

Chapter 2: The Molecular basis of Heredity

DNA structure

We think they are heroes

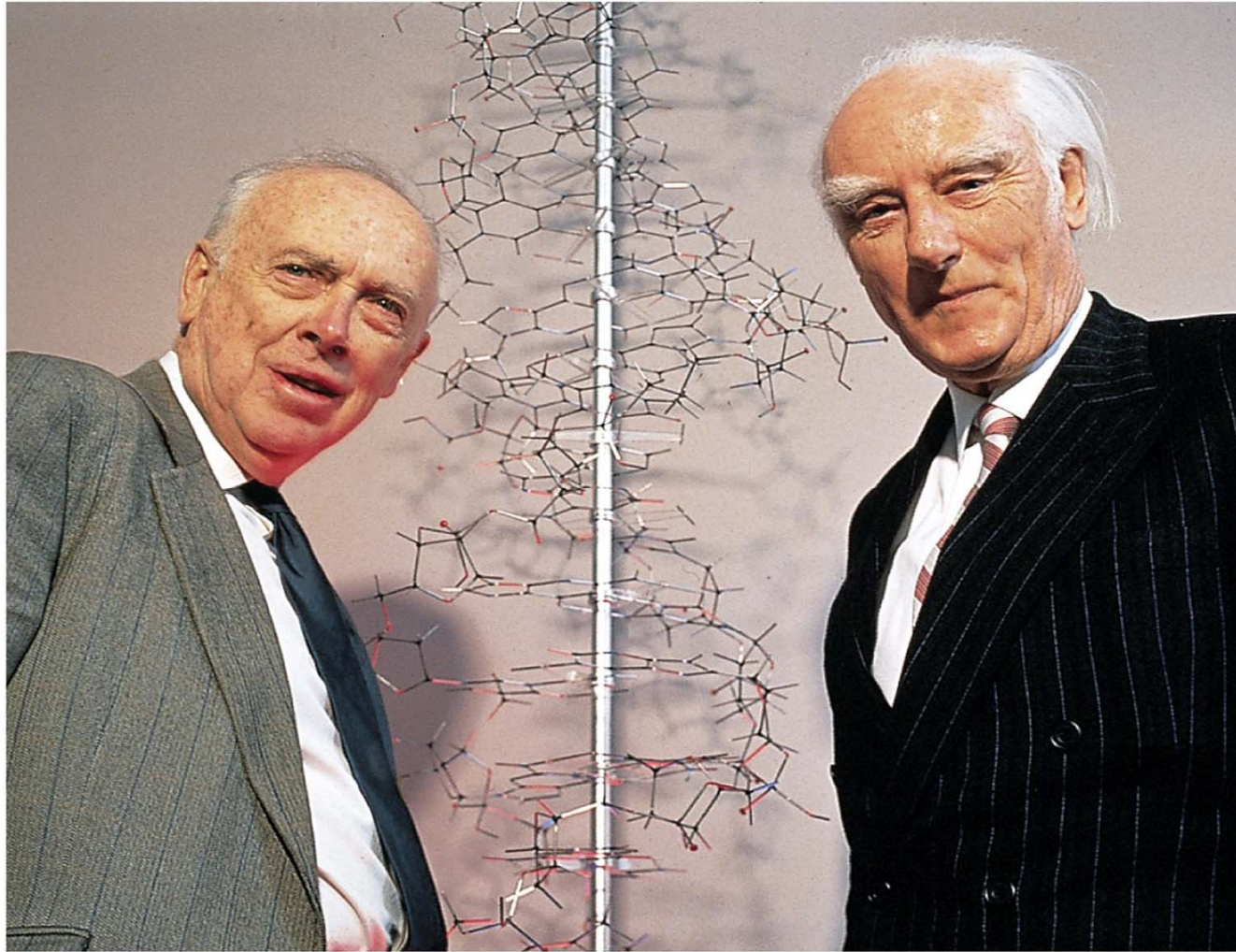


Figure 9-8 Principles of Genetics, 4/e

James D. Watson and Francis H. C. Crick

But, heroes are never made by themselves...



Rosalind Franklin's photograph 51

A famous X-ray diffraction image of nucleic acid revealing that DNA was a double helix



Watson & Crick used this double helix information to propose the double strand base pairing model

Chargaff's DNA base ratio rules

TABLE 9.1

Base Composition of DNA from Various Organisms						Molar Ratios	
Species	% Adenine	% Guanine	% Cytosine	% Thymine	$\frac{A + G}{T + C}$	$\frac{A + T}{G + C}$	
I. Viruses							
Bacteriophage λ	26.0	23.8	24.3	25.8	0.99	1.08	
Bacteriophage T2	32.6	18.1	16.6	32.6	1.03	1.88	
Herpes simplex	13.8	37.7	35.6	12.8	1.06	0.36	
II. Bacteria							
<i>Escherichia coli</i>	26.0	24.9	25.2	23.9	1.04	1.00	
<i>Micrococcus lysodeikticus</i>	14.4	37.3	34.6	13.7	1.07	0.39	
<i>Ramibacterium ramosum</i>	35.1	14.9	15.2	34.8	1.00	2.32	
III. Fungi							
<i>Neurospora crassa</i>	23.0	27.1	26.6	23.3	1.00	0.86	
<i>Aspergillus niger</i>	25.0	25.1	25.0	24.9	1.00	1.00	
<i>Saccharomyces cerevisiae</i>	31.7	18.3	17.4	32.6	1.00	1.80	
IV. Higher Eukaryotes							
<i>Zea mays</i> (corn)	25.6	24.5	24.6	25.3	1.00	1.04	
<i>Drosophila melanogaster</i>	30.7	19.6	20.2	29.4	1.01	1.51	
<i>Homo sapiens</i> (human)	30.2	19.9	19.6	30.3	1.01	1.53	

Chargaff's DNA base ratio rules



ERWIN CHARGAFF FOUND.

- ① THE COMPOSITION OF DNA VARIED FROM ONE SPECIES TO ANOTHER, IN PARTICULAR IN THE RELATIVE AMOUNTS OF THE BASES A, C, T, G.
- ② IN ANY DNA, THE NUMBER OF A'S WAS THE SAME AS THE NUMBER OF T'S; SIMILARLY, THE NUMBER OF C'S WAS EQUAL TO THE NUMBER OF G'S.

WHAT DID THIS MEAN?
CHARGAFF COULDN'T SAY...

DNA Structure

- The unit of heredity is a gene, genes are made of DNA, DNA is a polymer made up of a linear arrangement of subunits known as nucleotide
- Nucleotide = phosphate group+ sugar(deoxyribose) + N-containing base
- Four bases found in DNA: **A**denine, **T**hymine, **G**uanine, **C**ytosine
- DNA is double stranded molecule wound in helical arrangement = double helix

DNA Structure

- In double strand DNA, the base of one strand are paired with the base in the other strand by hydrogen bonds
- A and G are purine base, C and T pyrimidine bases. A pairs with T, C pairs with G by hydrogen bonds (complementary base pairing)
- Complementary sequences = two sequences which can be deduced from each other

Structure of DNA and RNA

Nucleic acids are composed of repeating subunits called nucleotides.
Each nucleotide is composed of three units.

