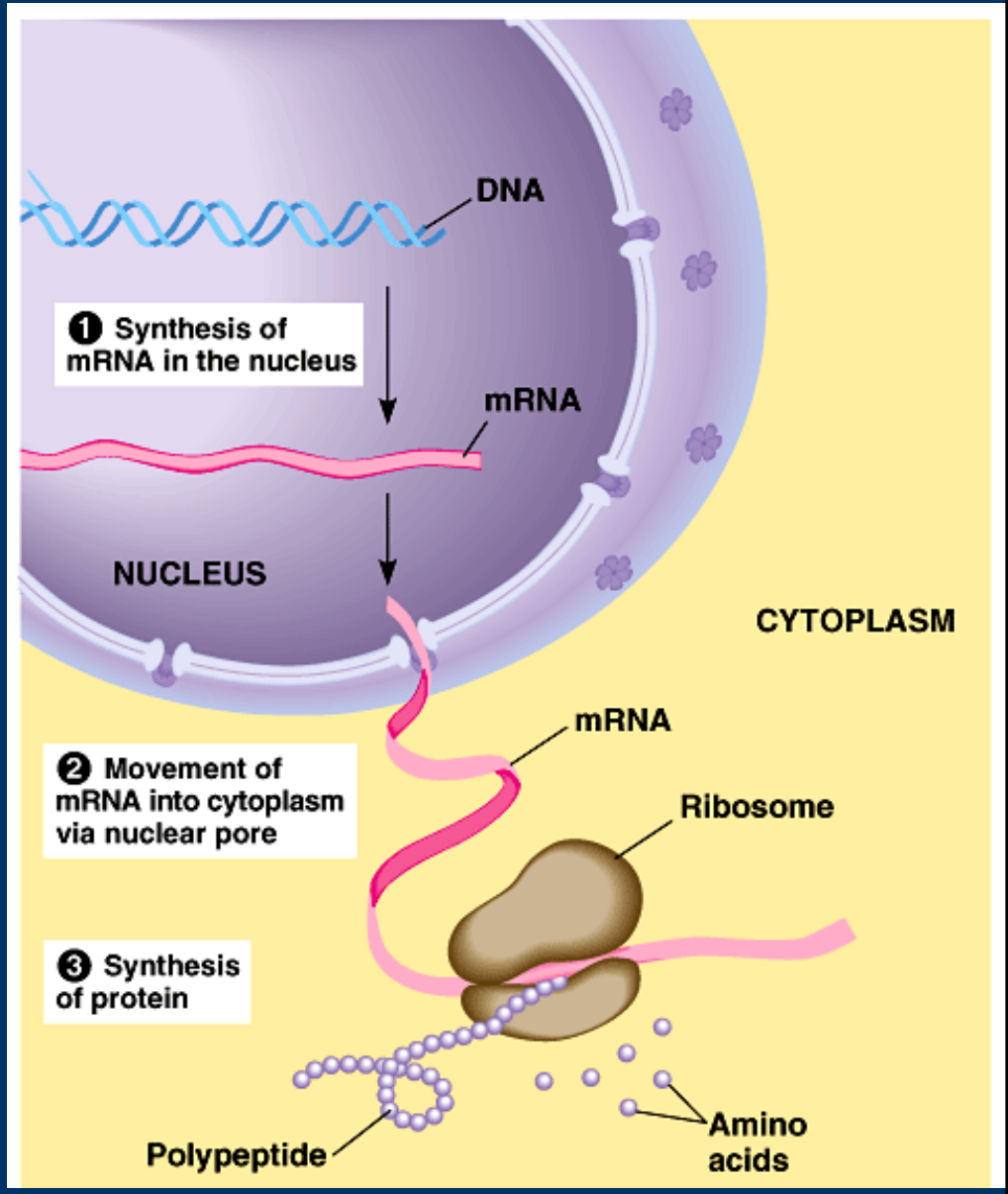
Nucleic Acids: Informational Polymers

-polymer of nucleotides = nitrogen base, pentose sugar, a phosphate group

-deoxyribonucleic acid (DNA), ribonucleic acid (RNA)

- "blueprint" of the cell: the amino acid sequence of a peptide is programmed by a gene.



