SEMESTER – V

PAPER : BOT-353

(*Cell Biology, Genetics & Evolution*)

UNIT – I I

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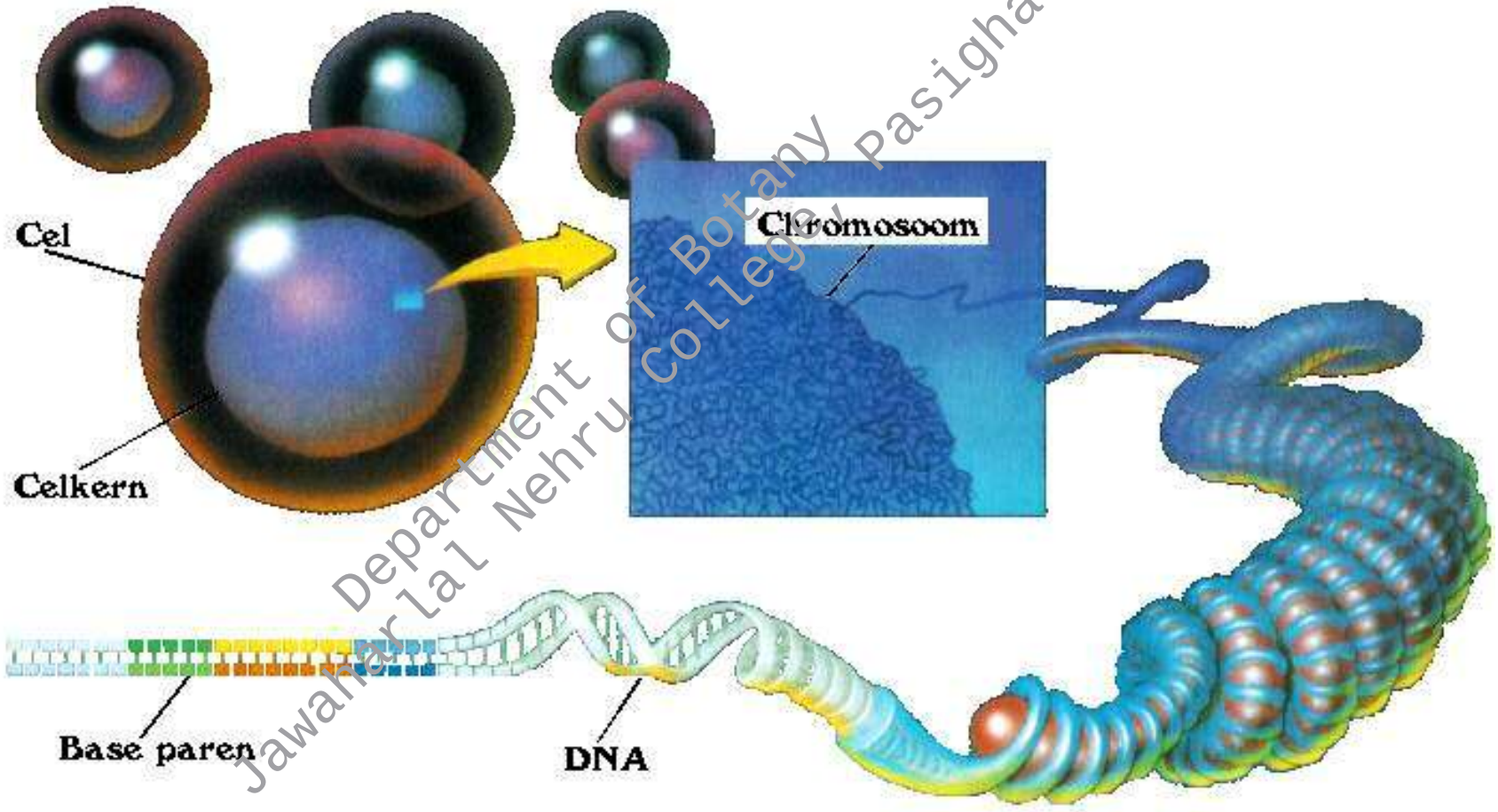
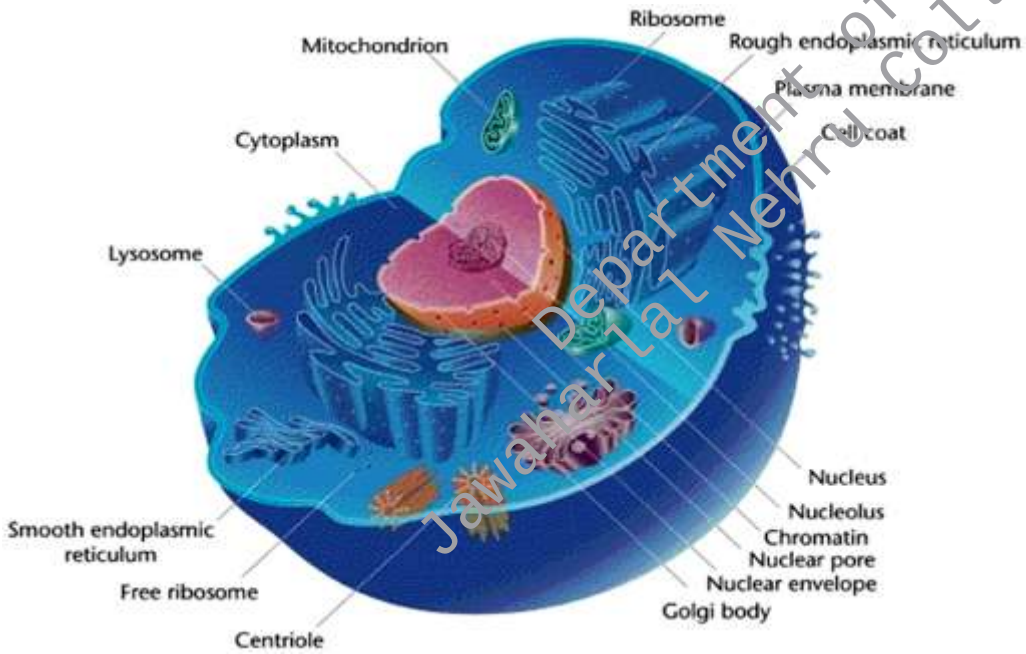
Lecture Overview