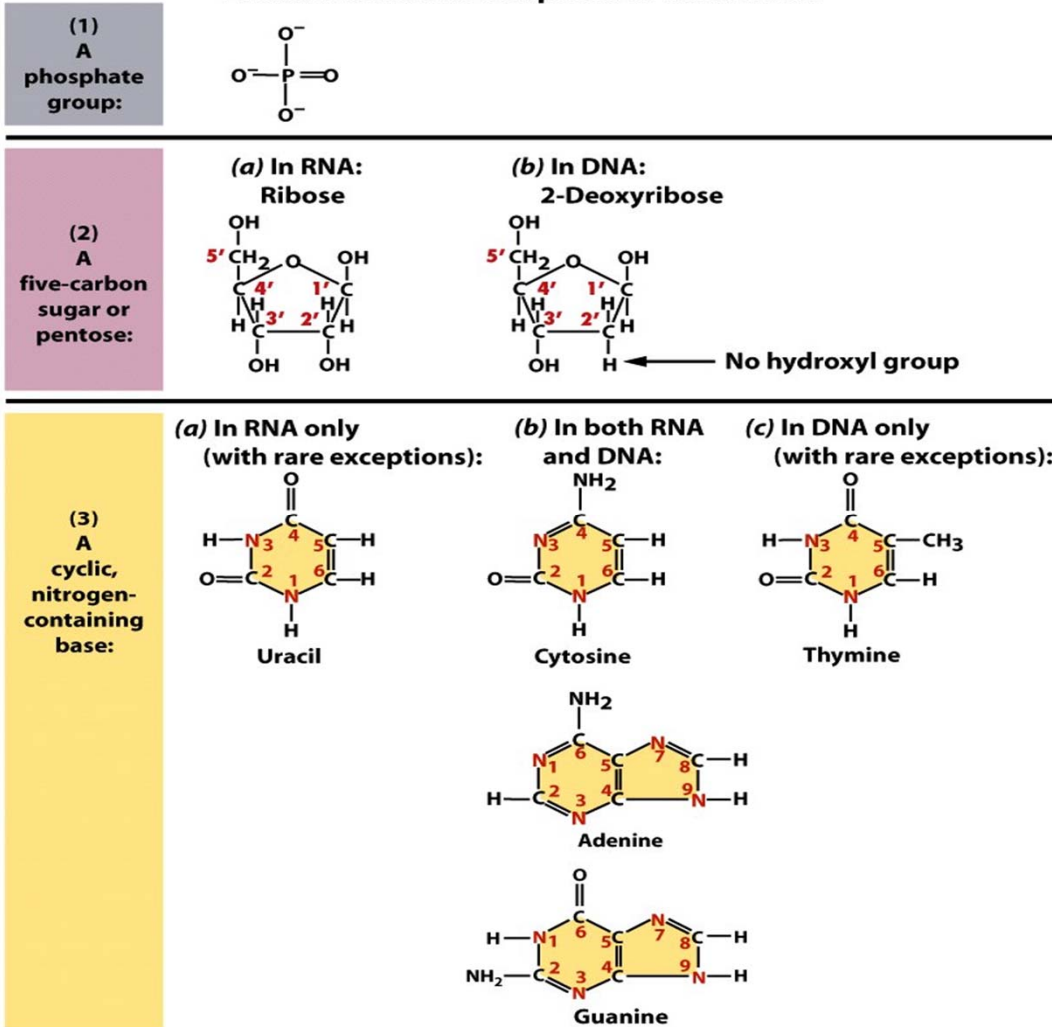


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Bases are composed of Pyrimidine and Purine

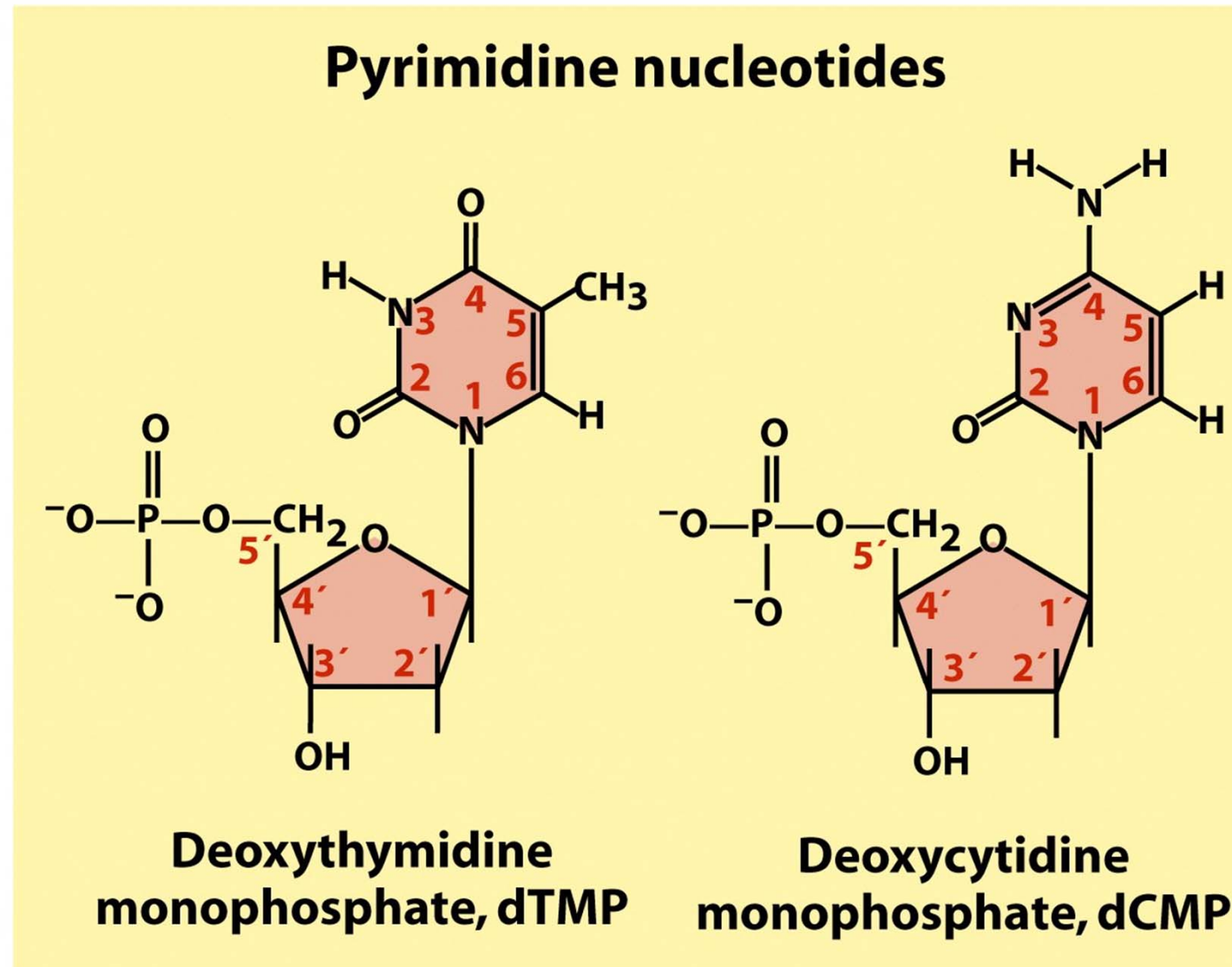


Figure 9-6 part 1 Principles of Genetics, 4/e
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Bases are composed of Pyrimidine and Purine