Information Flow in the Cell

DNA → mRNA

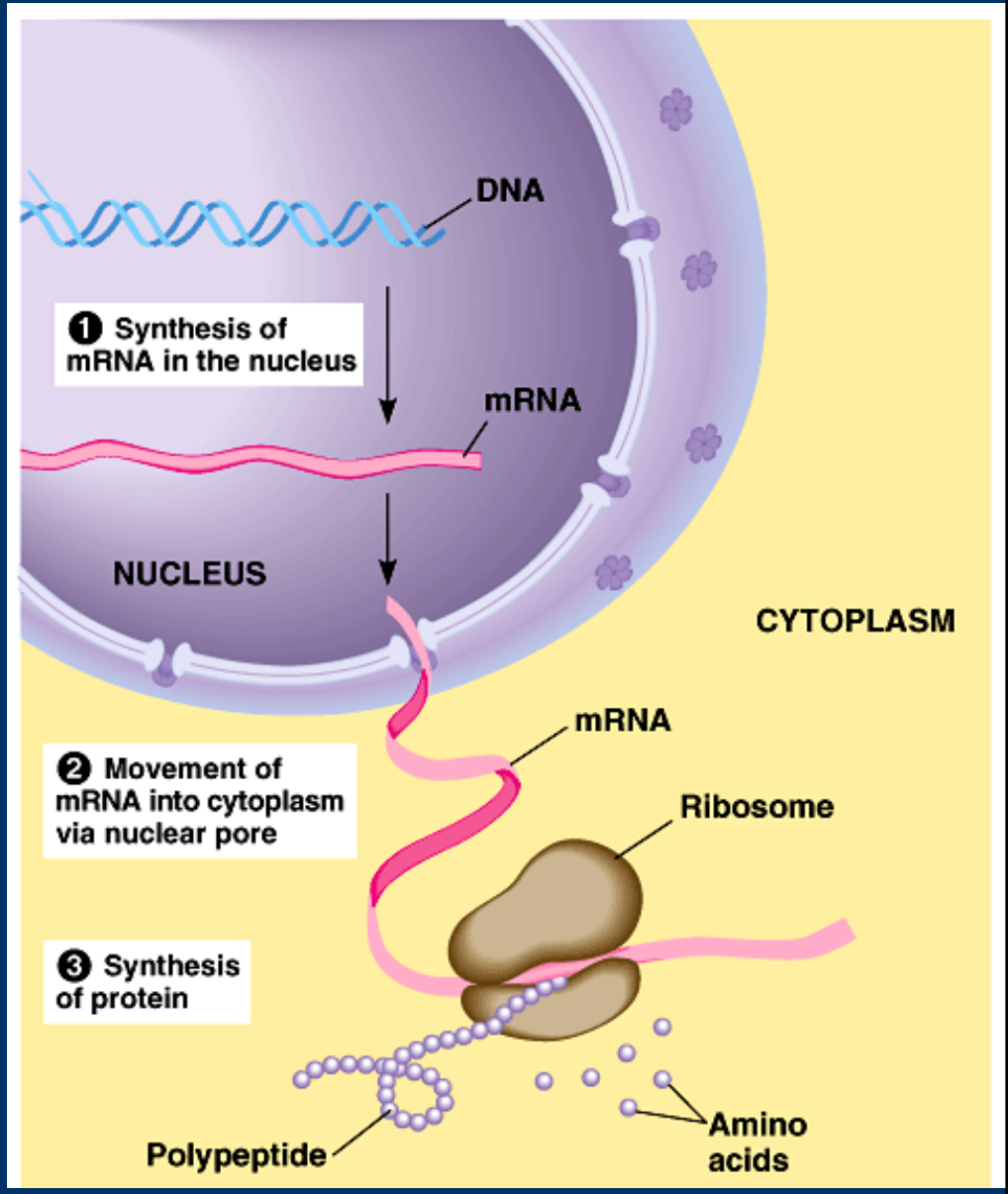
↓

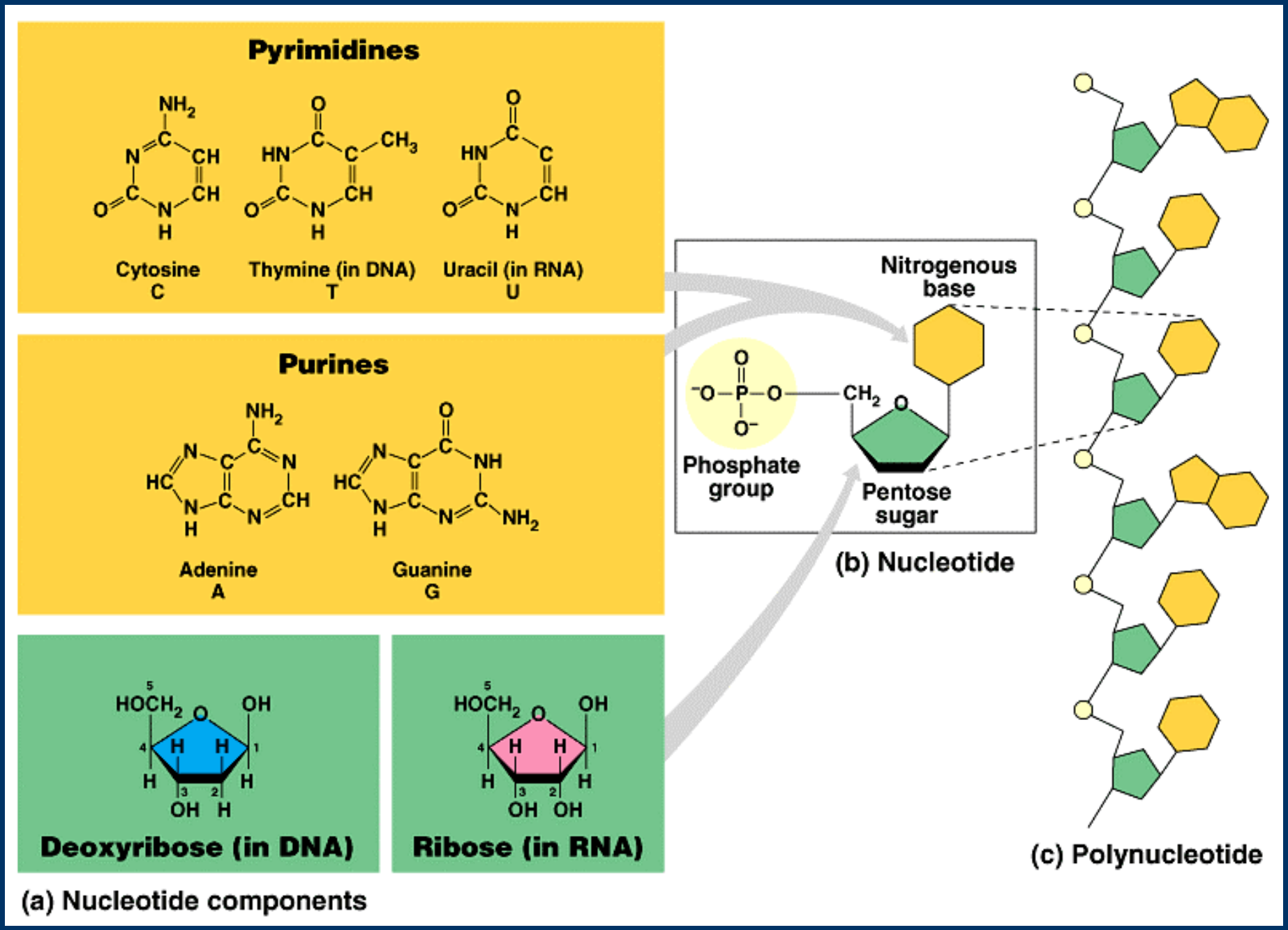
peptides

↓

protein

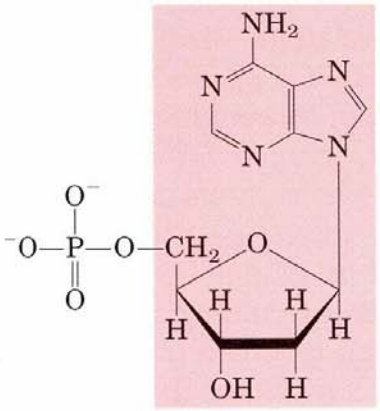
DNA = A	RNA = U
DNA = G	RNA = C
DNA = C	RNA = G
DNA = T	RNA = A





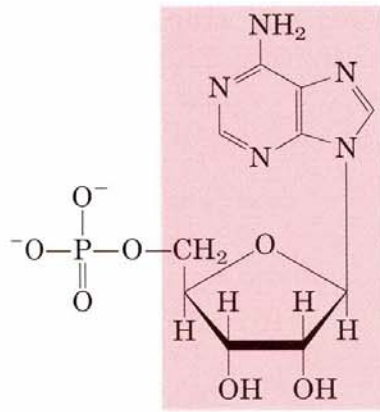
DNA = A,T,G,C

RNA = A, U, G, C



Nucleotide:	Deoxyadenylate (deoxyadenosine 5′-monophosphate)	Deoxyguanylate (deoxyguanosine 5′-monophosphate)	Deoxythymidylate (deoxythymidine 5′-monophosphate)	Deoxycytidylate (deoxycytidine 5′-monophosphate)
Symbols:	A, dA, dAMP	G, dG, dGMP	T, dT, dTMP	C, dC, dCMP
Nucleoside:	Deoxyadenosine	Deoxyguanosine	Deoxythymidine	Deoxycytidine

(a) Deoxyribonucleotides



Nucleotide:	Adenylate (adenosine 5′-monophosphate)	Guanylate (guanosine 5′-monophosphate)	Uridylate (uridine 5′-monophosphate)	Cytidylate (cytidine 5′-monophosphate)
Symbols:	A, AMP	G, GMP	U, UMP	C, CMP
Nucleoside:	Adenosine	Guanosine	Uridine	Cytidine

