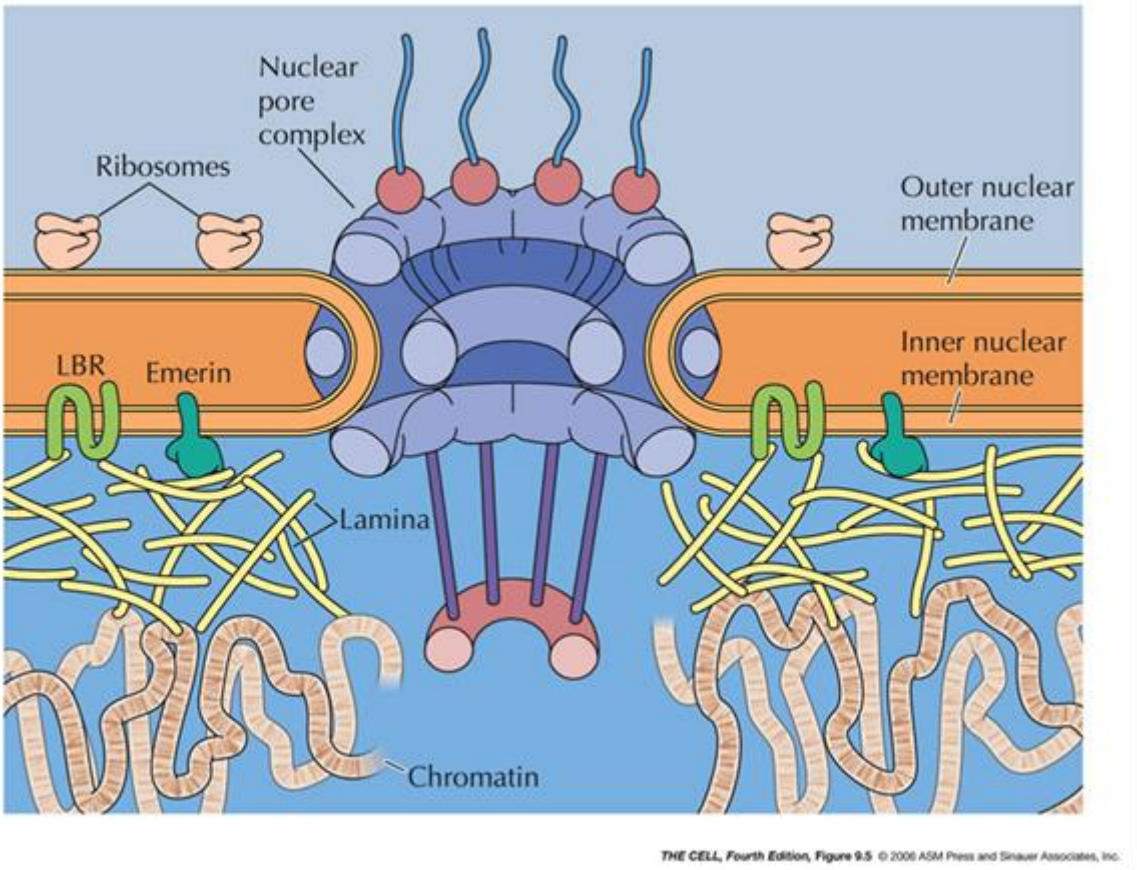
Note: Both Nuclear envelope and lamina enclose the nucleus entirely and isolates its contents from the cellular cytoplasm. So, it serves as a barrier to prevent macromolecules from diffusing freely between the nucleoplasm and the cytoplasm.

3. Nuclear pores:

   They are specialized opening in the nuclear envelope. In each pore, the inner and outer membranes of the envelope fused together forming a channel joining cytoplasm with nucleoplasm. This channel is lined with proteins complex called nucleoporines, which permit macromolecules to move across the nuclear envelope.

Nucleoporins, a family of 50 to 100 proteins, are the main components of the nuclear pore complex in eukaryotic cells. The nuclear membrane tightly controls what gets into the nucleus and what gets out. Movement of large water-soluble molecules such as proteins and RNA through the nuclear pores is required for both gene expression and the maintenance of chromosomes. Because the nuclear membrane is impermeable to large molecules, nuclear pores are required that regulate nuclear transport of molecules across this membrane. The pores cross both nuclear membranes, providing a channel through which larger molecules must be

actively transported by carrier proteins while allowing free movement of small molecules and ions. This regulation of communication by the nuclear membrane has a great effect on what a cell looks like and what it does.



