# EUCHROMATIN & HETEROCHROMATIN

**PRESENTED BY:**
**DR. SAPNA KUMARI**

**ZOO CC – 204**
**SEMESTER – II**

# CHROMATIN

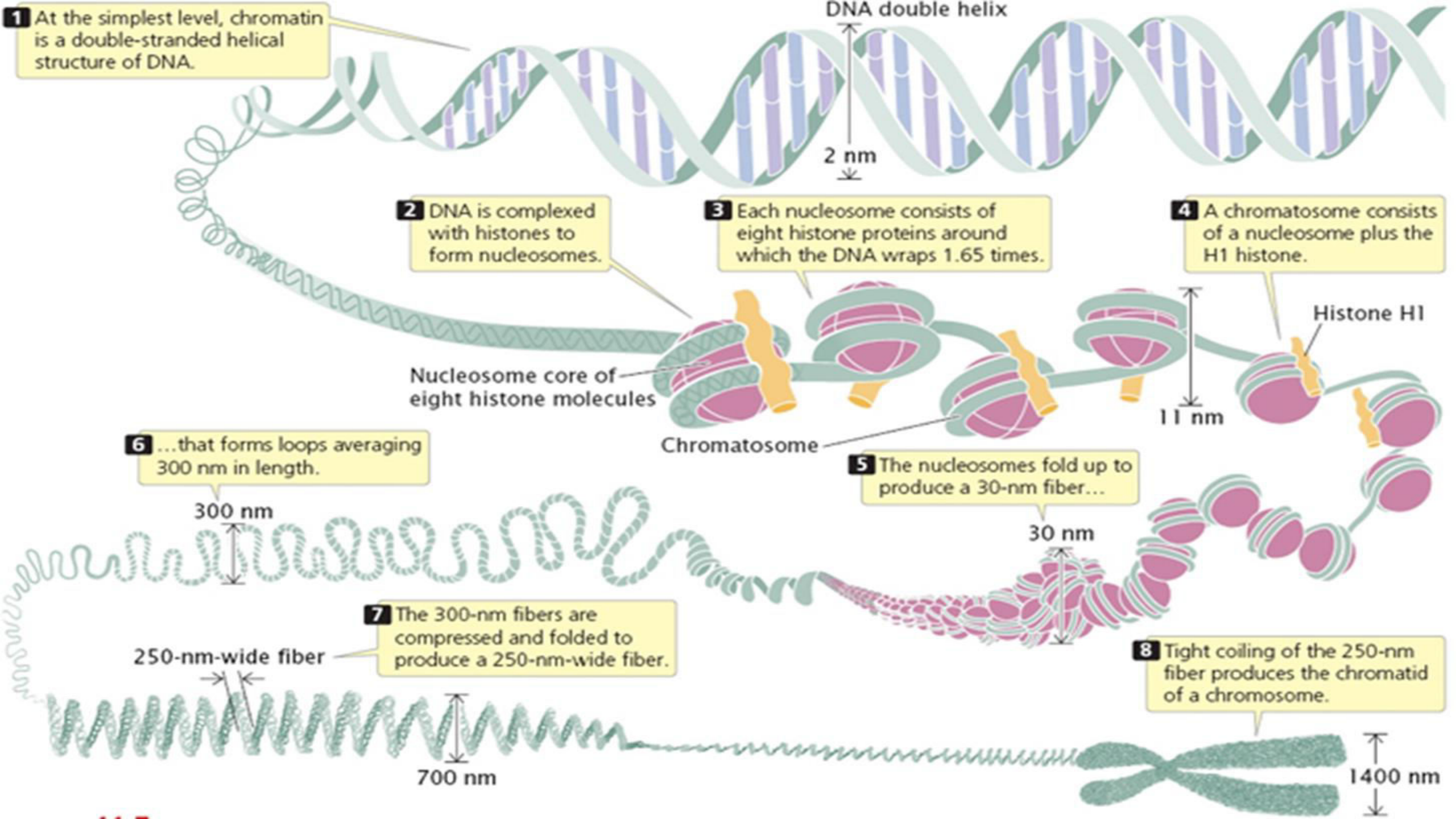
- Chromatin is a mass of genetic material composed of DNA & Proteins that condenses to form chromosomes during eukaryotic cell division.
- Chromatin is located in nucleus of the cells.