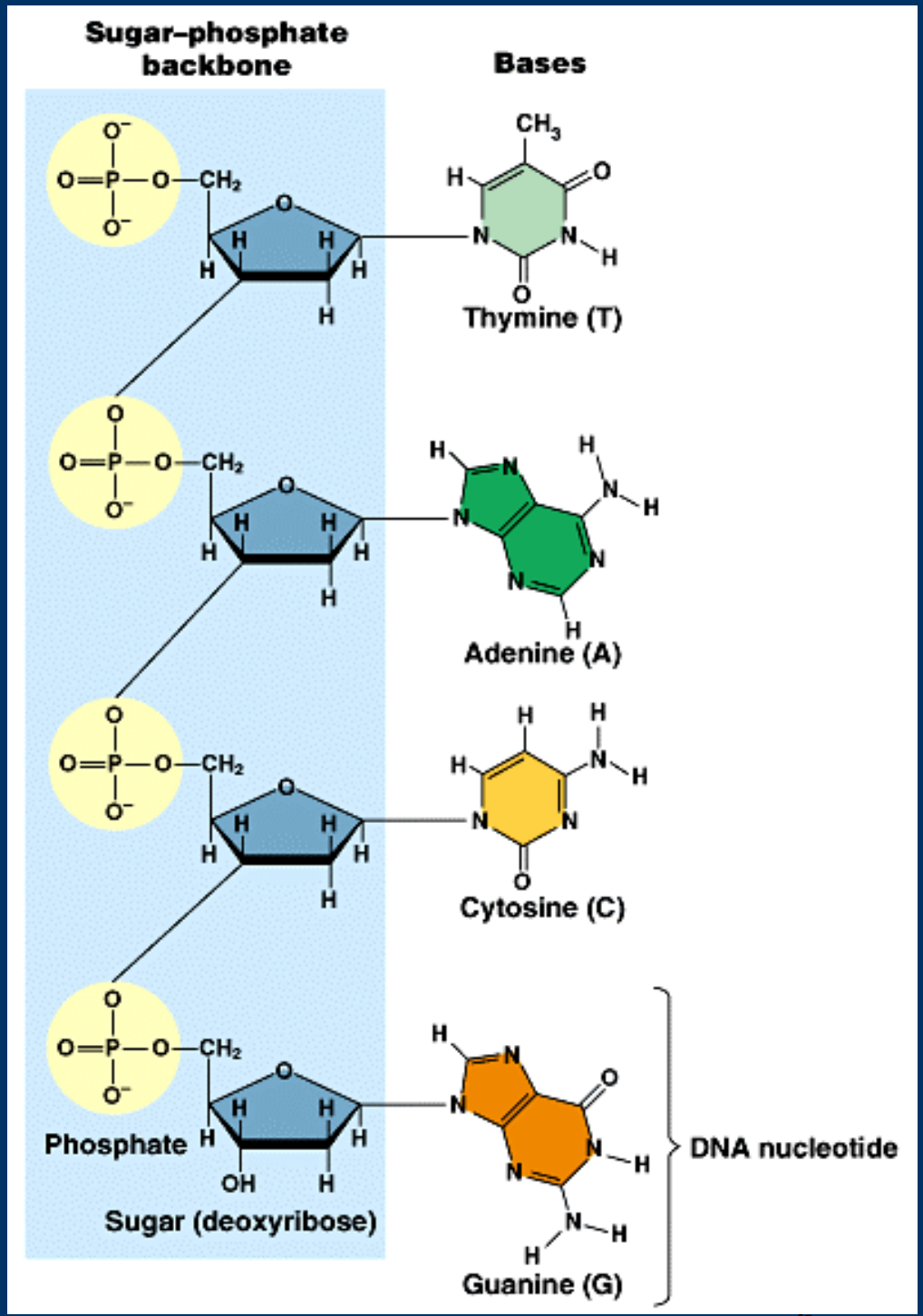
(b) Ribonucleotides

Nucleotide and Nucleic Acid Nomenclature

Base	Nucleoside*	Nucleotide*	Nucleic acid
Purines			
Adenine	Adenosine	Adenylate	RNA
	Deoxyadenosine	Deoxyadenylate	DNA
Guanine	Guanosine	Guanylate	RNA
	Deoxyguanosine	Deoxyguanylate	DNA
Pyrimidines			
Cytosine	Cytidine	Cytidylate	RNA
	Deoxycytidine	Deoxycytidylate	DNA
Thymine	Thymidine or deoxythymidine	Thymidylate or deoxythymidylate	DNA
Uracil	Uridine	Uridylate	RNA

Nucleotides are linked together by phosphodiester bond between the pentose sugar and phosphate group.

In the nucleotide strand the alternate pentose and phosphate linked by this covalent bond is the backbone of the DNA strand which is hydrophilic.