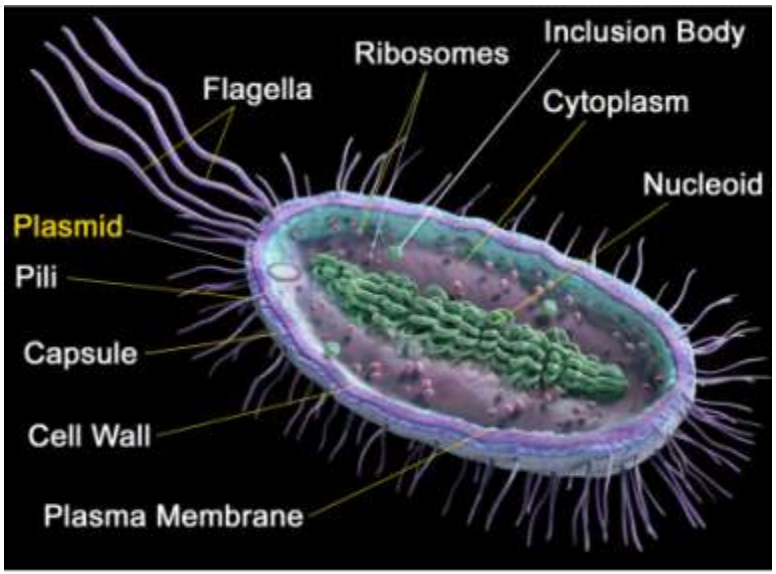
- Chromatin Organization.
- Packaging of Genome.



