CONCEPT: DNA PACKAGE

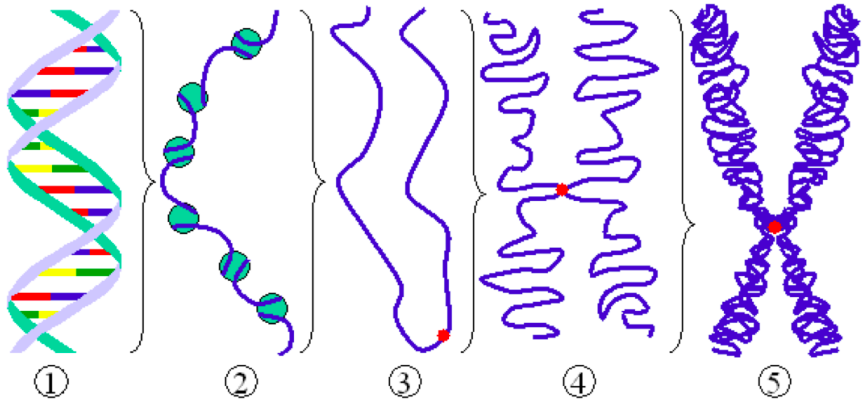
● Packaging of DNA is necessary in order to _____ within the confines of a cell

□ Average human cell contains 2 meters of DNA

- Cell nucleus is only 5-8 μm in diameter

□ There are four packaging levels of DNA: *nucleosome (2), 30nm-fiber (3), looping (4), chromosomes (5)*

EXAMPLE: Four packaging levels of DNA



Nucleosome:

● The **nucleosome** consists of DNA and histone proteins

□ Discovered by Dean Hewish and Leigh Burgonye

- Used nucleases that chopped DNA bound to protein – Found it cut only in 200 base-pair fragments

□ **Histone** proteins are a major class of proteins _____ to DNA to form the nucleosome

- There are five classes of histone proteins: *H1, H2A, H2B, H3, H4*

- Classified by the ratio of lysine:arginine amino acids present on the protein

□ Eight histone proteins compose a positively charged core around which the negatively charged DNA winds

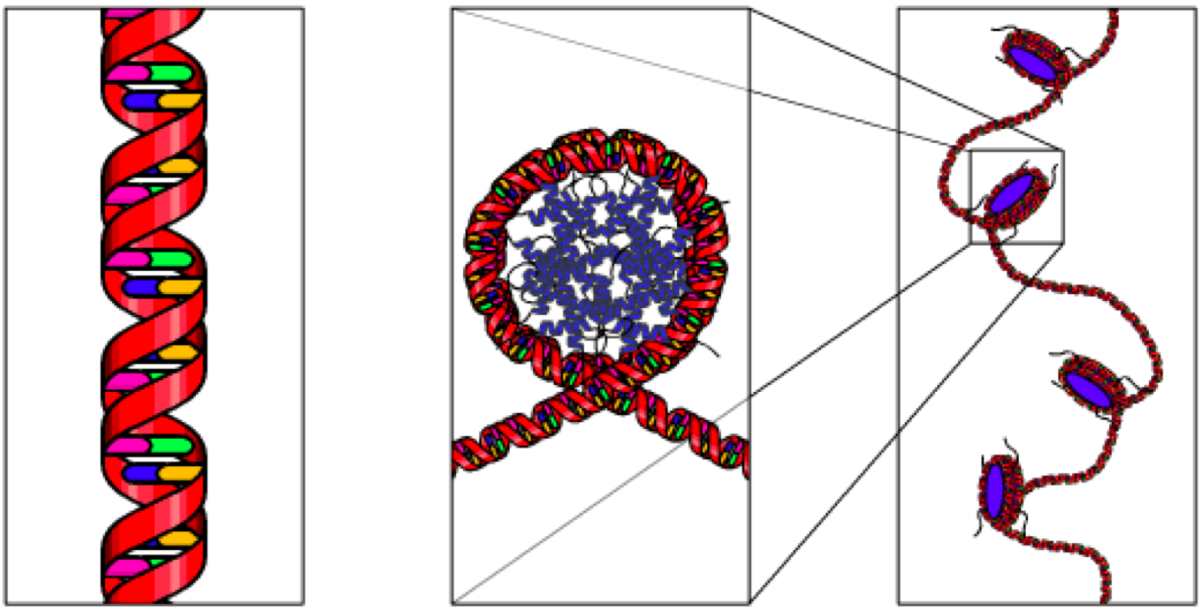
- two H2A:H2B pairs (*dimers)* and two H3:H4 pairs

- The H1 histone acts as a **linker histone** connecting each core together (*chromatosome)*

□ Nucleosomes are about 10nm long

- 147 bp DNA wrapped 1.67 times around the histone core

EXAMPLE: Nucleosome structure of DNA



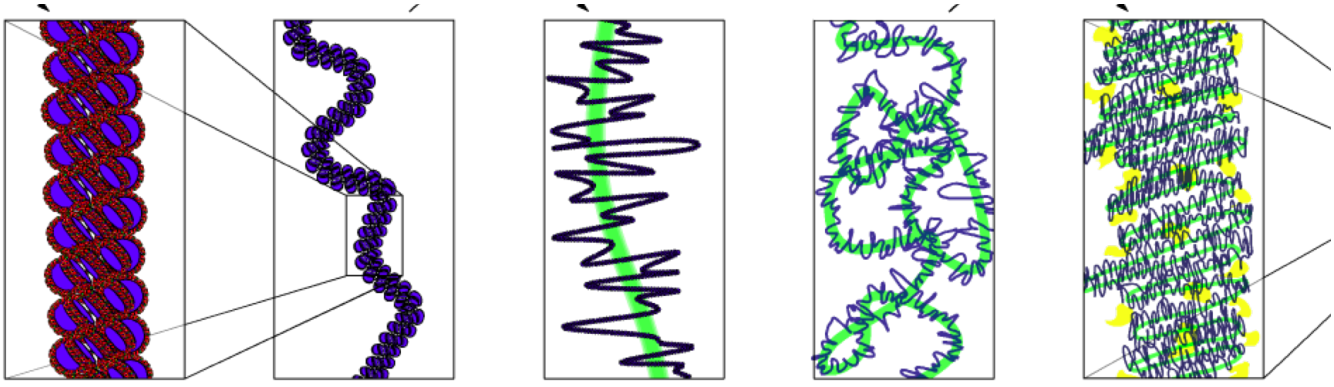
Chromatin Fiber:

- Nucleosomes are packaged into a **30nm chromatin fiber** through the H1 protein
  - □ The H1 histone protein connects _____ nucleosomes and is required for the 30nm fiber formation
  - □ Nucleosomes are packaged in *zig-zags* and wound into a double helix

DNA Looping:

- The 30nm fiber is then packaged into a **looping** structure that consists of thicker fibers
  - □ Each loop contains 50,000-100,000 base pairs
  - □ Maintained by non-histone proteins that form and attach DNA to a scaffold

EXAMPLE: Structure of the 30nm fiber and higher-order looping



Chromosomes:

● Finally, the chromatin is packed into **chromosomes**, which contain long strings of genes

□ Chromosomes exist in _____ distinct states

- *Interphase chromosomes*: Less condensed long threads of DNA; Occupy particular nuclear regions

- *Metaphase chromosomes:* More condensed; Can be seen during cell division

□ Chromosomes contain structural characteristics

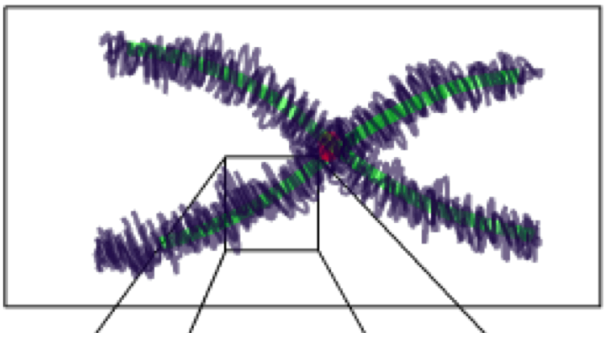
- **Centromere:** specialized DNA sequence that holds sister chromatids of a chromosome together