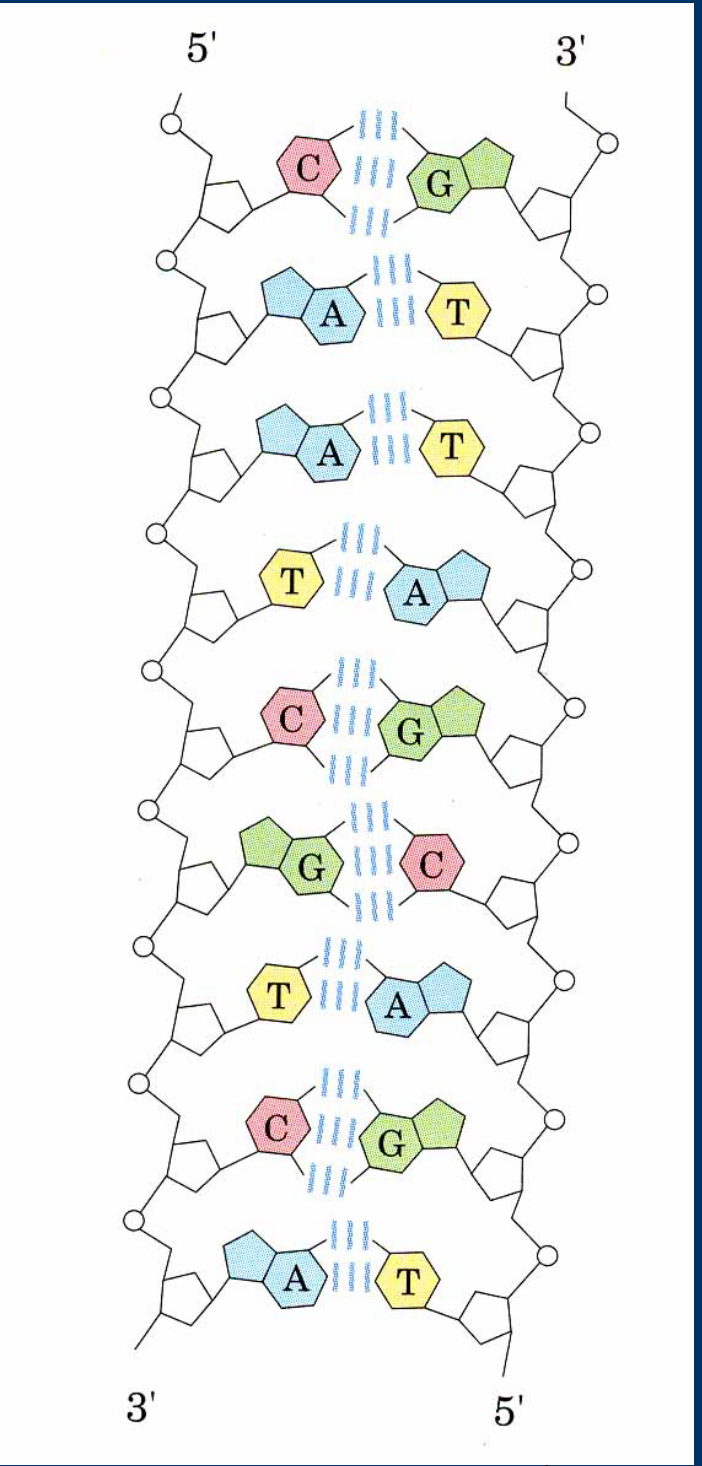
DNA = double stranded helix

-the alternating phosphate and sugar held by phosphodiester bonds are the backbone of the helix

-phosphate groups are on the outside of the helix

-nitrogen bases are paired in the interior of the helix

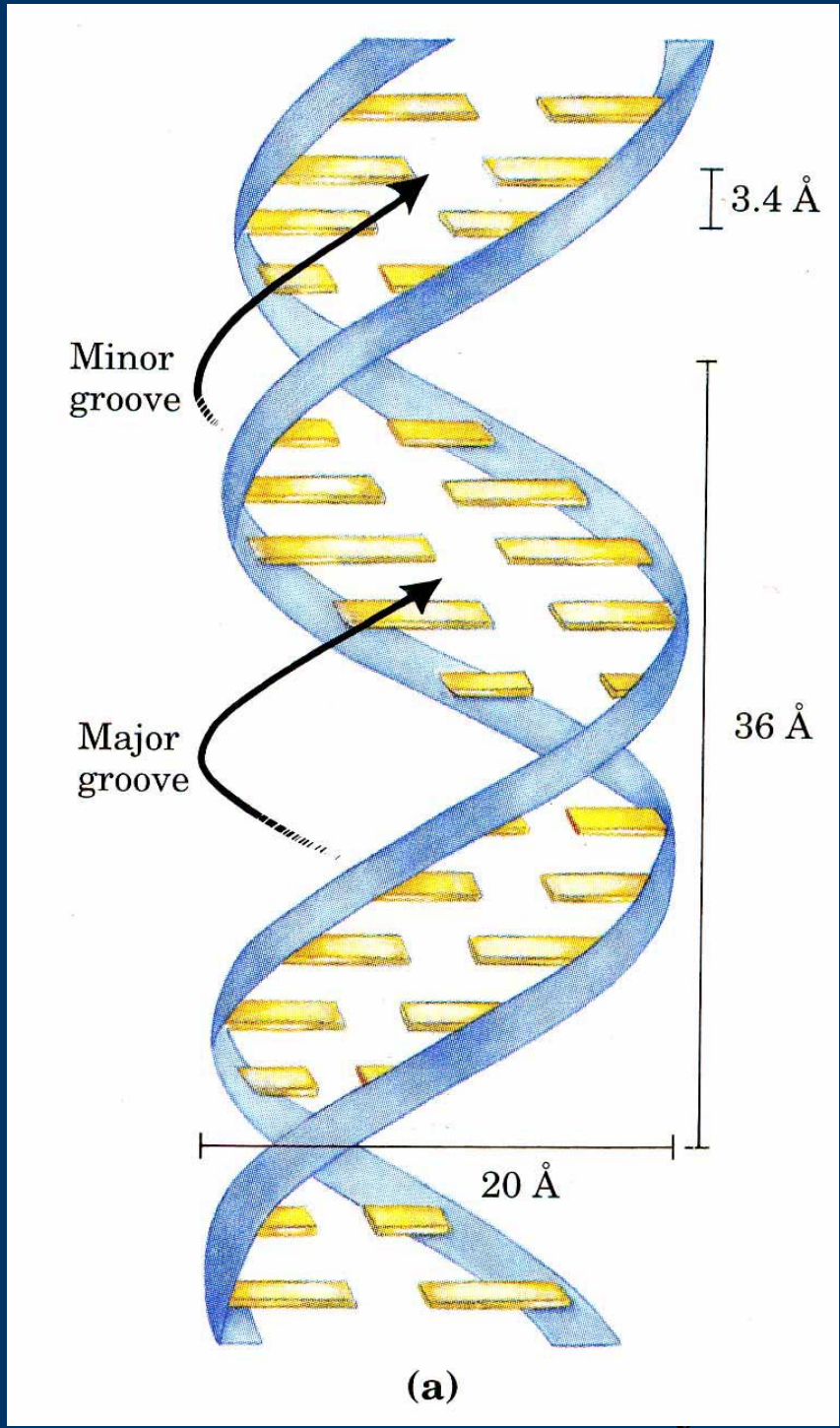
-the 2 strands are complementary to each other: A::T G:::C

