Lecture 6

DNA

Genome organization

Course 281

Lessons for life

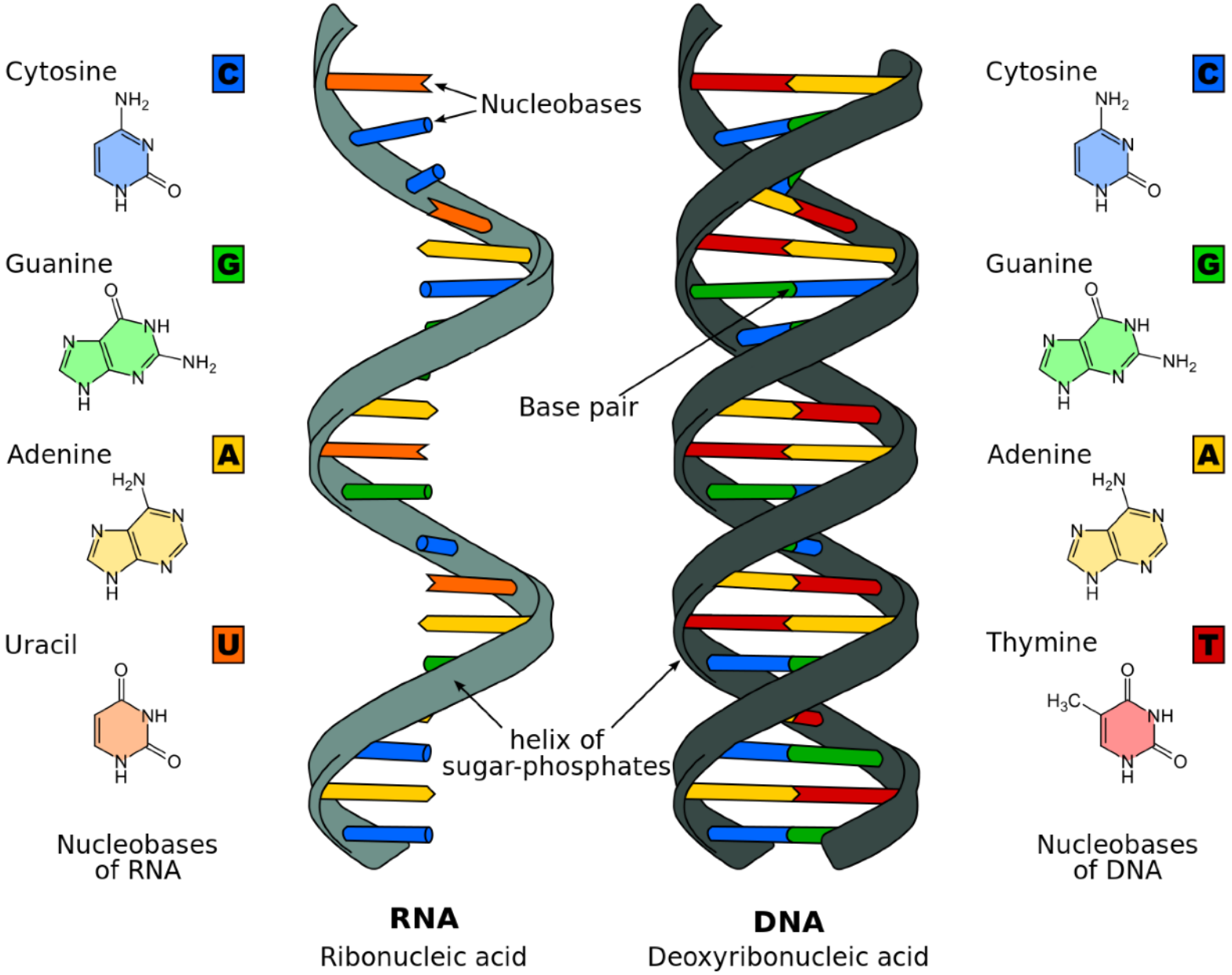
Jim Rohn
August 4 ·

"Failure is not a single, cataclysmic event. You don't fail overnight. Instead, failure is a few errors in judgment, repeated every day." -- Jim Rohn

AIMS

- Understand the differences and similarities between DNA and RNA.
- Learn the different structural forms of DNA.
- Understand genome organization in
    - Viruses
    - Prokaryotes
    - Eukaryotes
- Learn the levels of genome organization and the molecules involved.

Review


Cytosine
C
Guanine
G
Adenine
A
Uracil
U
Nucleobases of RNA
Nucleobases
Base pair
helix of sugar-phosphates
RNA
Ribonucleic acid
DNA
Deoxyribonucleic acid
Cytosine
C
Guanine
G
Adenine
A
Thymine
T
Nucleobases of DNA

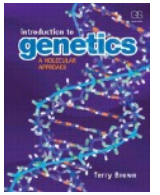
Review

What are the differences between DNA and RNA?

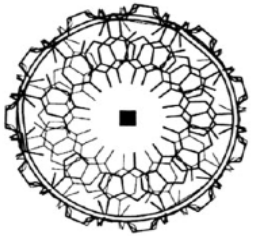
	DNA	RNA
Sugar	deoxyribose	ribose
Bases	A, G, C, T	A, G, C, U
Strands	Double strands	Single strand
Genetic material	Most life	Some viruses
Enzymatic	None	Many with
Structure	Double helix	Linear or folded

How many DNA structure exists?

Chapter2

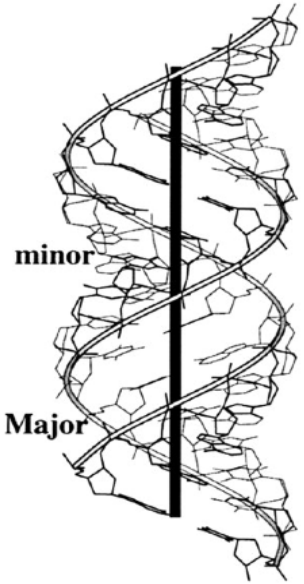


DNA structural forms



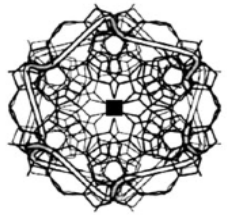
A-DNA:

- 11bp/turn.
- Diameter 2.2 nm.
- Right handed double helix.
- Short and wide.
- Found in low humidity.



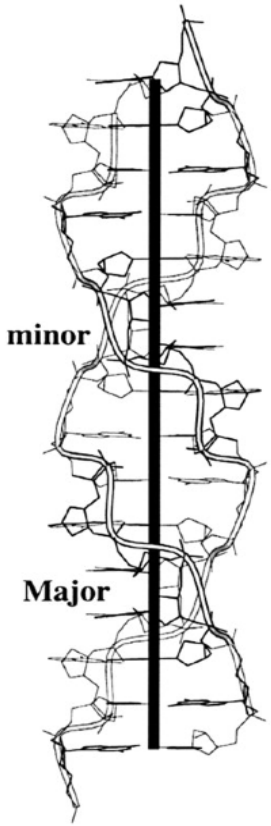
A-DNA

DNA structural forms



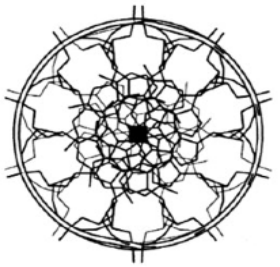
Z-DNA:

- 12bp/turn.
- Diameter 1.8nm.
- Left handed double helix.
- Thin and elongated.



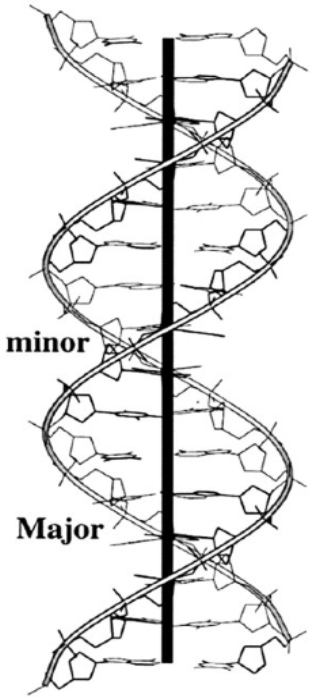
Z-DNA

DNA structural forms



B-DNA:

- 10bp/turn.
- Diameter 2nm.
- Right handed double helix.
- High humidity conditions
- **The one found in the cell!**



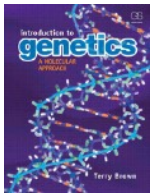
B-DNA

TABLE 2.1 FEATURES OF THE DIFFERENT CONFORMATIONS OF THE DNA DOUBLE HELIX

Feature	B-DNA	A-DNA	Z-DNA
Type of helix	Right-handed	Right-handed	Left-handed
Number of base pairs per turn	10	11	12
Distance between base pairs (nm)	0.34	0.29	0.37
Distance per complete turn (nm)	3.4	3.2	4.5
Diameter (nm)	2.37	2.55	1.84
Major groove	Wide, deep	Narrow, deep	Flat
Minor groove	Narrow, shallow	Wide, shallow	Narrow, deep

Table 2.1 Introduction to Genetics (© Garland Science 2012)

