MCB 150

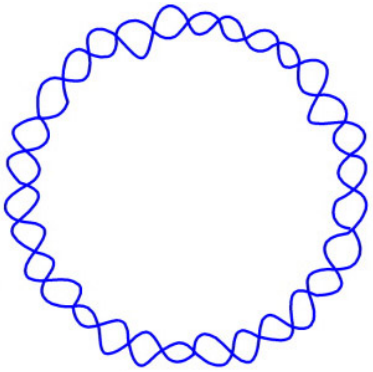
The Molecular and Cellular Basis of Life

DNA organization

Today's Learning Catalytics Session ID is:
83329188

DNA organization:

- Nucleotides make up nucleic acid chain.
- Bases pair with each other to make a double helix.
- A very long double helix of DNA (+associated proteins) is a chromosome.
- Chromosomes can be linear or circular.



Circular

Prokaryotes

Mitochondria
Chloroplasts

Linear

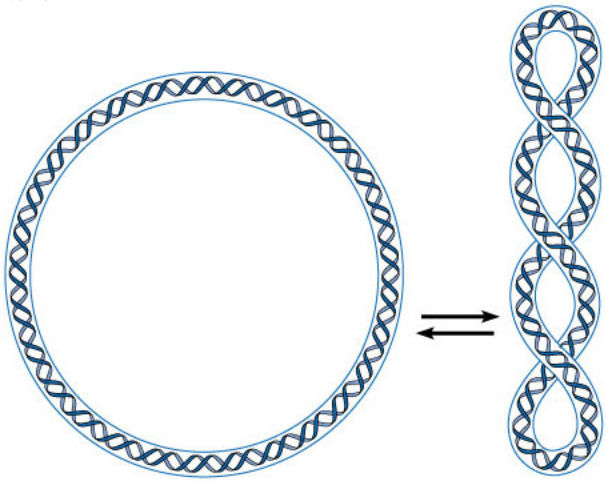
Eukaryotes

How do we pack millions or billions of bp (base pairs) of DNA into such a small space?

- In bacteria like *E. coli*, extended lengths of DNA can be 1,000 times the width of the cell.
- In humans, all of the chromosomes stacked end to end would be 2 meters in length!
- Either way, we need to compact all that chromatin into a space that's only 1–10 µm.

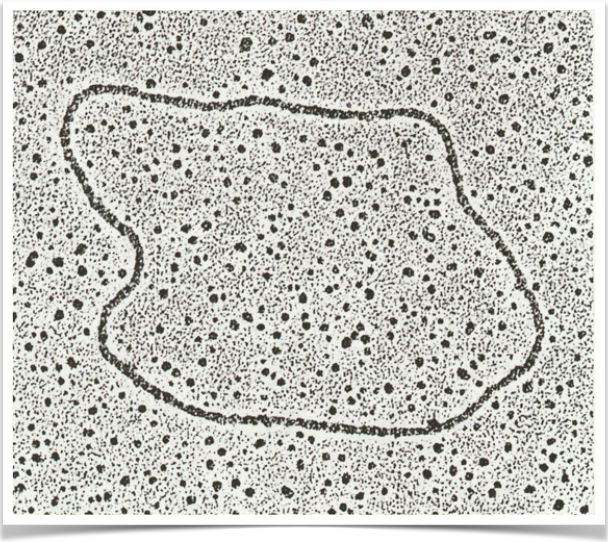
Bacterial chromosomes are **supercoiled**:

- Done by **topoisomerases**, which nick DNA, wind or unwind, then reseal DNA

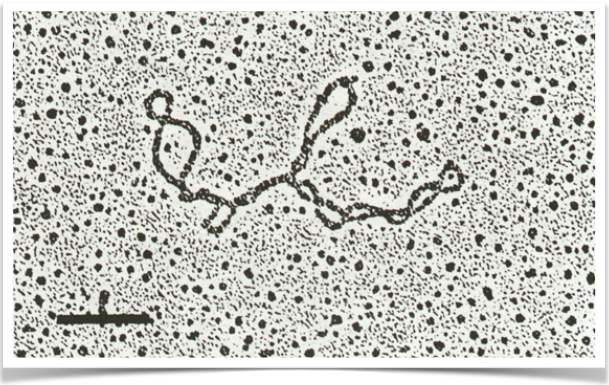


Relaxed Supercoiled

Relaxed versus supercoiled DNA:



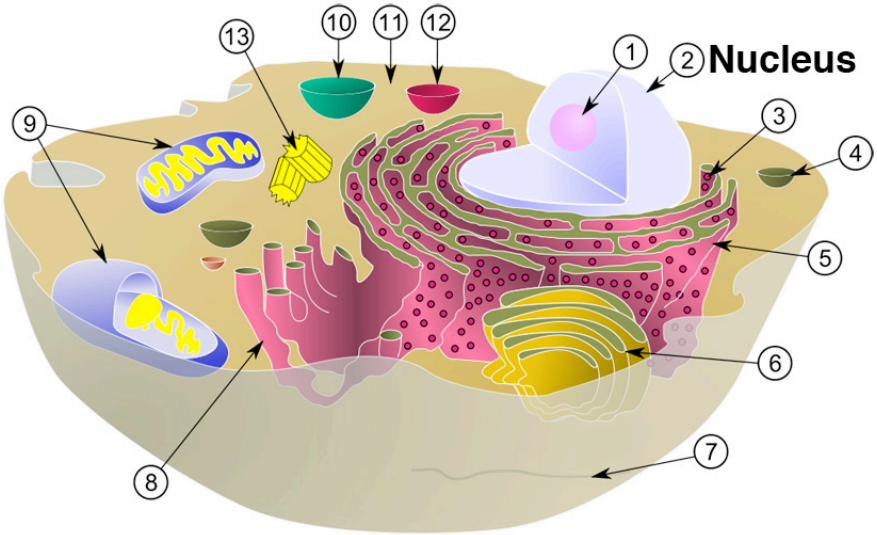
(A)



(B)

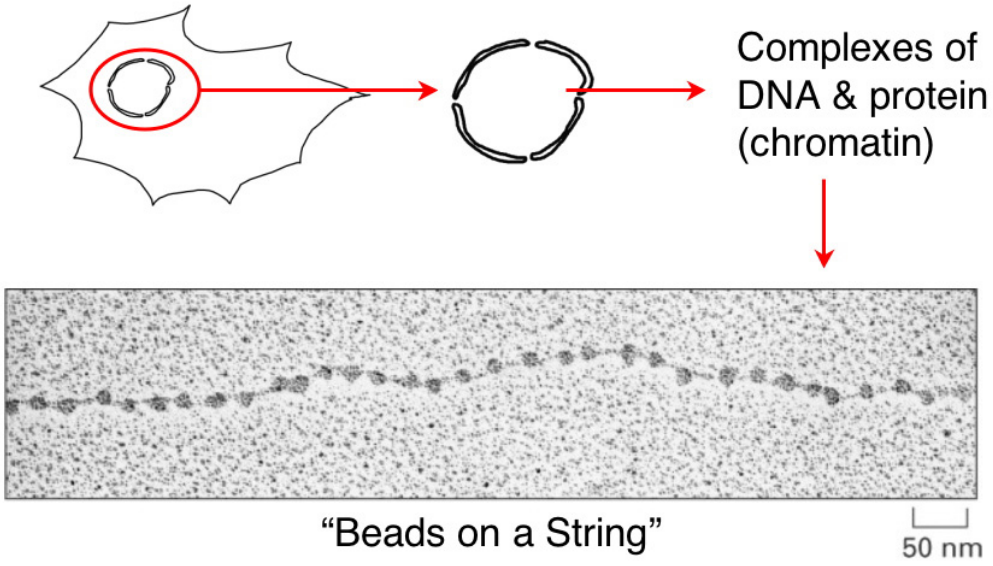
What about Eukaryotes?

- How do we get 2 meters of DNA into a nucleus that is 5–8 µm in diameter?

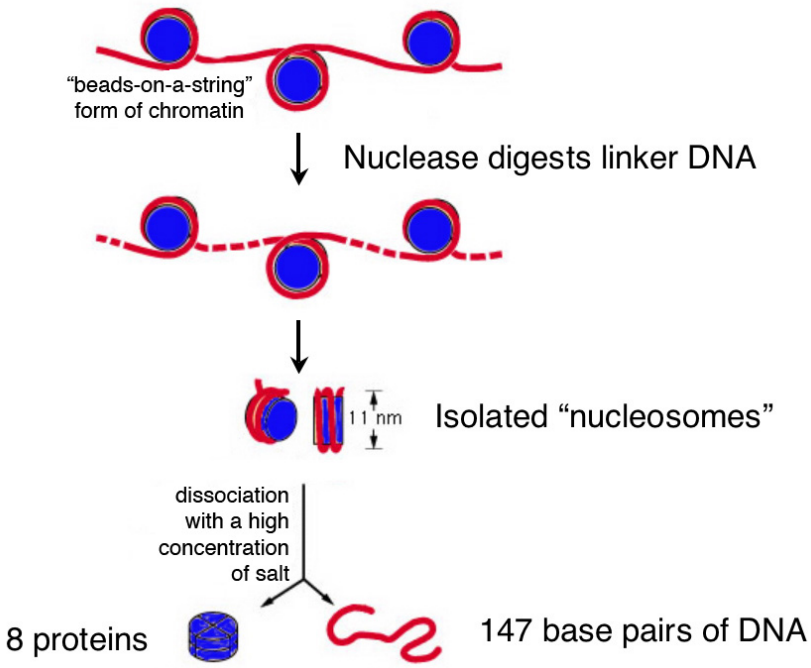


Organization of chromatin in the nucleus:

- Chromatin first described by R. Kornberg in 1974



Nucleosome isolation and dissociation:



What are the proteins that are part of chromatin?

- **Histones**

Histones:

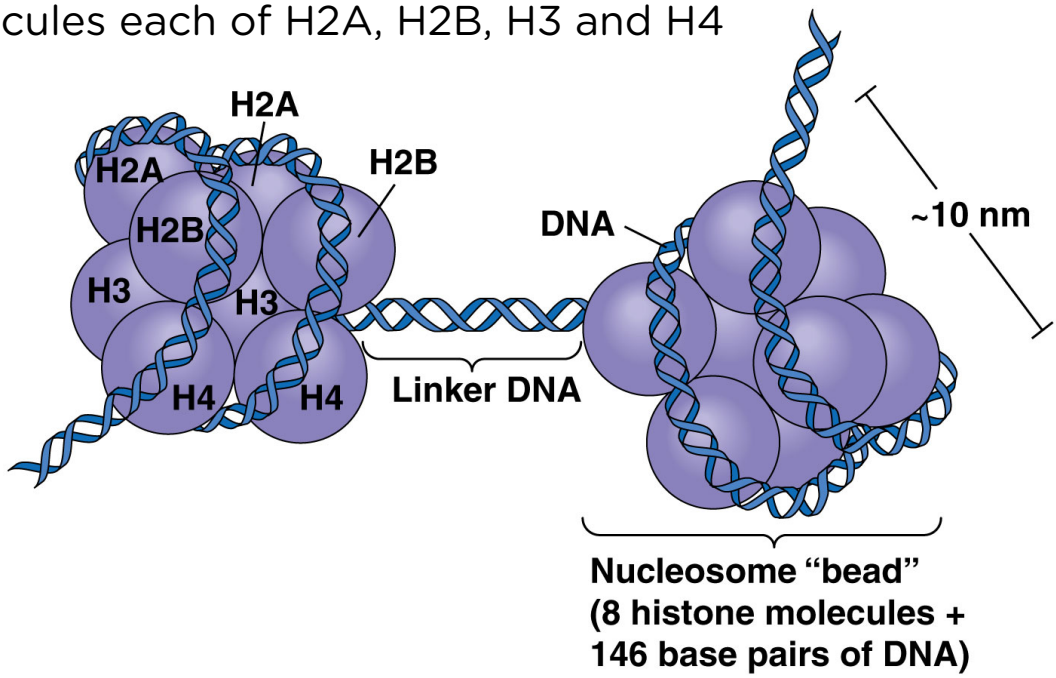
- Small, basic proteins
- Five major types of histones: H1, H2A, H2B, H3, and H4
- Sequence is highly conserved among species
- Bacteria do not have histones, but they have histone-like proteins

The (core) nucleosome:

- Two each of histones H2A, H2B, H3, and H4
- 146 (or 147) base pairs of DNA
- Packing of DNA and histones into nucleosomes yields chromatin fiber of approx. 10 nm diameter