## CHROMATIN FUNCTION:

To compress the DNA into a compact unit( Less voluminous) and can fit with in the nucleus.

- It consists of his tones and DNA.

**The DNA is packaged in the form of a nucleoprotein complex called "chromatin", which carries the hereditary message.**


1 At the simplest level, chromatin is a double-stranded helical structure of DNA.
DNA double helix
2 nm
2 DNA is complexed with histones to form nucleosomes.
3 Each nucleosome consists of eight histone proteins around which the DNA wraps 1.65 times.
4 A chromatosome consists of a nucleosome plus the H1 histone.
Histone H1
11 nm
Nucleosome core of eight histone molecules
Chromatosome
5 The nucleosomes fold up to produce a 30-nm fiber...
30 nm
6 ...that forms loops averaging 300 nm in length.
300 nm
7 The 300-nm fibers are compressed and folded to produce a 250-nm-wide fiber.
250-nm-wide fiber
700 nm
8 Tight coiling of the 250-nm fiber produces the chromatid of a chromosome.
1400 nm

- Histones help to organize DNA into structures called Nucleosides.
- A Nucleosome consists of a DNA sequence of about 150 base pairs that is wrapped around set of 8 histones.
- The Functional unit of chromatin is nucleosome.
- nucleosome further folded to form a chromatin fibers.
- The chromatin fibers coiled and it condensed to form chromosomes.
- Chromatin is responsible for DNA replication, transcription, DNA repair, genetic recombination and cell division.

- TYPES OF CHROMATIN:
  - Euchromatin
  - Heterochromatin

**Emil Heitz in the year 1928, coined the term Heterochromatin and Euchromatin.**

# Euchromatin

- Majority chromatin is in its extended (decondensed) state during interphase – only condenses during mitosis.
- Less condensed regions of chromosomes
- Transcriptionally active
- Regions where 30 nm fiber forms radial loop domains

## Heterochromatin

- Tightly compacted regions of chromosomes
- Transcriptionally inactive (in general)
- Radial loop domains compacted even further
- Remains highly condensed even in interphase.
- Accounts for the dark staining regions seen in interphase chromatin.
- **Constitutive:** always inactive and condensed: –e.g. repetitive DNA, centromeric DNA
- **Facultative:** can exist in both forms. –e.g.: Female X chromosome in mammals.

| constitutive HC | facultative HC |
| --- | --- |
| stable | reversible |
| contains satellite DNA | enriched in LINES sequences |
| polymorphism + | polymorphism - |
| C bands+ | C bands - |