Chapter2



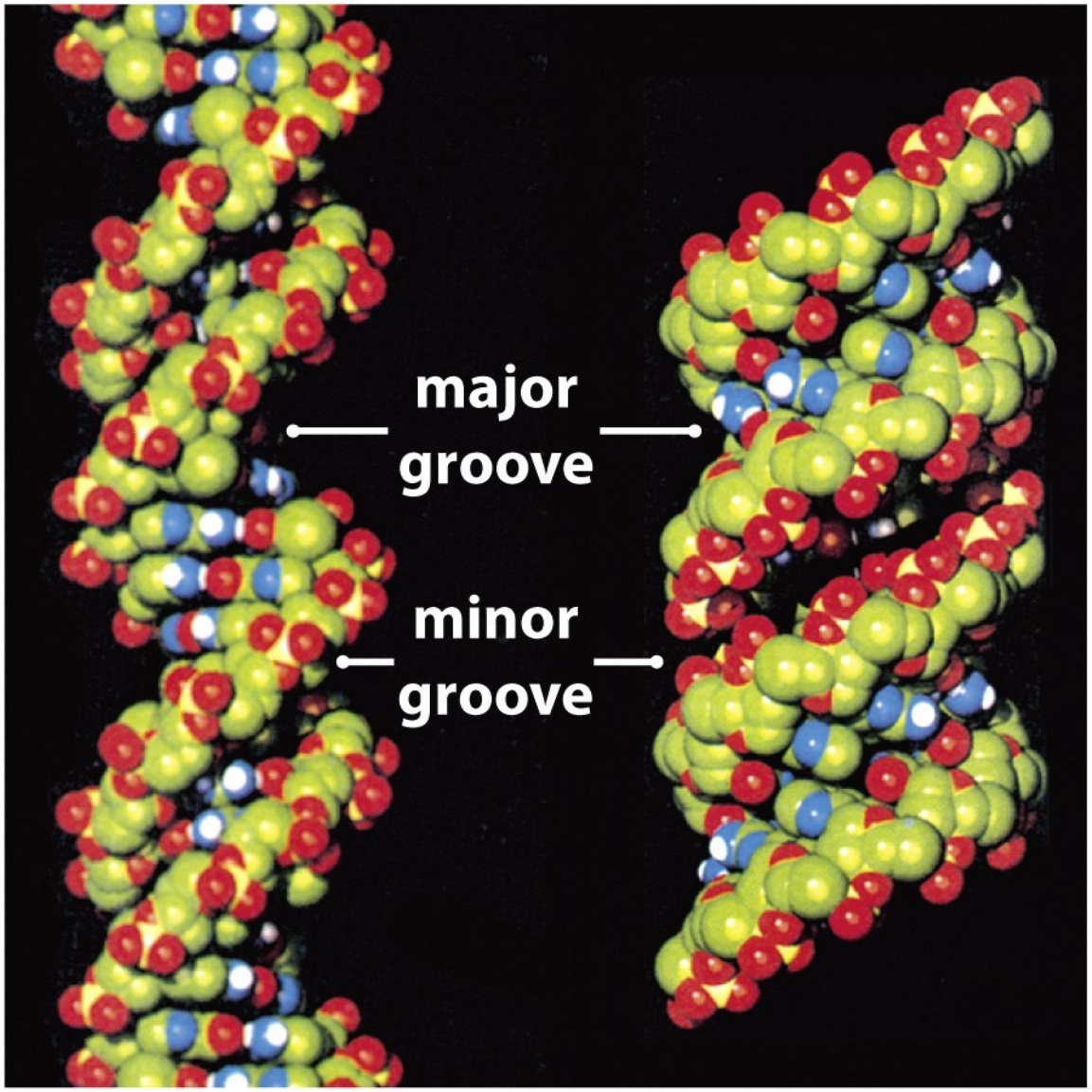
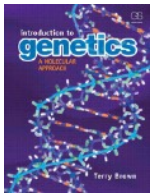


Figure 2.9 Introduction to Genetics (© Garland Science 2012)



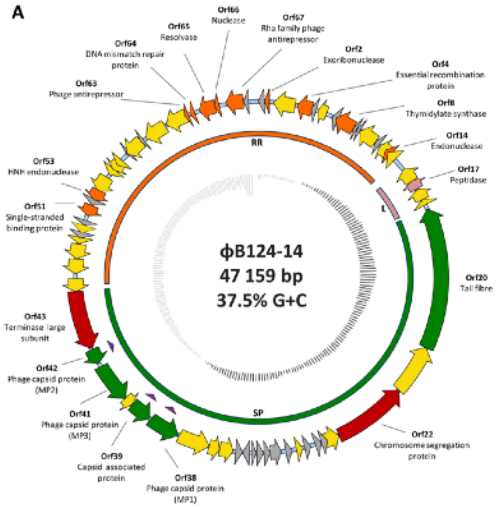
Genome organization

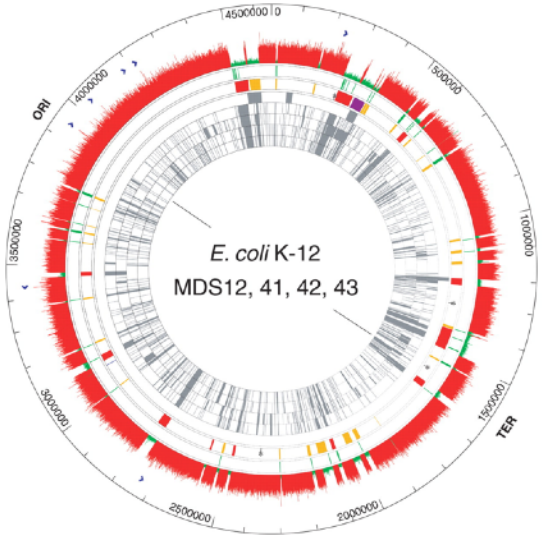
The characteristics of the genomes of different life forms

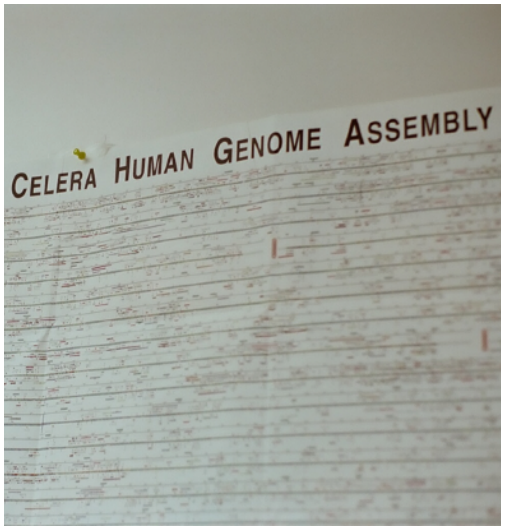
Viruses

Prokaryotes

Eukaryotes







Genome organization

What is a genome?

The entire genetic material of an organism

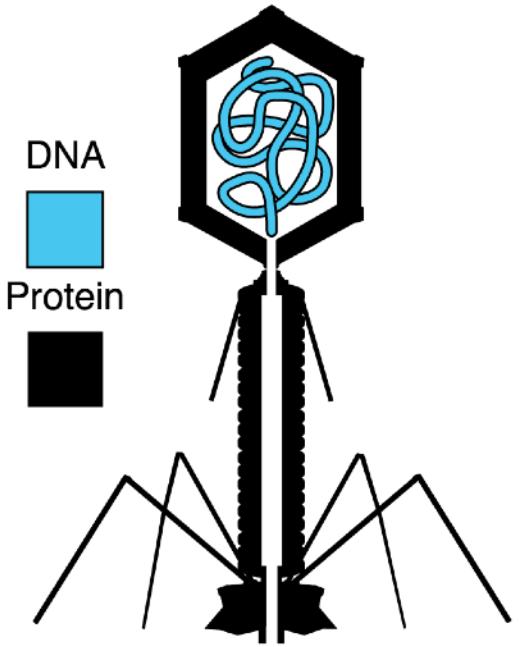
How is the genetic material organized?

Thousands / millions/ billions of nucleotide basepairs

How?

Viral genomes

- Genome can be:
    1. single stranded DNA.
    2. double stranded DNA.
    3. single stranded RNA.
    4. double stranded RNA.



- Genome can be linear or circular.

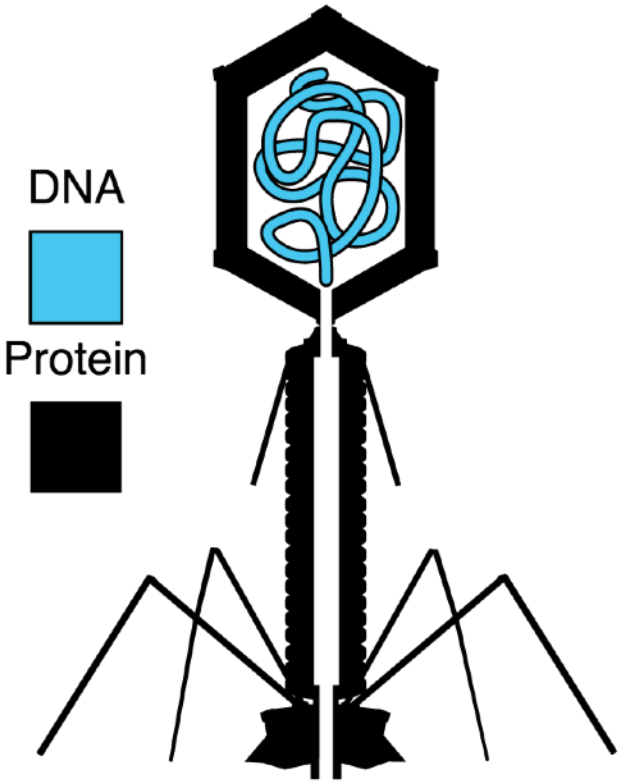
Viral genomes

•One molecule or segmented genome (many pieces).