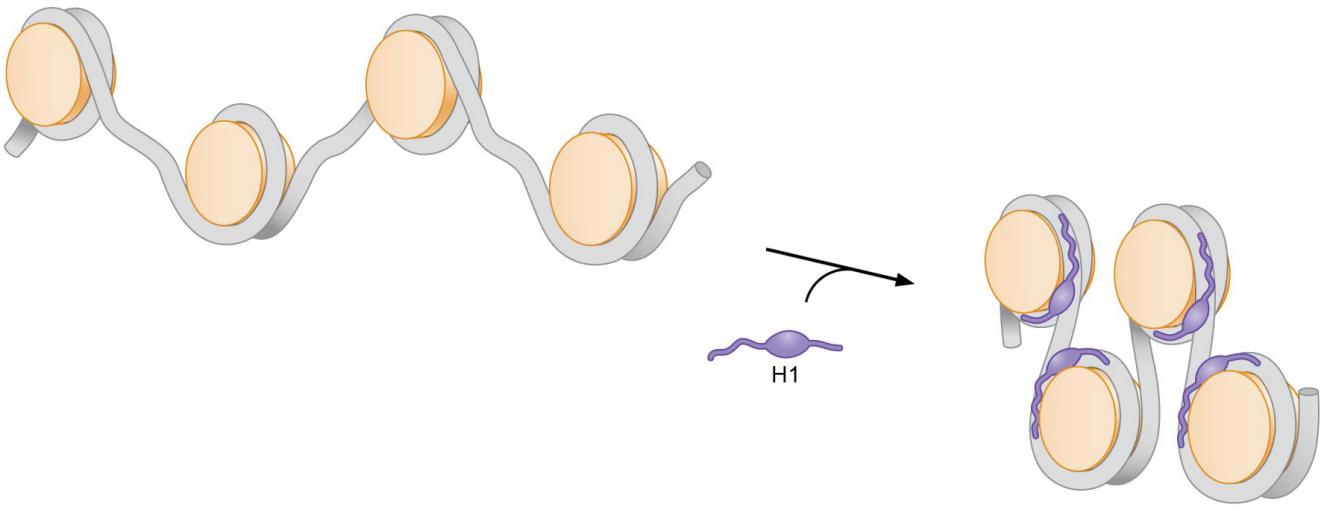
Nucleosome structure:

- Two molecules each of H2A, H2B, H3 and H4

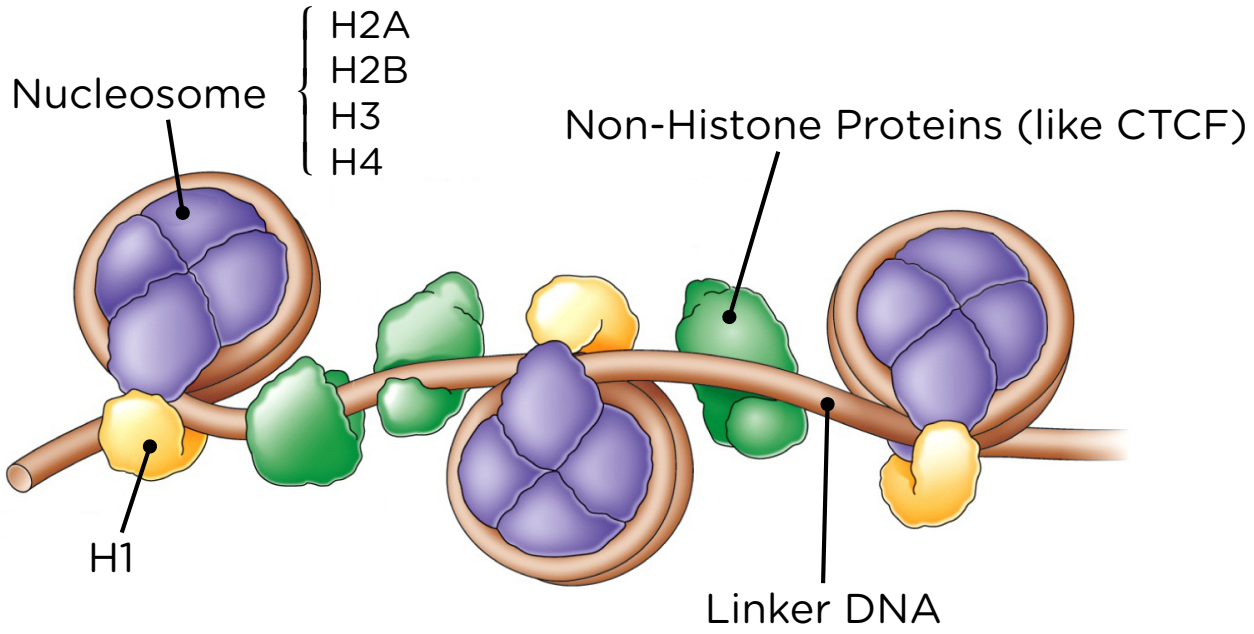


Chromatosome structure:

- A nucleosome plus a single molecule of H1

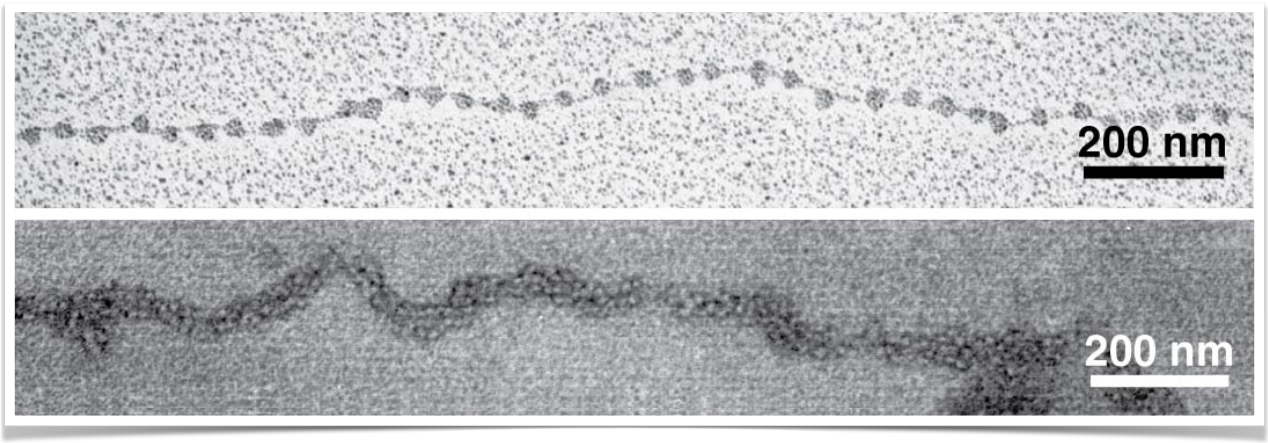


Summary of 10-nm chromatin fibers:



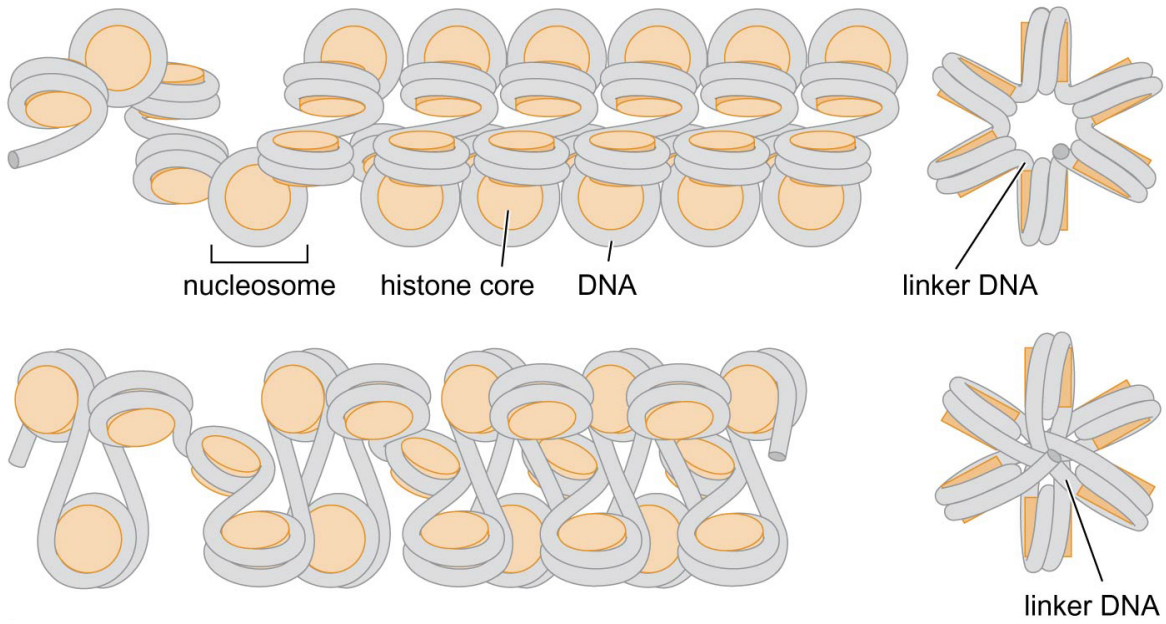
10–nm chromatin fibers "only" shorten the length of DNA by six-fold:

- Next level of organization is the 30-nm fiber

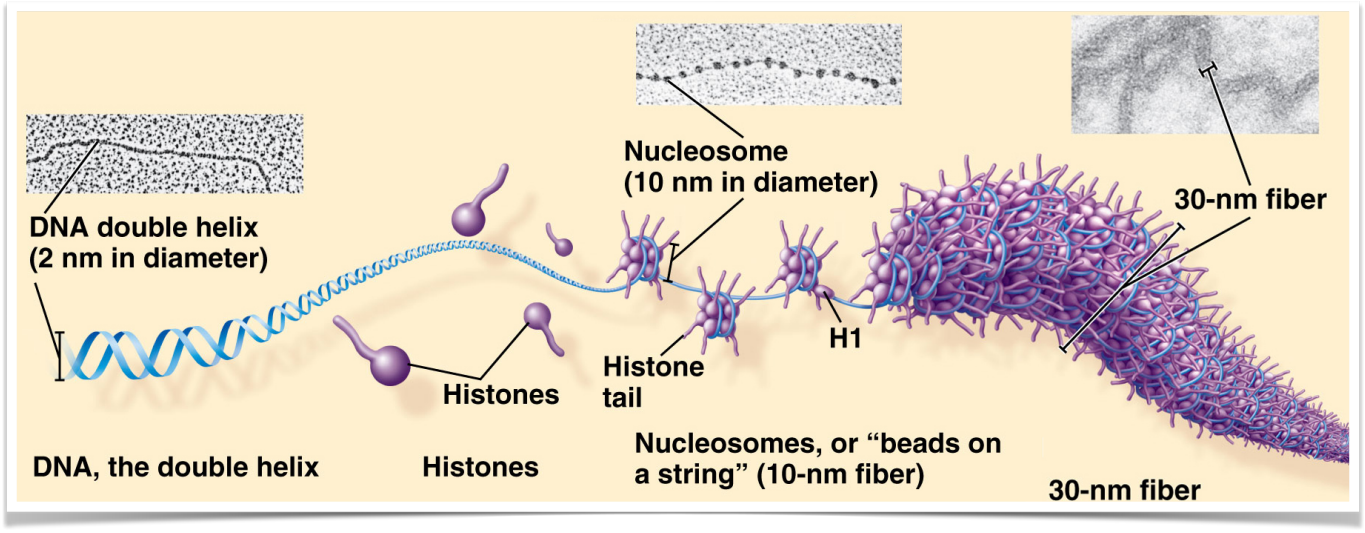


Possible conformations of 30–nm chromatin fibers:

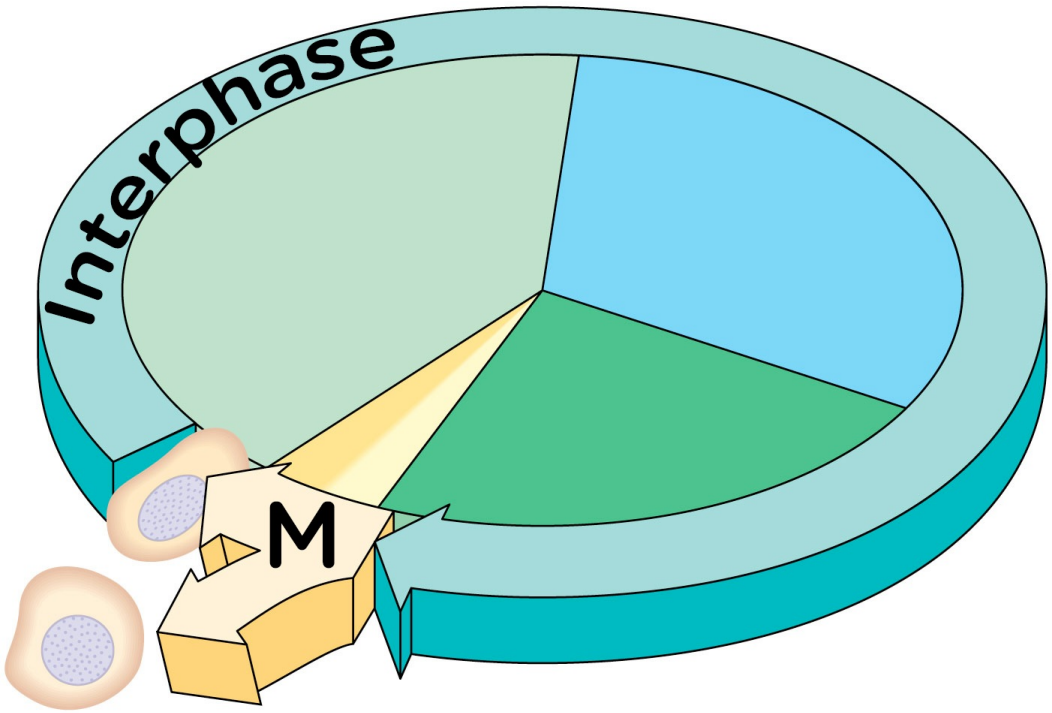
- Solenoid model versus flexible zigzag model



Double helix to 30-nm fibers:



The eukaryotic cell cycle:



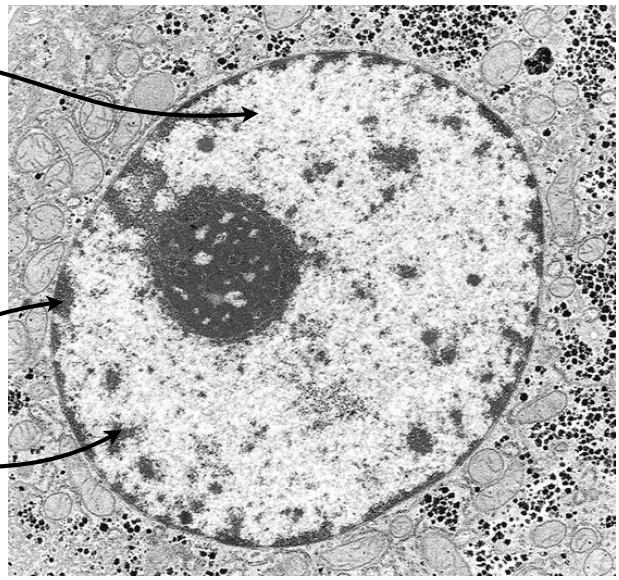
Interphase Chromatin exists in loosely condensed form (Euchromatin) and highly condensed form (Heterochromatin):