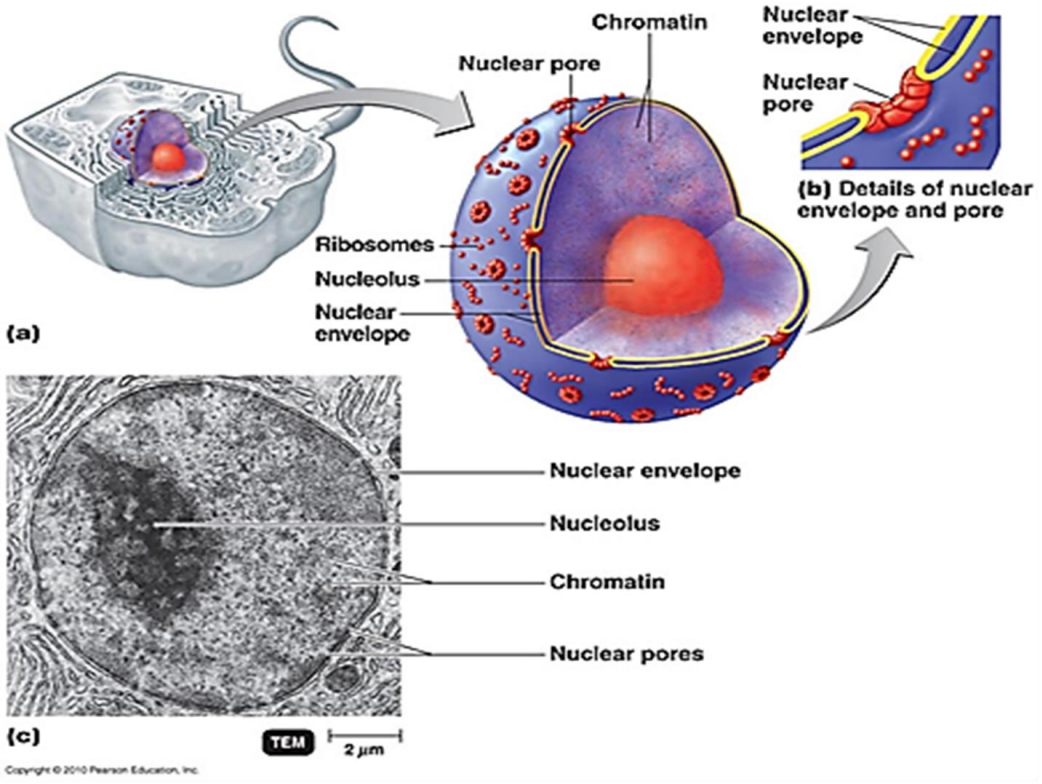
4. Nuclear sap:

   It is the inner clear viscous solution between chromatin granules and also known as *interchromatin substance* or *karyolymph*.

5. Nucleolus:

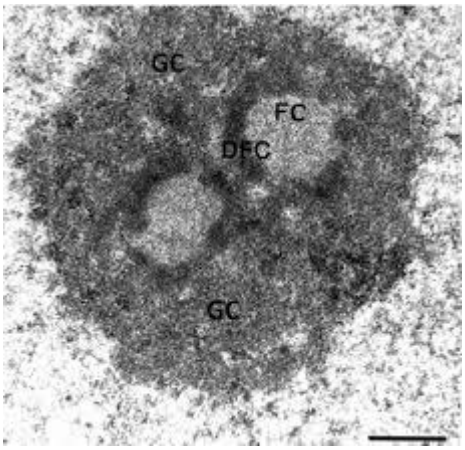
   The nucleolus is an irregular non-membranous mass and is sometimes called a suborganelle. The nucleolus occupies up to 25% of the volume of the cell nucleus. It consists of light and dark zonations. Light areas are rich in nucleosap, while dark ones are composed of fibrillar and granular parts.

Fibrillar part is formed of condensed filaments of newly formed ribosomal RNA surrounding DNA fibrils. Granular part is formed of ribonucleoprotein granules which are the early stages of ribosomal subunits.



Nucleolus is the ribosome factory of the cell in which rRNA is synthesized and assembled with ribosomal proteins to form the ribosomal subunits in eukaryotic cells.

The nucleolus is also the *nucleolar organiser regions* of chromosomes (NOR), which contain the genes for rRNA, serve as the foundation for nucleolar structure. The nucleolus disassembles at the beginning of mitosis, its components disperse in various parts of the cell and reassembly occurs during telophase and early G1 phase (interphase).