• Viruses with RNA genome are called retroviruses!

• Genome size 2 thousand basepairs (2Kb) – 2 million basepairs (2 Mb).

• No special organization of the genome.



Prokaryotic genomes

- Most genomes are:
    1. single molecule.
    2. one circular chromosome.
    3. double stranded DNA.
    4. some have small additional circular DNA that can replicate independently (**plasmid**).

- Genome is organized in a structure called (**Nucleoid**).

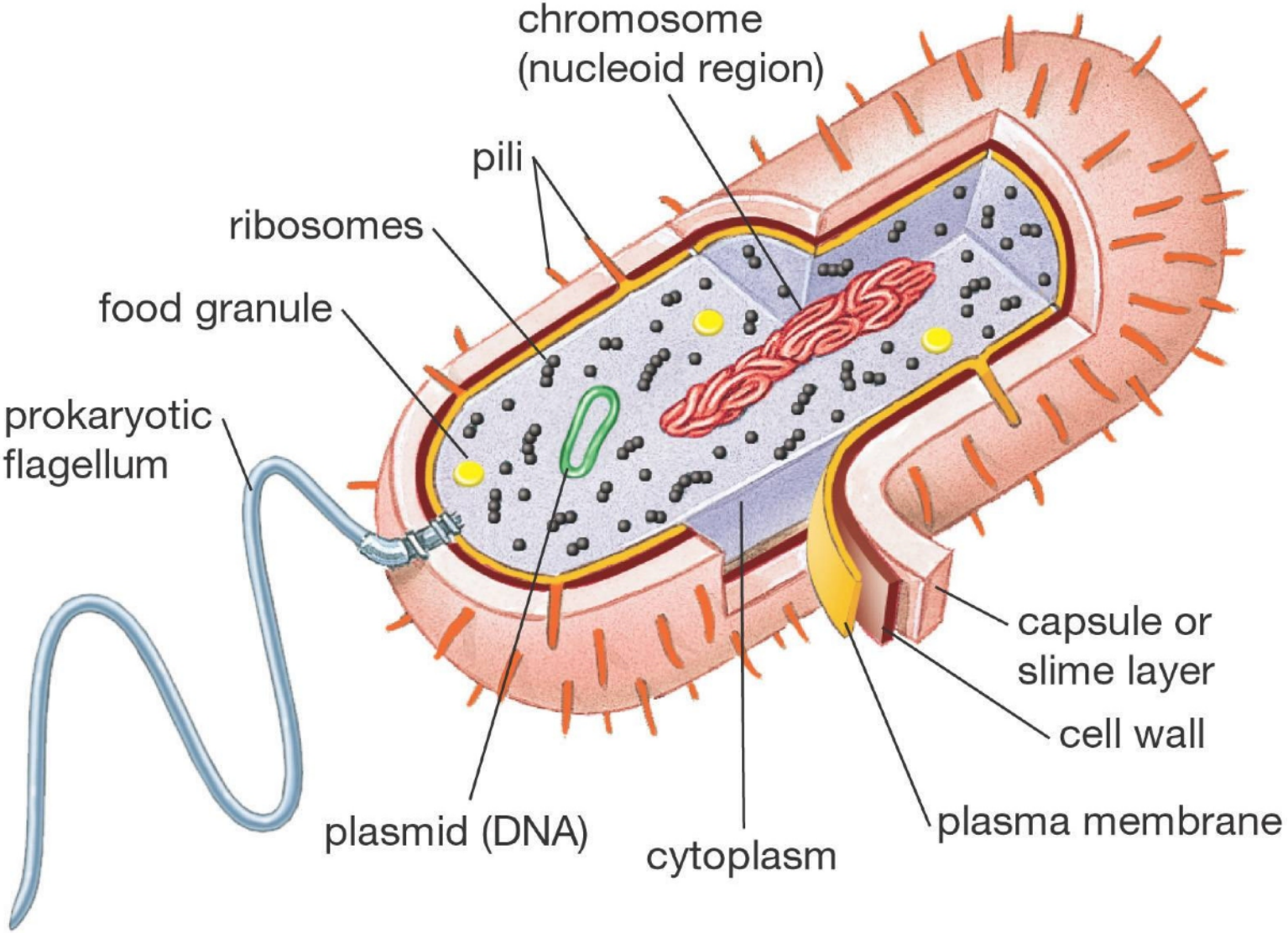
Prokaryotic genomes

•The genome is loose and not surrounded by a membrane (different than eukaryotes).

• **Loop domain** in bacterial genome contribute to the packaging.

• To fit the genome in a bacterial cell the DNA undergoes **supercoiling.**

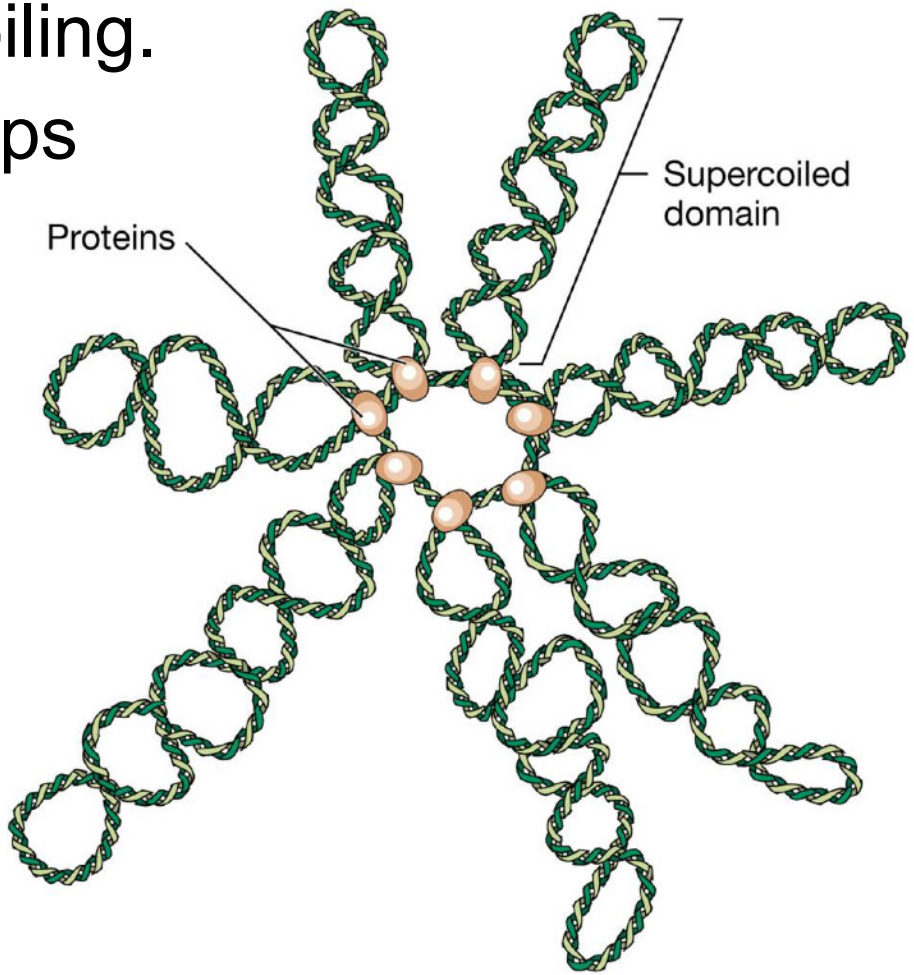
Prokaryotic genomes



Prokaryotic genomes organization

Prokaryote genome organization through:

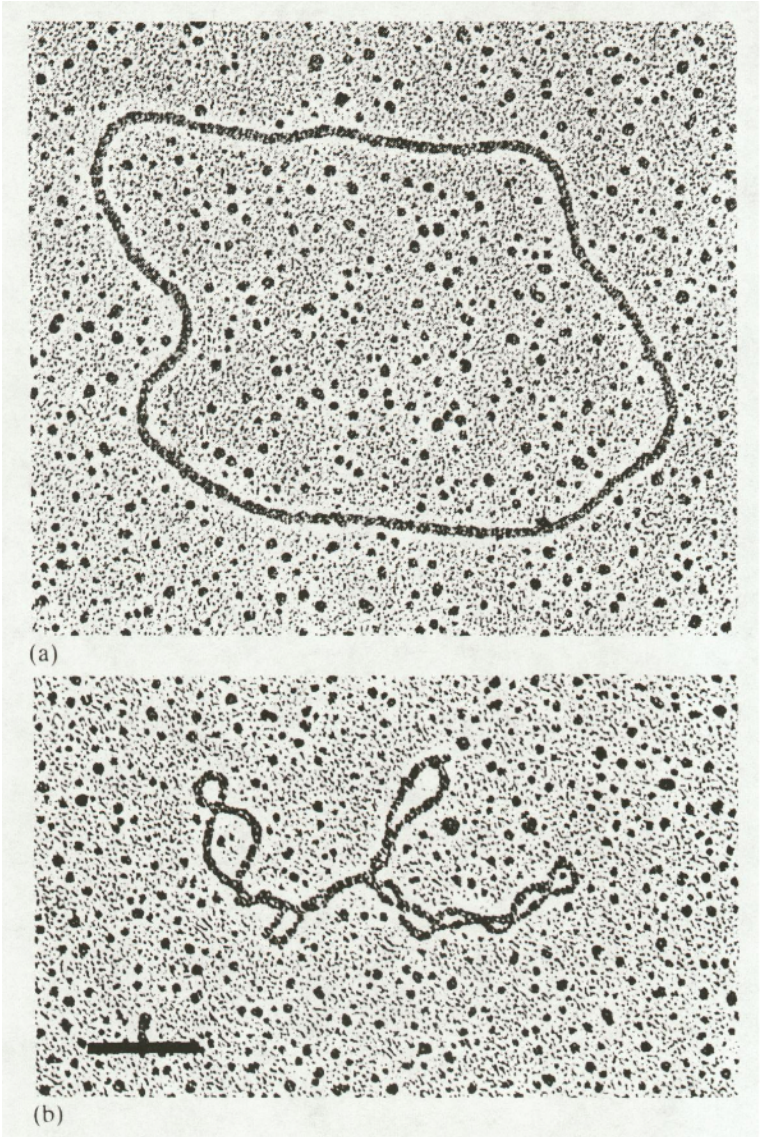
1. Nucleoid (protein DNA interaction).
2. Supercoiling.
3. DNA loops