INSERM U491

**Table: Properties which allow to differentiate constitutive from facultative heterochromatin**

# Constitutive heterochromatin

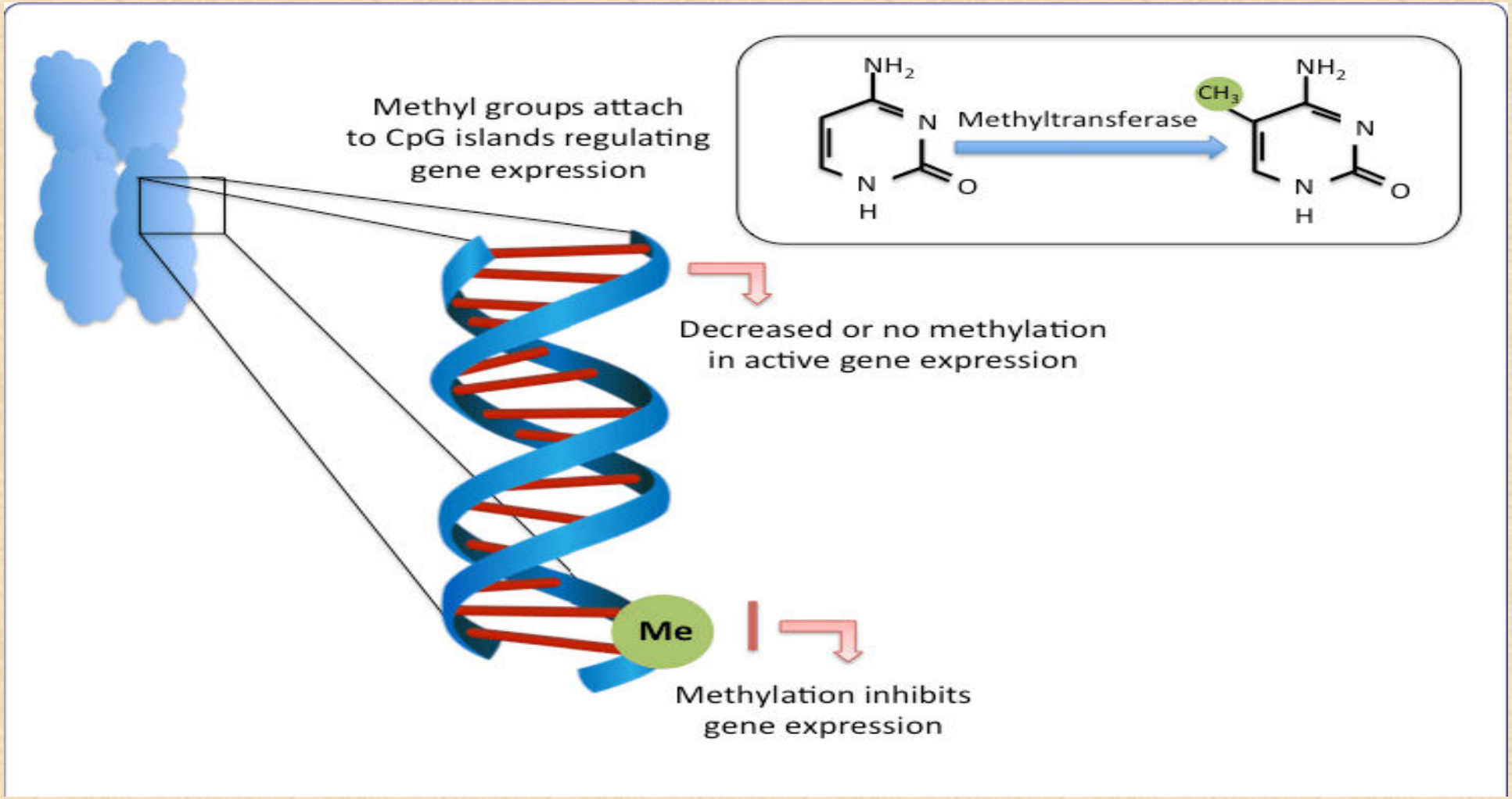
- Constitutive HC contains a particular type of DNA called satellite DNA, which consists of large numbers of short tandemly repeated sequences : Alpha-satellite DNA, DNA satellite I, II and III. These satellite DNA sequences are able to fold on themselves and may have an important role in the formation of the highly compact structure of the constitutive HC.
- Constitutive HC is stable and conserves its heterochromatic properties during all stages of development and in all tissues.
- Constitutive HC is highly polymorphic, probably because of the instability of the satellite DNA. This polymorphism can affect not only the size but also the localization of the heterochromatin, and apparently has no phenotypic effect.
- Constitutive HC is strongly stained by the C-band technique, which is the result of the very rapid renaturation of the satellite DNA following denaturation.

