Eukaryotic genome organization

fundamental facts about the eukaryotic nuclear genome.

- It is linear, as opposed to the typically circular DNA of bacterial cells.
- It conforms to the Watson-Crick double-helix structural model.
- it is embedded in nucleosomes—complex DNA-protein structures that pack together to form chromosomes.
- eukaryotic genomes vary dramatically in terms of size and gene counts.
- genome size and the number of genes present in an organism reveal little about that organism's complexity

- Two features of eukaryotic genomes present a major information-processing challenge.
- First, the typical multicellular eukaryotic genome is much larger than that of a prokaryotic cell.
- Second, cell specialization limits the expression of many genes to specific cells.
- The estimated 25,000 genes in the human genome include an enormous amount of DNA that does not code for RNA or protein.
- This DNA is elaborately organized. ° Not only is the DNA associated with protein, but also this DNA-protein complex called chromatin is organized into higher structural levels than the DNA-protein complex in prokaryotes.

- When compared with prokaryotic cell, Eukaryotic cell is having the large amount of DNA in its nucleus.
- The DNA is found associated with proteins.
- Chromatin is the complex basis of DNA and protein that makes up chromosomes consists of Linear unbroken double stranded DNA. Chromatin is of two types
  - a. **Euchromatin, and**
  - **b. Heterochromatin**

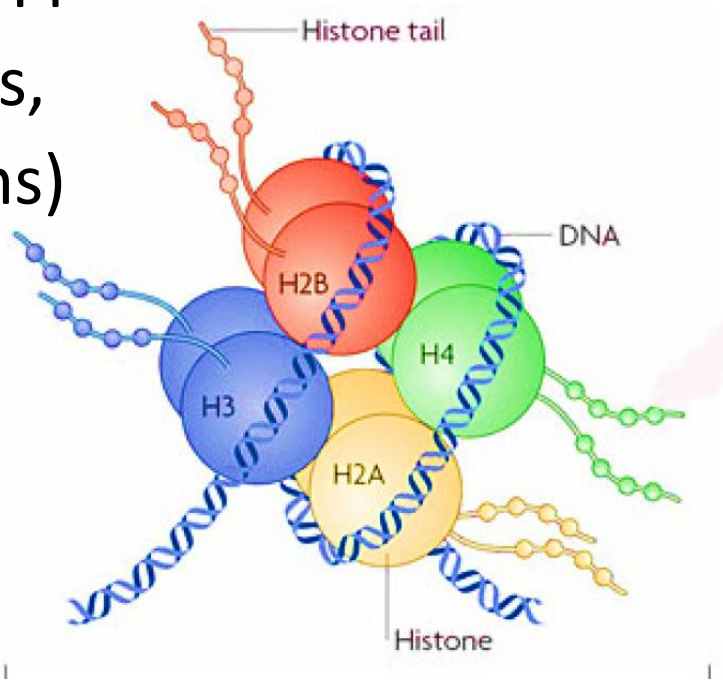
a. Euchromatin : type of chromatin which is genetically active. It consists of all functional genes which are expressive, stains very lightly.

b. Heterochromatin: It is genetically inactive, the genes are not expressive. heterochromatin stains darkly because the chromatin region here is highly condensed.