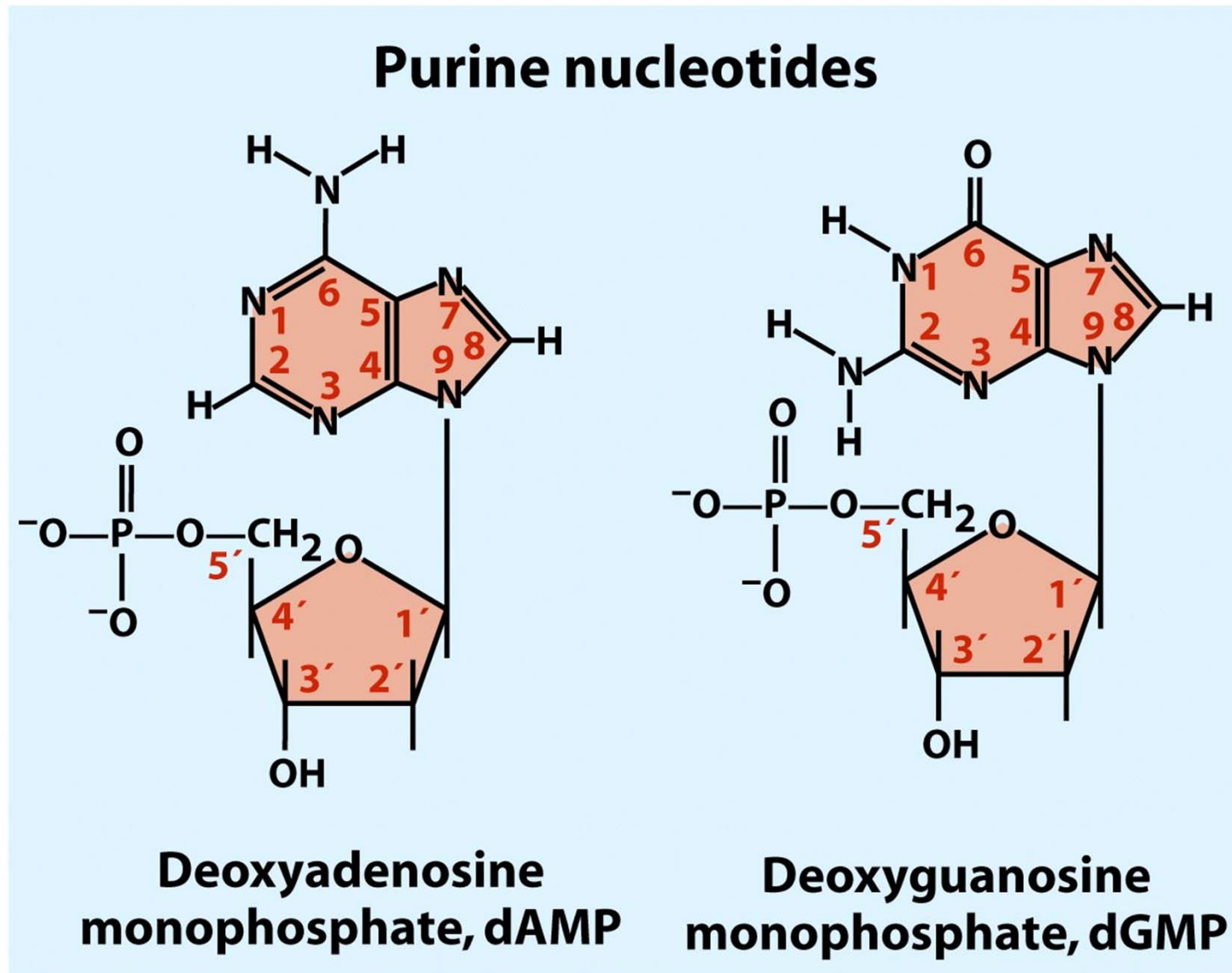


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Polynucleotide chain

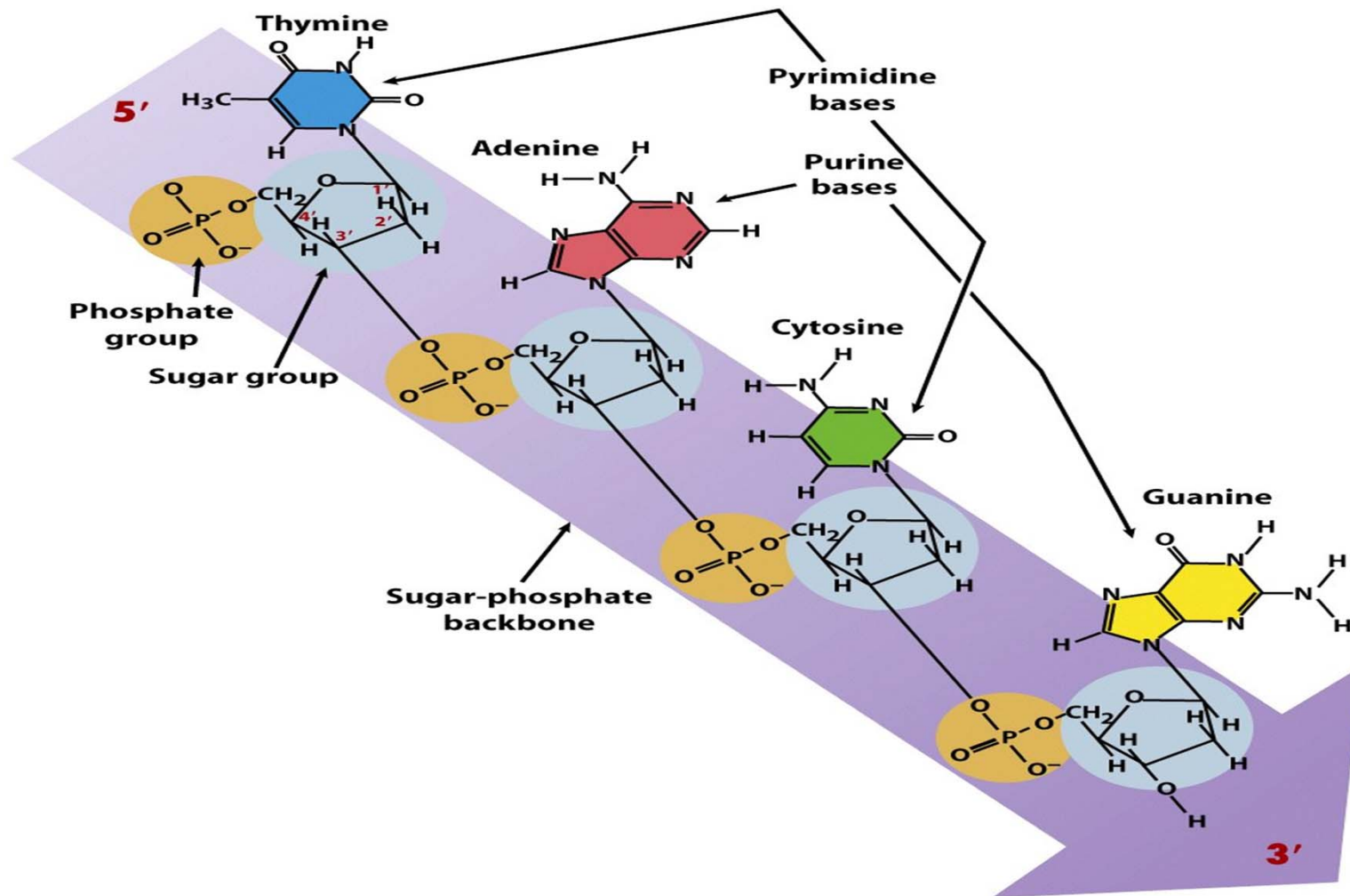
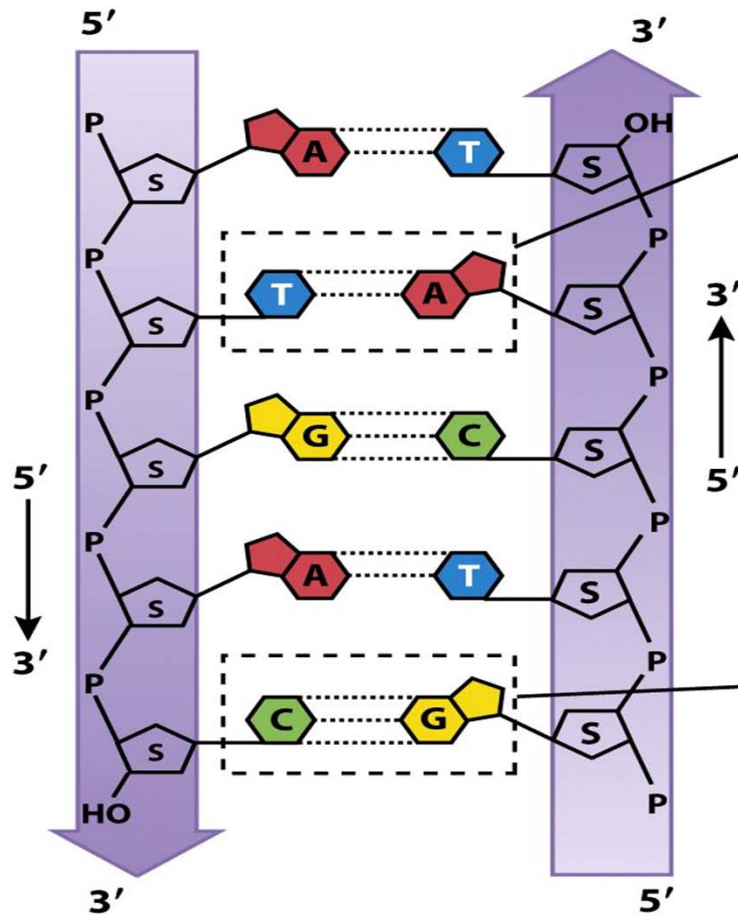


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Formation of a polynucleotide chain by joining nucleotides with phosphodiester linkages. Note that the polynucleotides has a 5' to 3' chemical polarity (top to bottom)