Euchromatin

- Distributed throughout the nucleus
- Most in the form of 10-30 nm structures

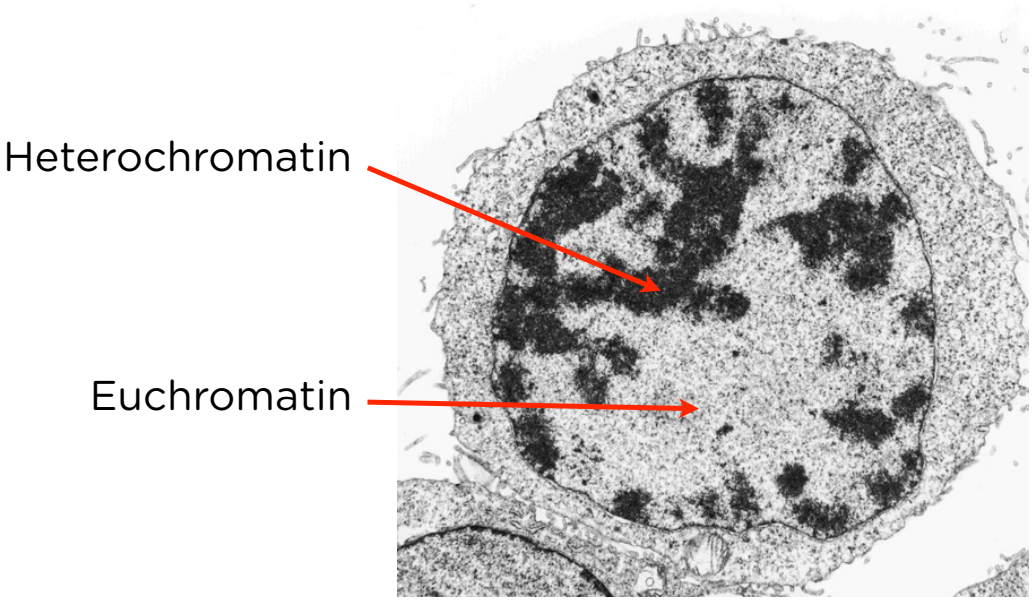
Heterochromatin

- Found at periphery of the nucleus and in pockets elsewhere in the nucleus

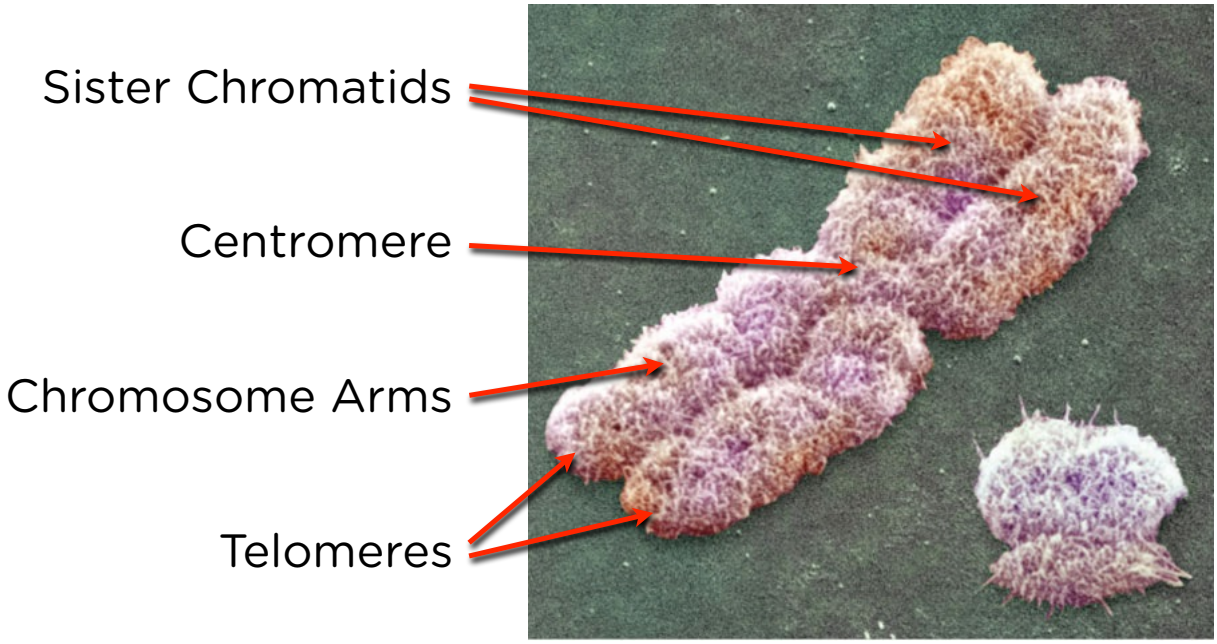


As a cell enters mitosis, chromatin must condense further:

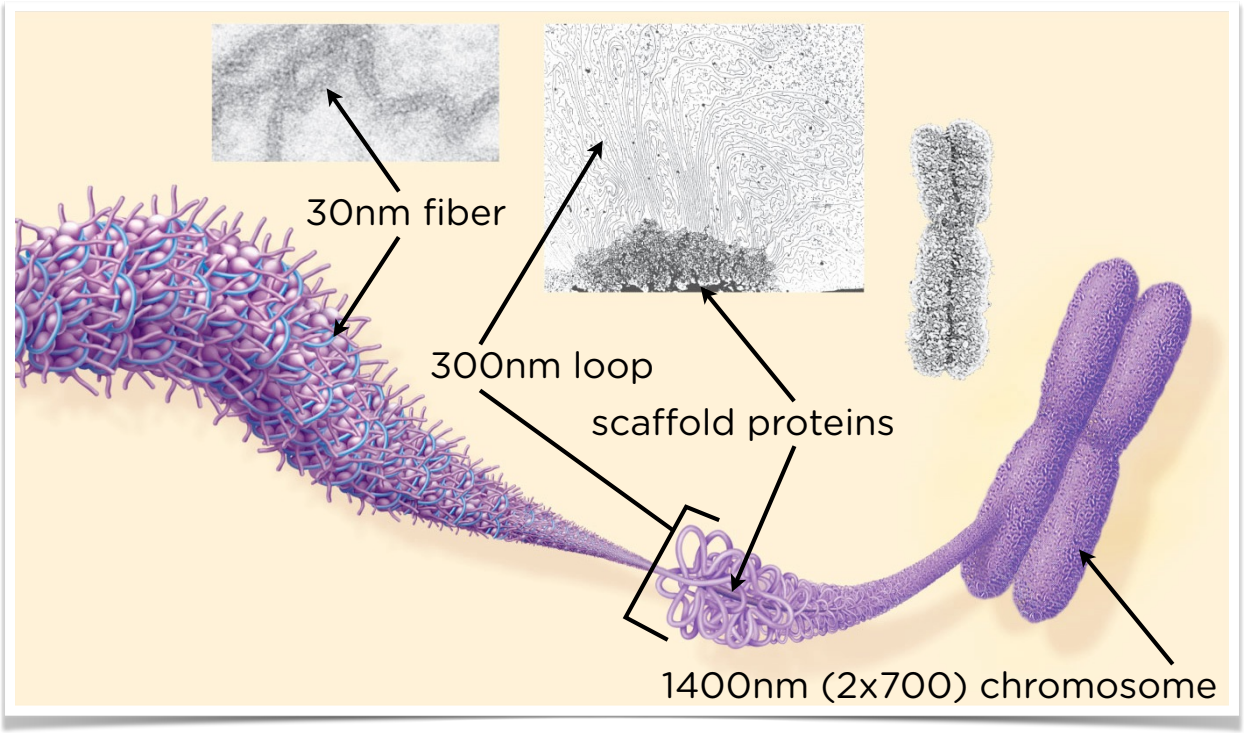
- Eventually condense into familiar "chromosomes"



Typical mitotic chromosome structure:



30-nm fibers condense to mitotic chromosomes:



Naked DNA to mitotic chromosomes: