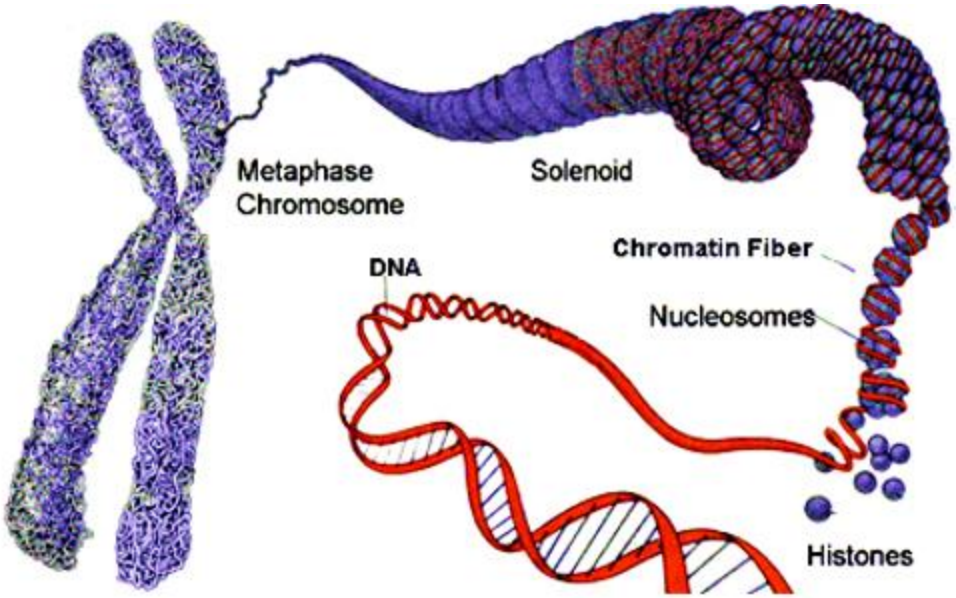
Bhagalpur National College, Bhagalpur

(A Constituent unit of Tilka Manjhi Bhagalpur University, Bhagalpur)

PPT Presentation for B.Sc. III- Chromosome Structure & Organization



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Chromosome

- Chromosome means: **chroma** - colour; **some** - body)
- A chromosome is a thread-like self-replicating genetic structure containing organized DNA molecule package found in the nucleus of the cell.
- Chromosomes are seen during metaphase stage of mitosis when the cells are stained with suitable basic dye and viewed under light microscope.
- E. Strasburger in 1875 discovered thread-like structures which appeared during cell division.
- In all types of higher organisms (eukaryote), the well organized nucleus contains definite number of chromosomes of definite size, and shape.

- **Waldeyer** coined the term chromosome first time in 1888.
- The **somatic chromosome number** is the number of chromosomes found in somatic cell and is represented by **2n (Diploid)**.
- The **gametic chromosome number** is half of the somatic chromosome numbers and represented by **n (Haploid)**.
- The two copies of chromosome are ordinarily identical in morphology, gene content and gene order, they are known as **homologus chromosomes.**

Chromosomes are of two types

Autosomes: that control characters other than sex characters or carry genes for somatic characters.

Sex chromosomes *(Gonosomes)* – Chromosomes involved in sex determination.

- Humans and most other mammals have two sex chromosomes X & Y, also called **heterosome.**
- Females have two X chromosomes in diploid cells; males have an X and a Y chromosome.
- In birds the female (ZW) is hetero-gametic and male (ZZ) is homo-gametic.

CHROMOSOME NUMBER

Diploid and Haploid chromosome number

- Diploid cells (2N where N- chromosome number) have two homologous copies of each chromosome.
- The body cells of animals are diploid.
- Haploid cells (N) have only one copy of each chromosome.
- In animals, gametes (sperm and eggs) are haploid.
- Chromosome number varies from 2n = 4 (n = 2) to 2n = > 1200. (n = gametic or haploid chromosome number 2n = somatic or diploid chromosome number)
- The number of chromosomes varies from species to species.
- Normally all individual of a species have the same chromosome number.

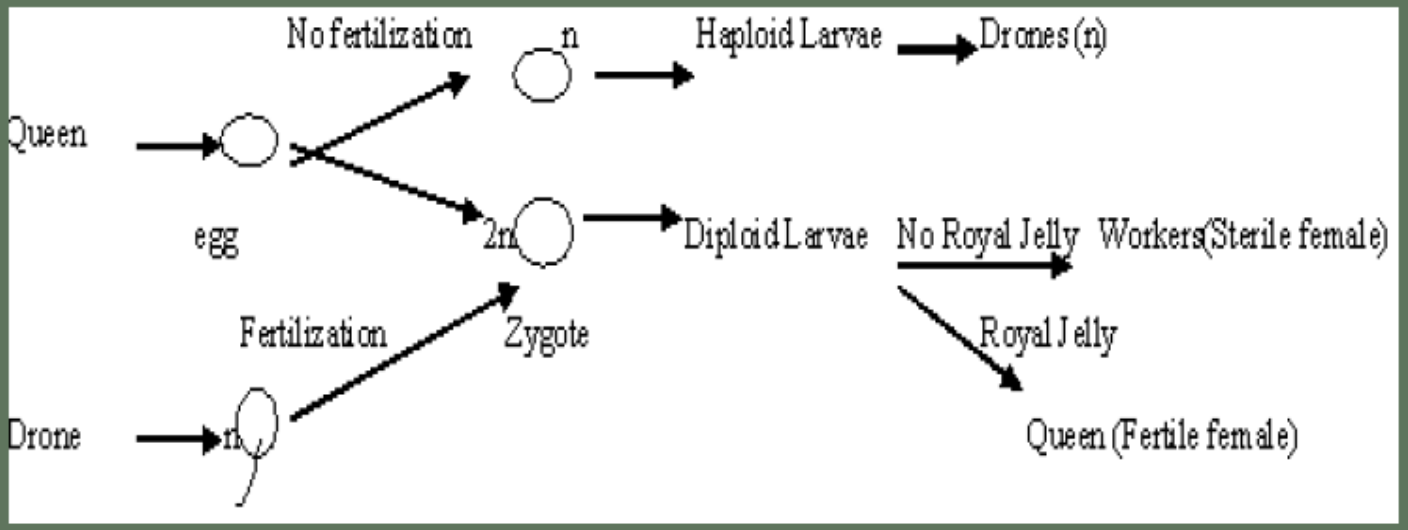
- The size of chromosome is normally measured at mitotic metaphase and may be as short as 0.25 μm in fungi and birds, or as long as 30 μm in some plants like Trillium.
- Each chromosome has two arms - p (the shorter of the two) and q (the longer).
- Chromosome shape is usually observed at anaphase, when the position of primary constriction (centromere) determines chromosome shape.
- This constriction or centromere can be terminal, sub-terminal or median in position.

Homologous Chromosomes

- Diploid organisms have two copies of each chromosome (**except the sex chromosomes**).
- Both the copies are ordinarily identical in morphology, gene content and gene order and hence known as **homologous chromosomes**.
- Each pair of chromosomes made up of two homologs.
- Homologous chromosome is inherited from separate parents; one homolog comes from the mother and the other comes from the father.

Species	2n	Species	2n	Species	2n
Human	46	Hamster	44	Guinea pig	64
Pea plant	14	Bison	60	Hare	48
River buffalo	50	Chimpanzee	48	Lion	38
Swamp buffalo	48	Deer	68	Mouse	40
Cat	38	Elephant	56	Musk ox	48
Cattle	60	Tiger	38	Rat	42
Dog	78	Honey bee*	32, 16	Pigeon	80
Donkey	62	House fly	12	pheasant	82
Goat	60	Fruit fly	8	Turkey	80
Horse	64	Reindeer	70	Domestic duck	80
Pig	38	Alligator	32	Emu	80
Camel	74	Chicken	78	Goose	80
Rabbit	44	Guinea fowl	74		
Sheep	54	Japanese quail	78		
Mule	63	Muscovy duck	80		
Gorilla	48	Ostrich	80		

In honey bee female (queen and workers) have 32 chrmosomes and male (drone) have 16 chromosomes



STRUCTURE OF CHROMOSOME

Chromosome Morphology

- Mitotic metaphase is the most suitable stage for studies on chromosome morphology.
- The chromosome morphology changes during cell division.
- Chromosomes are thin, coiled, elastic, thread-like structures during the interphase.
- As cells enter mitosis, their chromosomes become highly condensed so that they can be distributed to daughter cells.
- In mitotic metaphase chromosomes, the following structural features can be seen under

Morphology of Chromosome

Chromatid

- Each metaphase chromosome appears to be longitudinally divided into two identical parts each of which is called **chromatid**.
- Both the chromatids of a chromosome appear to be joined together at a point known as **centromere**.
- The two chromatids of chromosome separate from each other during mitotic anaphase (and during anaphase II of meiosis) and move towards opposite poles.
- Since the two chromatids making up a chromosome are produced through replication of a single chromatid during synthesis (S) phase of interphase, they are referred to as **sister chromatids**.
- In contrast, the chromatids of homologous chromosomes are known as **non-sister chromatids**.

Centromere (Primary constriction)

- Centromere is the landmark for identification of chromosome.
- Each chromosome has a constriction point called the **centromere** (Synonym: **Kinetochore**), 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.

Telomere

- The two ends of a chromosome are known as telomeres, they play critical roles in chromosome replication and maintenance of chromosomal length.
- The telomeres are highly stable and telomeres of different chromosomes do not fuse.
- The telomeric region of chromosome is made up of repeatative sequence of **T** and **G** bases

Secondary constriction

- In some chromosome addition to centromere / primary constriction, one or more constrictions in the chromosome are present termed secondary constrictions.