Base pairing and double strand polynucleotide chain

Opposite polarity of the two strands



Hydrogen bonding in A-T and G-C base pairs

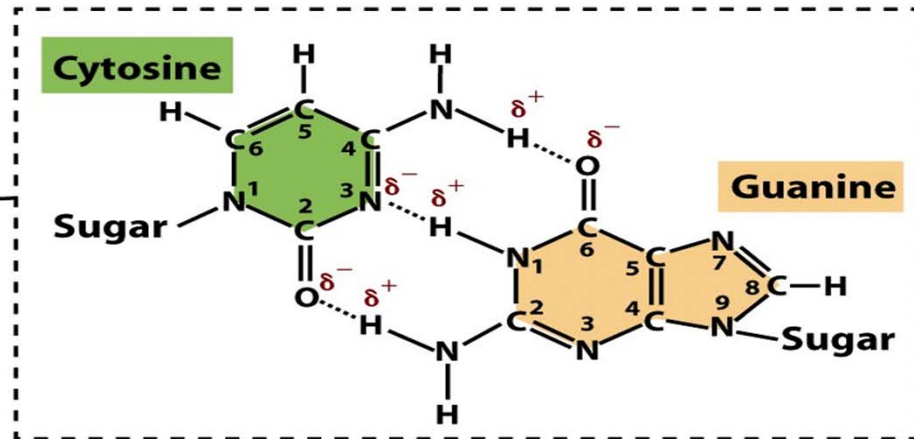
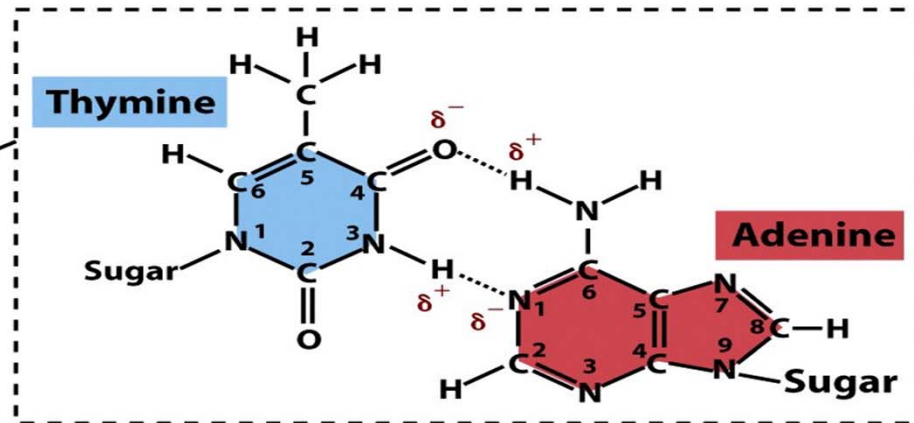


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The sugar-phosphate backbones of the two complementary strands are **antiparallel**

Right-handed
DNA double helix
(B-DNA conformation)