- **Facultative heterochromatin**

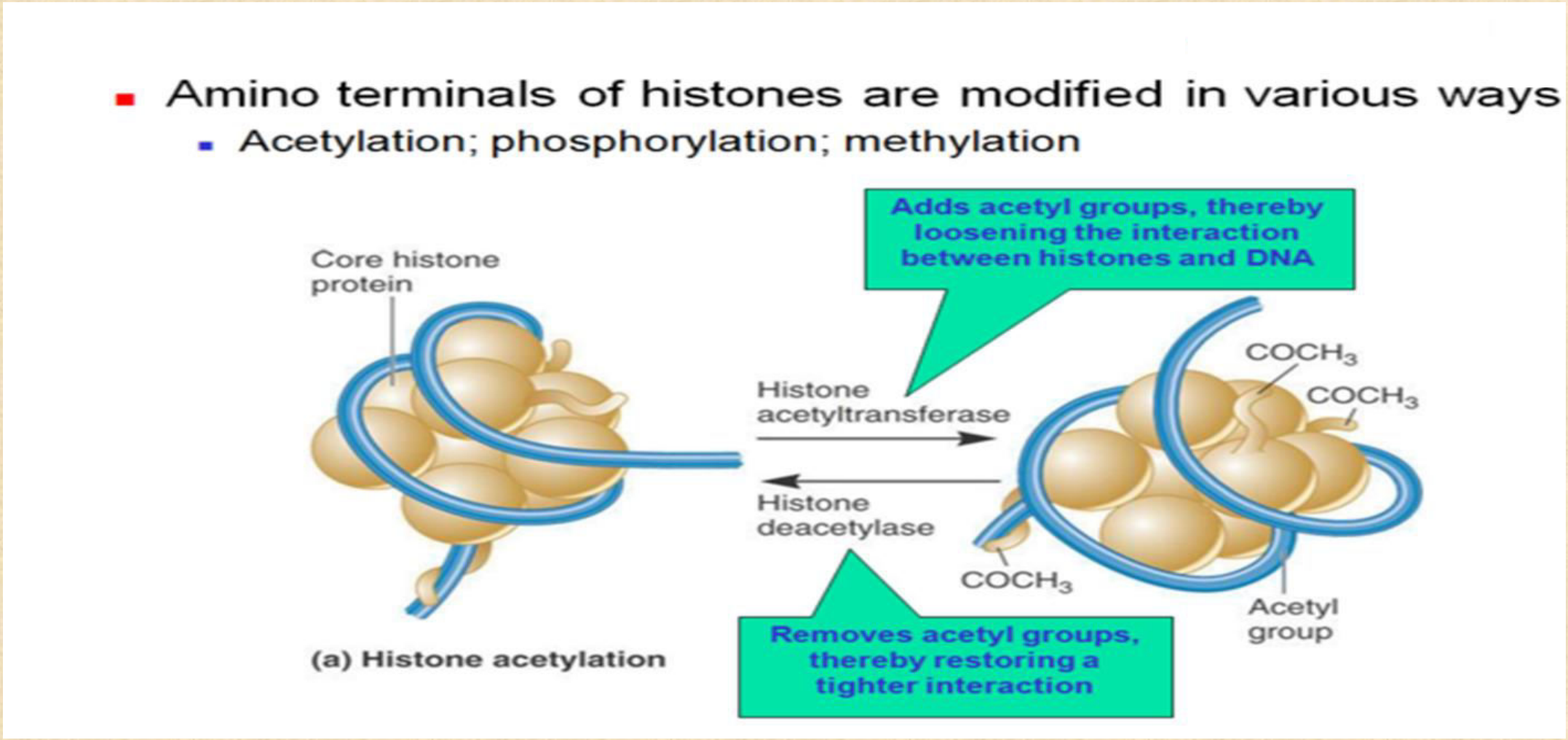
- Facultative HC is characterized by the presence of Long Interspersed Nucleotide Elements (LINE) -type repeated sequences. These sequences, dispersed throughout the genome, could promote the propagation of a condensed chromatin structure.
- Facultative HC is reversible, its heterochromatic state depending on the stage of development or the cell type examined. The inactive X (Barr body) in the somatic cells females and the inactive sex vesicle at the pachytene stage of male meiosis provide two examples of facultative HC.
- Facultative HC is not particularly rich in satellite DNA, and is therefore not polymorphic.
- Facultative HC is never stained by the C-band technique.