Satellite

- The chromosomal region between the secondary constriction and nearest telomere is called as satellite and chromosomes that possess this region called as **satellite chromosome** or **sat chromosome**.

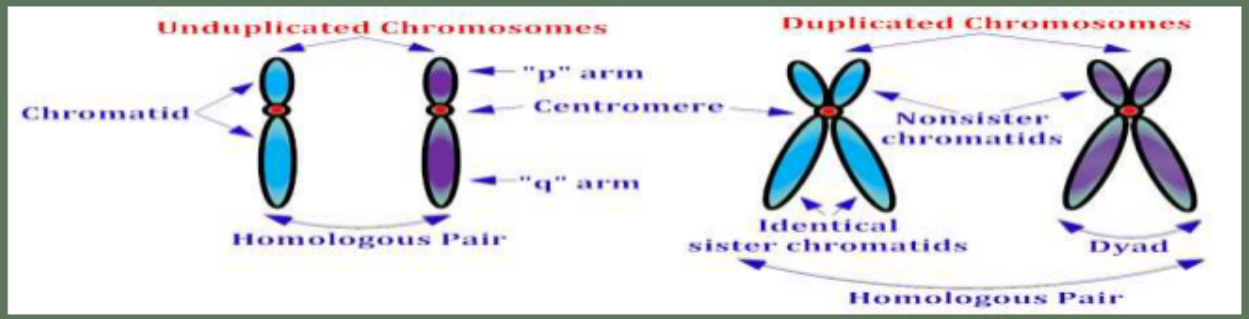
- A small chromosomal segment separated from the main body of the chromosome by a secondary constriction is called **Satellite**.

Centromere positions

Size of the chromosome

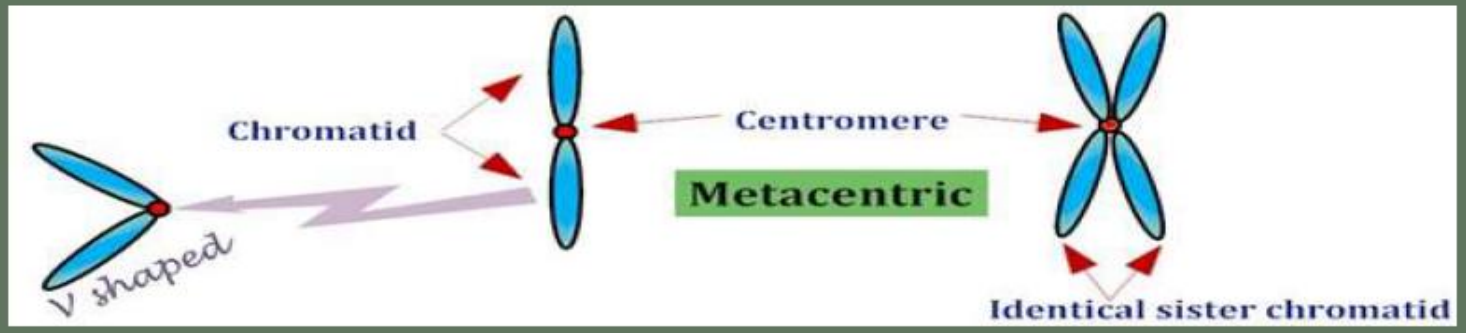
- The size of the chromosome varies from stage to stage of cell division.
- The chromosomes are the **longest and thinnest during interphase** (resting stage) and hence not visible under light microscope.
- Chromosomes are the **smallest and thickest during mitotic metaphase**.
- Chromosome size is **not** proportional to the number of genes present on the chromosome.
- The location of the centromere on each chromosome gives the chromosome its characteristic shape.

- Chromosomes are classified according to the centromere position :
- At one end : Acrocentric
- Closer to one end: Submetacentric
- Middle: Metacentric
- Each chromosome has two arms, labeled **p (the shorter of the two)** and **q (the longer)**.
- The p arm is named for **"petite"** meaning **"small"**; the q arm is named q simply because it follows p in the alphabet.