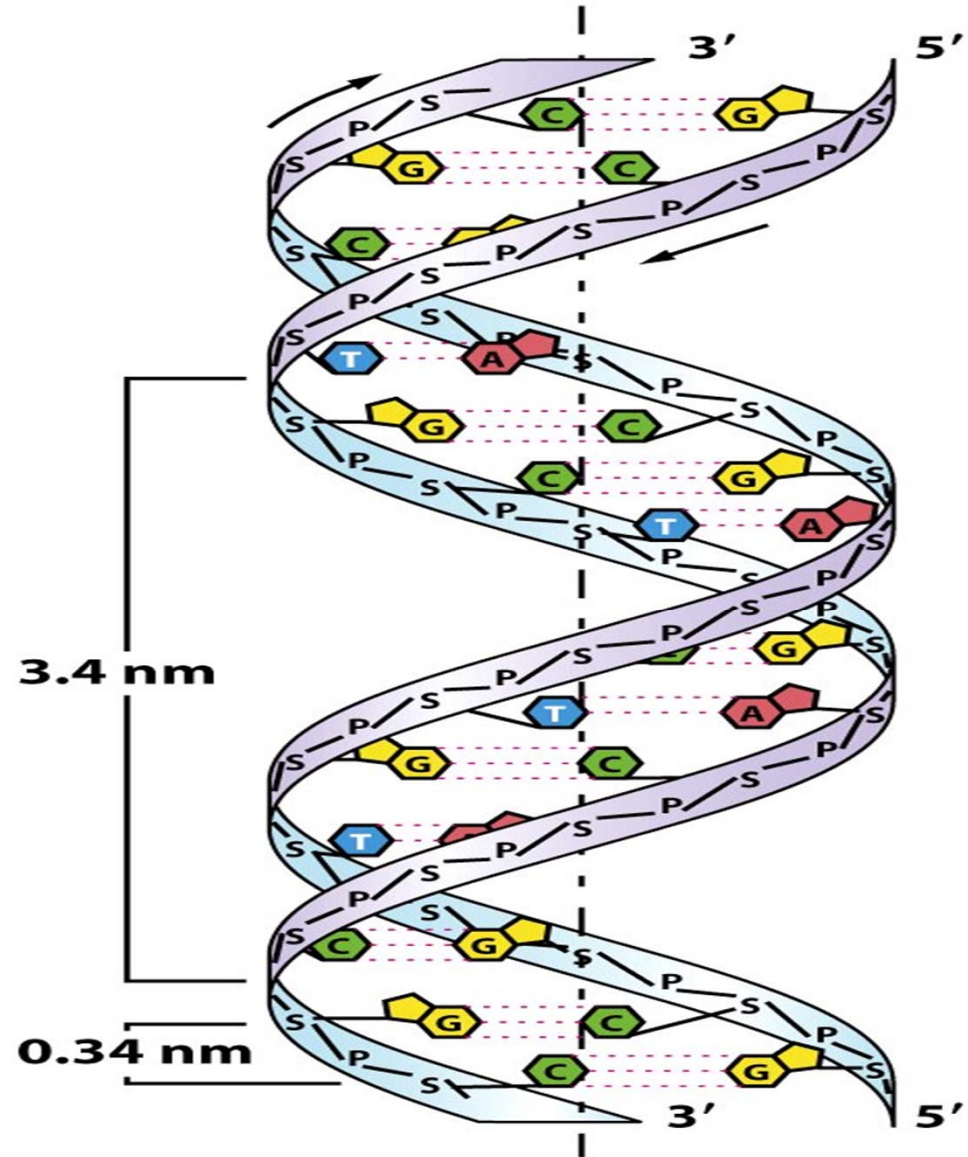


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DNA Structure

- 1 mm helical DNA of bacteria is twisted (supercoiling) and packed inside 1 μm bacterial cell
- Plants and animals fold their DNA in more complex way to fit into the cell nucleus
- In eukaryotic cells, genes dispatch genetic information in forms of special messenger molecules, messenger RNA (mRNA) through pores in the nucleic membrane

How 1 mm helical DNA of bacteria is packed inside 1 μm ?

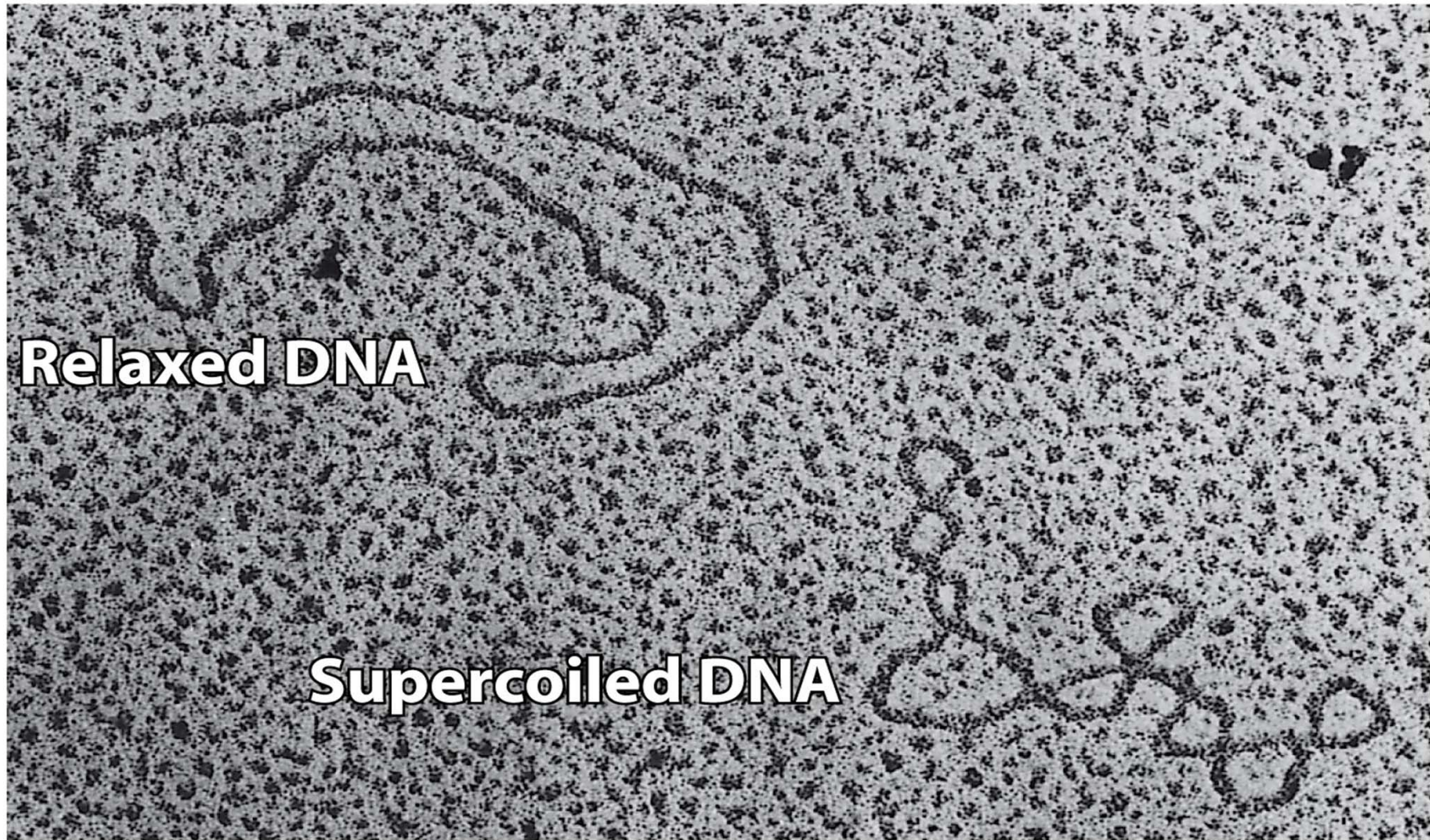


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DNA Structure: Negative Supercoils *In Vivo*