Genetic Material in the Living Cells

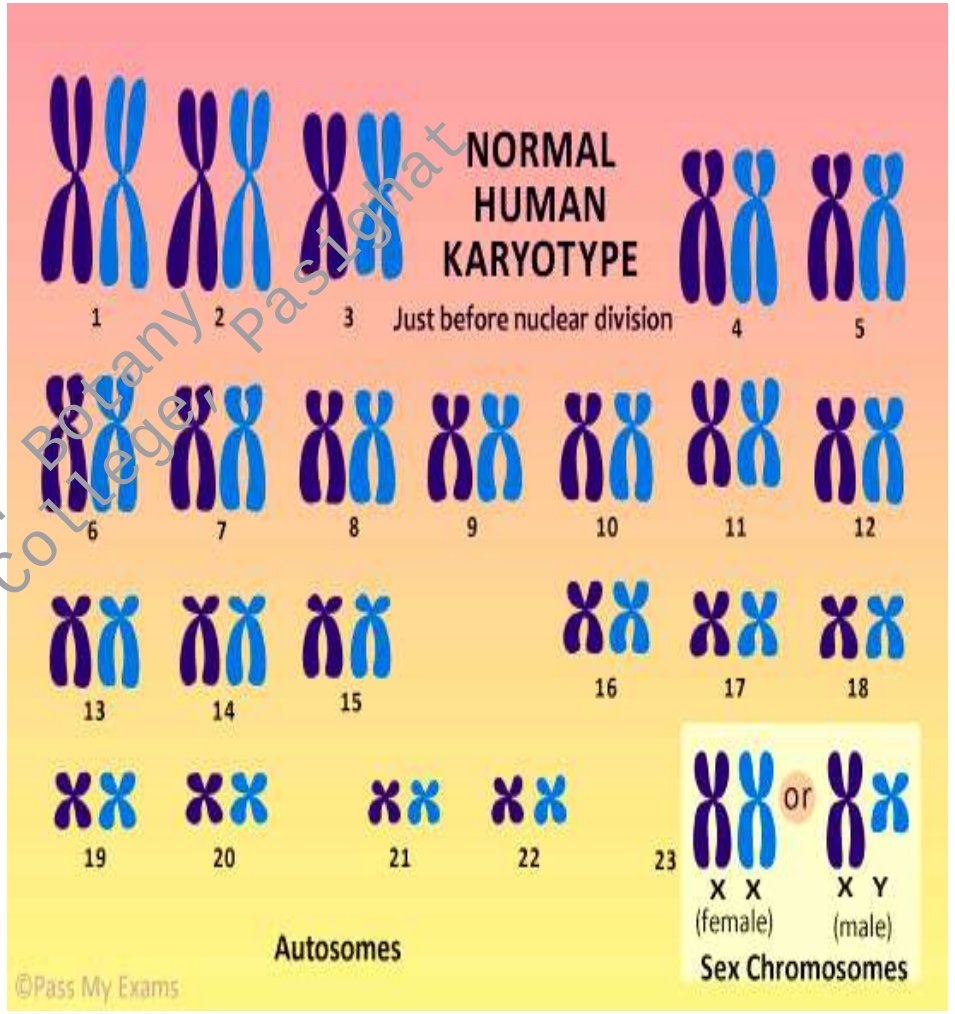
- Cells contain a nucleus surrounded by a nuclear membrane in eukaryotic cells, and a nuclear region in the prokaryotic cells (Nucleoid).
- In a non-dividing cell the nucleus is filled with a thread-like material known as "chromatin".
- Chromatin is made up of DNA and proteins (mainly histones and some non-histone acidic proteins).





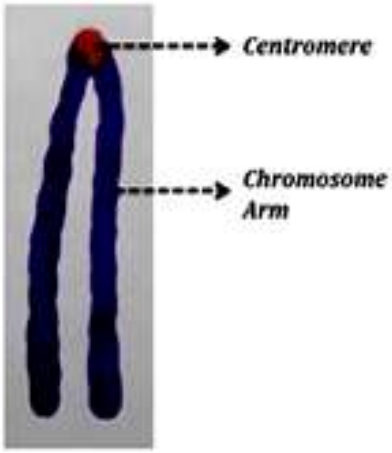
The Normal Human Chromosomes

- Normal human cells contain 23 pairs of homologous chromosomes:
  i. 22 pairs of autosomes.
  ii. 1 pair of sex chromosomes.
- Autosomes are the same in males and females
- Sex chromosomes are:
  i. XX in females
  ii. XY in males.
- Both X are homologous. Y is much smaller than X and it contains a fewer genes than X.