Prokaryotic genomes organization

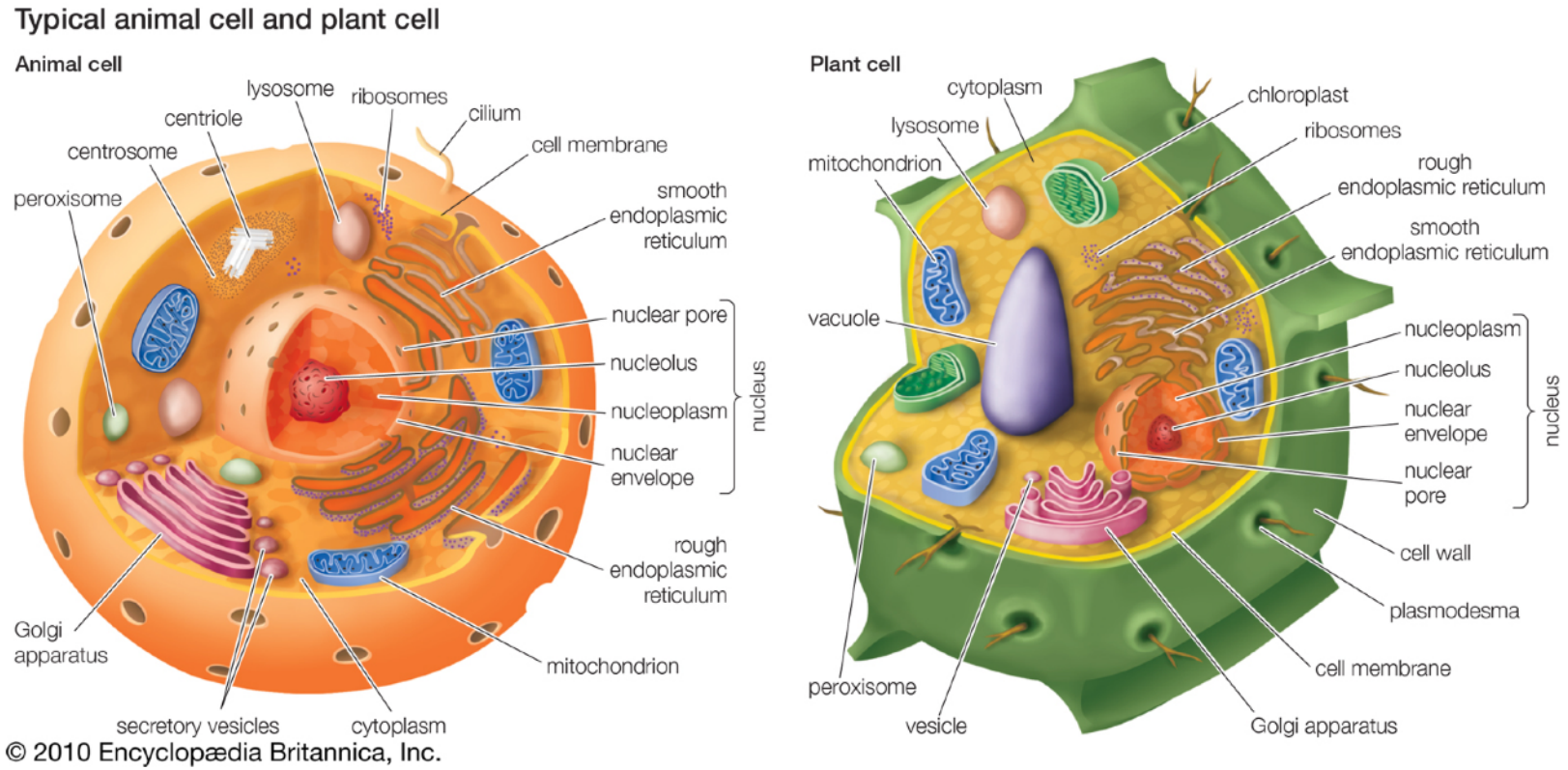
Relaxed circular chromosome

Supercoiled circular chromosome



Eukaryotic genomes

Where is eukaryotic genome located?



Nuclear genome, mitochondrial genome, chloroplast genome

Eukaryotic genomes

- Genomes are:

    1. Genome is a double stranded DNA.

    2. Genome arranged in several linear packages called **chromosomes** through interactions with several proteins**.**

Eukaryotic genomes

• The chromosomes in their most condensed form are called metaphase chromosomes.

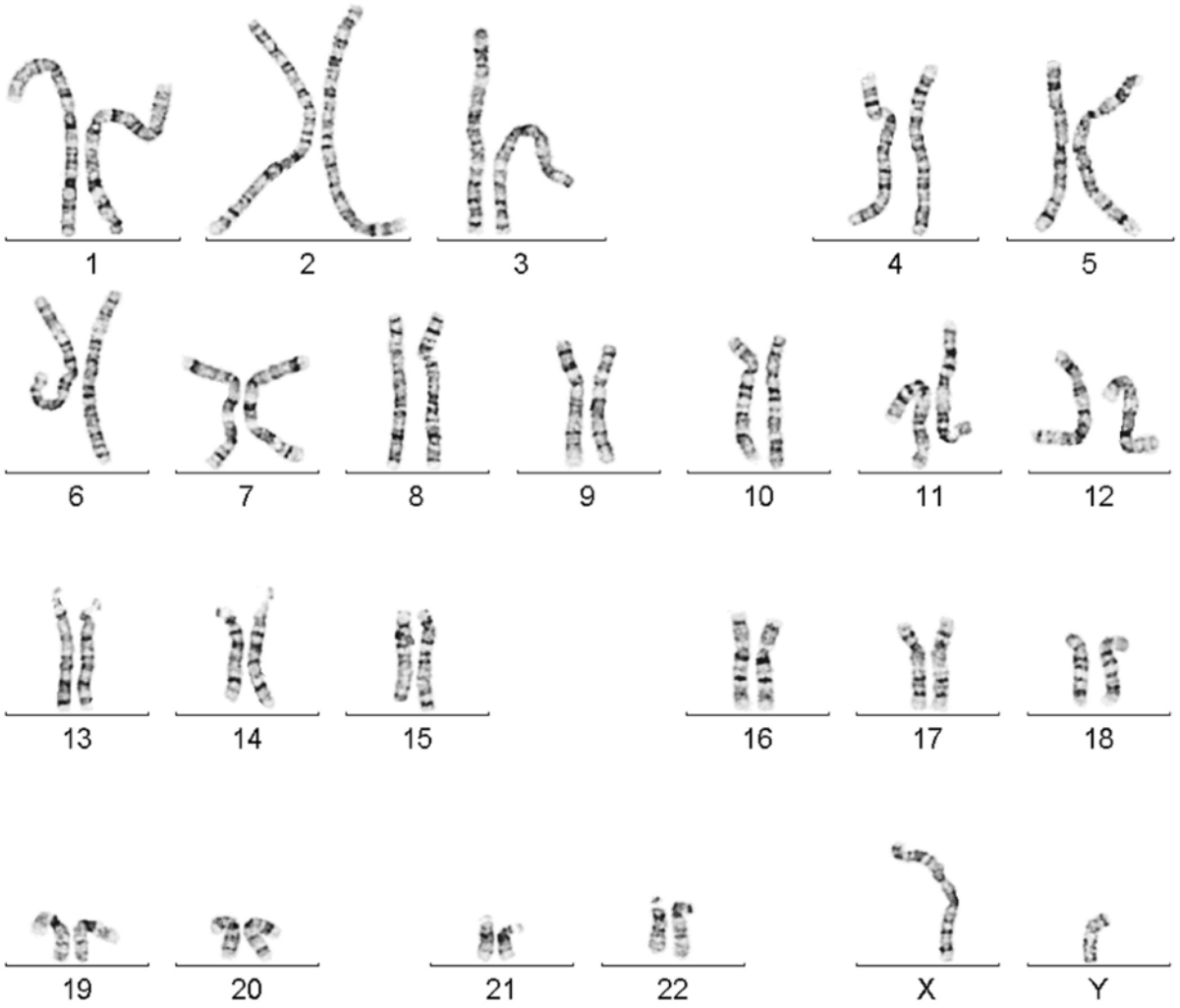
• The entire genome represented by metaphase chromosomes is called **karyotype**.