Octamer of histones
2 H2a + 2 H2b + 2 H3 + 2 H4

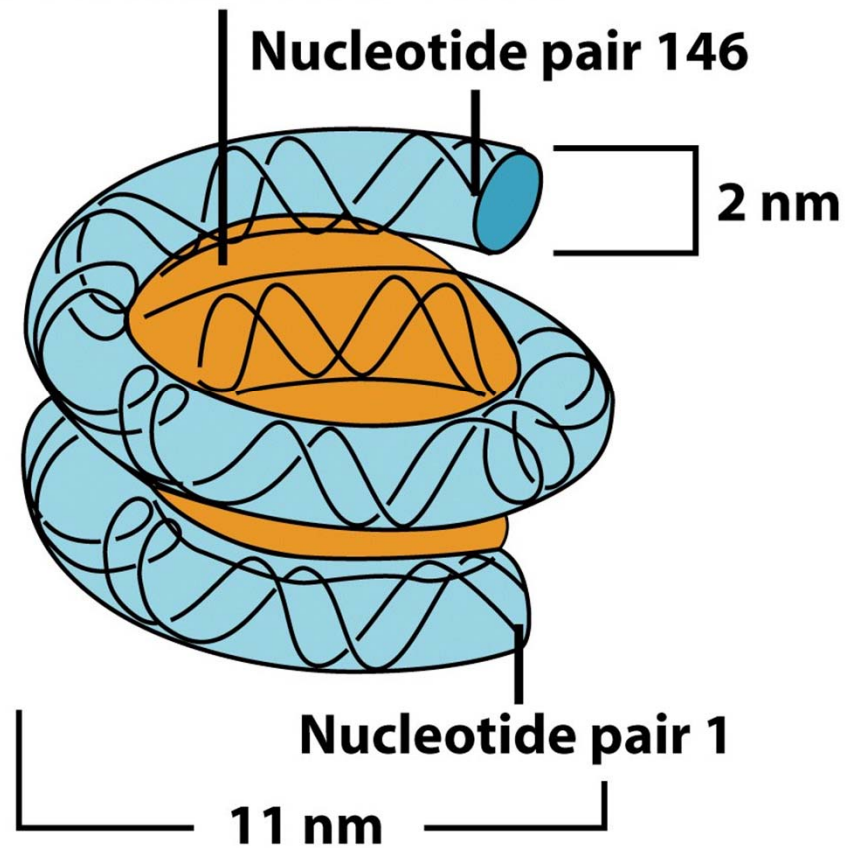
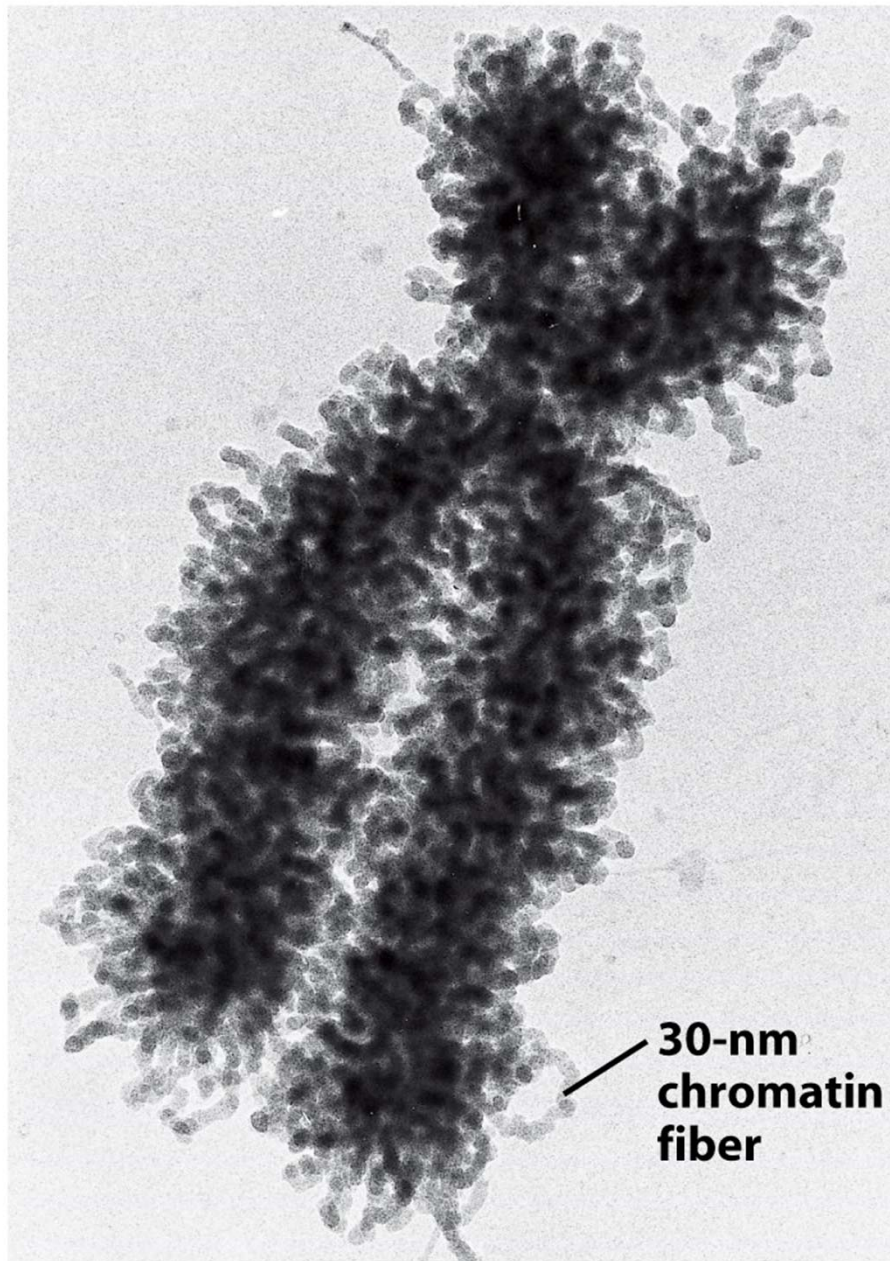


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How 6 feet helical DNA of human chromosome is packed inside 0.5 mm cell?



chromatin fibers A basic organizational unit of eukaryotic chromosomes that consists of DNA and associated proteins assembled into strands of average diameter 30 nm.

