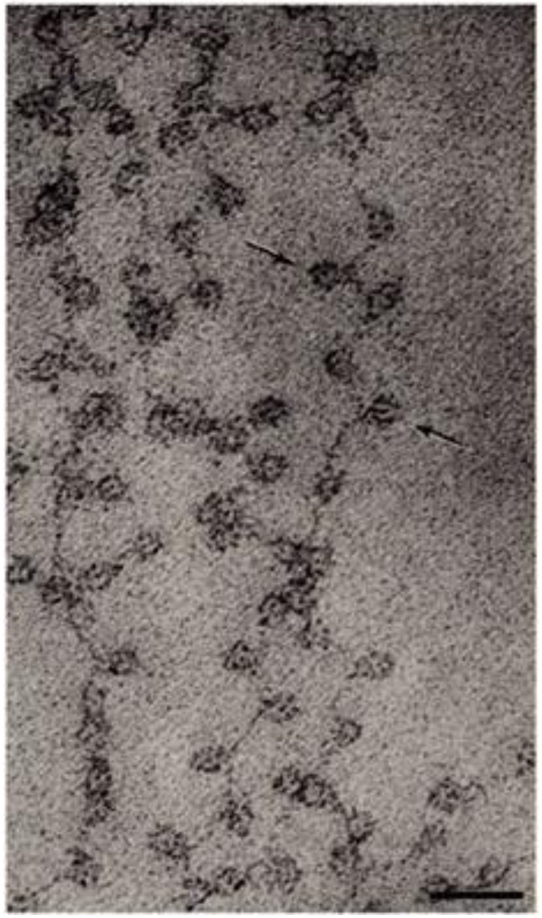
Nucleosomes

- A nucleosome is a section of DNA that is wrapped around a core of proteins.
- Inside the nucleus, DNA forms a complex with proteins called chromatin, which allows the DNA to be condensed into a smaller volume.
- When the chromatin is extended and viewed under a microscope, the structure resembles beads on a string.
- Each of these tiny beads is a called a nucleosome and has a diameter of approximately 11 nm.
- The nucleosome is the fundamental subunit of chromatin.
- Each nucleosome is composed of a little less than two turns of DNA wrapped around a set of eight proteins called histones, which are known as a histone octamer.
- Each histone octamer is composed of two copies each of the histone proteins H2A, H2B, H3, and H4. The chain of nucleosomes is then compacted further and forms a highly organized complex of DNA and protein called a chromosome.

The Nucleosome: The Unit of Chromatin

- Nucleosome is the basic repeating structural and functional unit of chromatin. It contains eight histone proteins and about 146 base pairs of DNA.
- Chromatin appeared similar to beads on a string.
- Two each of the histones H2A, H2B, H3, and H4 come together to form a histone octamer, which binds and wraps approximately 1.7 turns of DNA, or about 146 base pairs.
- The addition of one H1 protein wraps another 20 base pairs, resulting in two full turns around the octamer, and forming a structure called a chromatosome.
- The resulting 166 base pairs is not very long, considering that each chromosome contains over 100 million base pairs of DNA on average.
- Therefore, every chromosome contains hundreds of thousands of nucleosomes, and these nucleosomes are joined by the DNA that runs between them (an average of about 20 base pairs).
- This joining DNA is referred to as linker DNA.
- Each chromosome is thus a long chain of nucleosomes, which gives the appearance of a string of beads under electron microscope.

- The amount of DNA per nucleosome was determined by treating chromatin with an enzyme that cuts DNA (such enzymes are called DNases).
- One such enzyme, micrococcal nuclease (MNase), has the important property of preferentially cutting the linker DNA between nucleosomes well before it cuts the DNA that is wrapped around octamers.
- By regulating the amount of cutting that occurs after application of MNase, it is possible to stop the reaction before every linker DNA has been cleaved.
- At this point, the treated chromatin will consist of mononucleosomes, dinucleosomes (connected by linker DNA), trinucleosomes, and so forth.
- If DNA from MNase-treated chromatin is then separated on a gel, a number of bands will appear, each having a length that is a multiple of mononucleosomal DNA . `



Electron micrograph of chromatin: the beads on a string
In this micrograph, nucleosomes are indicated by arrows.

- The simplest explanation for this observation is that chromatin possesses a fundamental repeating structure.
- When this was considered together with data from electron microscopy and chemical cross-linking of histones, the "subunit theory" of chromatin (Kornberg, 1974; Van Holde *et al*., 1974) was adopted.
- The subunits were later named nucleosomes (Oudet *et al*., 1975) and were eventually crystallized (Luger *et al*., 1997).
- The model of the nucleosome that crystallographers constructed from their data is shown in Figure .
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Phosphodiester backbones of the DNA double helix are shown in brown and turquoise, while histone proteins are shown in blue (H3), green (H4), yellow (H2A), and red (H2B). Note that only eukaryotes (i.e., organisms with a nucleus and nuclear envelope) have nucleosomes. Prokaryotes, such as bacteria, do not.

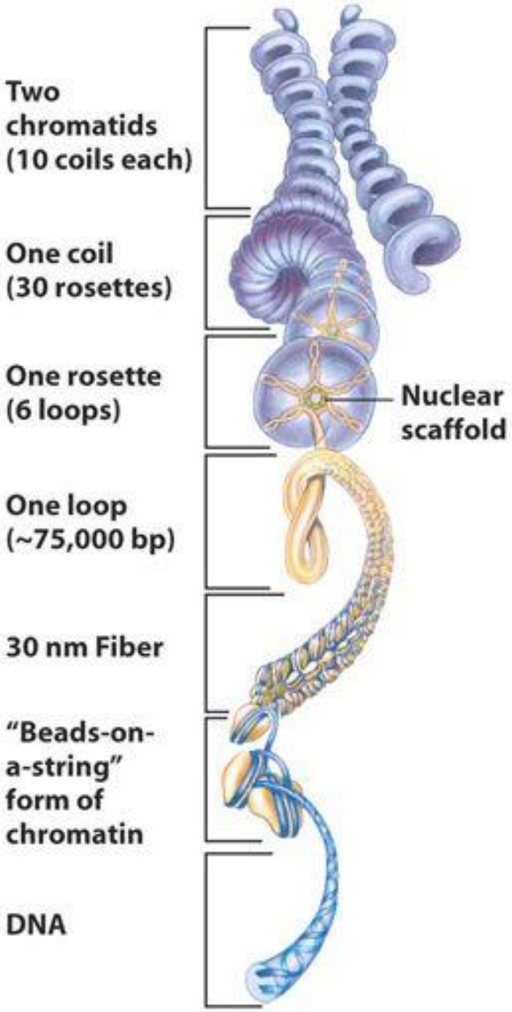
Nucleosome core particle: ribbon traces for the 146-bp DNA phosphodiester backbones (brown and turquoise) and eight histone protein main chains (blue: H3; green: H4; yellow: H2A; red: H2B)

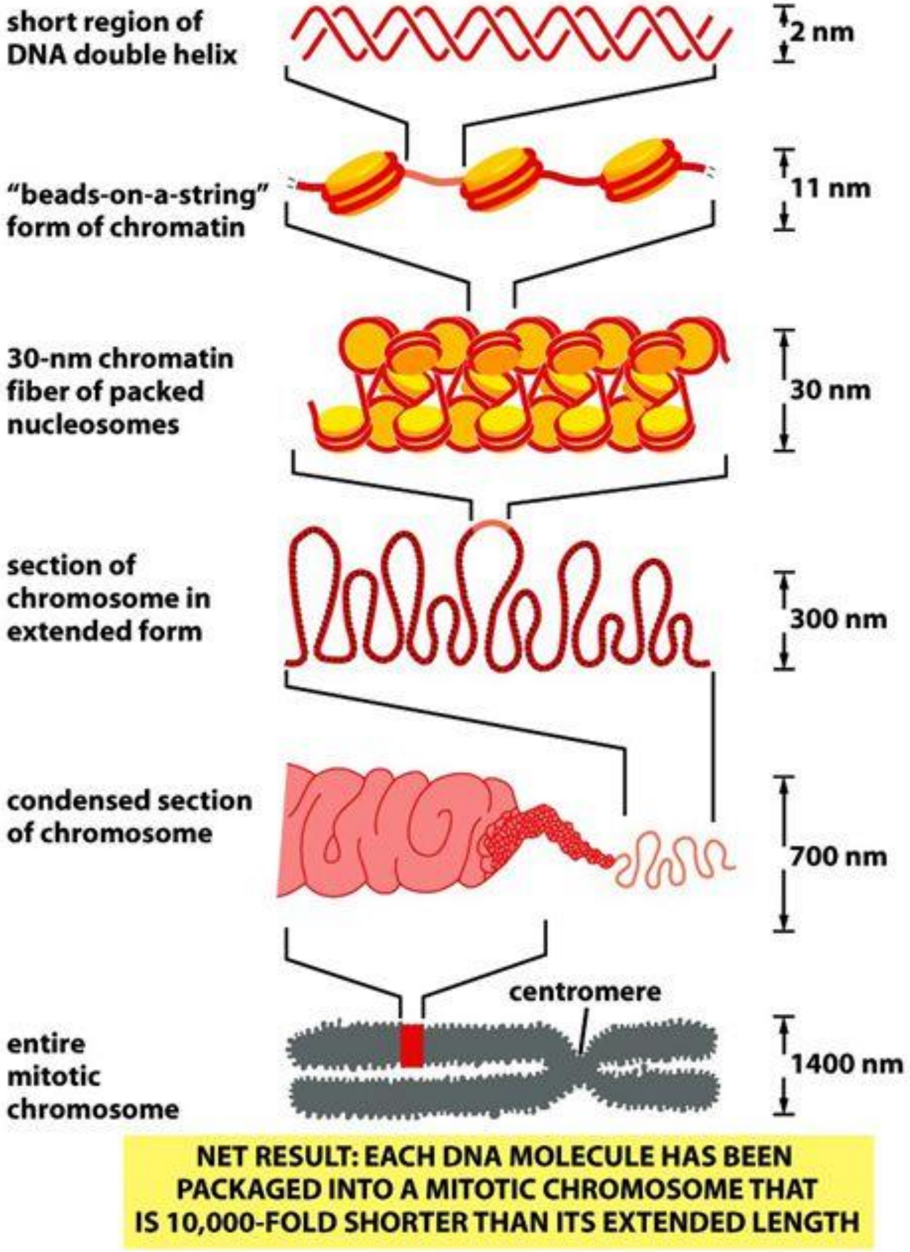
The views are down the DNA superhelix axis for the left particle and perpendicular to it for the right particle. For both particles, the pseudo-twofold axis is aligned vertically with the DNA center at the top.

Chromatin

- Chromatin is a complex of DNA and proteins that forms chromosomes within the nucleus of eukaryotic cells. Nuclear DNA does not appear in free linear strands; it is highly condensed and wrapped around nuclear proteins in order to fit inside the nucleus.
- The packaging of DNA into nucleosomes shortens the fiber length about sevenfold. In other words, a piece of DNA that is 1 meter long will become a "string-of-beads" chromatin fiber just 14 centimeters (about 6 inches) long. Despite this shortening, a half-foot of chromatin is still much too long to fit into the nucleus, which is typically only 10 to 20 microns in diameter. Therefore, chromatin is further coiled into an even shorter, thicker fiber, termed the "30-nanometer fiber," because it is approximately 30 nanometers in diameter

Chromatin packing





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