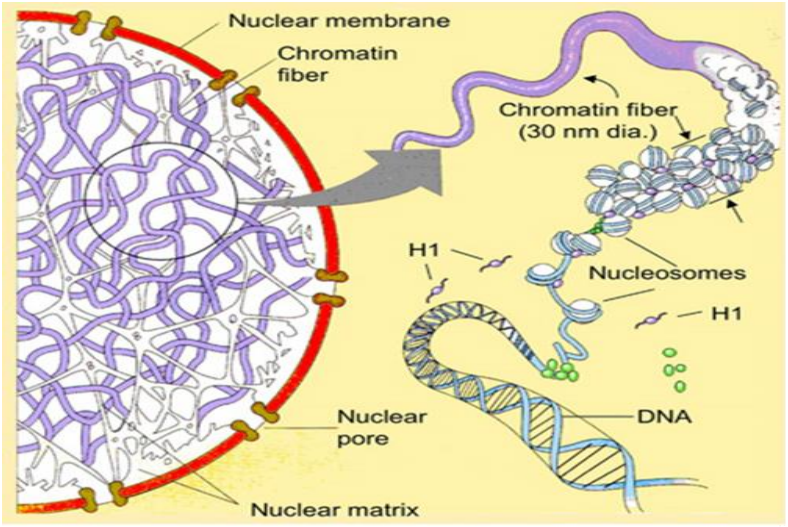
6- CHROMOSOMES

Chromosomes are also located in the nucleus and are basically organized from DNA and proteins. In eukaryotes, the chromosomal DNA is packaged and organized into chromatin (figure below). **How those happen?** Double-stranded **DNA** wraps twice around (loops) 8 special proteins called histones, forming the nucleosome, which is the building block of chromatin **packaging.** These nucleosomes coil and stack together to form fibers called chromatin. Chromatin in turn forms larger loops and coils to form chromosomes (figure below).

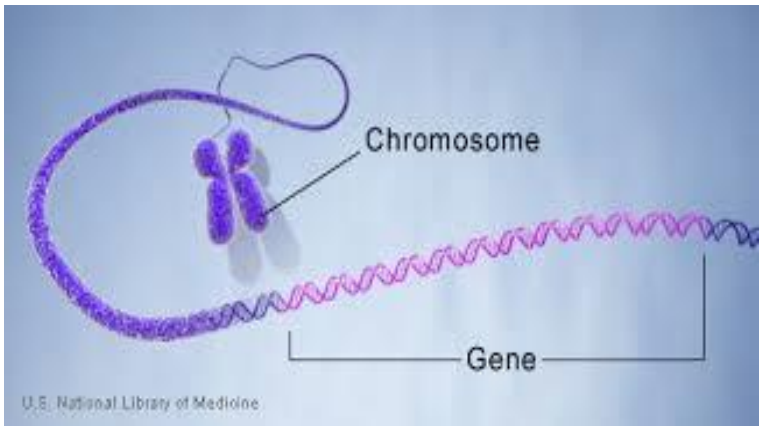
There are two types of chromatin:

Heterochromatin: is the condensed inactive type present as aggregations of granules in the nuclear sap (central), close to the inner nuclear membrane (peripheral) and associated with the nucleolus.

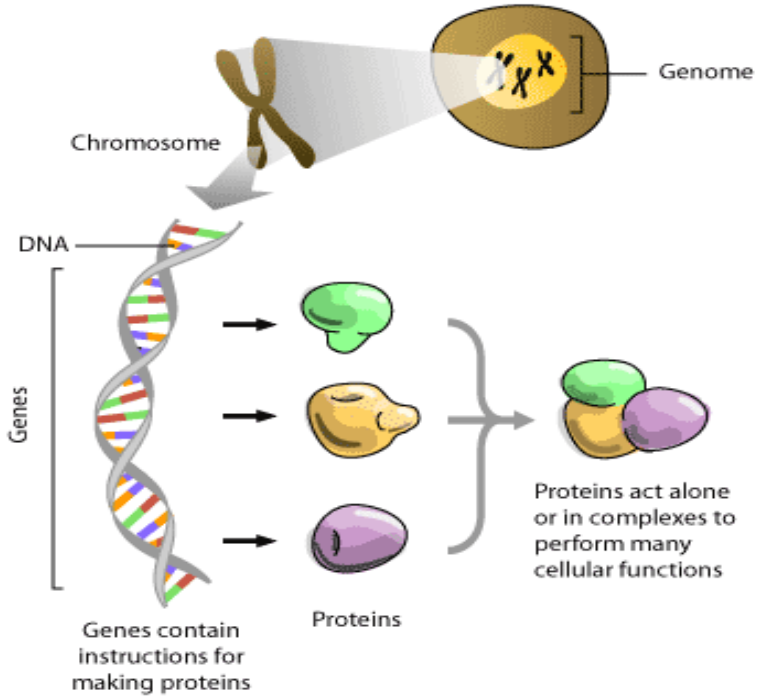
Euchromatin: is the extended, uncoiled and active type.