Figure 9-25 Principles of Genetics, 4/e

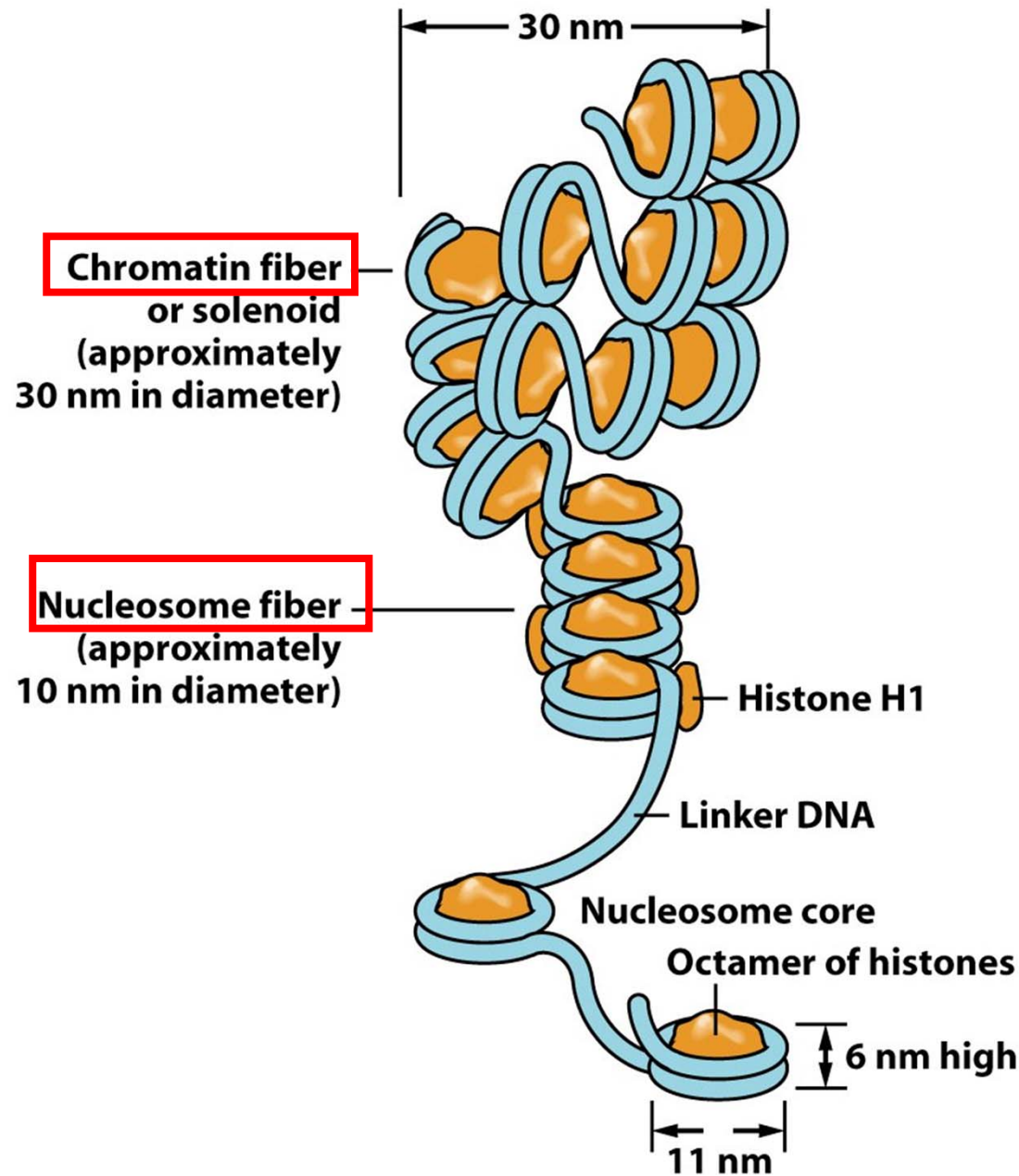
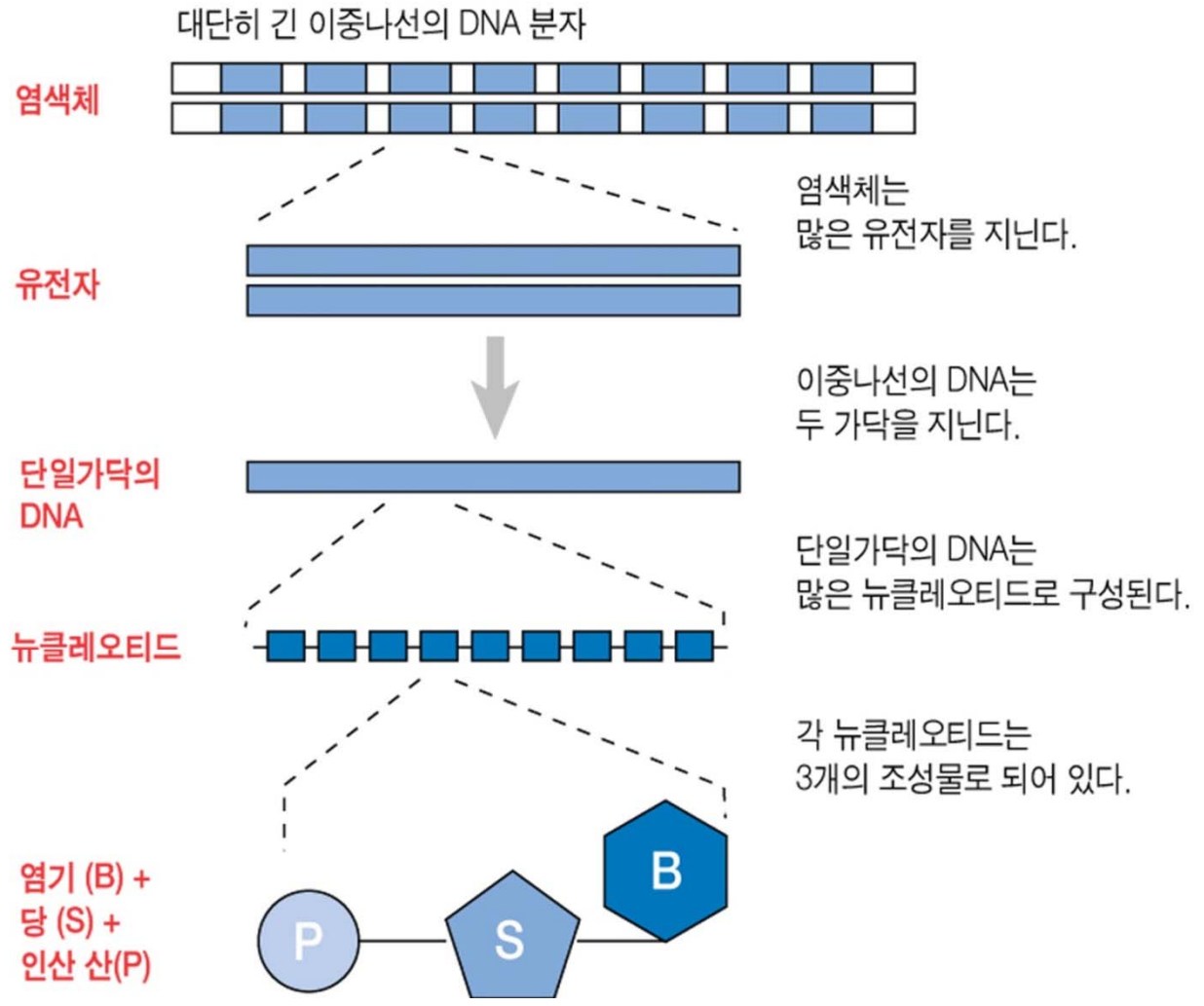


Diagram of the solenoid model of the 30-nm chromatin fiber.

