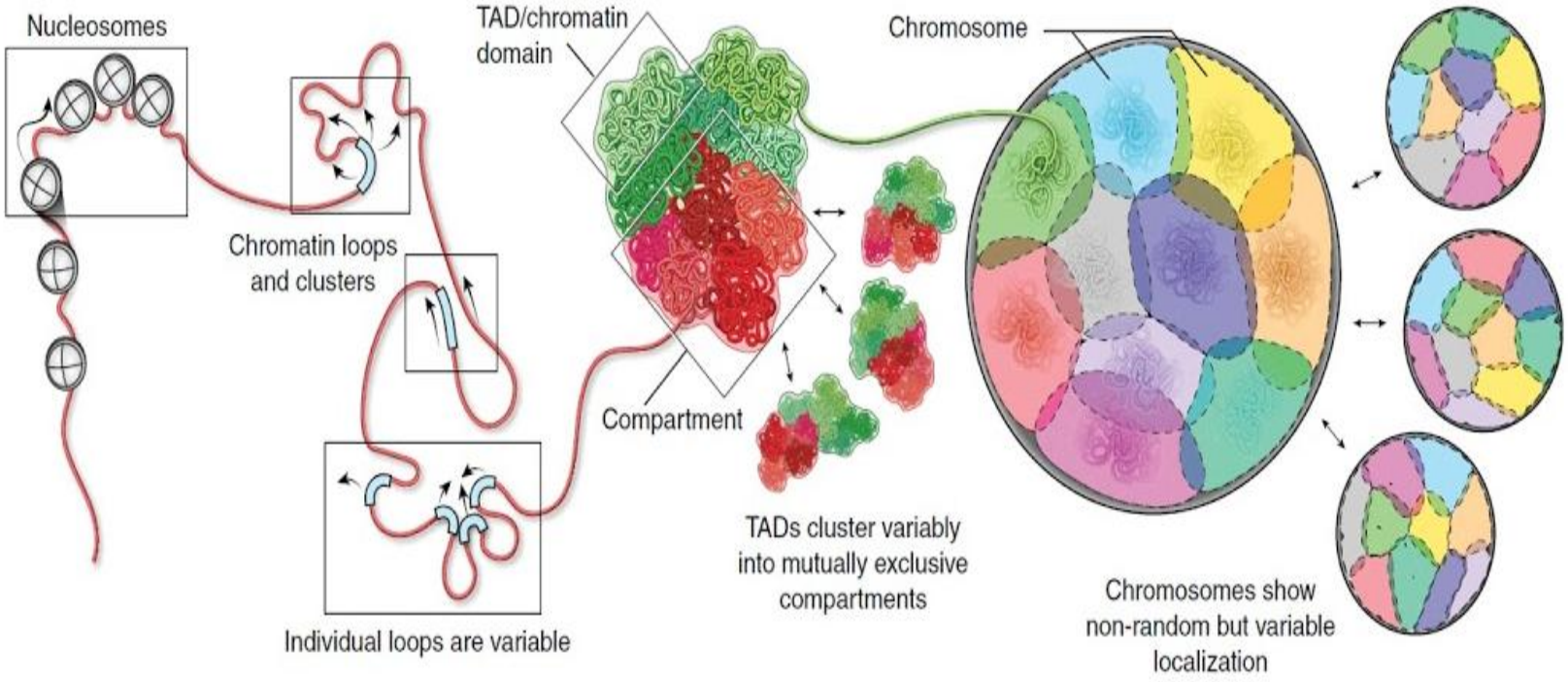
Eukaryotic Genome Organization



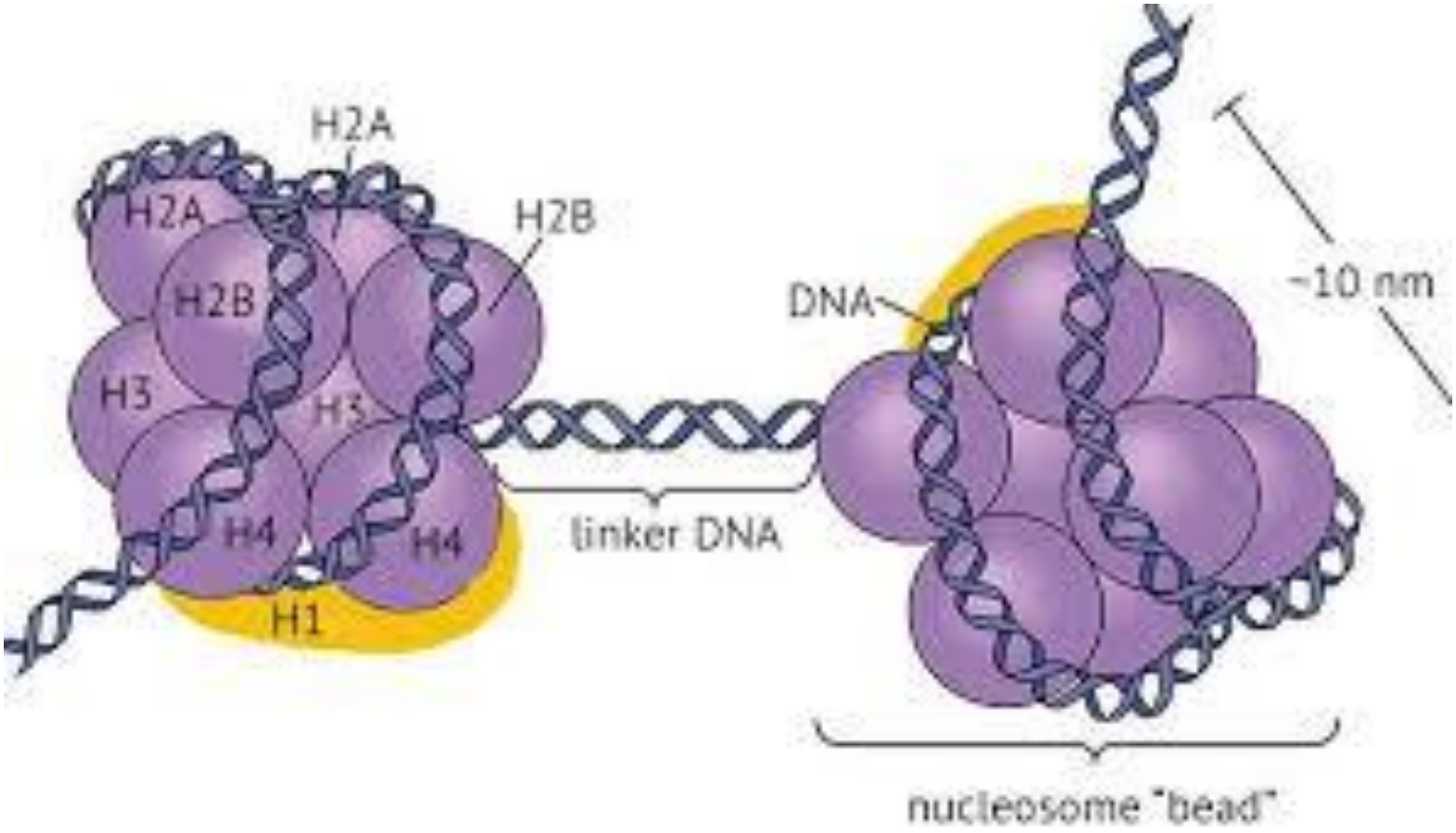
Introduction

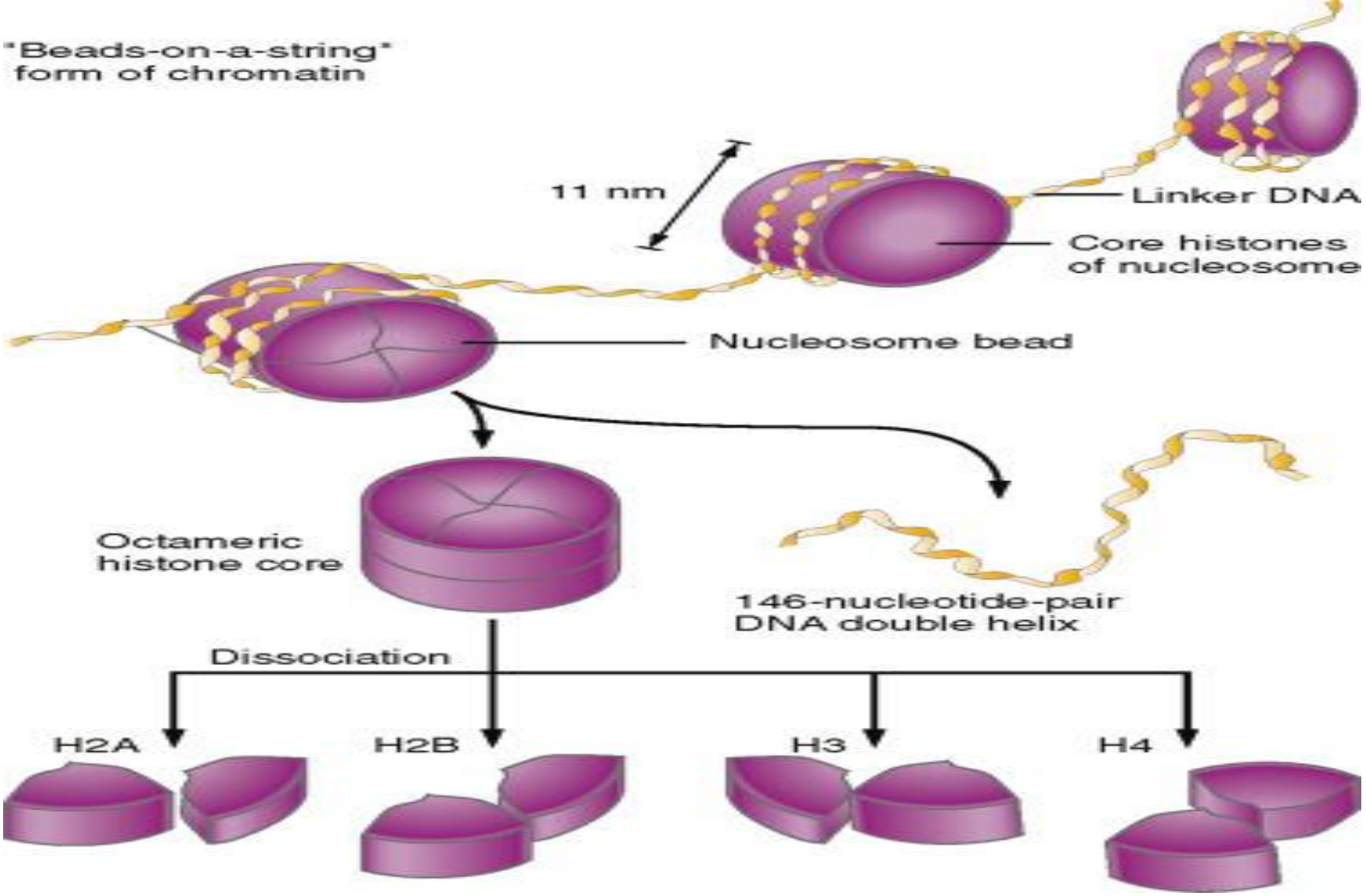
- Eukaryotic cells are complex cells that consist of compact packaging of the genome within the nucleus. These eukaryotic cells consist of a complete set of chromosomes called a genome, and the specific part of DNA called a gene provides the basic information for the protein production.
- Genes, inherited from parent to offspring, form various proteins such as structural proteins, tRNA, rRNA, and mRNA. Functional proteins, promoters, and operators provide basic transcription information where transcription factors bind and non-structural proteins, introns, and repetitive units.