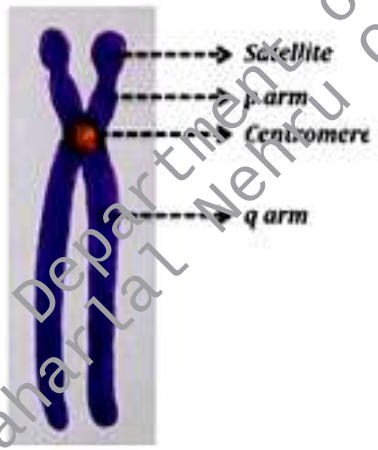


Chromosomes

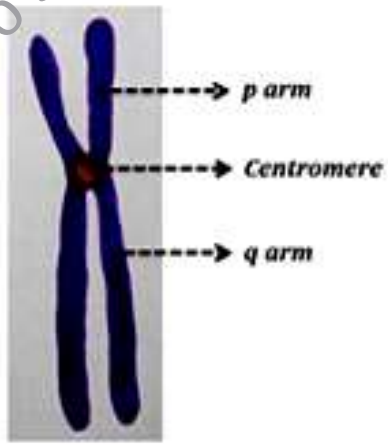
- **One** member of each chromosome pair is derived from each **parent**.
- **Somatic cells** have **diploid** complement of chromosomes i.e. 46.
- **Germ cells** (Gametes: sperm and ova) have **haploid** complement i.e 23.
- Individual chromsomes are recognized by
  i. Arm lengths (p- short, q -long).
  ii. Centromere position (metacentric, sub-metacentric, acrocentric, telocentric).



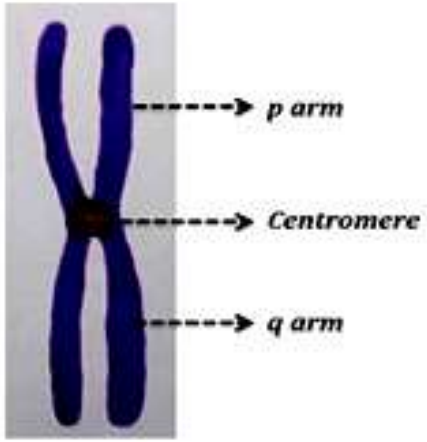
Telocentric



Accrocentric

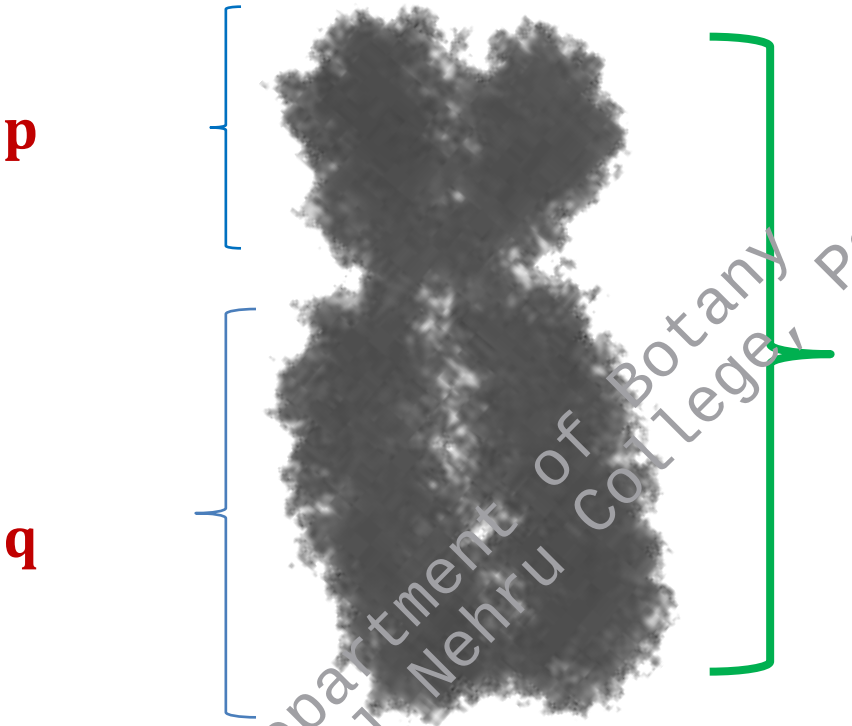


Sub-metacentric



Metacentric

Composition of Chromosome



DNA

Histones
(Major proteins)

Non-histone
(Small amounts)

- The chromosomes themselves are macromolecular entities that must be synthesized, packaged, protected, and properly distributed to daughter cells at cell division.
- Significant segments of every chromosome are dedicated to these functions.