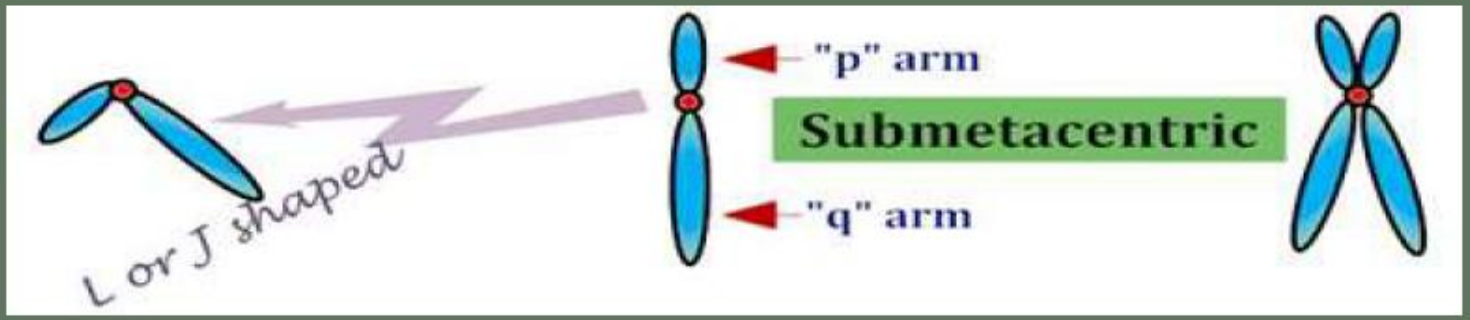
Metacentric chromosome

- The centromere is located in the centre of chromosomes, i.e. the centromere is median. The centromere is localized approximately midway between each end and thereby two arms are roughly equal in length.
- Metacentric chromosome take V shape during anaphase.



Submetacentric Chromosome

- Centromere is located on one side of the central point of a chromosome. Centromere is submedian giving one longer and one shorter arms.
- Submetacentric chromosome may be J or L shaped during anaphase.



Acrocentric Chromosome

- The centromere located close to one end of chromosomes. The centromere is more terminally placed and forms very unequal arm length (The "acro-" in acrocentric refers to the Greek word for **"peak"**).
- The **p (short)** arm is so short that is hard to observe, but still present.
- Acrocentric chromosome may be rod shape during anaphase.

Telocentric Chromosome

- Centromere located at one end of chromosome (at terminal part of chromosome) lies at one end.
- Telocentic chromosome may be rod shape during anaphase.

- According to the number of the centromere the eukaryotic chromosomes may be
- **Acentric :without any centromere**
- **Mono centric: with one centromere**
- **Dicentric : with two centromeres**
- **Polycentric: with more than two centromeres**

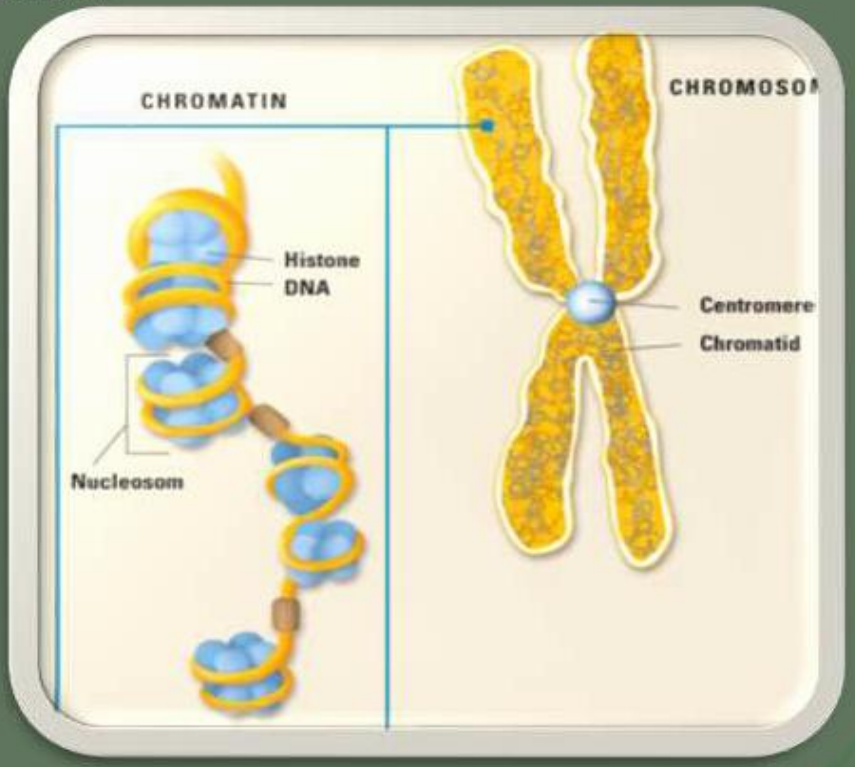
How large size sequential DNA can fit in to small size chromosome ?