- consists of large sequences of repetitive DNA

- **Kinetochore:** protein structure assembled on the centromere where the spindle fibers attach during cell division

- **Telomere:** sequence of repetitive DNA at the end of a chromosome that protects the chromosome from degradation

EXAMPLE: Structure of a metaphase chromosome



□ A **karyotype** is an ordered _____ of the full set of an organism's chromosomes

- In humans, chromosomes exist in *homologous pairs* (exception = the "Y" sex chromosomes)

EXAMPLE: A karyotype of the 23 human chromosomes

Conservation of DNA Packaging

● Packaging of DNA is highly _____

□ Histone proteins are extremely well conserved

- H3 sequence of sea urchin and calf thymus differs by 1 amino acid

□ Histone variants do exist, but usually have a distinct function

- Centromeric H3 (CenH3) exists only at centromeres for the assembly of kinetochore proteins

EXAMPLE: Histone H1 conservation

Histone H1 (residues 120-180)

HUMAN	KKASKPKKAASKAPTKKPKATPVKKAKKKLAATPKKAKKPKTVKAKPVKASKPKKAKPVK
MOUSE	KKAAKPKKAASKAPSKKPKATPVKKAKKKPAATPKKAKKPKVVKVKPVKASKPKKAKTVK
RAT	KKAAKPKKAASKAPSKKPKATPVKKAKKKPAATPKKAKKPKIVKVKPVKASKPKKAKPVK
COW	KKAAKPKKAASKAPSKKPKATPVKKAKKKPAATPKKTKKPKTVKAKPVKASKPKKTKPVK
CHIMP	KKASKPKKAASKAPTKKPKATPVKKAKKKLAATPKKAKKPKTVKAKPVKASKPKKAKPVK

Unusual Chromosomal Structures

● Certain organisms contain _____ chromosomal structures

□ **Polytene** chromosomes are found in *Drosophilia* (fruit flies)

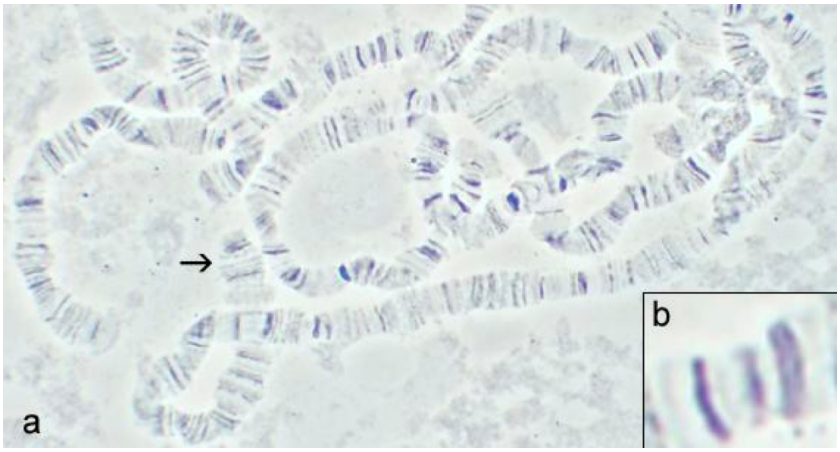
- Form by linking chromosomes together, instead of separating them during division

- Has characteristic banding, which is created through differential condensation of DNA

□ **Lampbrush** chromosomes are found in many animal's oocytes (ovarian cells), but not mammals

- Are the largest chromosomes known – visible in light microscope

EXAMPLE: Polytene chromosomes



PRACTICE:

1. Which of the following histone proteins do not form dimers that make up the nucleosome core?
   a. H2A
   b. H2B
   c. H3
   d. H4
   e. H1

2. How many histone proteins are found within the nucleosome core?
   a. 2
   b. 4
   c. 8
   d. 9

3. True or False: Interphase chromosomes are more condensed than other forms of chromosomes?
    a. True
    b. False