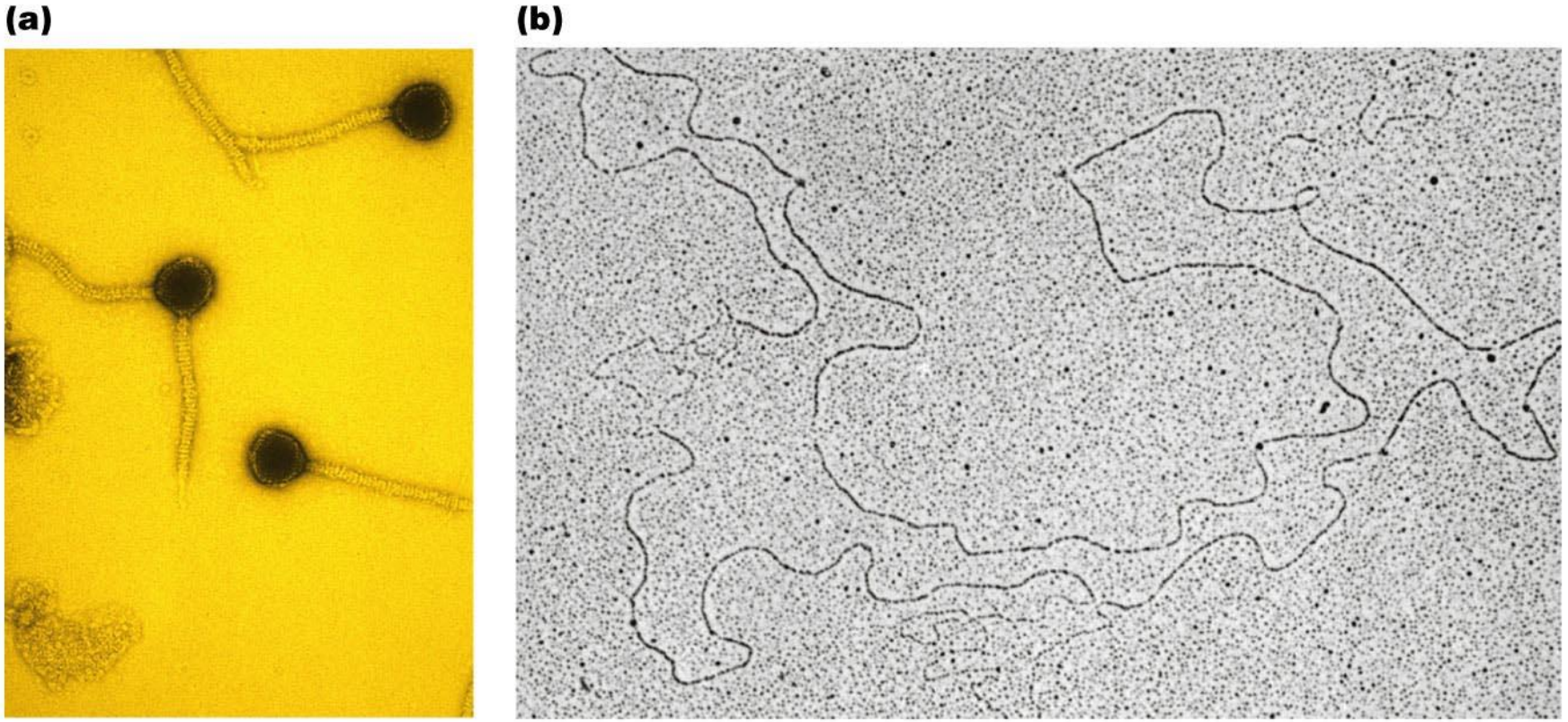
DNA ORGANIZATION IN CHROMOSOMES

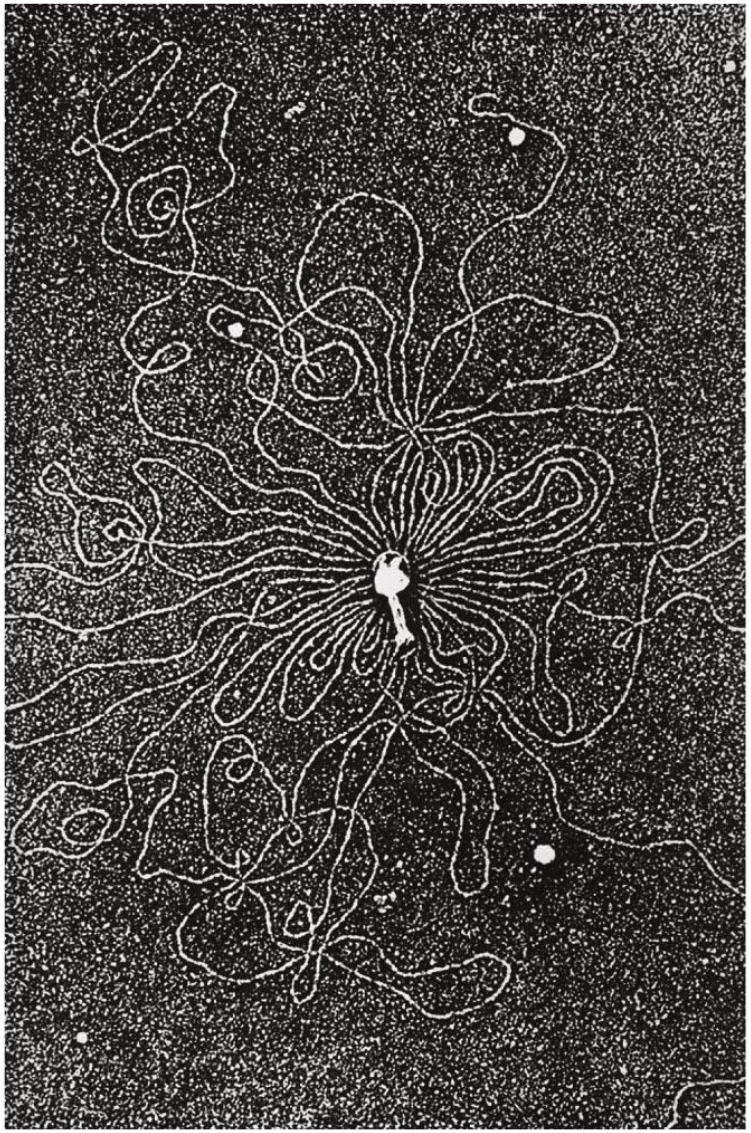
Viral and Bacterial Chromosomes Are Relatively Simple DNA Molecules

Bacterial and viral chromosomes are usually:

- a single nucleic acid molecule
- largely devoid of associated proteins
- much smaller than eukaryotic chromosomes

Chromosomes of **Viruses** consist of single- or double-stranded DNA or RNA





Electron micrograph of bacteriophage T2, which has had its DNA released by osmotic shock. The chromosome is 52μm long.