- High condensation of heterochromatin renders it strongly chromophilic and inaccessible to DNAse I and to other restriction enzymes in general.
- DNA from both constitutive and facultative HC, is late replicating.
- Because high degree of condensation, which prevents the replicating machinery from easily accessing the DNA, and
- Its location is peripheral in nuclear domain that is poor in active elements.
- The DNA of constitutive HC is highly methylated on the cytosines. An anti-5-methyl cytosine antibody therefore strongly labels all the regions of constitutive HC.
- As regards facultative HC, the methylation of the DNA is more discrete, but restriction enzymes sensitive to methylation reveals strong methylation of the CpG islands, which are specifically located in the control regions of the genes.

- Methylation of the histone H3 lysine 9 (H3-K9) has only very recently been found to be involved in the process of heterochromatinisation of the genome, both in constitutive and facultative HC.



- Acetylation/de-acetylation of histones is a mechanism that is absolutely essential for the control of gene expression. Numerous transcription factors have been shown to have, either an activity Histone Acétyl Transférase or Histone De-Acétylases.

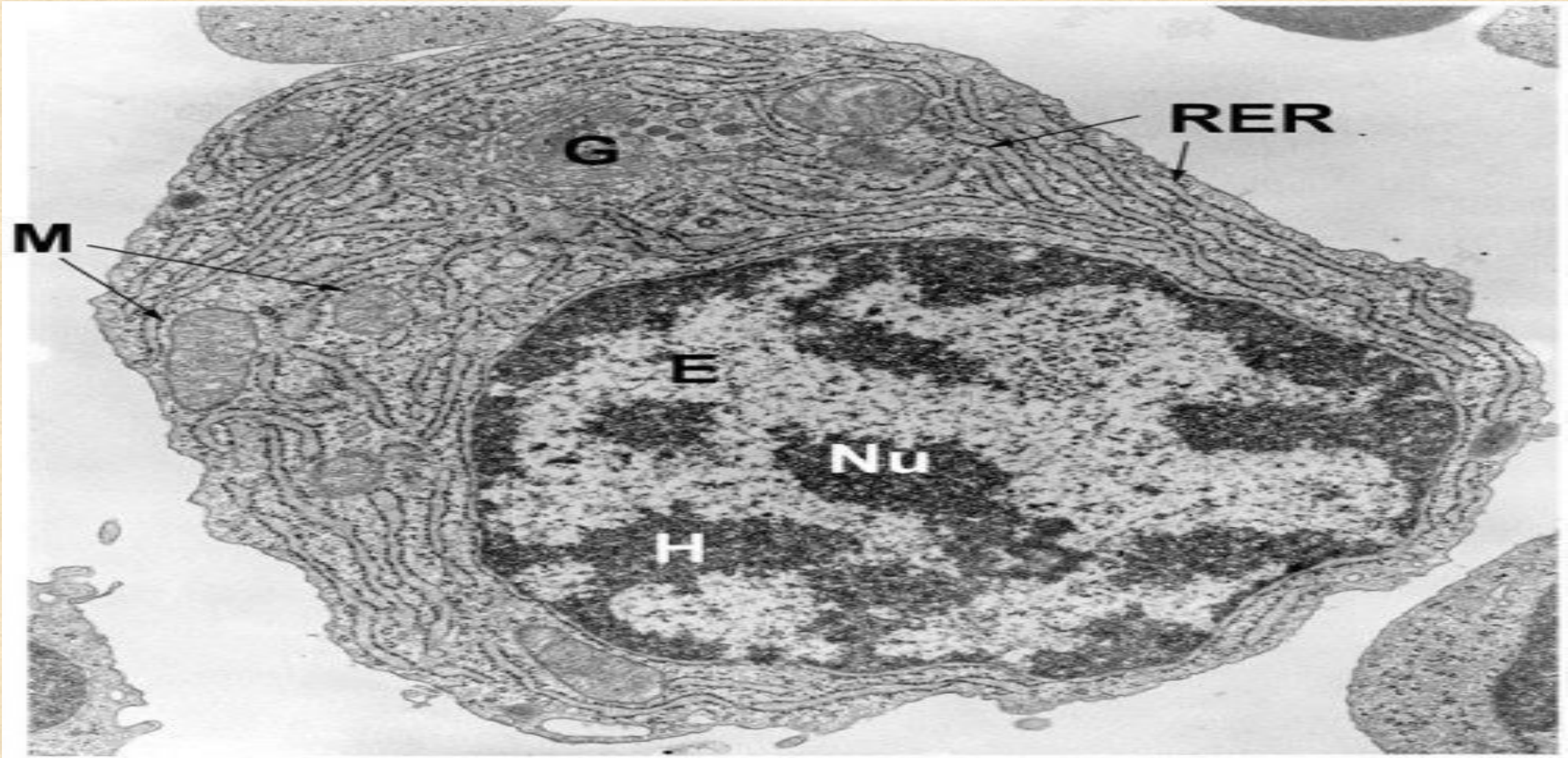


# Role of HC in the organisation of nuclear domains

- Heterochromatin and euchromatin occupy different nuclear domains. HC is usually localized in the periphery of the nucleus and is attached to the nuclear membrane. In contrast, the active chromatin occupies a more central position.

- The preferential localisation of HC against the nuclear membrane may be due to the interaction of the protein HP1 with the lamin B receptor, which is an integral component of the inner membrane of the nucleus.

- The peripheral localisation of HC concentrates the active elements towards the centre of the nucleus, allowing the active euchromatin to replicate and be transcribed with maximum efficiency.




Nu-nucleus, E-euchromatin, H-heterochromatin, M-mitochondria, RER-rough endoplasmic reticulum, G-golgi complex

# Role of HC in the centromeric function

- In most eukaryotes, the centromeres are loaded with a considerable mass of heterochromatin. It has been suggested that centromeric HC is necessary for the cohesion of sister chromatids and that it allows the normal disjunction of mitotic chromosomes.

- In the yeast *Schizosaccharomyces pombe*, the homologue of the HP1 protein Swi6 is absolutely essential for efficient cohesion of sister chromatids during cell division.