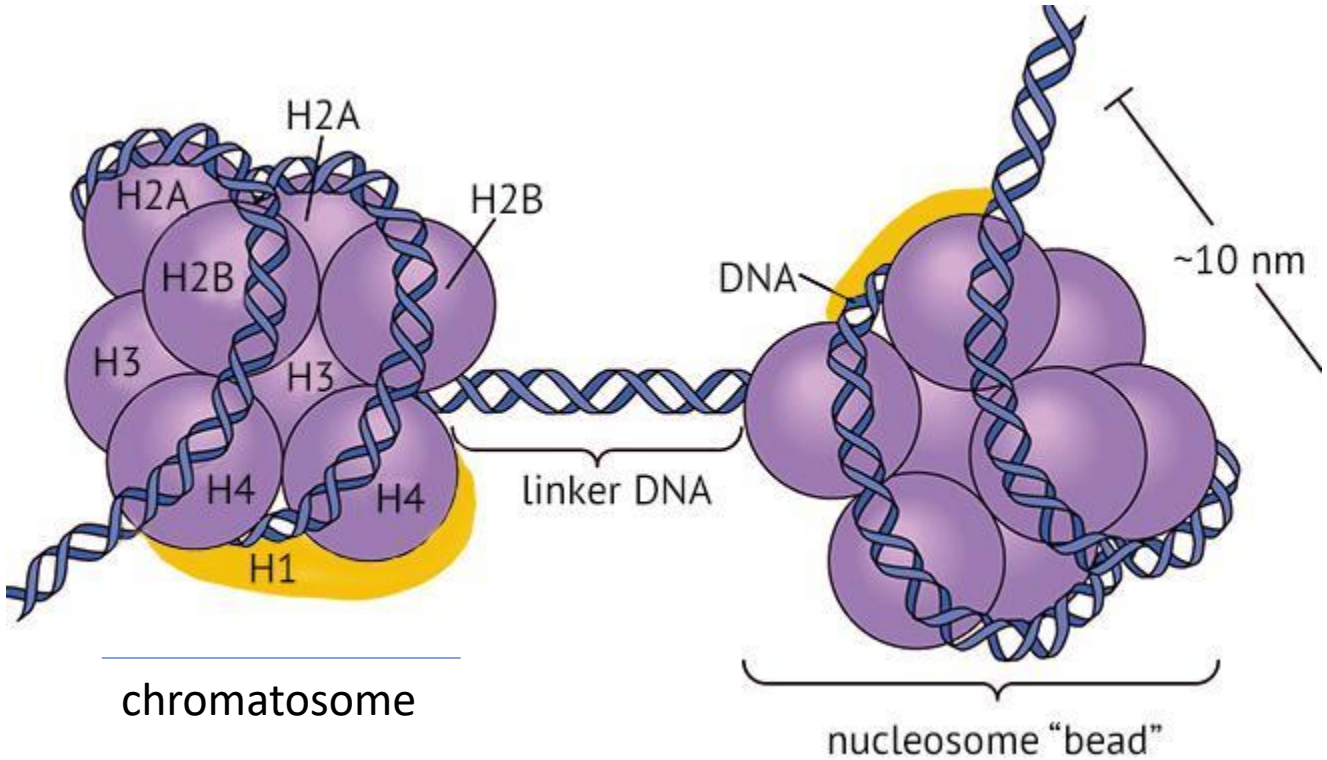
- Histones are the chief protein components of chromatin they act as spools around which DNA winds and play a role gene regulation.
- Five major histone classes are present which are associated with eukaryotic genome i.e., H_1, H_2A, H_2B, H_3 & H_4.
- these are basic proteins which have a positive charge at normal pH which facilitates the binding of negatively charged DNA

- The simplest level of packing of DNA which is found winding around Histones is known as Nucleosome.
- There are two molecules of each of four types of Histones namely H_2A, H_2B, H_3 & H_4. this give rise to a complex of 8 proteins named as “Histone octomer”
- This Histone octomer is flattened cylindrical particle of about 11 nm and thickness of nucleosome is 5.7nm.
- The H1 protein is present only in single set. These nucleosomes are attached to each other by means of a thin naked DNA which is known as Linker DNA (the H_1 is associated with Linker DNA)
- Higher order organization is seen further where this nucleofilament has the appearance of beats on a string at 11 nm
- The complexity in the organization may be represented further by the packing of chromosomes in a highly compact fashion giving rise to 30 nm, then 300 nm, 700 nm and finally 1400 nms in thickness which are able to see as rod like chromosome at metaphase of cell division.