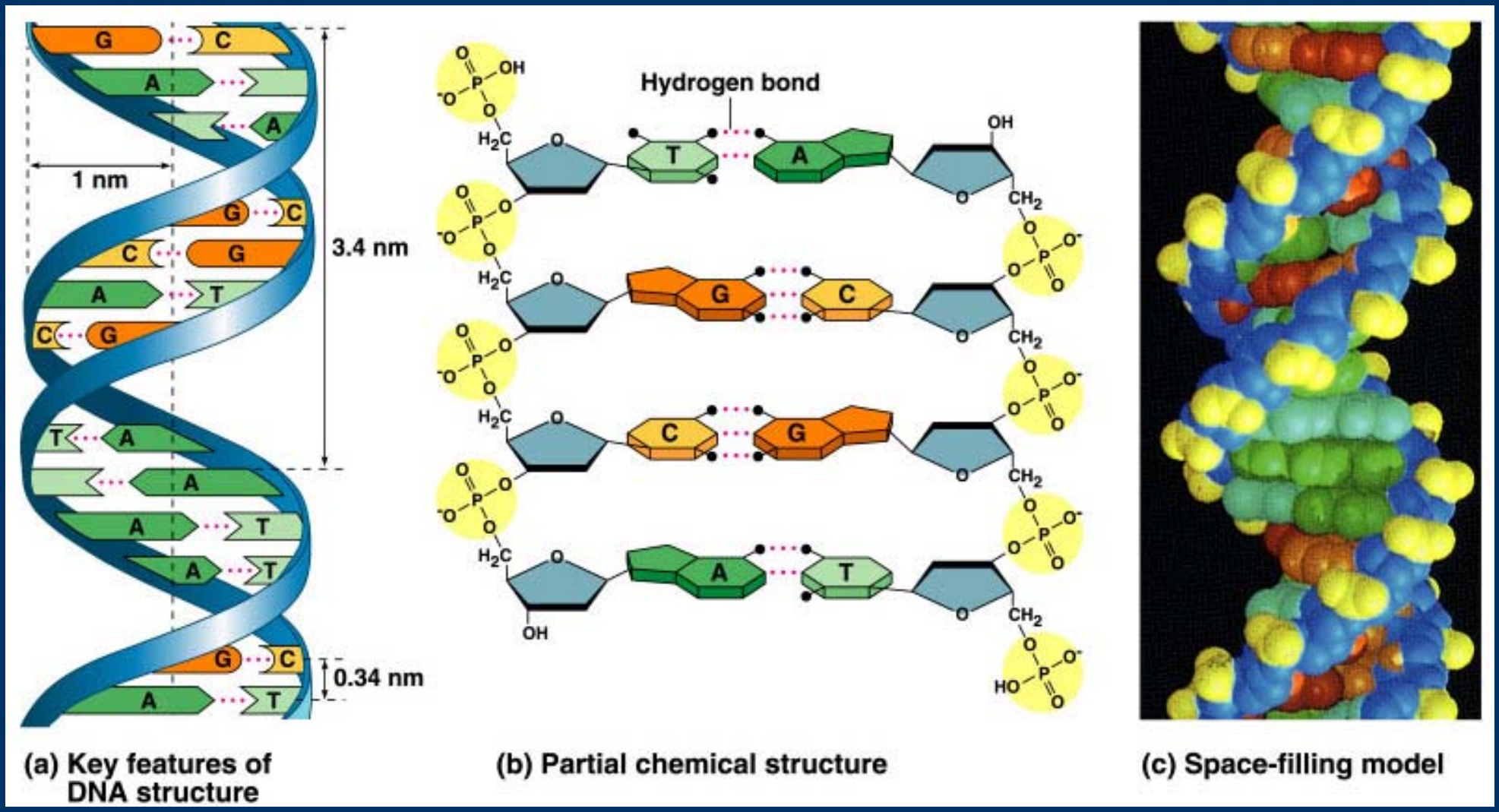


-the DNA strands are twisted with 36^0A or ~ 10 base pairs per turn

-the 2 strands are held by hydrogen bonds between the paired bases and Van der Waals interactions between the stacked bases