- The eukaryotic genome organization consists of compact packing of DNA having the network or support using histone and non-histone protein.

Structural protein of eukaryotic genome organization:

- **Histone protein:** Histone proteins are structural proteins that form core proteins to bind with DNA. Histone proteins, such as H2A, H2B, H3, and H4, form a core of two molecules of each protein, forming an octamer formation. These histone proteins are lysine and arginine-rich and consist of positive charges (+ve) and are mainly basic in nature, helping the negatively charged phosphate backbone.

- **Non-histone protein:** the non-histone protein provides a network and structure to compact the DNA inside the chromosome.


H2A
H2A
H2B
H2B
H3
H3
H4
H4
H1
linker DNA
DNA
~10 nm
nucleosome "bead"


"Beads-on-a-string"
form of chromatin
11 nm
Linker DNA
Core histones
of nucleosome
Nucleosome bead
Octameric
histone core
146-nucleotide-pair
DNA double helix
Dissociation
H2A
H2B
H3
H4

Models of eukaryotic genome organization:

- **Multi-stranded model:** Ris and Chandler, in 1963, demonstrated the model called the “multi-stranded model.” In this model DNA contains a double helix structure (each chromatids is made up of half a chromatids, forming a 2 nm (diameter), but they said it's not multi-stranded.