• The number of sets of chromosomes in a given eukaryotic cell is referred to as the level of ploidy**.**

What is your level of ploidy?

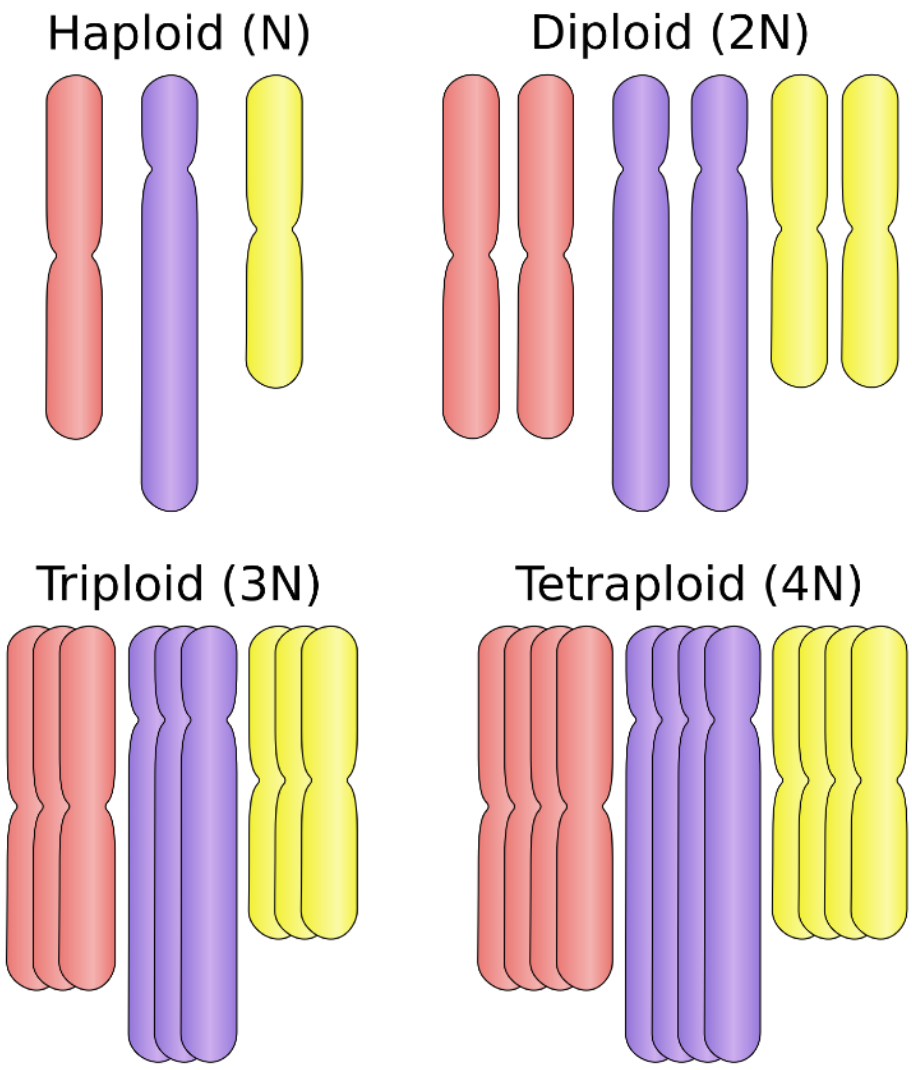
The genome packaged into chromosomes

Karyotype



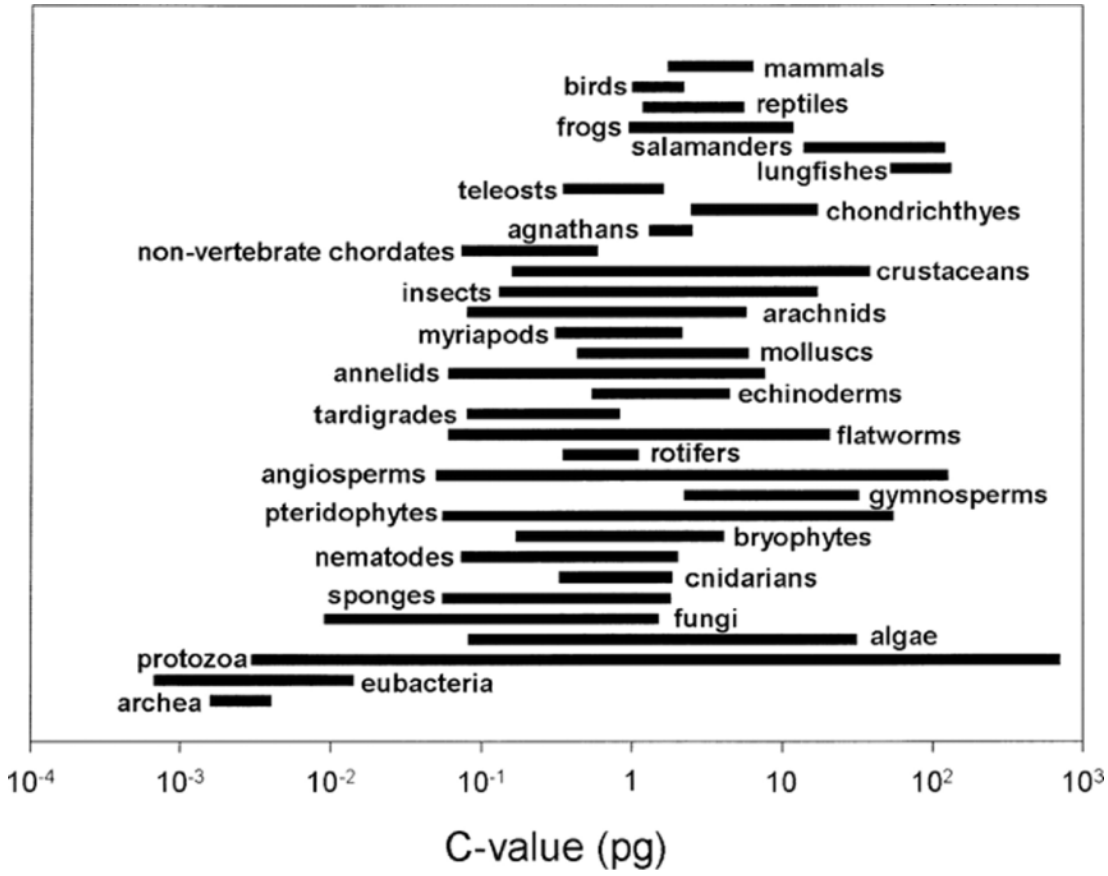
Ploidy

- **Haploid (1N):** cells that contain one set of chromosomes. Which of human cells are haploid and what 1N = ?
- **Diploid (2N):** cells that contain two sets of chromosomes. Which of human cells are haploid and what 2N = ?