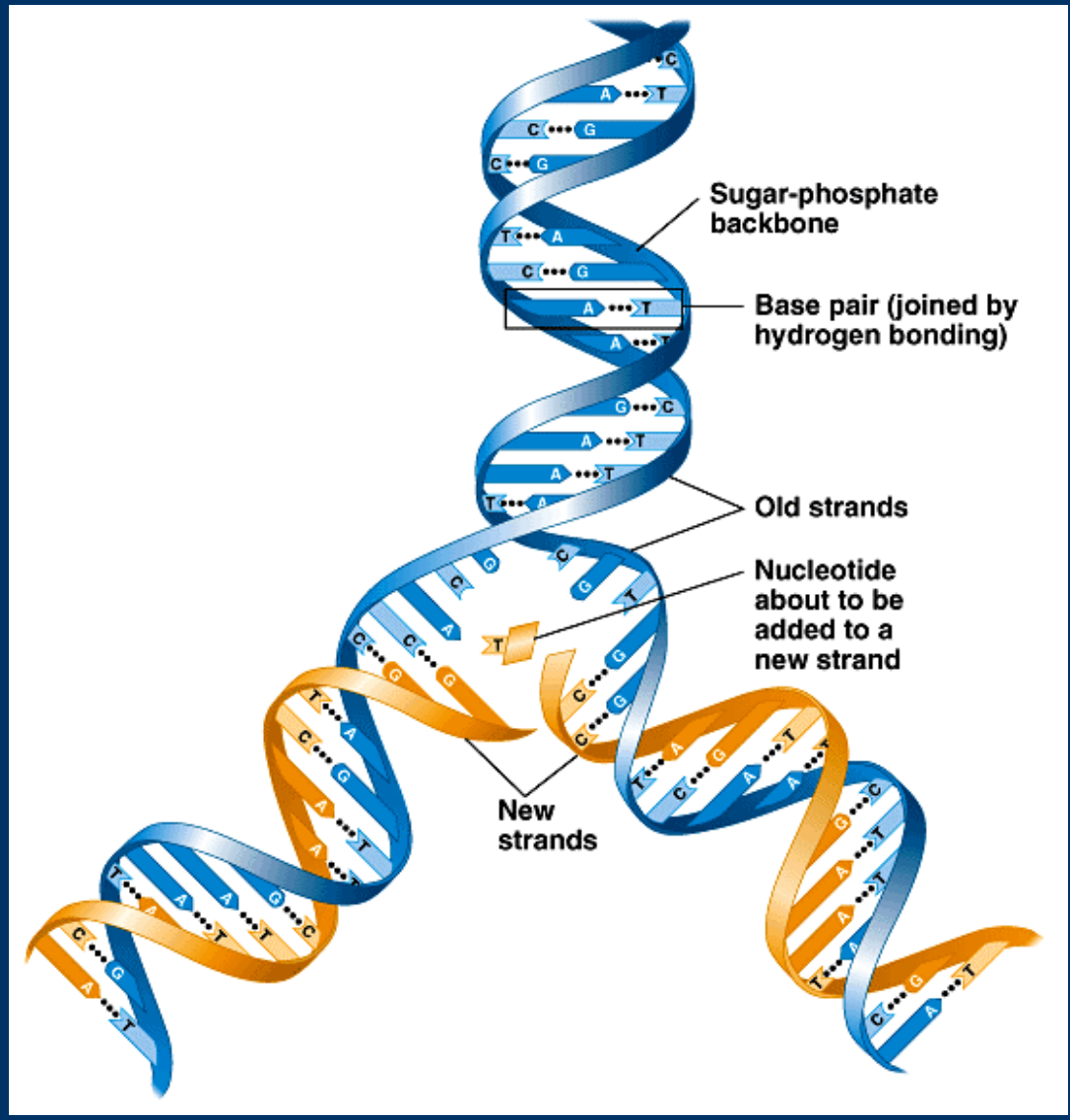
Watson-Crick Model of the DNA Structure




1 nm
3.4 nm
0.34 nm
Hydrogen bond
(a) Key features of DNA structure
(b) Partial chemical structure
(c) Space-filling model