Histone H1 appears to stabilize the 10-nm nucleosome fiber and contribute to the formation of the 30-nm chromatin fiber.

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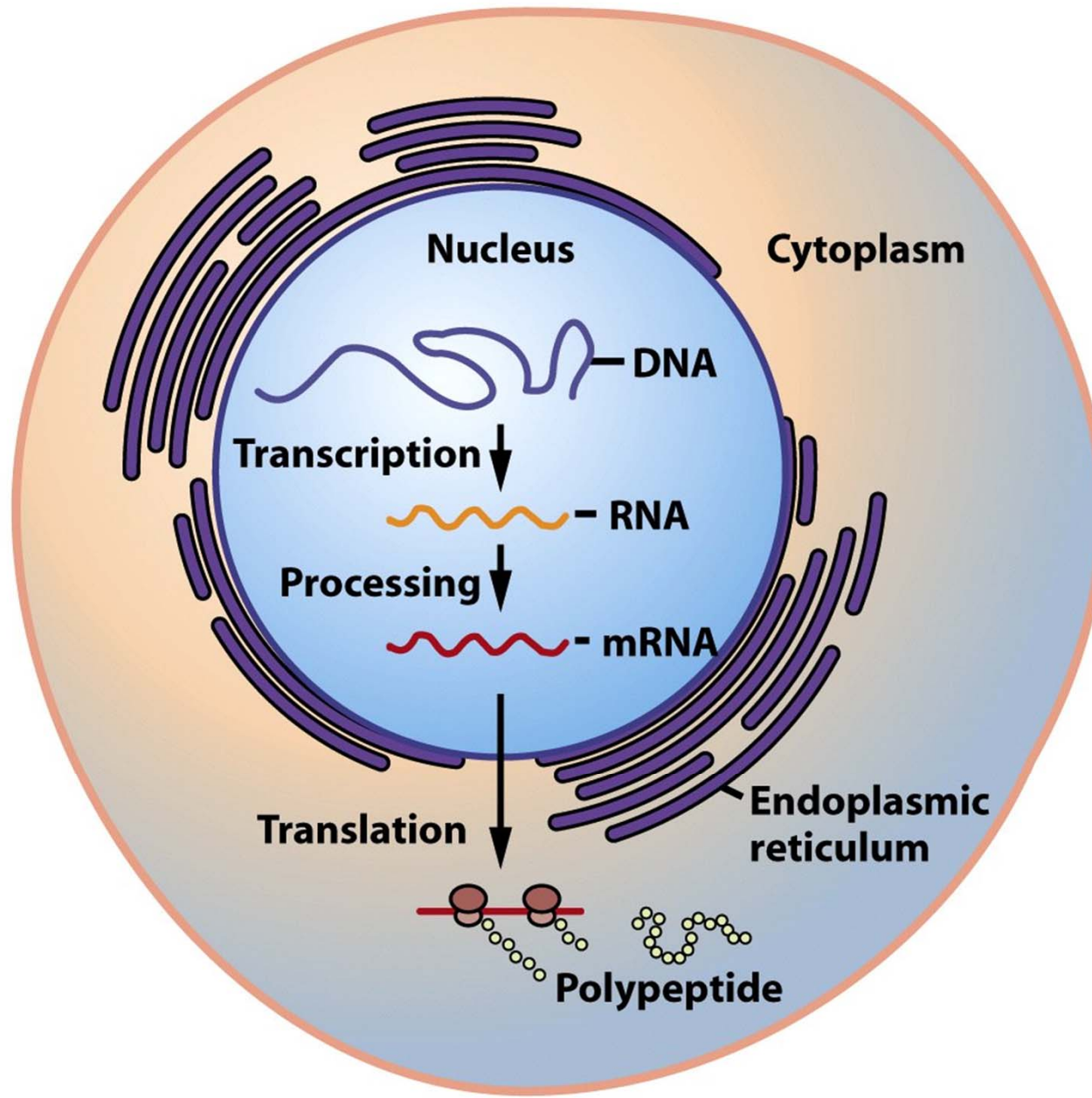


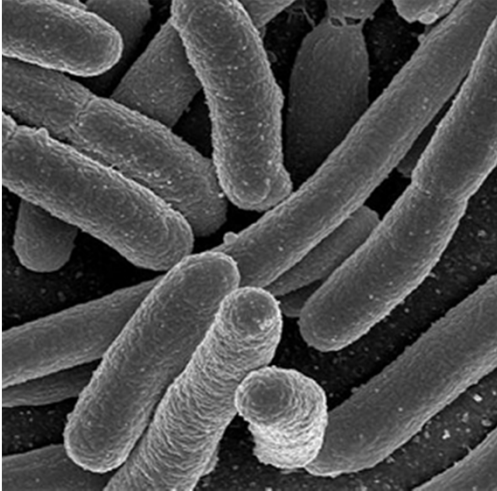
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DNA Structure

- The genes are found in linear order on a chromosome
- The DNA of the chromosome is divided into segments
(Chromosomal DNA = Intergenic region + Regulatory region + Gene)
- Intergenic region = non-coding region (junk DNA?)
 - **C-value** (1948, Roger and Colette Vendrey)
"remarkable constancy in the nuclear DNA content of all the cells
in all the individuals within a given animal species"
 - **C-value paradox(enigma)?**

Complexity of organism and amount of DNA per cell: **what would you tell?**

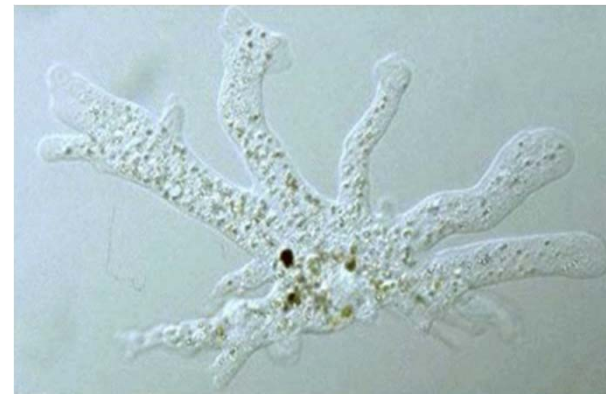
Escherichia coli (4.5Mb, 4,300 genes) *Homo sapiens* (3.3Gb, 25,000 genes)



Triticum aestivum (16Gb, 30,000 genes)



Amoeba dubia (670Gb, ?)



C-value vary enormously among species...Genome size dose not reflect gene number!