BACTERIAL CHROMOSOMES ARE DOUBLE-STRANDED DNA AND ARE COMPACTED INTO A **NUCLEOID**

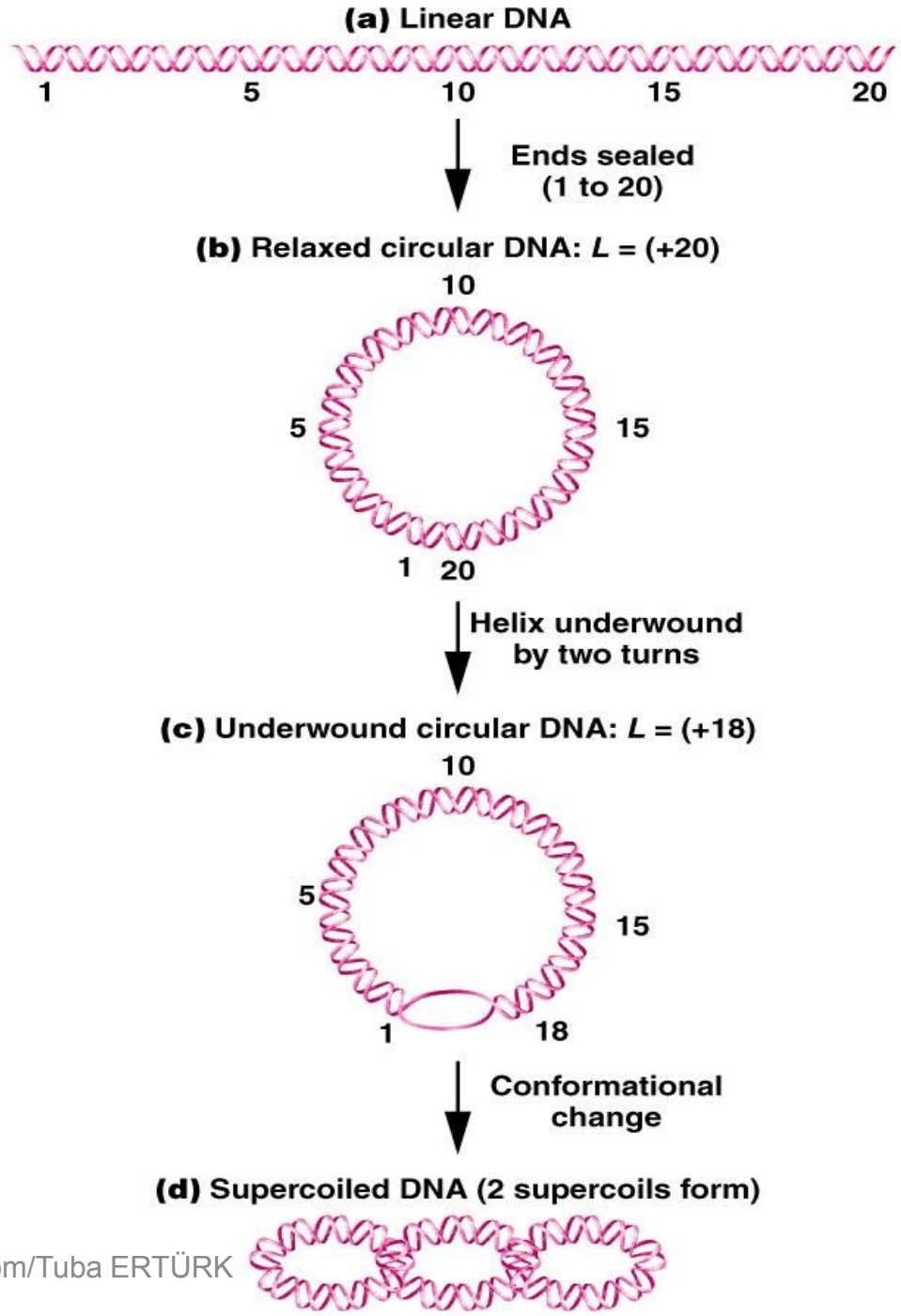
DNA IN BACTERIA MAY BE ASSOCIATED WITH **HU** AND **H1 DNA-BINDING PROTEINS**

Electron micrograph of the bacterium Escherichia coli, which has had its DNA released by osmotic shock. The chromosome is 1200μm long.

SUPERCOILING

FACILITATES COMPACTION OF THE DNA OF VIRAL AND BACTERIAL CHROMOSOMES

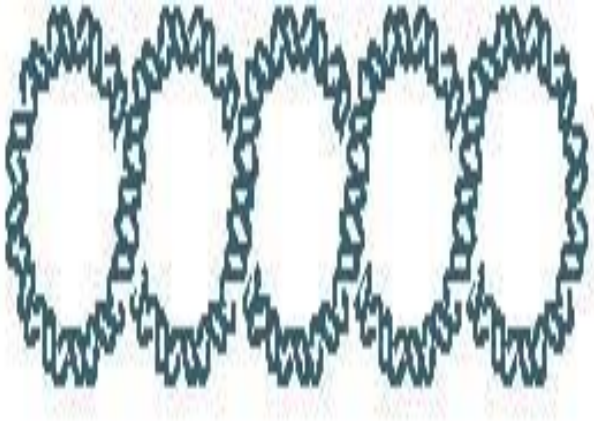
MOST CLOSED CIRCULAR DNA MOLECULES IN BACTERIA ARE SLIGHTLY UNDERWOUND AND SUPERCOILED



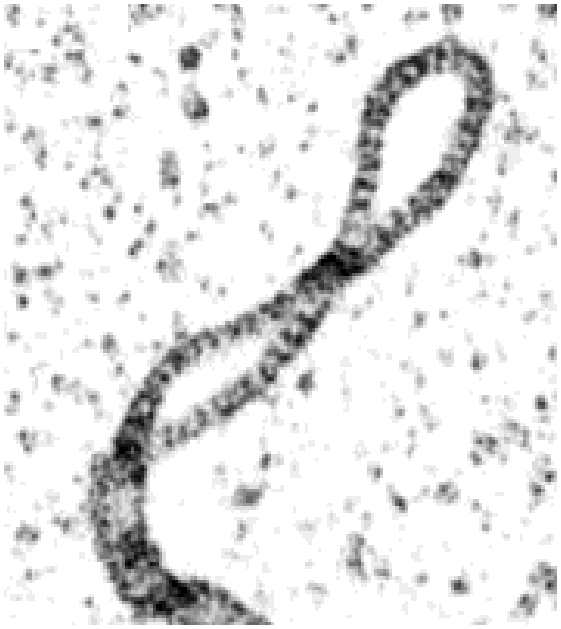
TWO OTHERWISE IDENTICAL MOLECULES THAT DIFFER ONLY IN THEIR LINKING NUMBER ARE **TOPOISOMERS** OF ONE ANOTHER

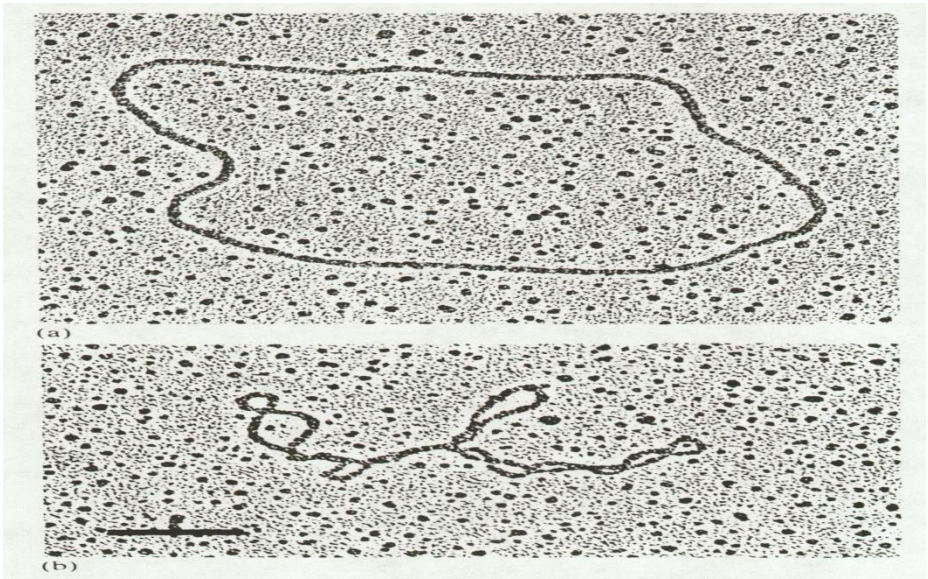
CONVERTING DNA FROM ONE TOPOISOMER TO THE OTHER IS ACCOMPLISHED BY A GROUP OF ENZYMES -**TOPOISOMERASES**

THESE ENZYMES CUT ONE OR BOTH OF THE STRANDS AND WIND OR UNWIND THE HELIX BEFORE RESEALING THE ENDS



Underwound DNA can also compensate by forming negative supercoils





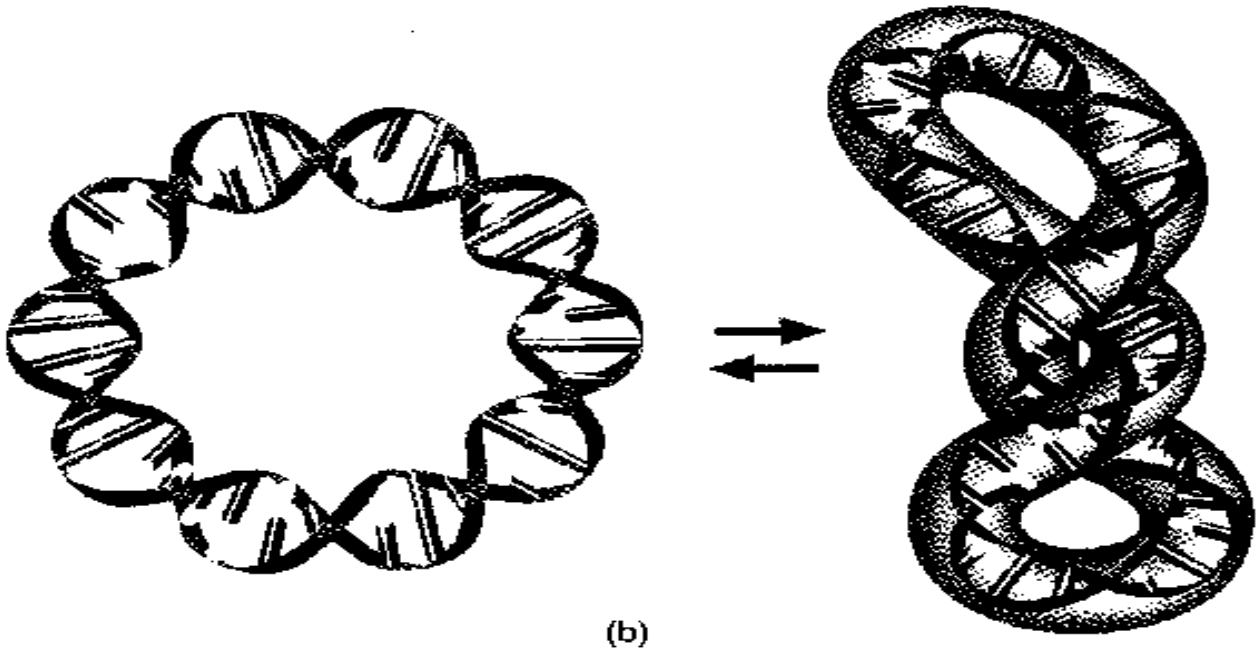
THESE CATALYTIC MOLECULES ARE KNOWN AS EITHER **TYPE I** OR **TYPE II,** DEPENDING ON WHETHER THEY CLEAVE ONE OR BOTH STRANDS IN THE HELIX

IN *E. coli*, **TOPOISOMERASE I** SERVES TO REDUCE THE NUMBER OF NEGATIVE SUPERCOILS IN A CLOSED-CIRCULAR DNA MOLECULE
TOPOISOMERASE II INTRODUCES NEGATIVE SUPERCOILS INTO DNA (Ex: DNA GYRASE)

Lear double-stranded DNA molecule

Circular DNA molecule

(a)



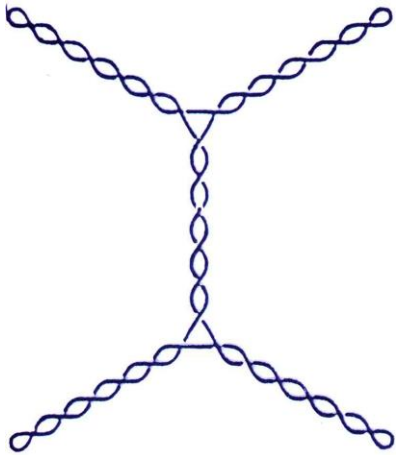
(b)

SUPERCOILED DNA AND TOPOISOMERASES ARE ALSO FOUND IN EUKARYOTES

WHILE THE CHROMOSOMES IN THESE ORGANISMS ARE NOT USUALLY CIRCULAR, SUPERCOILS CAN OCCUR WHEN AREAS OF DNA ARE EMBEDDED IN A LATTICE OF PROTEINS ASSOCIATED WITH THE CHROMATIN FIBERS

SPECIAL SUPER COILING TYPES

- Plectonemic



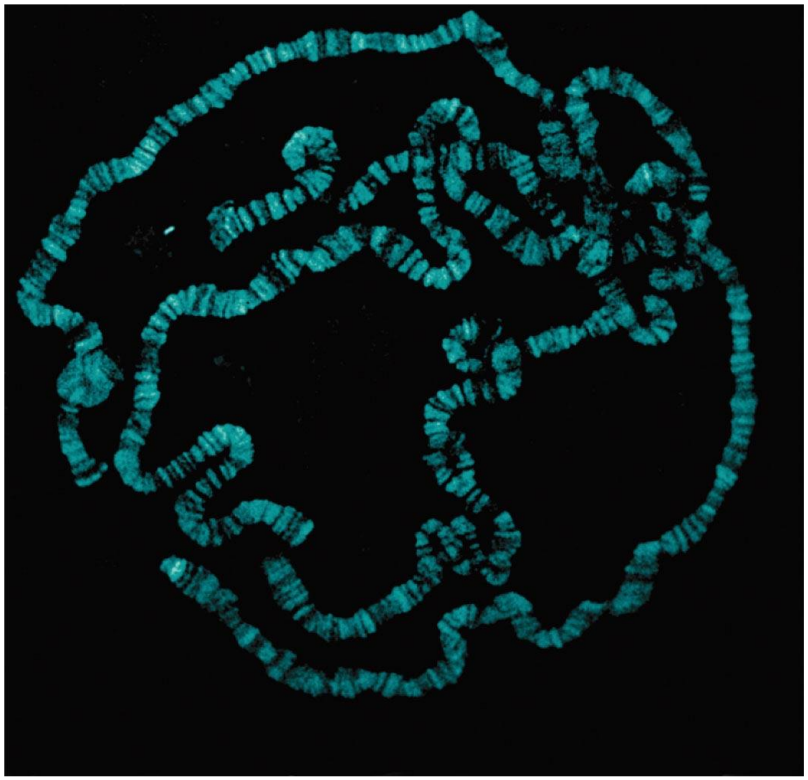
- Solenoidal

SPECIALIZED CHROMOSOMES REVEAL VARIATIONS IN THE ORGANIZATION OF DNA

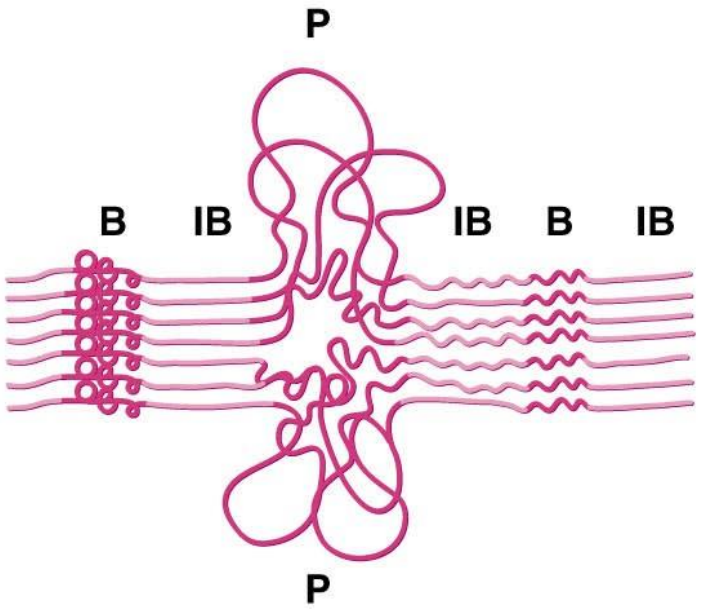
POLYTENE CHROMOSOMES AND **LAMPBRUSH CHROMOSOMES** ARE VERY LARGE AND CAN BE VISUALIZED BY LIGHT MICROSCOPY

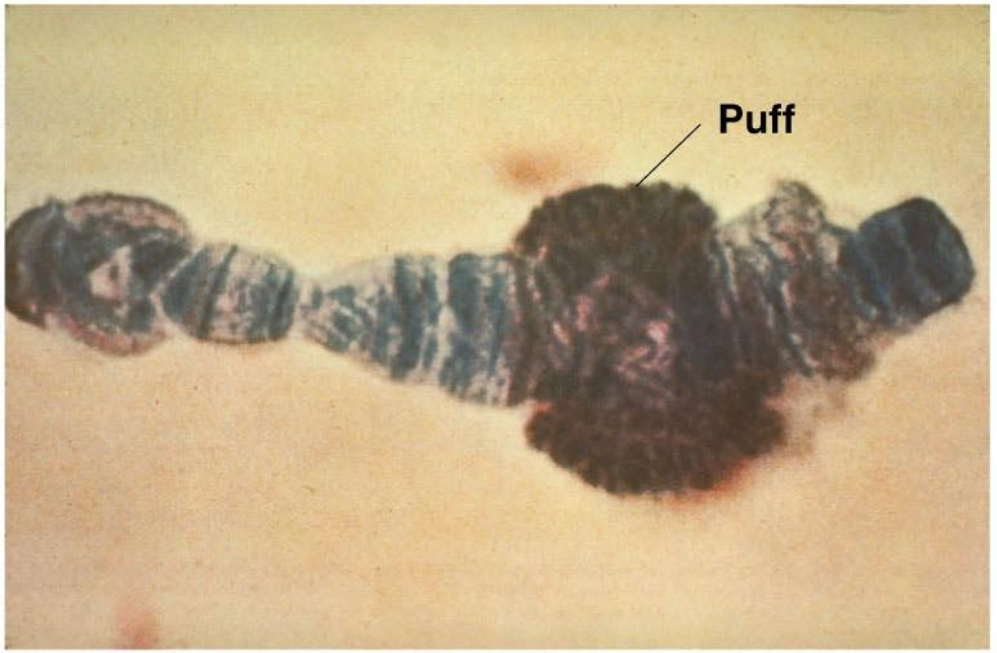
Polytene chromosomes:

- have distinctive banding patterns
- represent paired homologs
- are composed of many DNA strands



- Polytene chromosomes have **puff** regions where the DNA has uncoiled and are visible manifestations of a high level of gene activity.

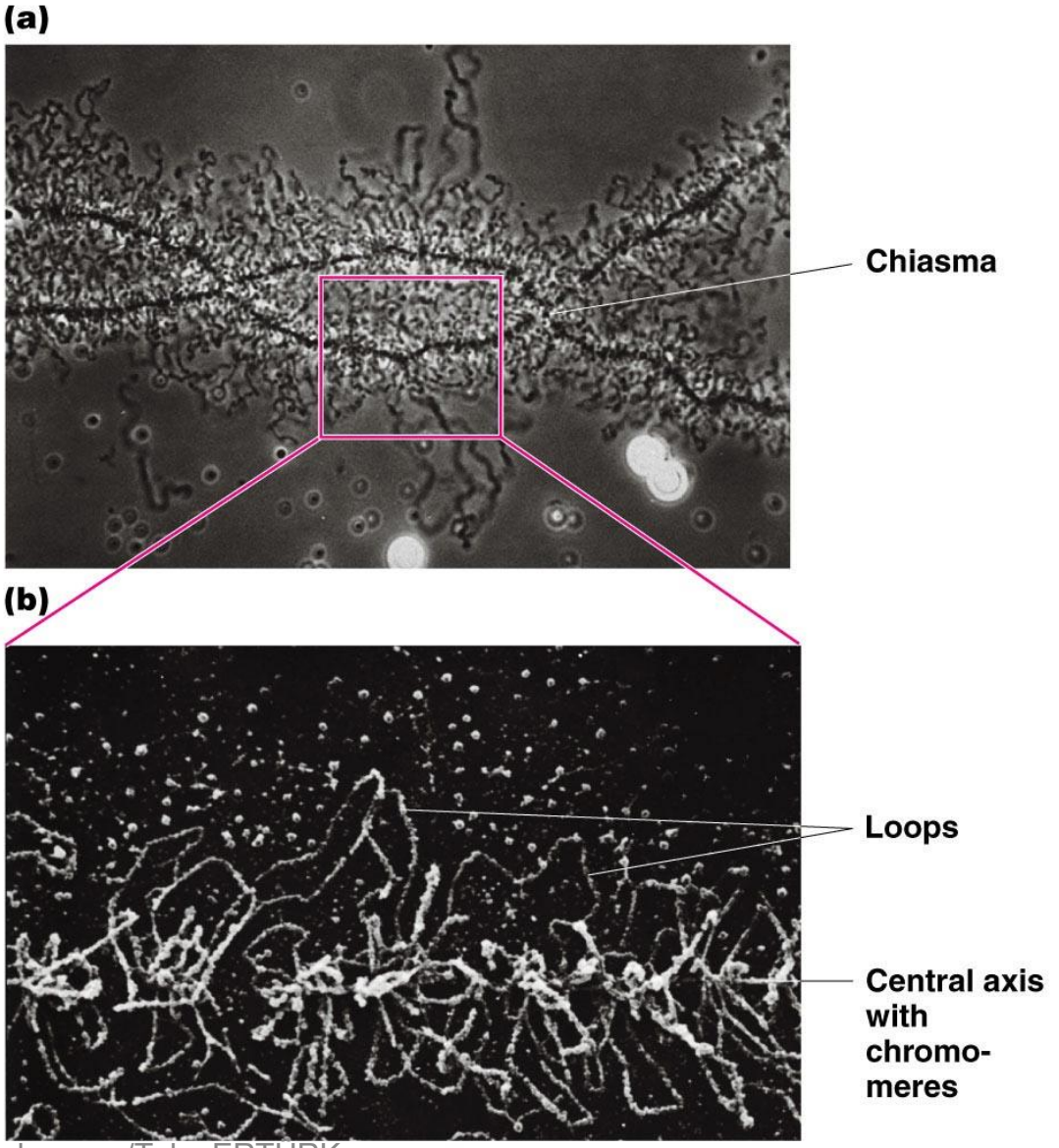




Lampbrush Chromosomes

large and have extensive DNA looping.

Found in oocytes in the diplotene stage of meiosis.



DNA Is Organized into Chromatin in Eukaryotes

Eukaryotic chromosomes are complexed into a nucleoprotein structure called **chromatin**

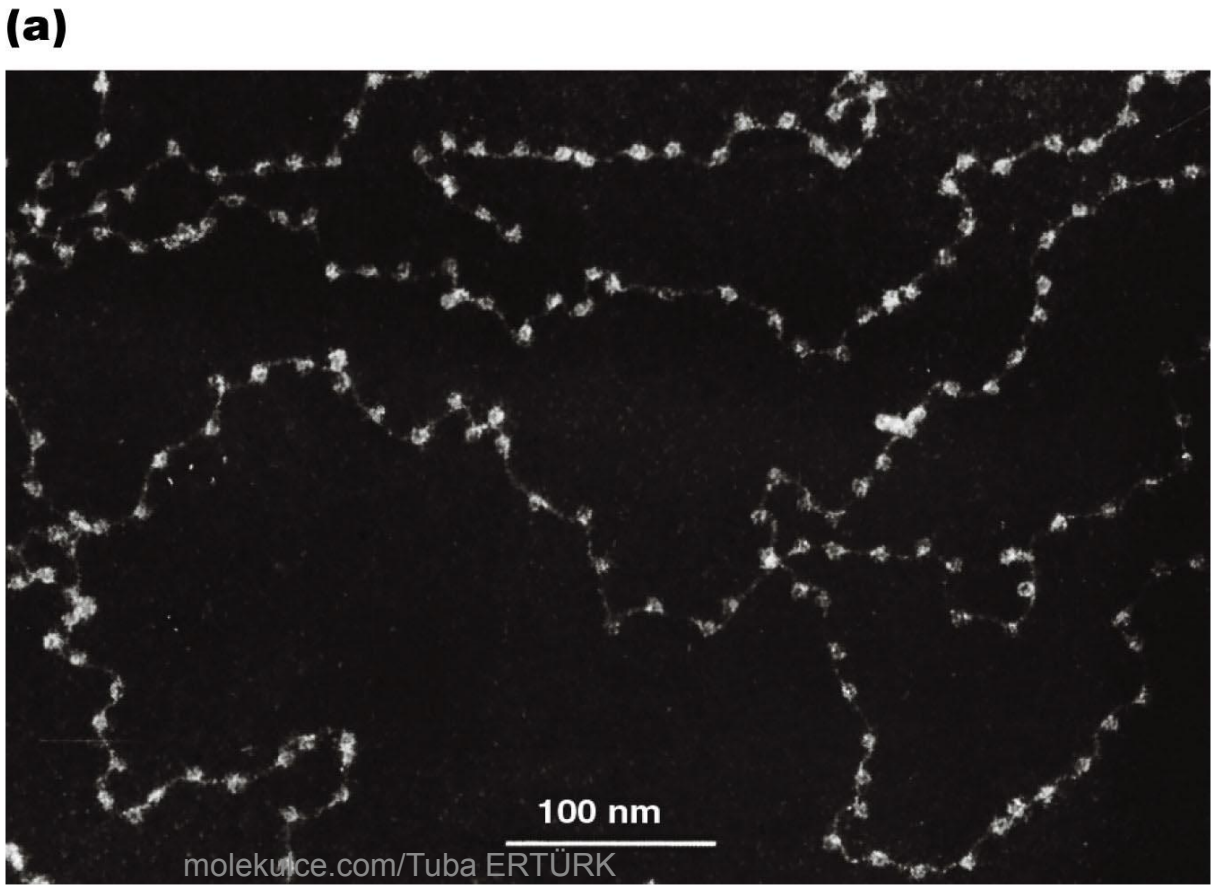
- Chromatin is bound up in nucleosomes with **histones** H2A, H2B, H3, and H4.

TABLE 12.2

Categories and Properties of Histone Proteins

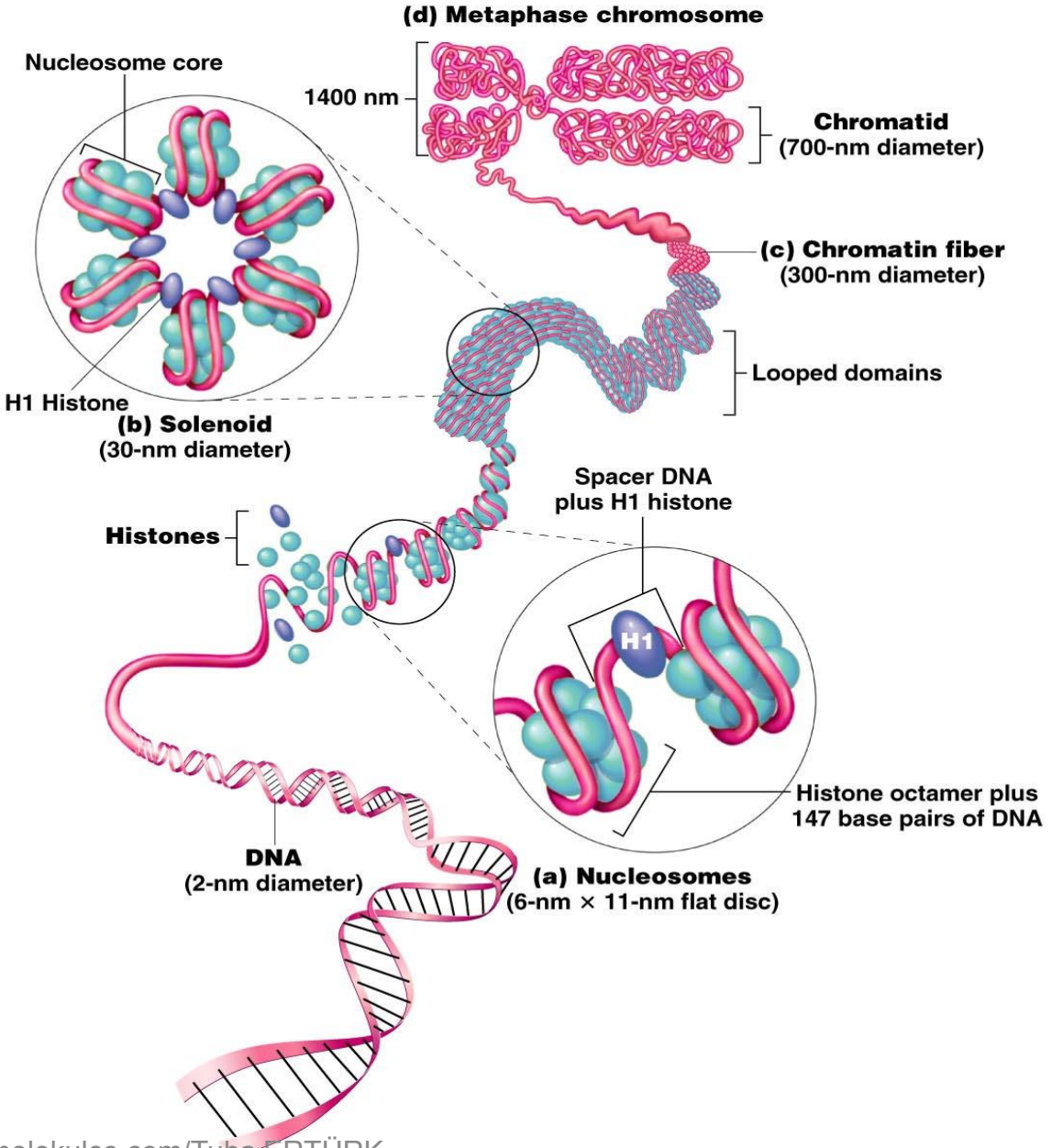
Histone Type	Lysine-Arginine Content	Molecular Weight (Da)
H1	Lysine-rich	23,000
H2A	Slightly lysine-rich	14,000
H2B	Slightly lysine-rich	13,800
H3	Arginine-rich	15,300
H4	Arginine-rich	11,300

ELECTRON MICROSCOPIC OBSERVATIONS OF CHROMATIN HAVE REVEALED ITS FIBERS ARE COMPOSED OF A LINEAR ARRAY OF SPHERICAL PARTICLE

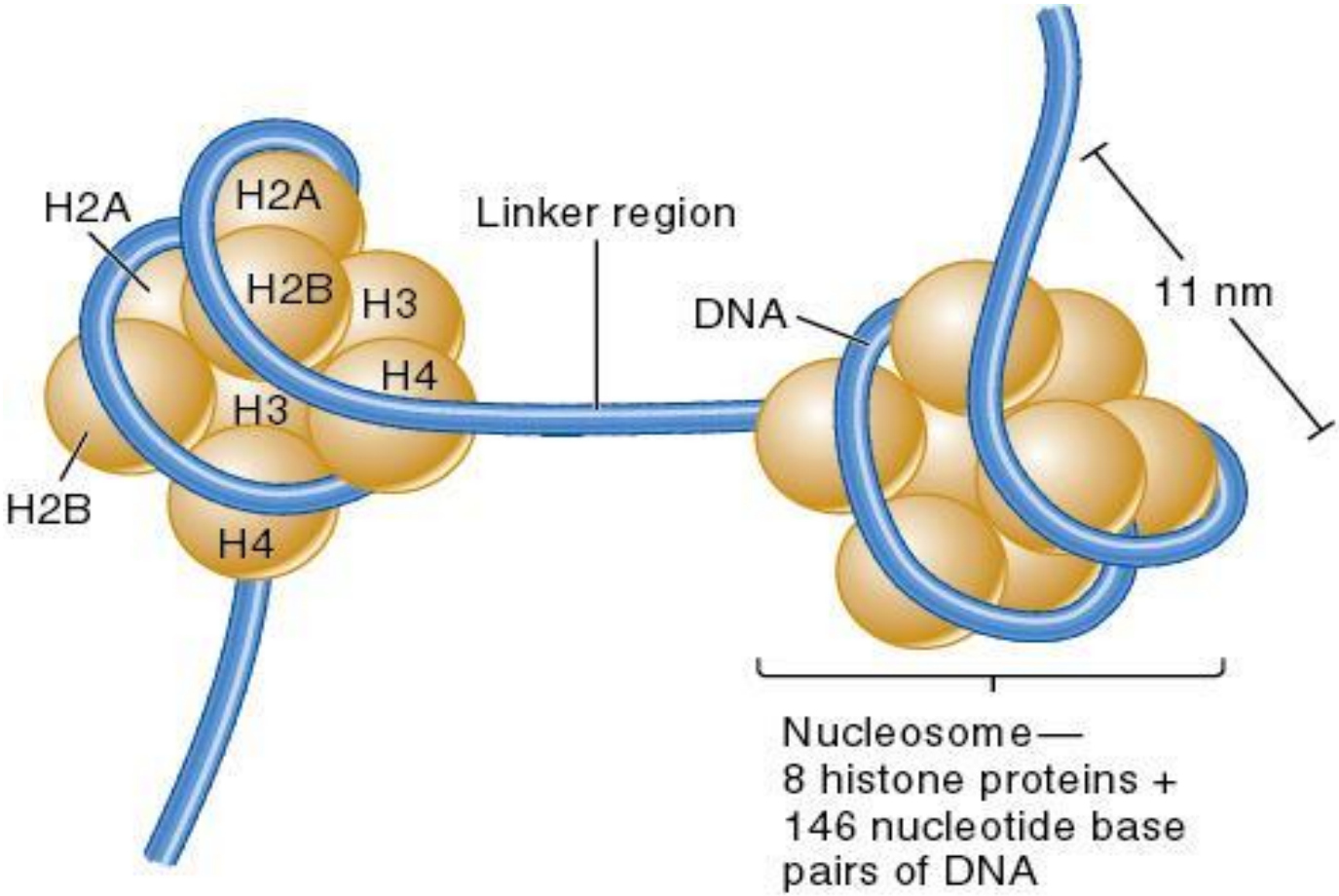


NUCLEOSOMES

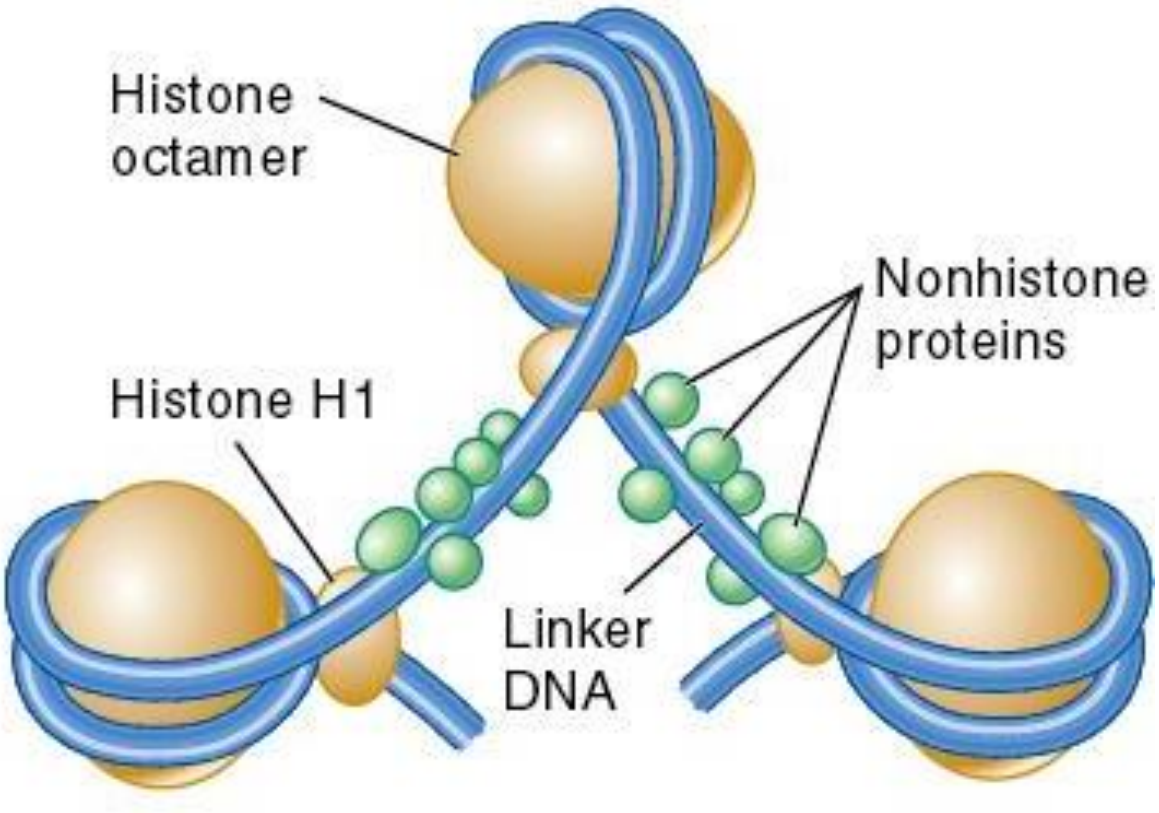
ARE CONDENSED SEVERAL TIMES TO FORM THE INTACT CHROMATIDS



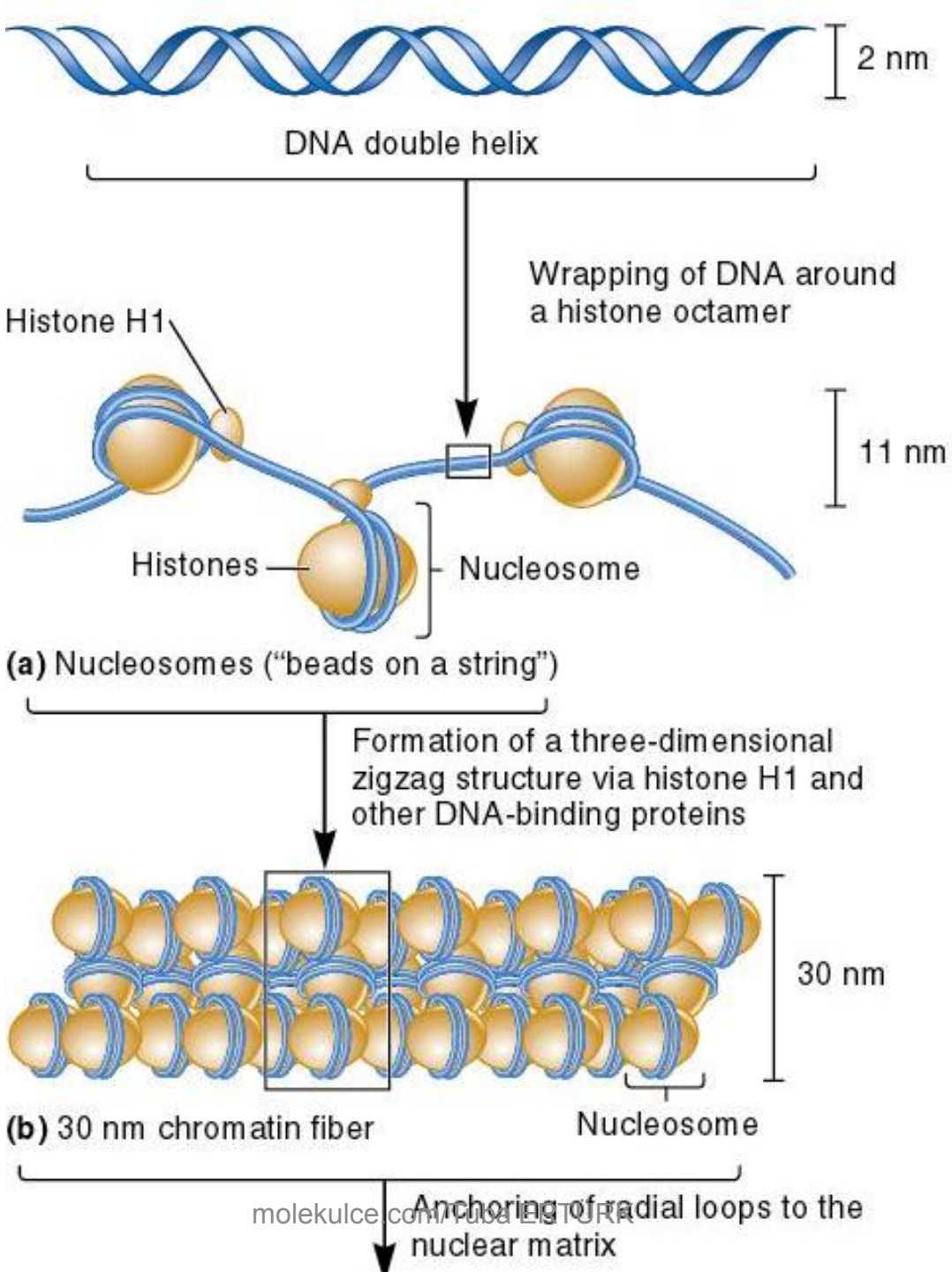
Nucleosomes

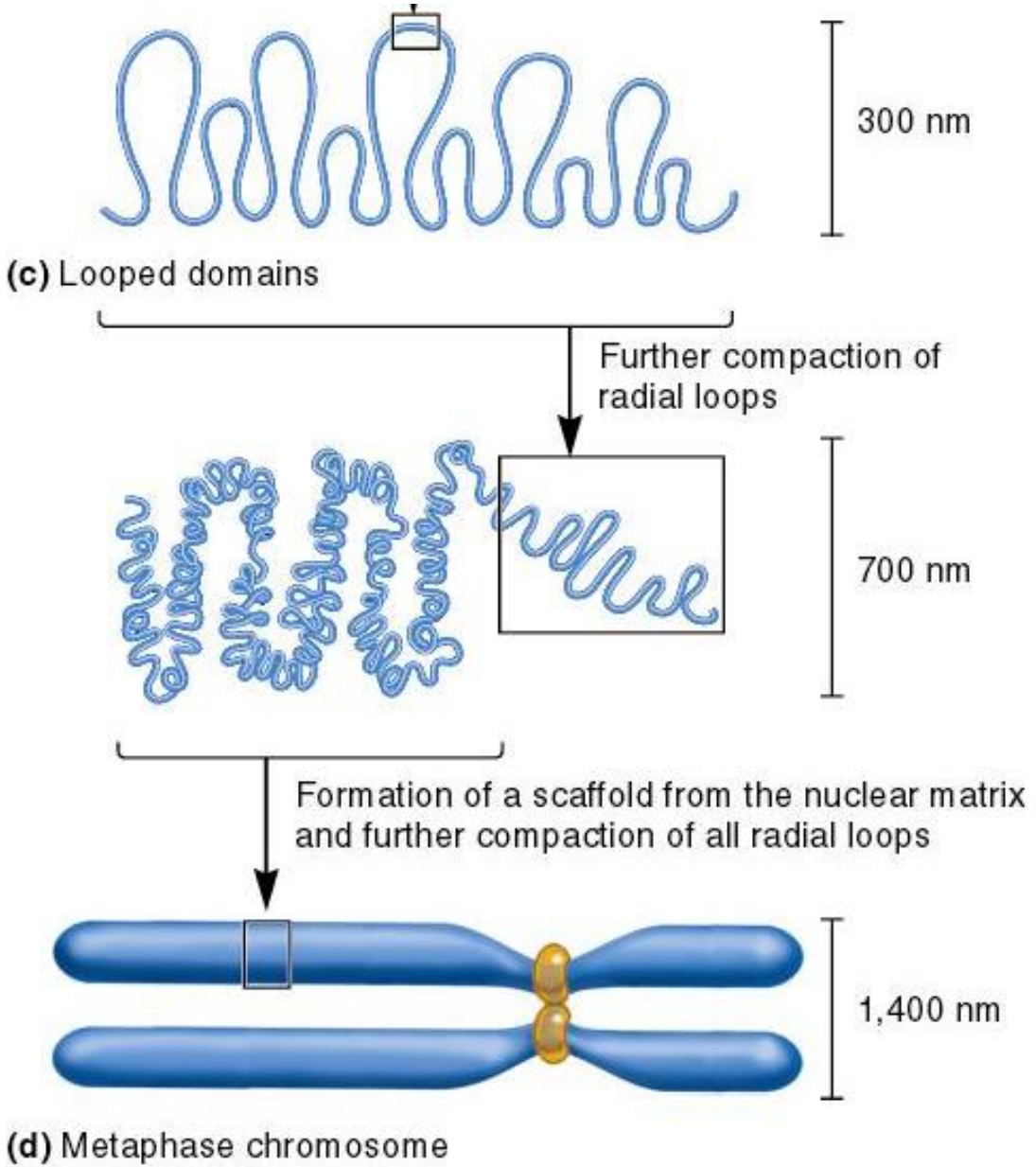


Nucleosomes



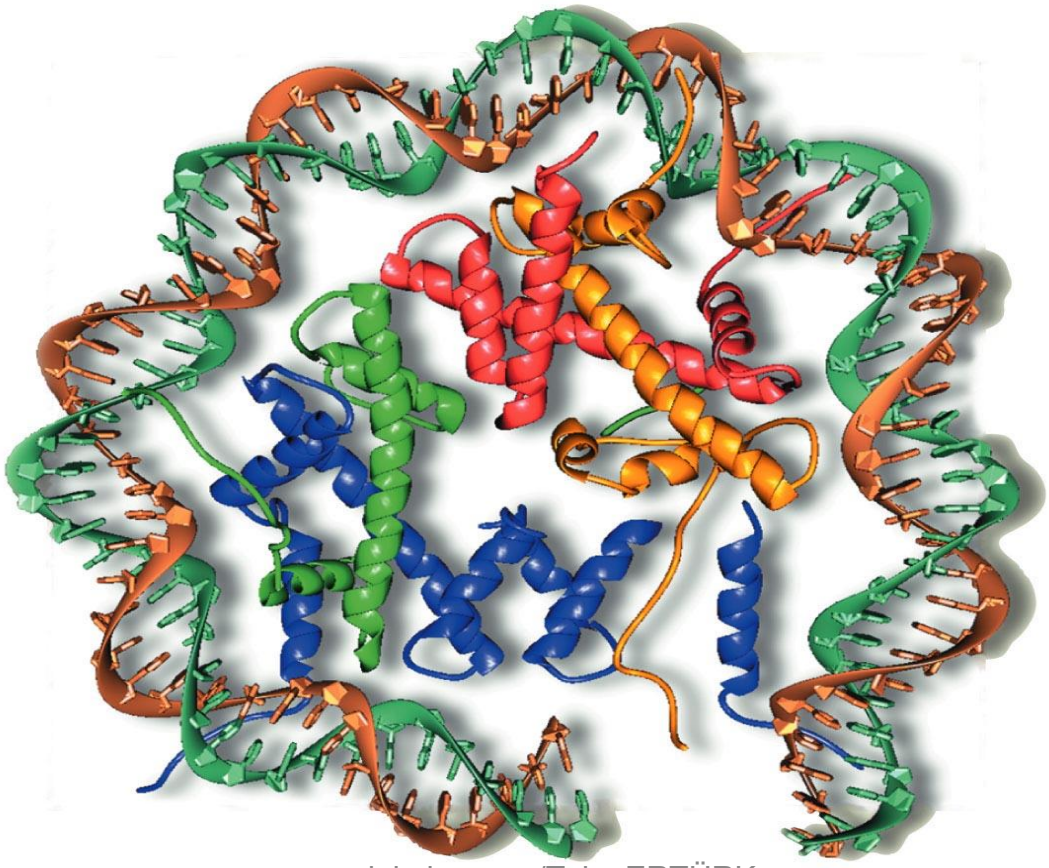
(b) Nucleosomes showing linker histones and nonhistone proteins



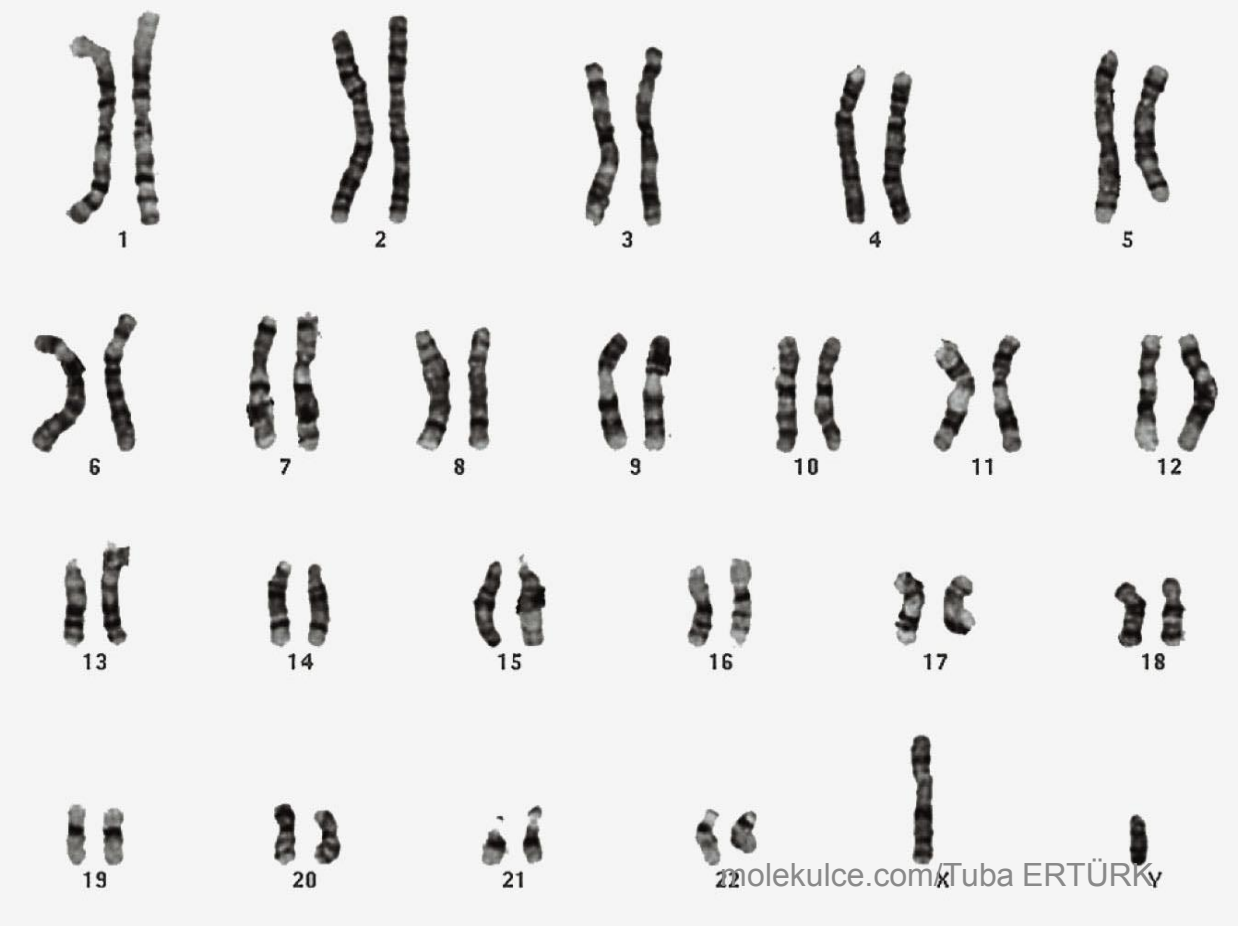


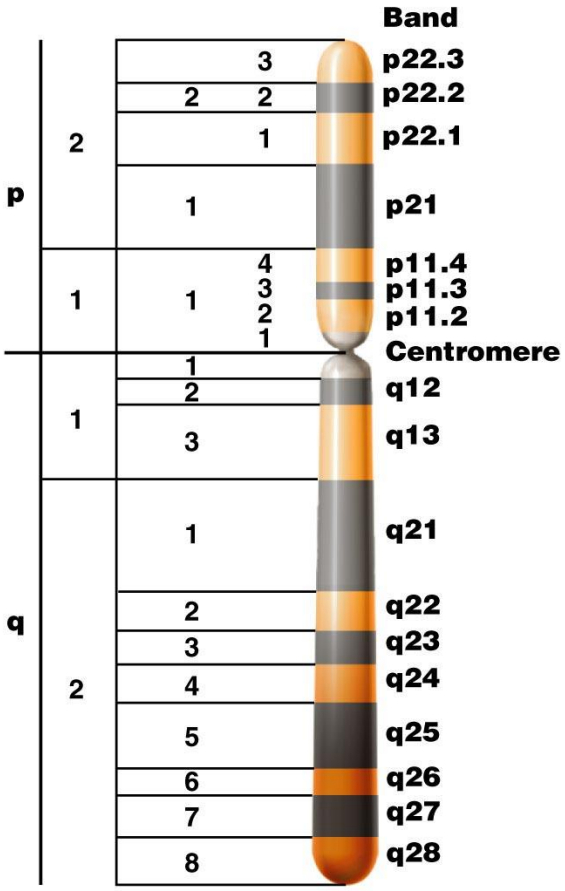
CHROMATIN REMODELING MUST OCCUR TO ALLOW THE DNA TO BE ACCESSED BY DNA BINDING PROTEINS

HISTONE TAILS ARE IMPORTANT FOR HISTONE MODIFICATIONS SUCH AS **ACETYLATION**, **METHYLATION**, AND **PHOSPHORYLATION**



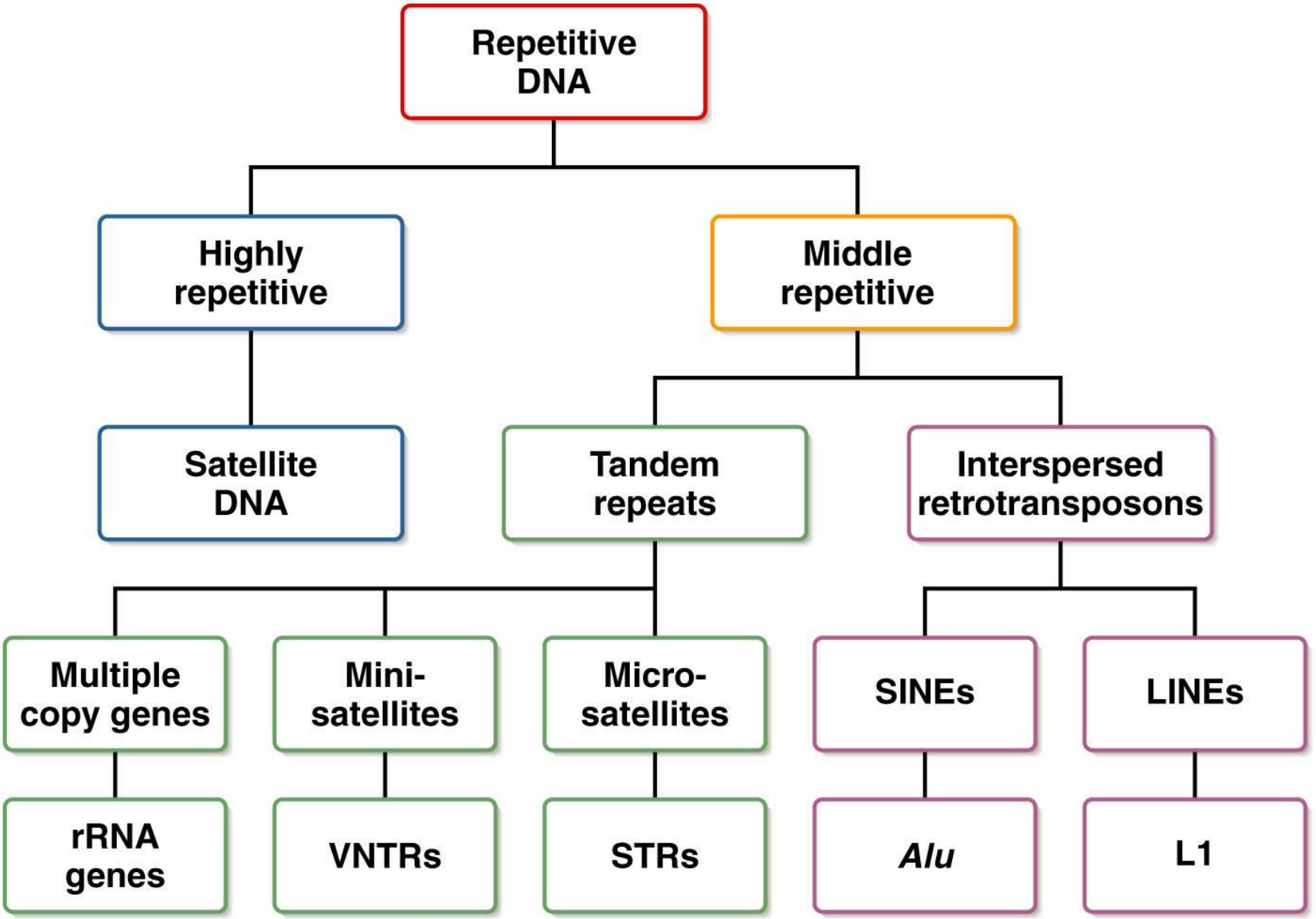
EUCHROMATIN IS UNCOILED AND ACTIVE, WHEREAS **HETEROCHROMATIN** REMAINS CONDENSED AND IS INACTIVE





Eukaryotic Chromosomes Demonstrate Complex Organization Characterized by Repetitive DNA

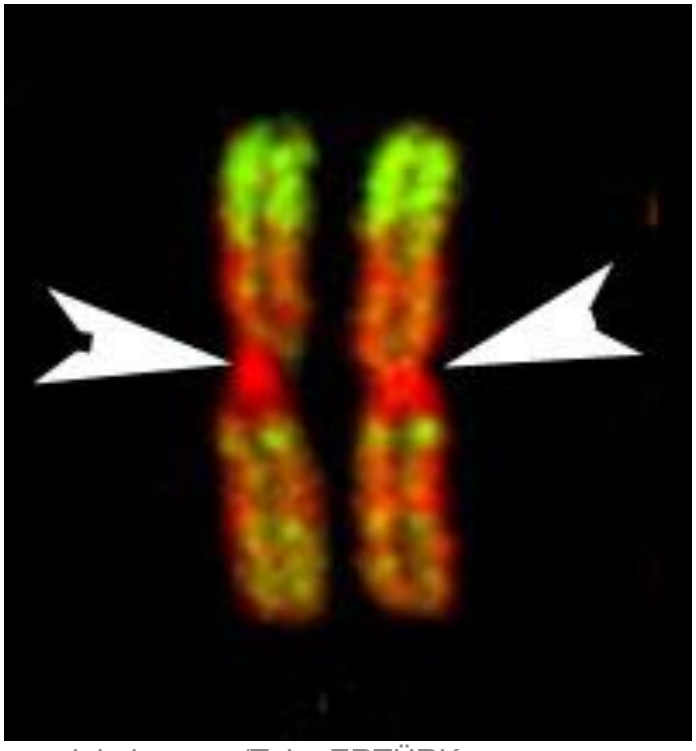
Repetitive DNA sequences are repeated many times within eukaryotic chromosomes



Satellite DNA is highly repetitive and consists of short repeated sequences

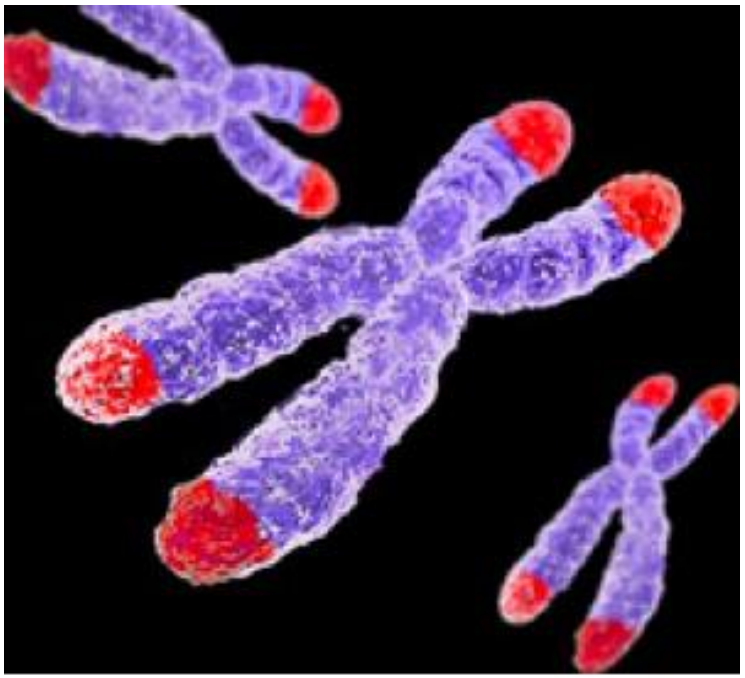
Centromeres

- are the primary constrictions along eukaryotic chromosomes
- mediate chromosomal migration during mitosis and meiosis



http://cellbiology.med.unsw.edu.au/units/images/centromeres2.jpg

Telomeric DNA sequences consist of short tandem repeats that contribute to the stability and integrity of the chromosome



http://topnews.com.sg/images/telomeres-logo.jpg

- **Moderately repetitive DNA** includes:
  - variable number tandem repeats (VNTRs)
  - minisatellites
  - microsatellites

- **Short interspersed elements (SINES)** and **long interspersed elements (LINES)** are dispersed throughout the genome rather than tandemly repeated, and constitute over 1/3 of the human genome.
- These transposable elements are generated via an RNA intermediate and are referred to as **retrotransposons**.

- The Vast Majority of a Eukaryotic Genome Does Not Encode Functional Genes
- Only a small portion of the eukaryotic genome (2%–10%) constitute protein-encoding genes.
- There are also a large number of single-copy noncoding regions, some of which are **pseudogenes**.