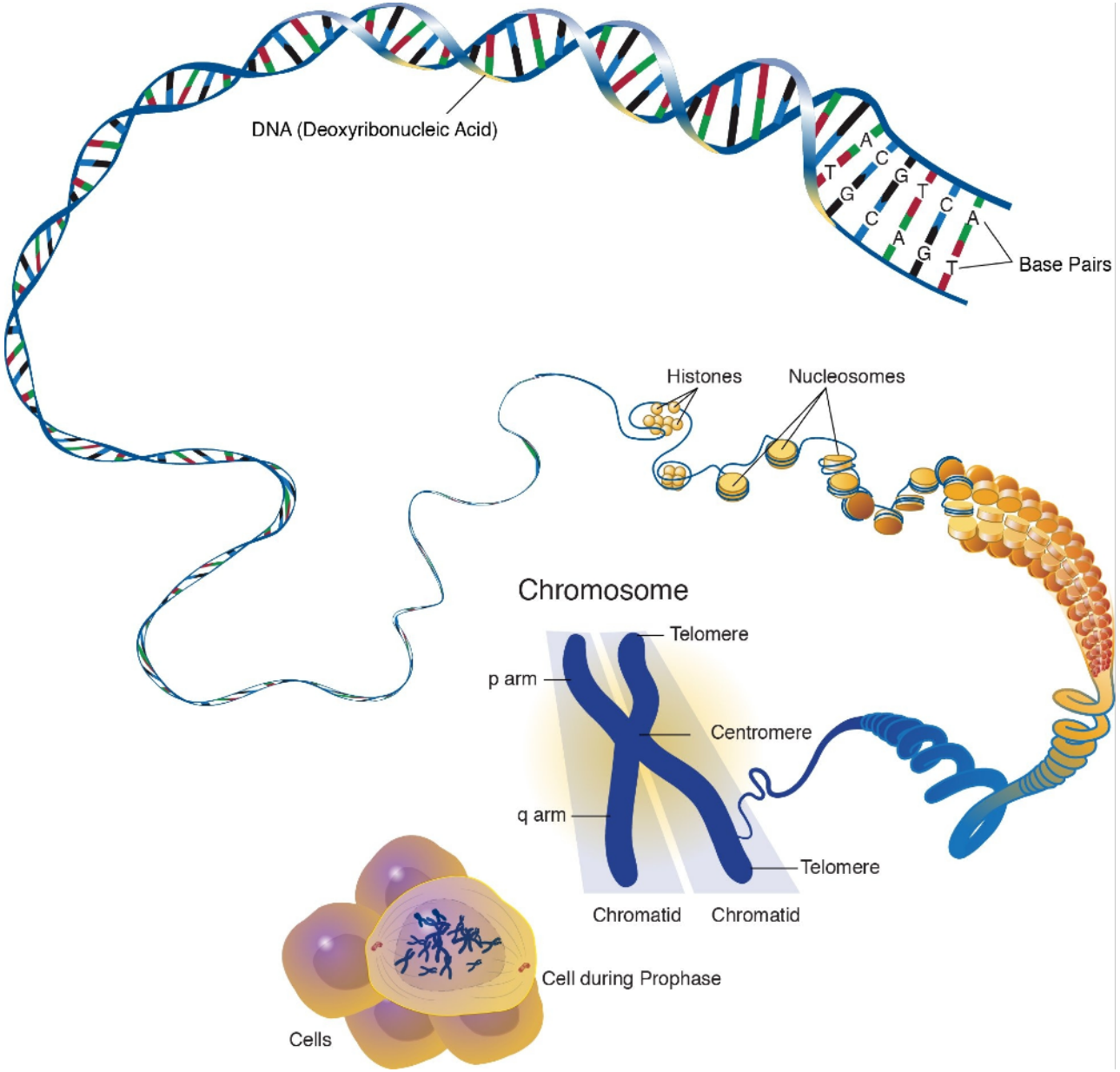


Measurement of Eukaryotic genome sizes

- Eukaryotic genome size are measured by the total amount of DNA found in a **haploid genome** and that is due to the level of ploidy exhibited by such organisms**.**
- The size of a haploid genome is called the **C-value**.



Eukaryotic genome packaging

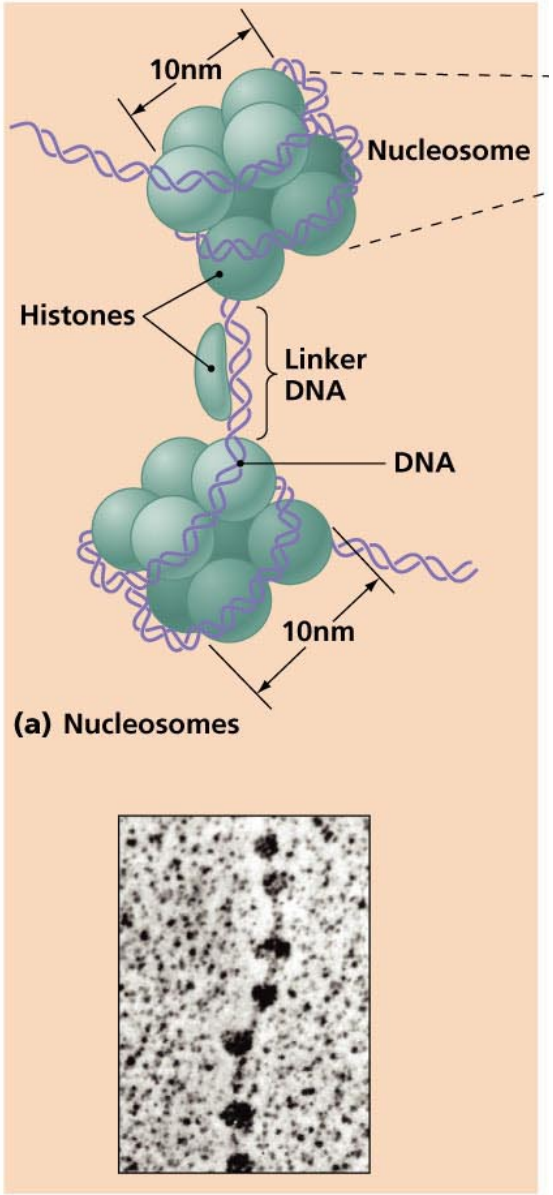


1. Double stranded DNA + histones

- DNA interacts with **histone** proteins to form **Nucleosomes**.

- A histone octamer (H2A, H2B, H3, H4) x 2 interacts with DNA to form a nucleosome.

- 147 bp of DNA goes around each histone octamer around 1.65 times.

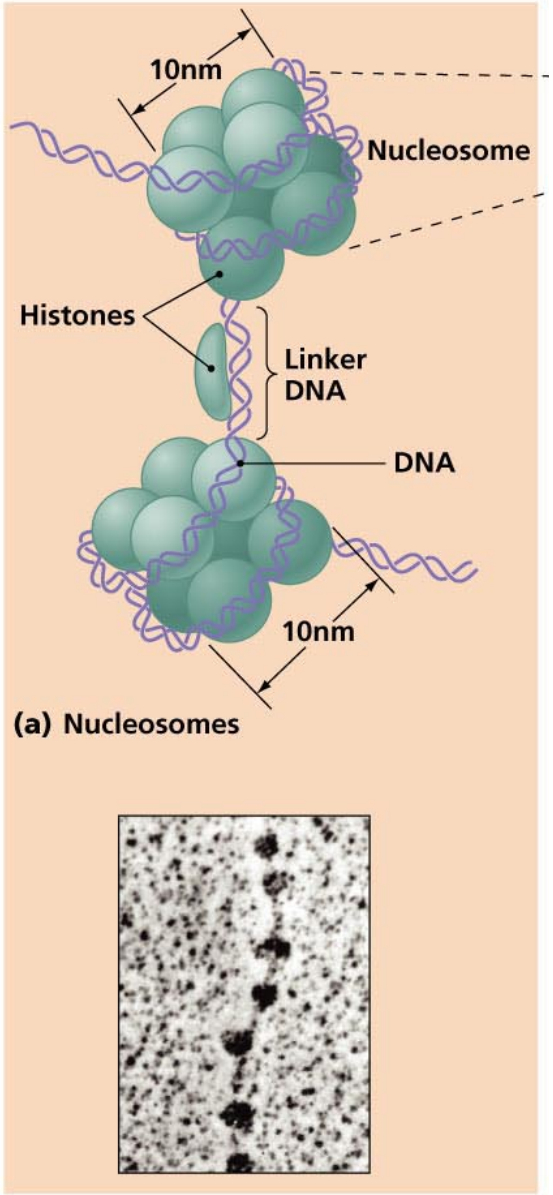


1. Double stranded DNA + histones

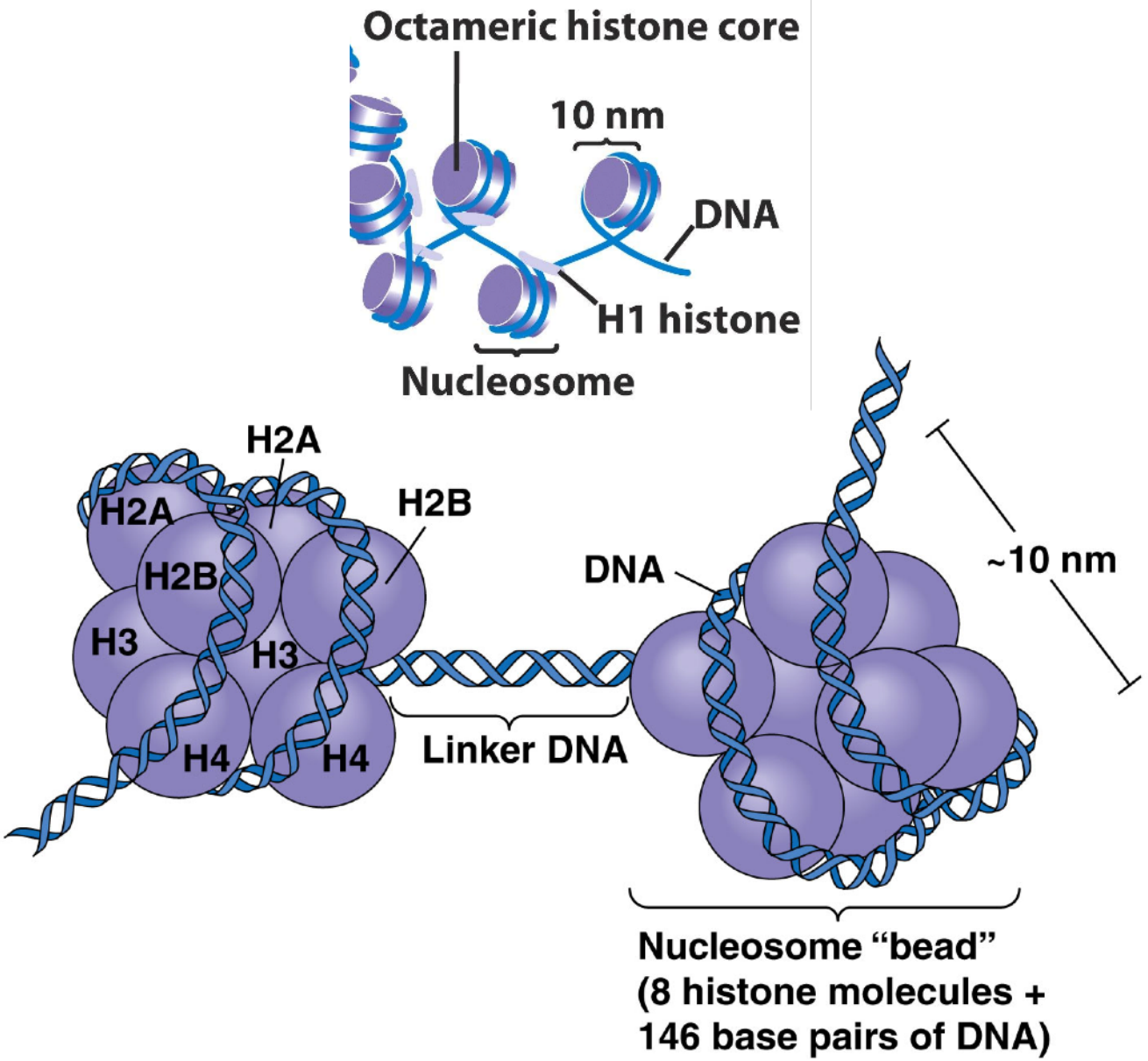
• Between two nucleosomes there is a linker DNA that is ~ 40-50 bp.