1. the simplest level is chromatin: a double stranded structure of DNA
2. This DNA forms a complex with proteins called “ histone proteins”
3. This histone-protein complex is known as nucleosome
4. These histone proteins are H1, H2A, H2B, H3 and H4
5. Each nucleosome consists of eight histone proteins,
   (two of each H2A, H2B, H3 and H4 histone proteins)
6. These histone proteins forms a core of nucleosome
7. DNA wrapped around these core by 1.65 times.
   (less then 2 rounds)

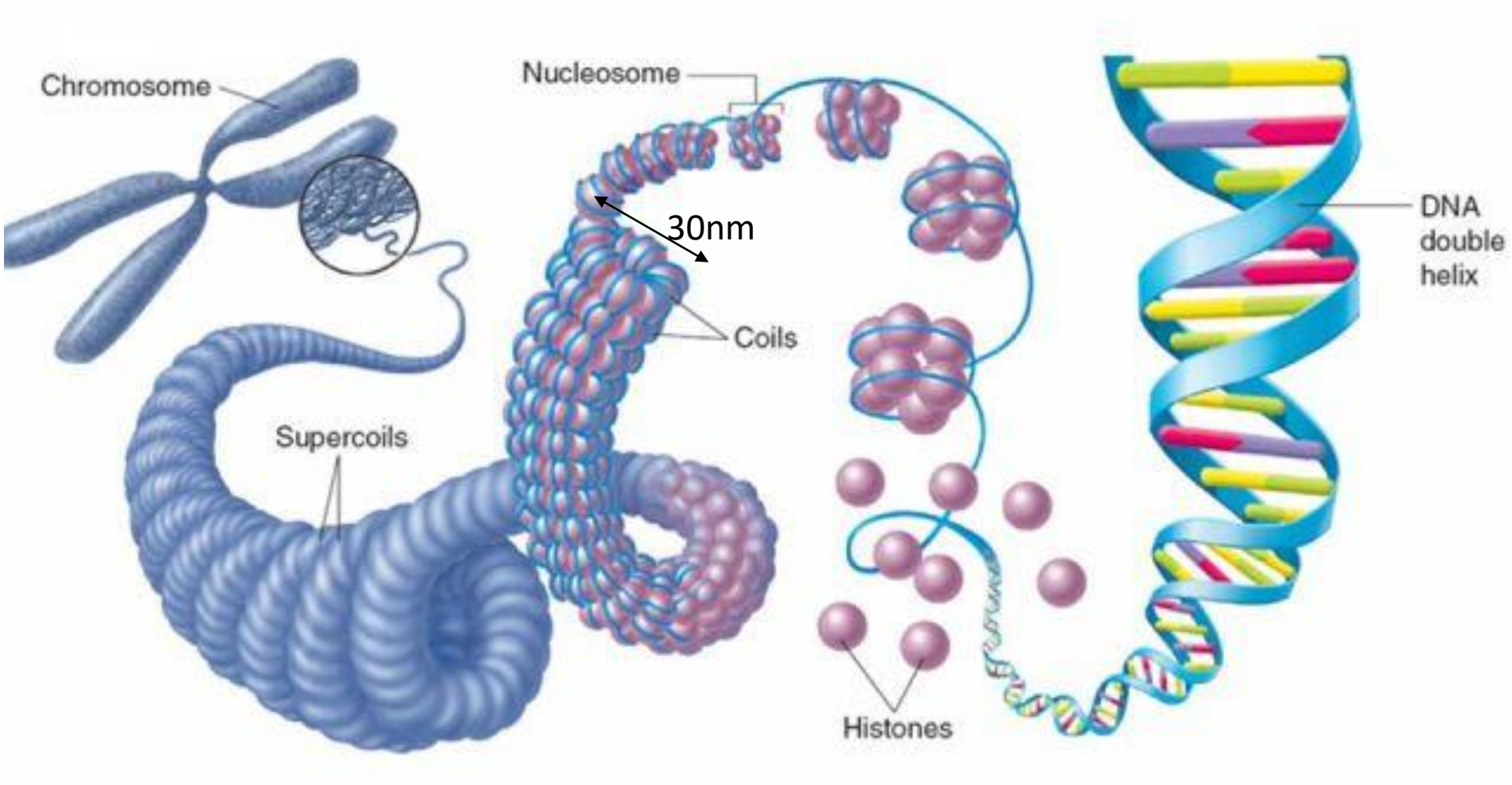