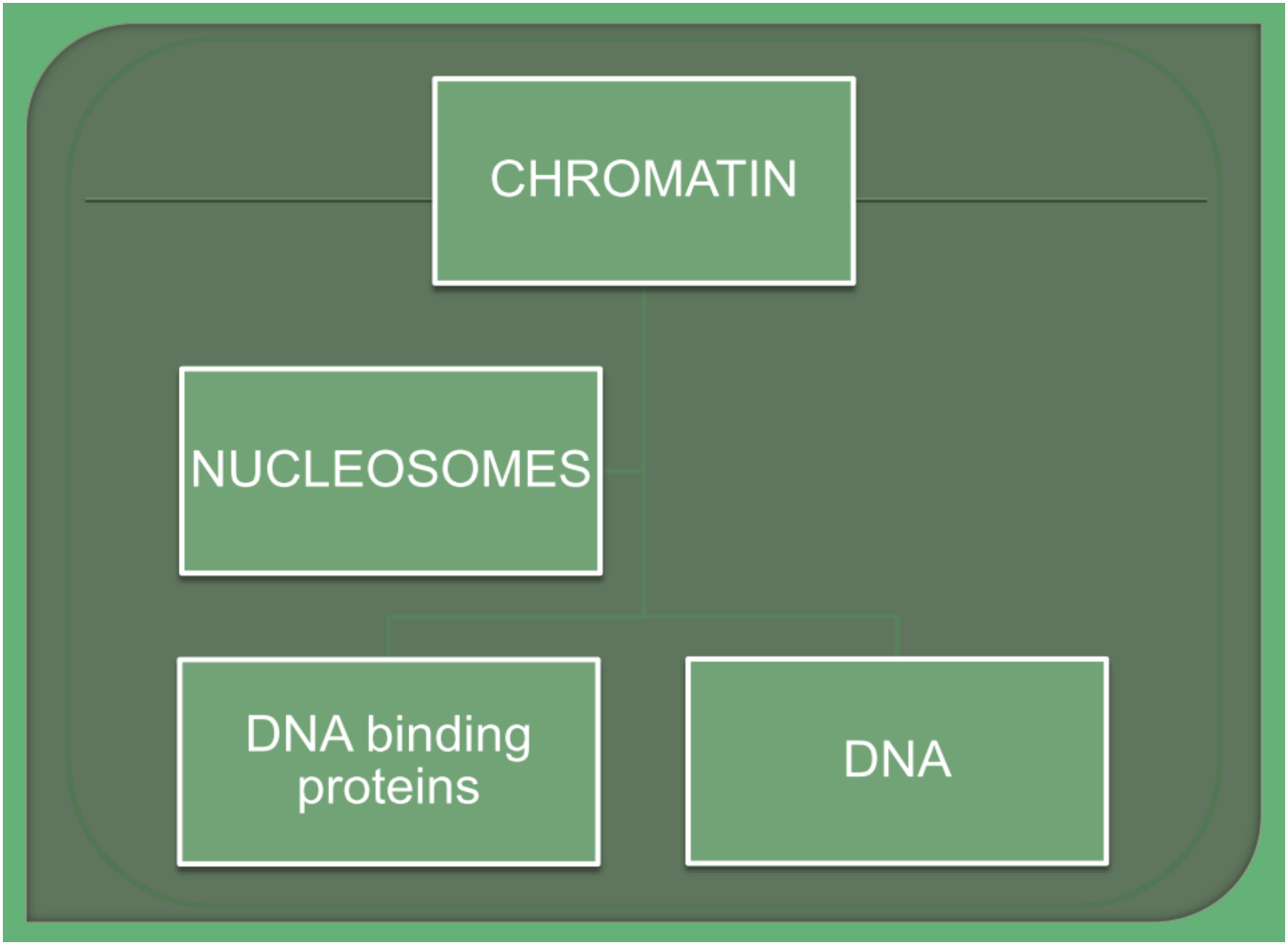
The DNA + histone = chromatin

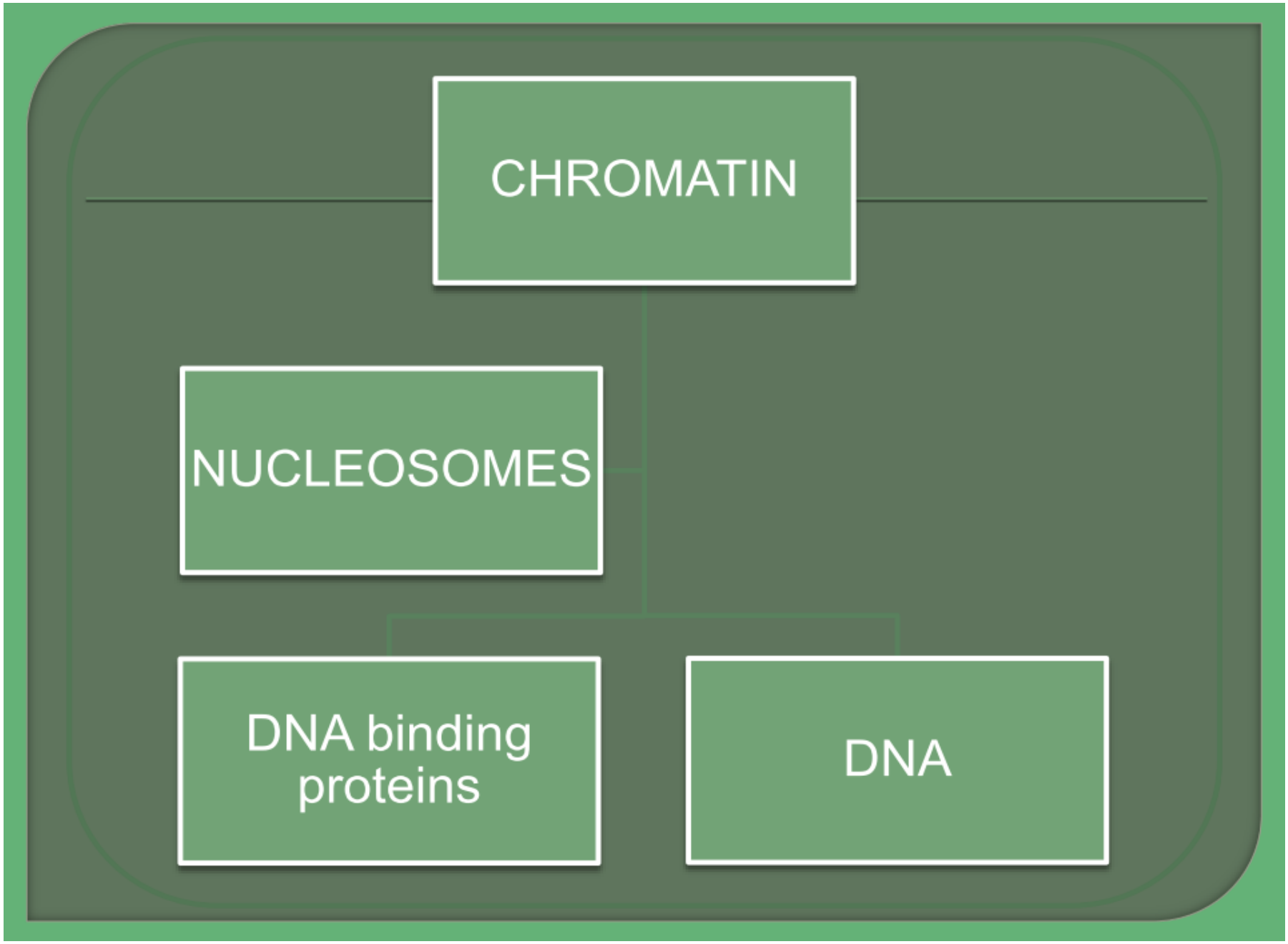
- The DNA double helix in the cell nucleus is packaged by special proteins termed histones.