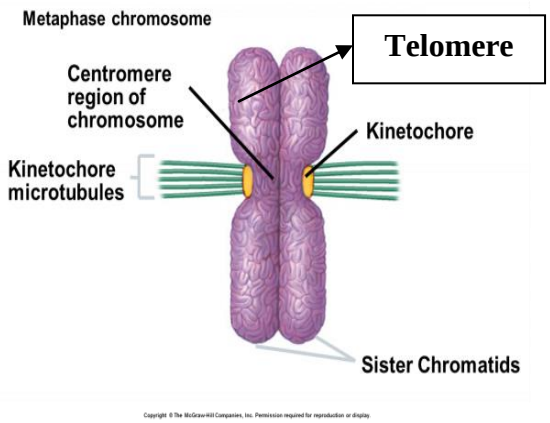
Chromosomes are single pieces of coiled double-stranded DNA along with genes, proteins, and nucleotides, and chromatin is condensed forming chromosomes that basically allow DNA to fit inside the nucleus, so the genes within these chromosomes are known as the cell's nuclear genome.



The information stored in DNA gets transferred to the rest of the cell by a very elegant process—a process so common and so important to life on Earth that it is called the central dogma of biology **(**DNA → RNA → Protein**).** Chromosomal DNA encodes most or all of an organism's genetic information.

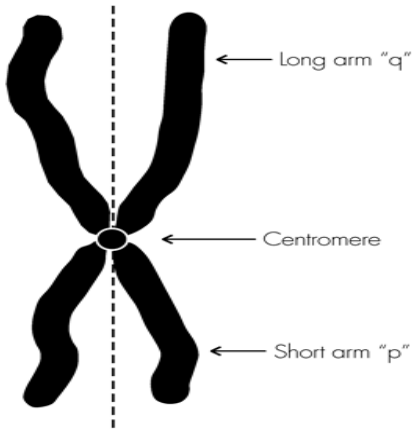


The **centromere** is a constricted region of the chromosome containing a specific DNA sequence, to which is bound 2 discs of protein called **kinetochores**. Kinetochores serve as points of attachment for microtubules that move the chromosomes during cell division. The regions at both ends of chromosome are the **telomeres**.



Chromosome Classification:

Each chromosome has two arms, p (the short one) and q (the longer). The p arm is named for "petit" meaning 'small'; the q arm is named q simply because it follows p in the alphabet.



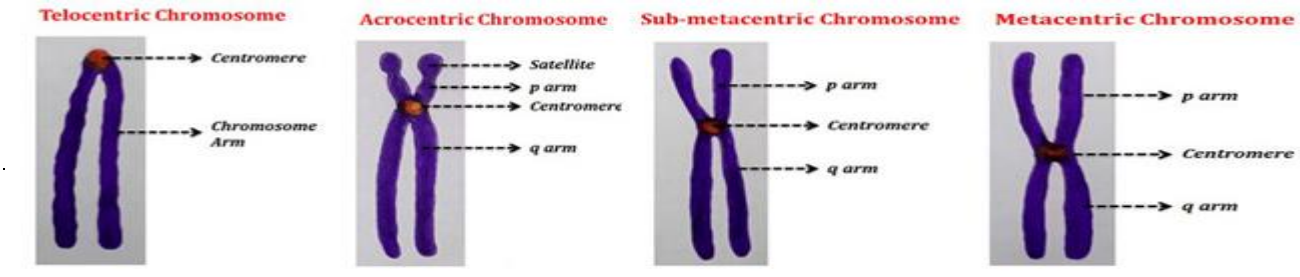
1-Chromosomes are classified according **to centromere position** to Metacentric, Sub-metacentric, Acrocentric and Telocentric (figure below).

Metacentric: These are X-Shaped chromosomes, have centromere in the middle so that the two arms of the chromosomes are almost equal.

Submetacentric: The arms' lengths are unequal and the centromere is near the middle of the chromosome so, one arm is shorter than other.

Acrocentric: The p (short) arm is so short that it is hard to observe, but still present, as the centromere is located near the terminal end of the chromosome.

Telocentric: The chromosome's centromere is located very close to its end than to its center.



2- Chromosomes may be classified according to structure into:
duplicated (**dyad**) or unduplicated (**monad**) in mitosis and as **tetrad** in meiosis.

Note:

The cell may be classified according to the number of chromosomes copies (figure below) into either haploid (n) or diploid (2n) or polyploidy (n_s)**:**

Haploid - A cell possessing a single copy of each chromosome (human/plant sex cells).

Diploid - A cell possessing two copies of each chromosome (human/plant body cells). Most eukaryotes have between 10 and 50 chromosomes in their body cells. Human cells have 46 chromosomes: 22 nearly-identical pairs (autosomes) and a pair of sex chromosome.

Polyploid- A cell possessing numerous copies of each chromosome, so it may be triploid, tetraploid,…..