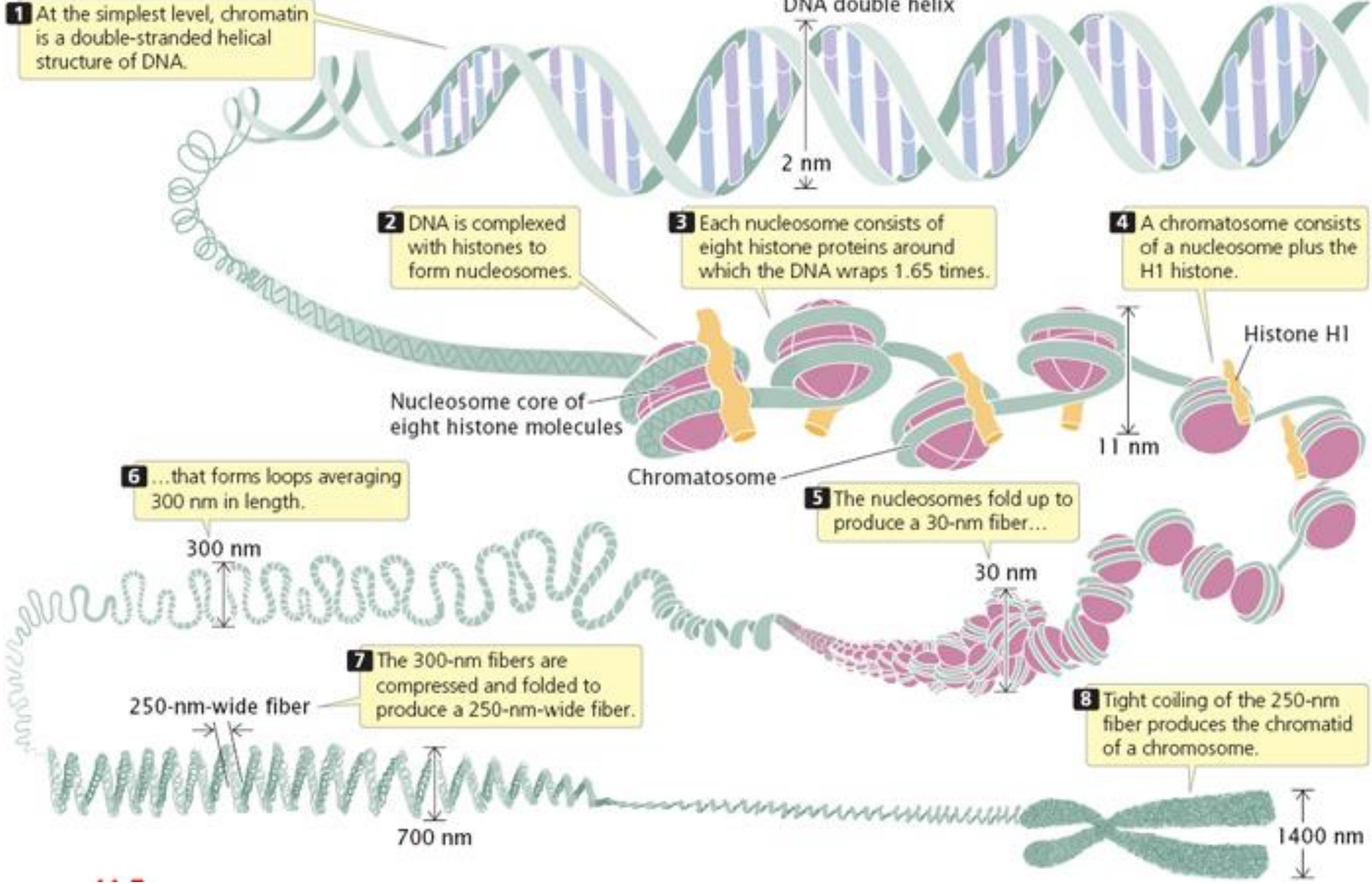
- These nucleosomes forms a bead like structure
- Two nucleosome beads attached with each other through linker region
- a nucleosome with H1 protein is chromatosome



DNA and Chromosomes

- Eukaryotic Chromosome Structure




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
Nucleosome core of eight histone molecules
11 nm
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
8 Tight coiling of the 250-nm fiber produces the chromatid of a chromosome.
700 nm
1400 nm