• This structure is referred to as **beads-on-a-string**.

• Another histone protein (H1) also facilitate into further condensation.

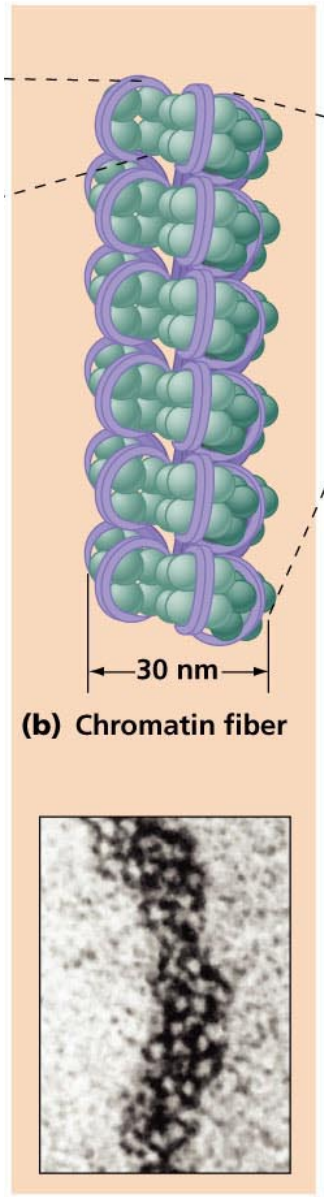


1. Double stranded DNA + histones



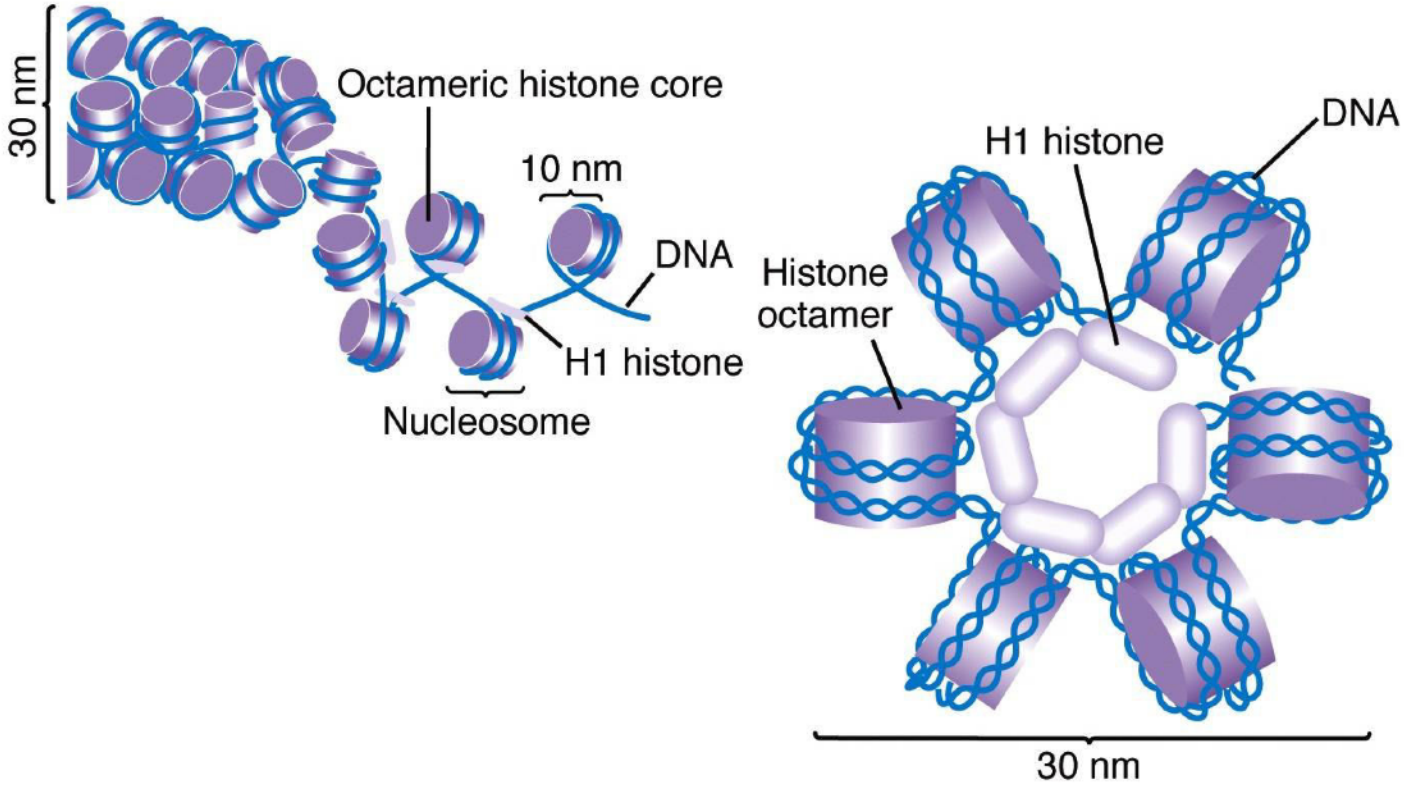
2. Nucleosomes to chromatin fiber

• Nucleosomes condense to form the **Solenoid or the 30nm fiber.**



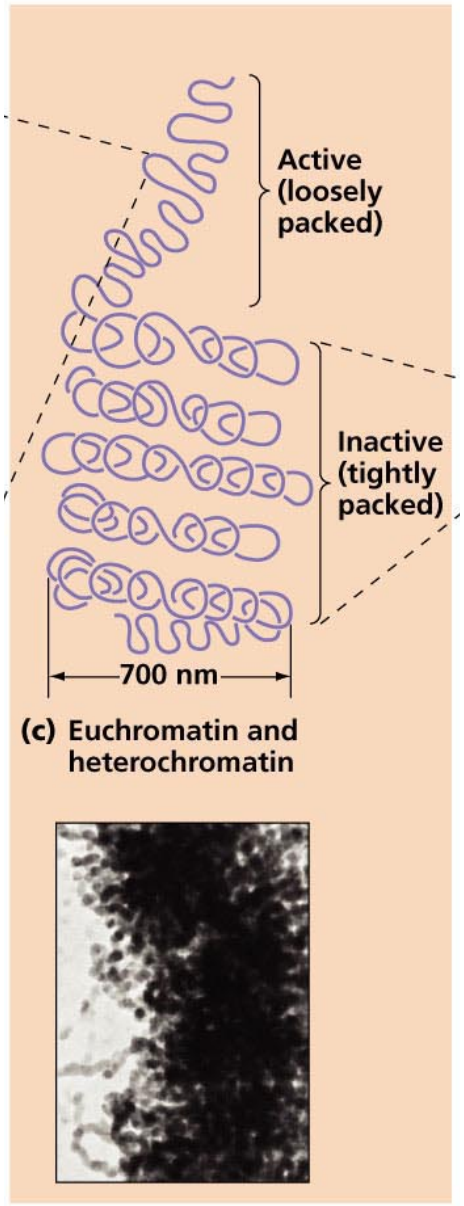
2. Nucleosomes to chromatin fiber

- Nucleosomes condense in a spiral orientation.
- As the name indicates the width of the molecule is 30nm.



3. Chromatin to Euchromatin and Heterochromatin

- Chromatin packs into:
  - **Euchromatin**
  - **Heterochromatin.**



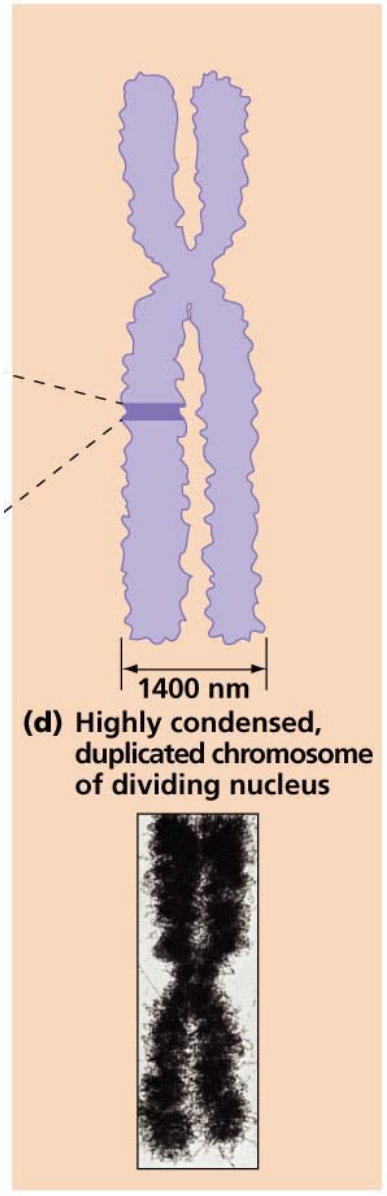
3. Chromatin to Euchromatin and Heterochromatin

- **Euchromatin:** regions that condense and decondense during the cell cycle and normally represent active (loosely packed) regions because:
    - The regions are transcribed
    - The regions do not have a lot of repeat sequences.