- The formed protein/ DNA complex is called chromatin.

- The structural entity of chromatin is the nucleosome.




CHROMATIN
NUCLEOSOMES
DNA binding proteins
DNA


CHROMATIN
NUCLEOSOMES
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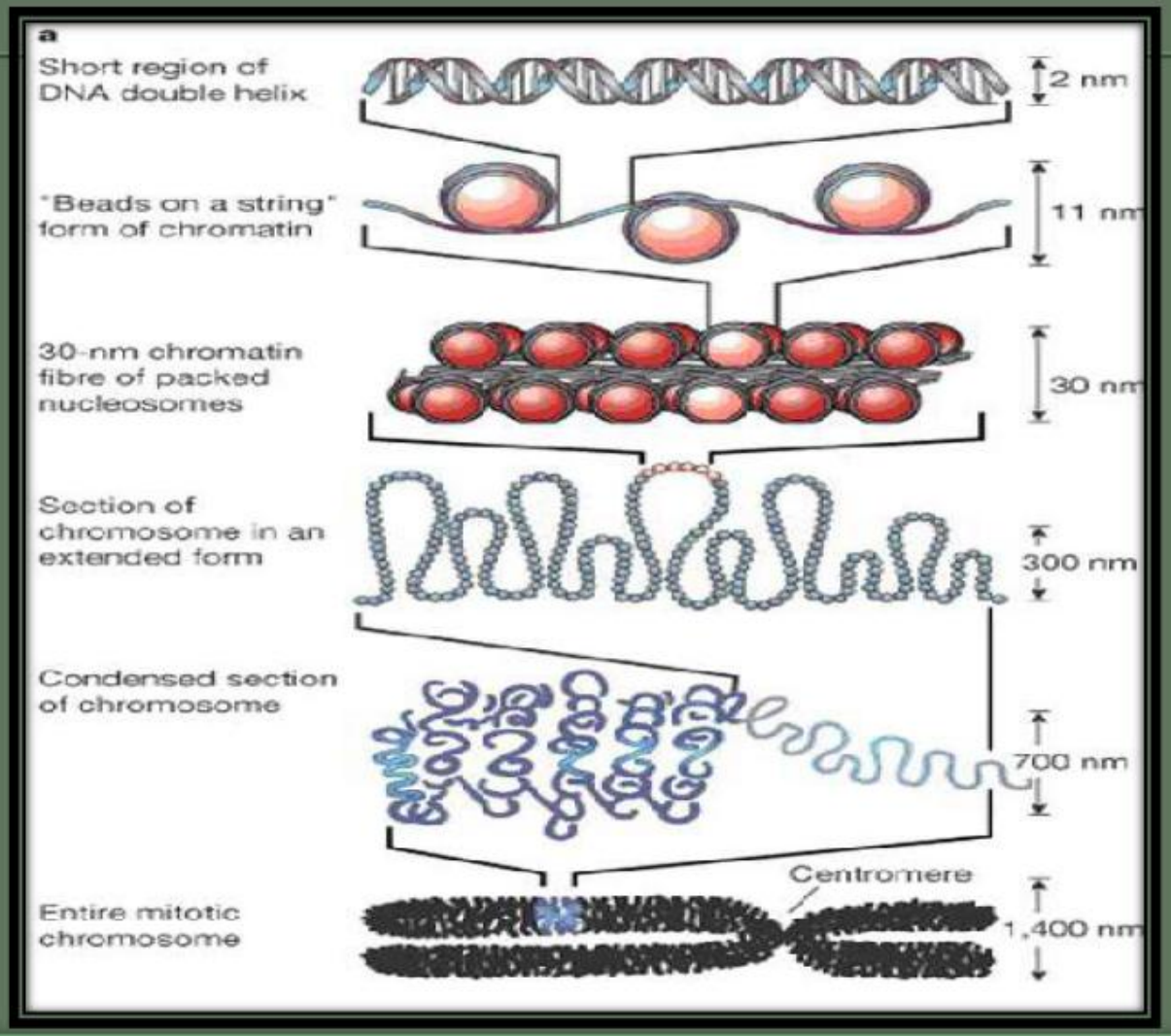
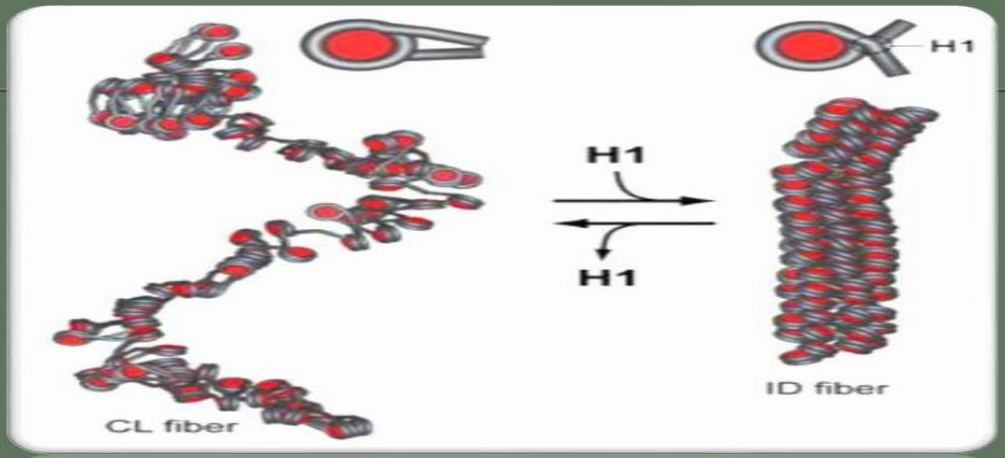
DNA