- Experiments involving the deletion of satellite DNA show that a large region of satellite DNA repeats is indispensable for the correct functioning of the centromere.

- It is supposed that centromeric HC might, in fact, create a compartment by increasing the local concentration of the centromeric histone variant, CENP-A, and by promoting the incorporation of CENP-A rather than the histone H3 during replication.

# Role of HC in gene repression (epigenetic regulation)

- Gene expression may be controlled at two levels:
- Firstly, at the local level which is transcription control, thanks to the formation of local transcription complexes. This level involves relatively small DNA sequences linked to individual genes.
- At a global level, in which case it is the transcriptability that is controlled. It involves much larger sequences that represent a large chromatin domain, which can be either in an active or an inactive state. Heterochromatin appears to be involved in controlling the transcriptability of the genome. Genes that are usually located in the euchromatin can, therefore, be silenced when they are placed close to a heterochromatic domain.

| BASIS FOR COMPARISON | HETEROCHROMATIN | EUCHROMATIN |
|---|---|---|
| Meaning | The tightly packed form of DNA in the chromosome is called as heterochromatin. | The loosely packed form of DNA in the chromosome is called as euchromatin. |
| DNA density | High DNA density. | Low DNA density. |
| Kind of stain | Stained dark. | Lightly stained. |
| Where they are present | These are found at the periphery of the nucleus in eukaryotic cells only. | These are found in the inner body of the nucleus of prokaryotic as well as in eukaryotic cells. |
| Transcriptional activity | They show little or no transcriptional activity. | They actively participate in the process of transcription. |
| Other features | They are compactly coiled. | They are loosely coiled. |
| | They are late replicative. | They are early replicative. |

| BASIS FOR COMPARISON | HETEROCHROMATIN | EUCHROMATIN |
| --- | --- | --- |
| | Regions of heterochromatin are sticky. | Regions of euchromatin are non-sticky. |
| | Genetically inactive. | Genetically active. |
| | Phenotype remains unchanged of an organism. | Variation may be seen, due to the affect in DNA during the genetic process. |
| | It permits the gene expression regulation and also maintains the structural integrity of the cell. | It results in genetic variations and permits the genetic transcription. |


Thank
you