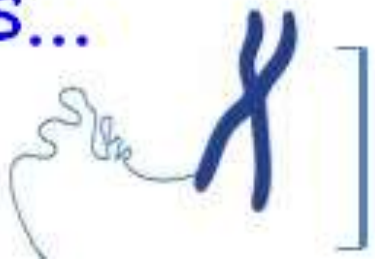
DNA Condensation: Why?

The length of DNA in one chromosome

4 cm

How can this be packed

into this...

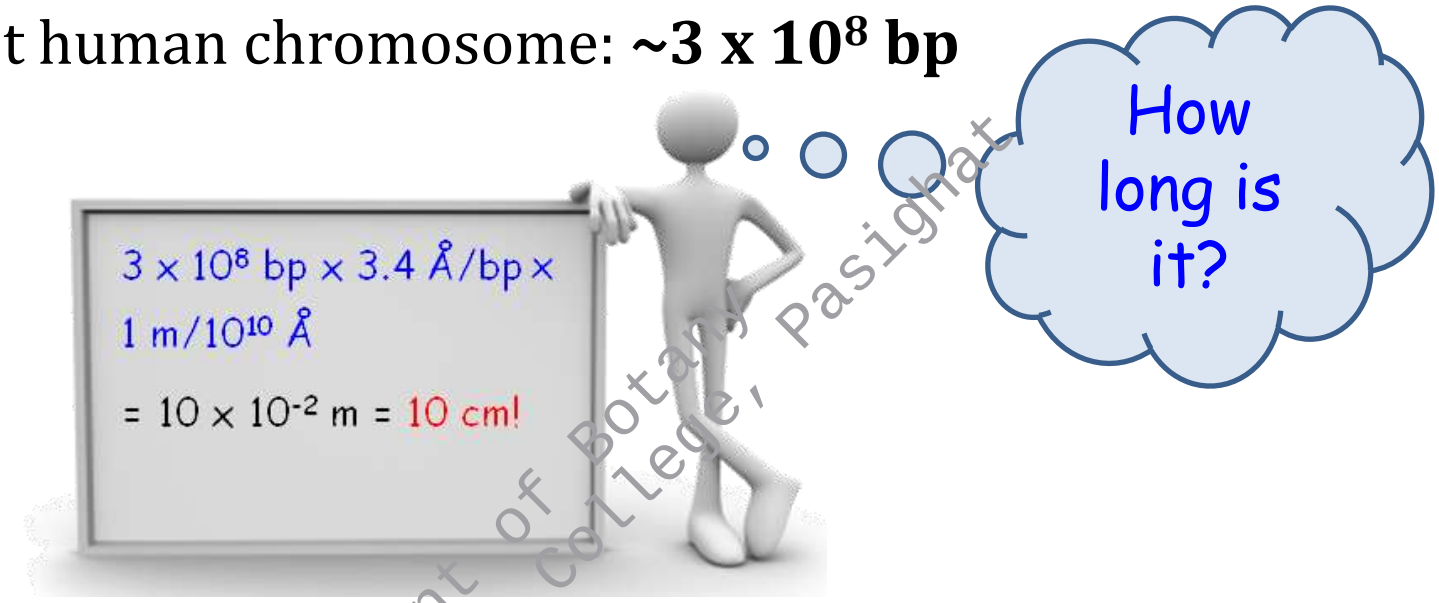


2 µm

This would be equal to packing a 40 km long rope into a space of 1 meter

A serious problem of packaging

1. Largest human chromosome: **~3 x 10^8 bp**



2. A typical cell nucleus = 10 μm = 10 x 10^{-6} m
3. Therefore the DNA must be compacted ~10^4-fold.

This is like fitting a 40 km-long rope into a 1 meter box !