- **Heterochromatin:** regions that is condensed throughout the cell cycle.
    - These regions do not have genes or have genes that are not transcribed.

4. Chromosome formation

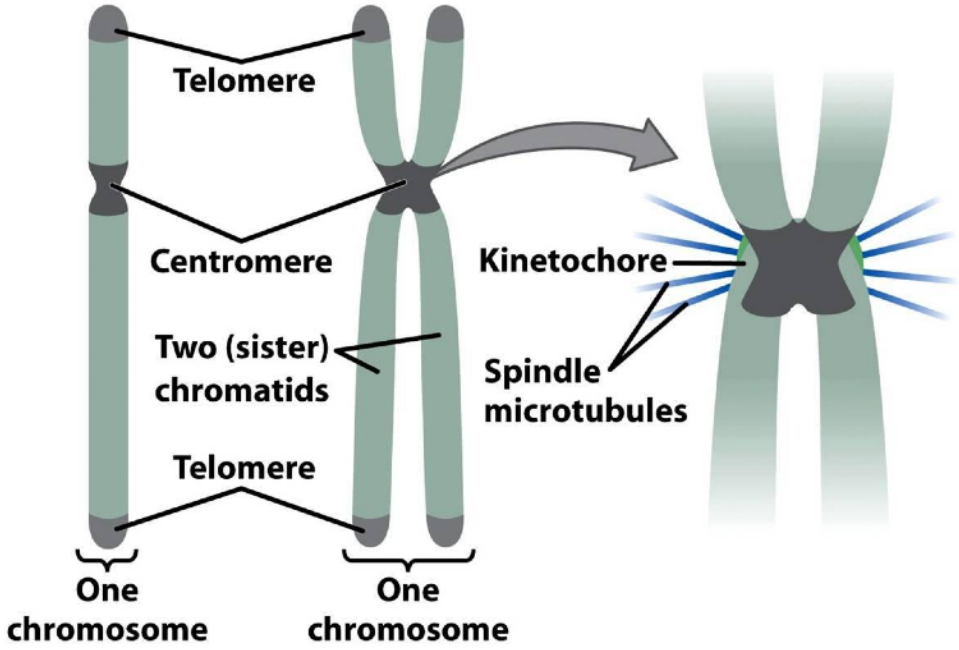
The genome in its most condensed form is represented by chromosomes.



4. Chromosome formation

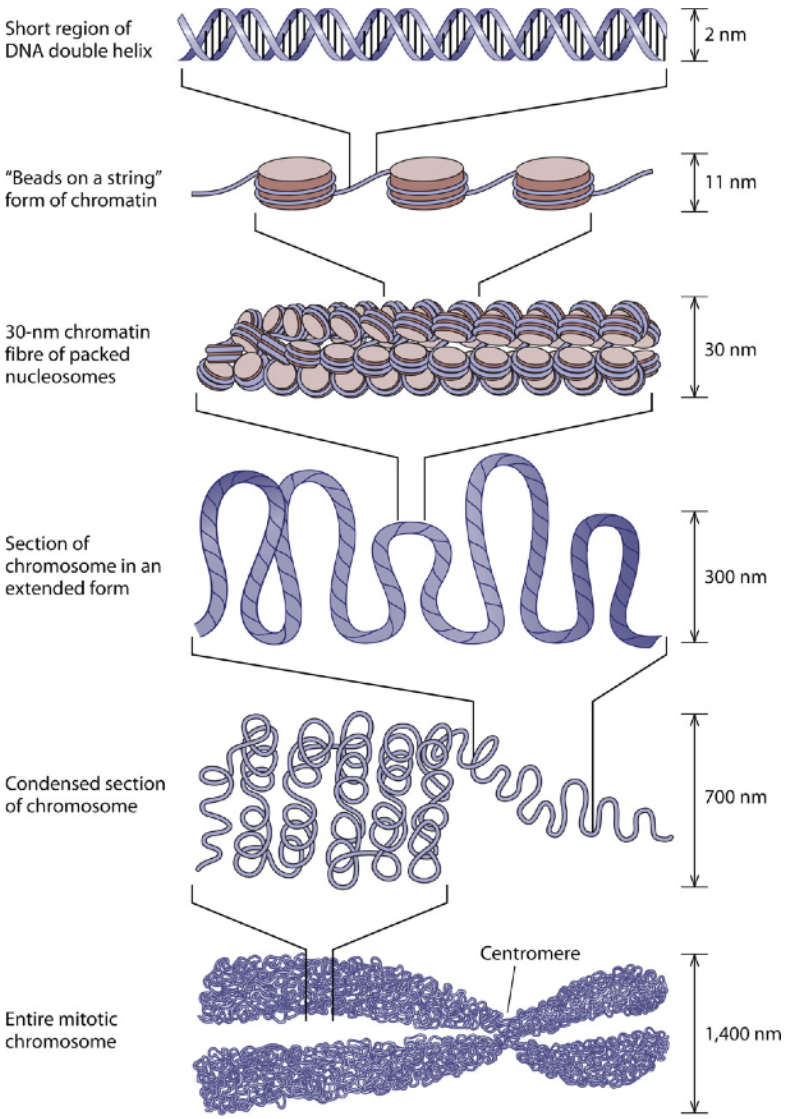
- Metaphase chromosomes have:

  1. Two arms (short p, long q) and separated by centromere.
  2. Centromere (region holds the arms).
  3. telomeres (ends of the chromosome).



Review of genome condensation

- Double helix.
  - Nucleosomes (DNA histones).
    - Beads on a string.
      - 30 nm chromatin fiber/ solenoid.
        - Eu/Heterochromatin.
          - Metaphase chromosome.



Quiz

While prokaryotic genomes are ……., eukaryotic genomes are …….

a) small, large

b) circular, linear

c) in cytoplasm, in the nucleus

d) single chromosome, multiple chromosomes

e) All of the above

Expectations

- You know the differences between DNA and RNA.
- You general characteristics between the genomes of different forms of life.
- You know the levels of genome organization in prokaryotes and eukaryotes.
- know why genomes need to be organized.
- Know the locations in your cells where you can find DNA.
- Study, Study, Study. Chapter 2 is done!

To study

Telomere

Eukaryotic genome

Nuclear genome

Nucleosome

30nm fiber

A-DNA

Circular DNA

B-DNA

Chromatin

Heterochromatin

C-value

Plasmid

Nucleoid

RNA

Diploid

Supercoiling

Polyploid

Chromosome

Beads-on-a-string

Karyotype

Chloroplast genome

q chromosomal arm

Solenoid

DNA

Viral genome

Z-DNA

DNA loops

Octamer

Histone

Euchromatin

Mitochondrial genome

Prokaryotic genome

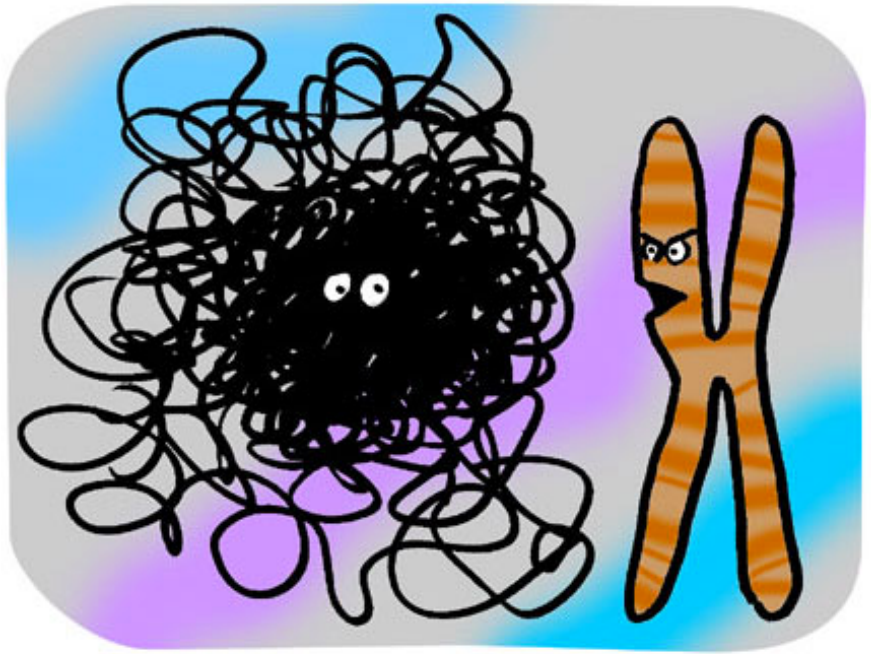
DNA vs. RNA

Haploid

p chromosomal arm

Centromere

For a smile



Dude, mitosis starts in five minutes...
I can't believe you're not condensed yet.

http://www.promega.com/