CHROMOSOME PACKAGING



HISTONE

- Histone can be grouped into five major classes: H1/H5, H2A, H2B, H3, and H4
- These are organised into two super-classes as follows:
  - **Core histones – H2A, H2B, H3 and H4**
  - **Linker histones – H1 and H5**



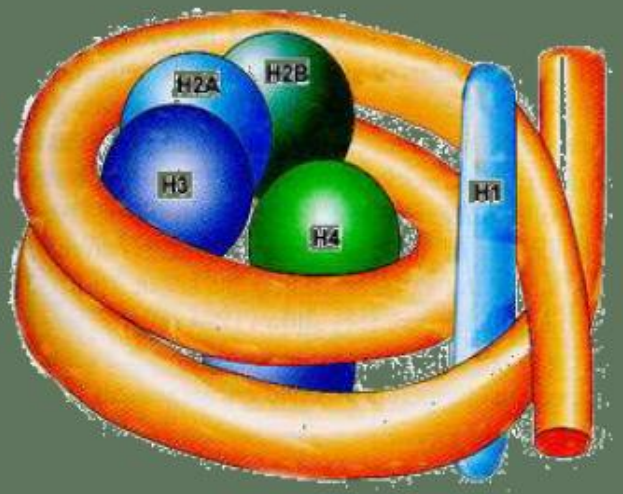
Linker DNA is double-stranded DNA in between two nucleosome cores that, in association with histone H1, holds the cores together.

NUCLEOSOME

- basic unit of DNA packaging in eukaryotes
- consists of a segment of DNA wound around histone protein core
- fundamental repeating units of eukaryotic chromatin
- The nucleosome core particle consists of approximately 147 base pairs of DNA wrapped in 1.67 left-handed superhelical turns around a histone octamer consisting of 2 copies each of the core histones H2A, H2B, H3, and H4
- The nucleosome cores themselves coil into a solenoid shape which itself coils to further compact the DNA

- Core particles are connected by stretches of "linker DNA", which can be up to about 80 bp long.
- Technically, a nucleosome is defined as the core particle plus one of these linker regions; however the word is often synonymous with the core particle
- Linker histones such as H1 and its isoforms are involved in chromatin compaction and sit at the base of the nucleosome near the DNA entry and exit binding to the linker region of the DNA
- Non-condensed nucleosomes