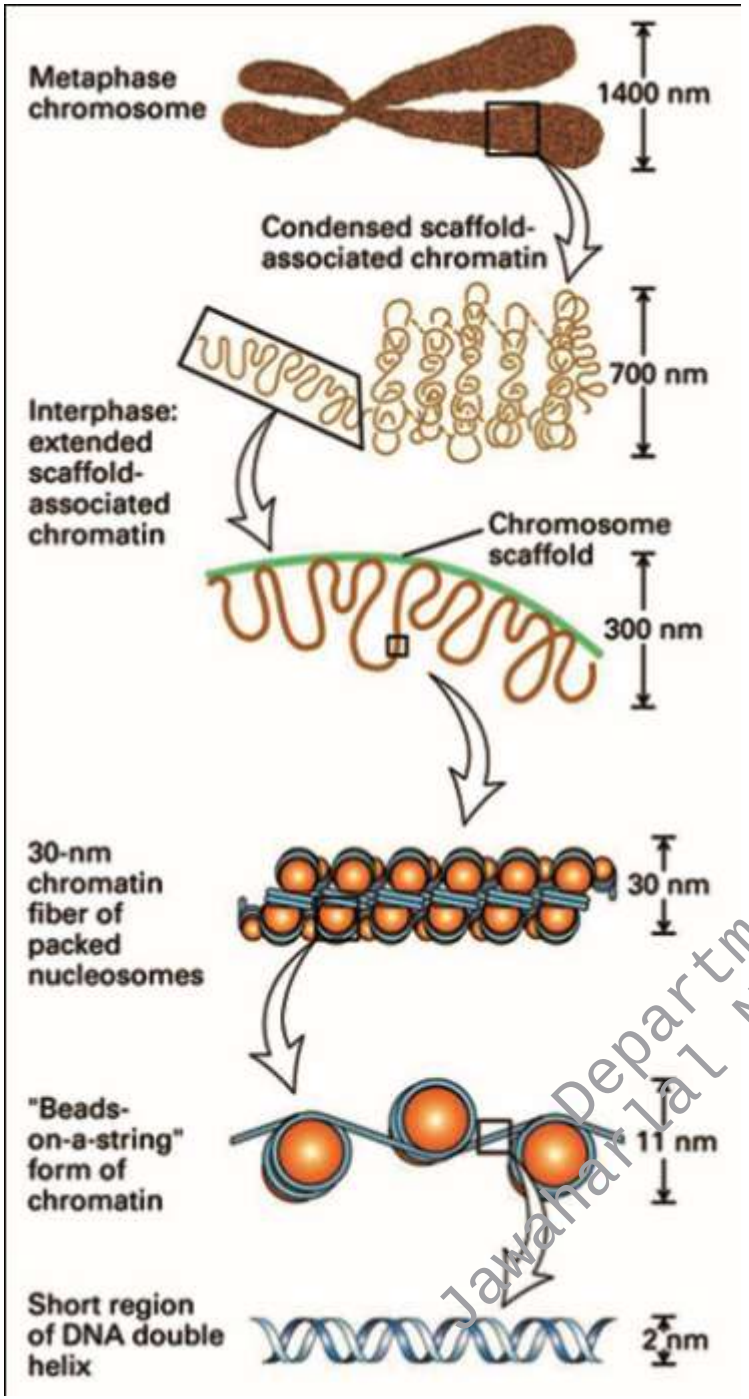
- Eukaryotes contain thousands of times more DNA than do bacteria, and as a result, the DNA–condensation problems of eukaryotes—(compacting the DNA so that it fits in the cell nucleus)—are more complex than those of bacteria.

- Bacteria do not contain nucleosomes, although they have small, basic (+'vely charged) proteins that are involved in condensing their DNA.

- DNA compaction must be dynamic, because changes in the degree of condensation must occur quickly and when needed, as the cell passes through the stages of the cell cycle. ***Conserved ?***

- Furthermore, when in its most highly compacted form, DNA is not accessible to transcription or replication enzymes, so it must be able to rapidly expose regions containing genes that are required at any given moment, and then condense again.

- Done by modification enzymes that alter the state of DNA condensation, and can target their activity to specific regions of the chromosome that must be transcribed or replicated.



The DNA packaging SUPERSTRUCTURE

Higher-order DNA compaction in a eukaryotic chromosome.

This model shows the levels of organization that could provide the observed degree of DNA compaction in the chromosomes of eukaryotes. **First** the DNA is wrapped around histone octamers, **then** H1 stimulates formation of the 30 nm filament. Further levels of organization are not well understood but seem to involve further coiling and loops in the form of rosettes, which also coil into thicker structures. **Overall**, progressive levels of organization take the form of coils upon coils upon coils. It should be noted that in cells, the higher-order structures (above the 30 nm filament) are unlikely to be as uniform as depicted here.

The DNA packaging SUPERSTRUCTURE