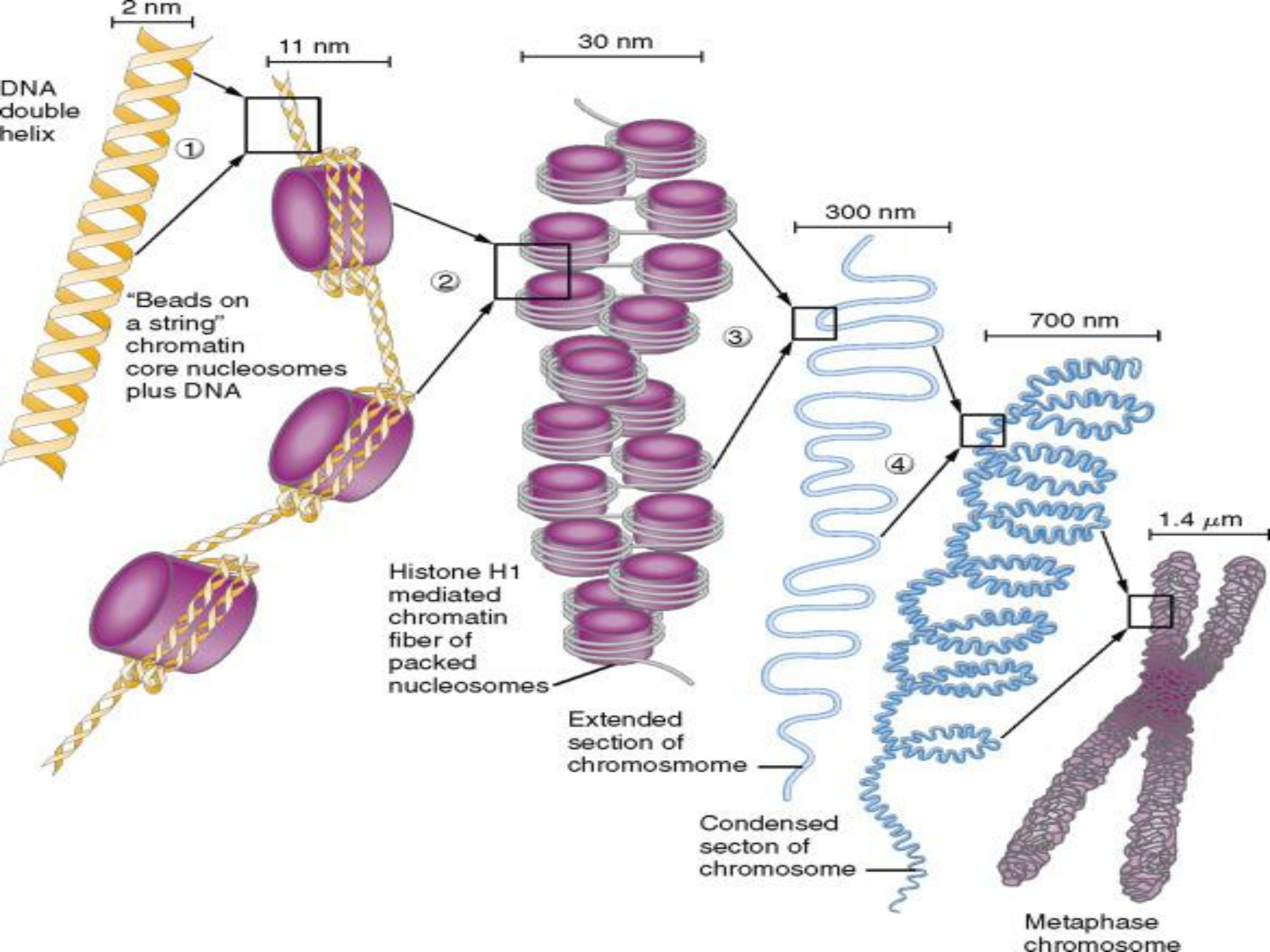
- **Folded—Fiber Model:** Dupraw, in 1965, demonstrated the next model to study genome organization in eukaryotes. He said DNA consists of a double helix with associated protein to pack spiral DNA to form 10-100A, called type A, and 200-2000A, called type B. The protein called histone forms a shell-like structure around the DNA called a histone shell by Dupraw. In S-phase, chromatin fiber is held together by two sister chromatids.

- **Nucleosome Model:** Roger from the Nucleosome model describes the histone core protein (octamer) binding to dsDNA for their compact packaging.

Level of Organization

The packaging of the genome in eukaryotes has different levels of organization:

- **1. First level of organization:** the first or initial level of organization, where the dsDNA, which is 2 nm in diameter, wrapped around the core histone protein (H2A, H2B, H3, and H4) with 146 bp and around 1.7 turns, formed an ellipsoidal model. These histone and DNA packages formed the nucleosome model, and then H1 as a linker joined or attached them together with 10-40 bp.
- **2. Second level of organization:** the second level formed two models 1. Zig-Zag Model and 2. Solenoid Model. In the Zig-Zag Model, the uneven distribution of histone and DNA is from 11 nm in diameter, and in the Solenoid Model, the even distribution of DNA + histone + H1 as a linker forms 30 nm in diameter.
- **3. Third level of organization:** the third level of organization consists of the compact or highly organized packaging formed by the chromatid loop of 300 nm diameter, the haploid chromosome packaging of 700 nm diameter, and the whole chromosome formed with a 1400 nm diameter.


2 nm
11 nm
30 nm
DNA double helix
①
"Beads on a string" chromatin core nucleosomes plus DNA
②
Histone H1 mediated chromatin fiber of packed nucleosomes
300 nm
③
700 nm
④
1.4 μm
Extended section of chromosmome
Condensed secton of chromosome
Metaphase chromosome