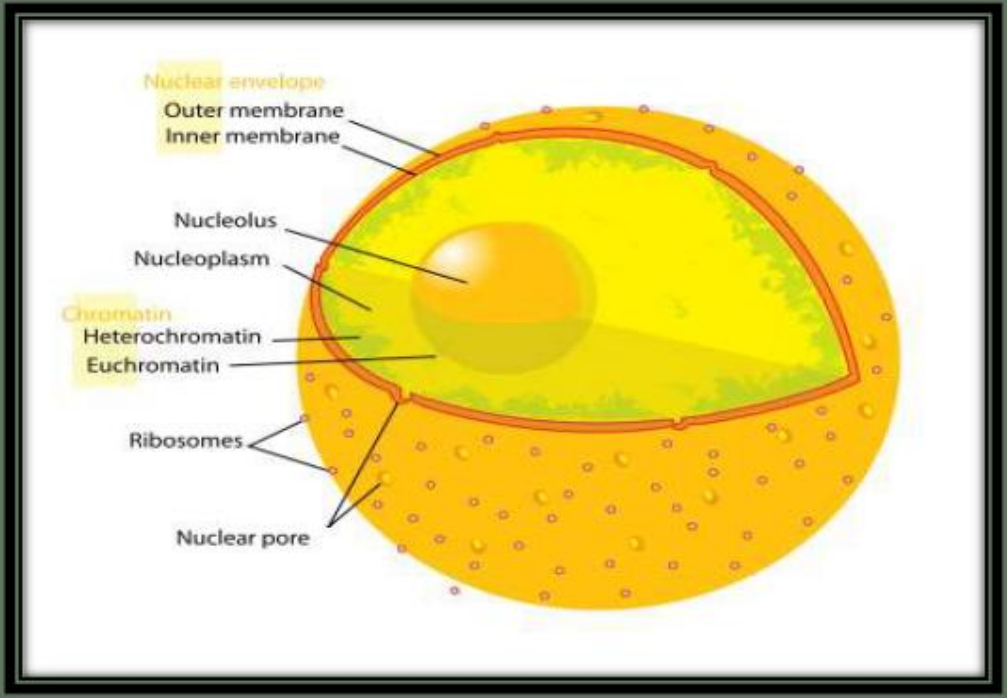
without the linker histone resemble "beads on a string of DNA" under an electron microscope.



- The protein-DNA structure of chromatin is stabilized by attachment to a non-histone protein scaffold called the nuclear matrix.
- In contrast to most eukaryotic cells, mature sperm cells largely use protamines to package their genomic DNA, most likely to achieve an even higher packaging ratio
- Histone equivalents and a simplified chromatin structure have also been found in Archea, proving that eukaryotes are not the only organisms that use nucleosomes.

HETEROCHROMATIN

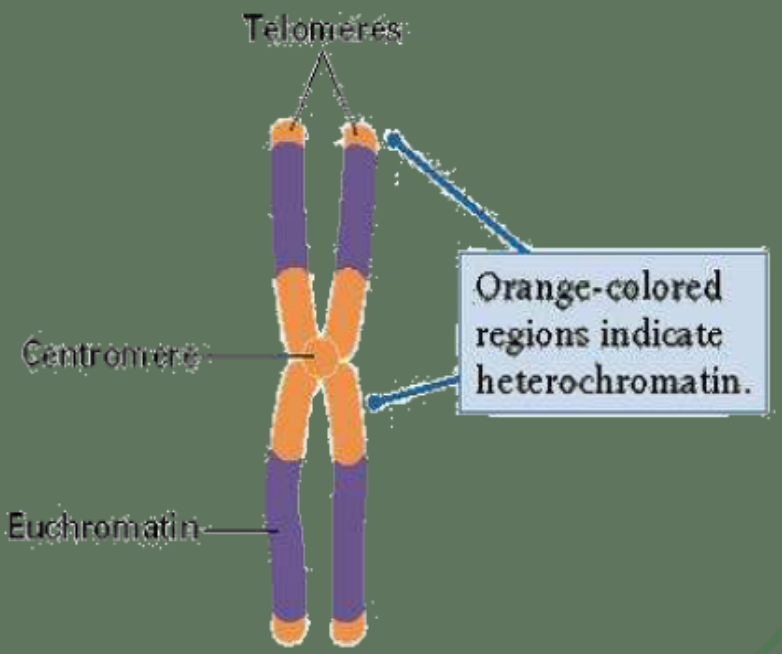
- Tightly packed chromosome
- Intensely stained
- consists of genetically inactive satellite sequences
- Both centromeres and telomeres are heterochromatic



EUCHROMATIN

- lightly packed form of chromatin (DNA, RNA and protein) that is rich in gene concentration
- often (but not always) under active transcription
- Unlike heterochromatin,

it is found in both cells with nuclei (eukaryotes) and cells without nuclei (prokaryotes) most active portion of the genome within the cell nucleus



THANX