DNA Replication

-DNA is copied and passed to the next generation (inheritance)
-DNA can be copied due to the complementary base pairing: A-T, G-C



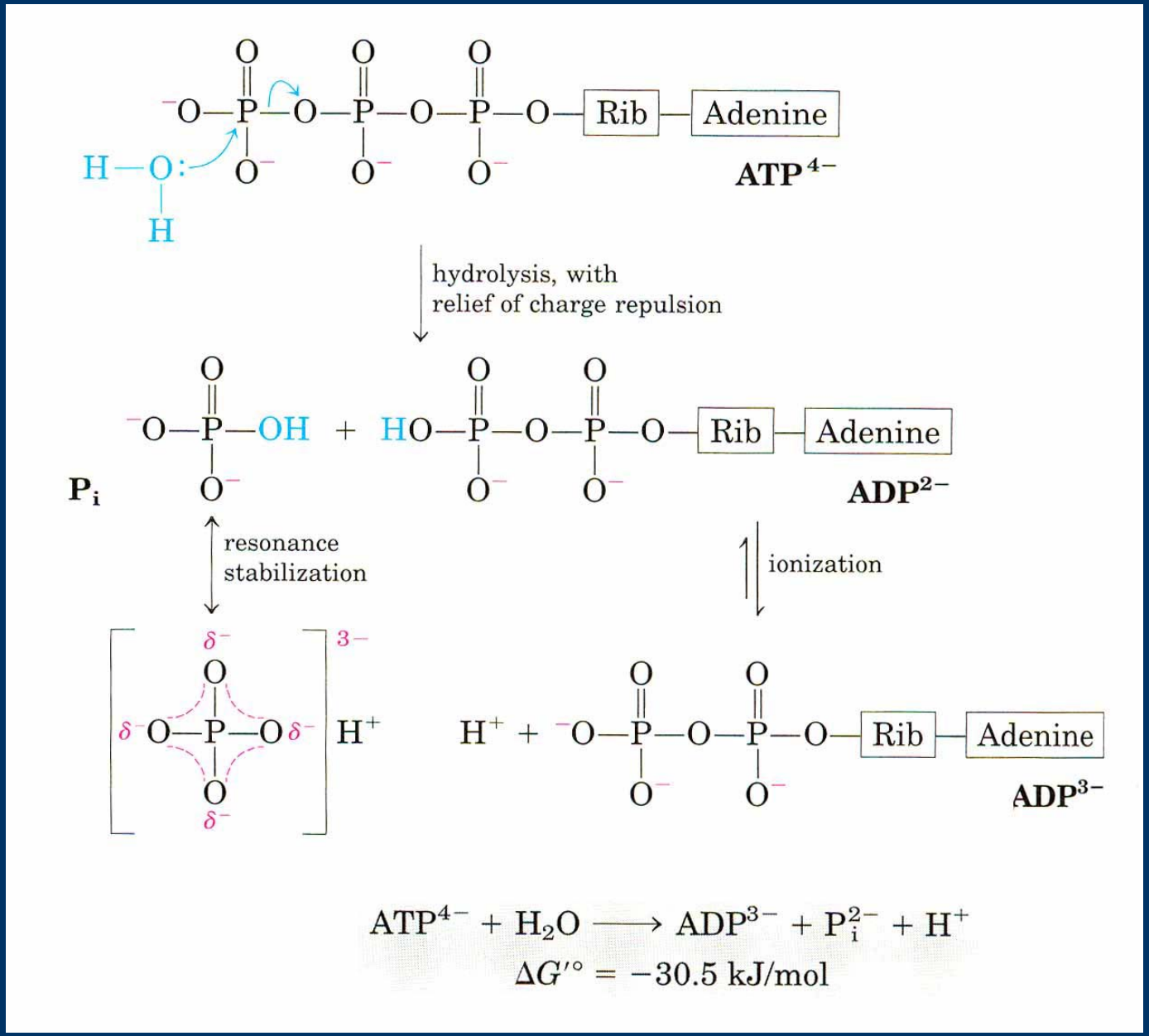
-5′ ⟶ 3′ of newly synthesized strand

Table 5.2 Polypeptide Sequence as Evidence for Evolutionary Relationships

Species	Number of Amino Acid Differences in the β Chain of Hemoglobin, Compared to Human Hemoglobin (Total Chain Length = 146 Amino Acids)
Human	0
Gorilla	1
Gibbon	2
Rhesus monkey	8
Mouse	27
Frog	67

Comparison of amino acid sequences of proteins or nucleotide sequences of genes can lead to the evolutionary divergence of related organisms.

Nucleotides Carry Chemical Energy in Cells



$$ATP^{4-} + H_2O \longrightarrow ADP^{3-} + P_i^{2-} + H^+$$
$$\Delta G'^\circ = -30.5 \text{ kJ/mol}$$

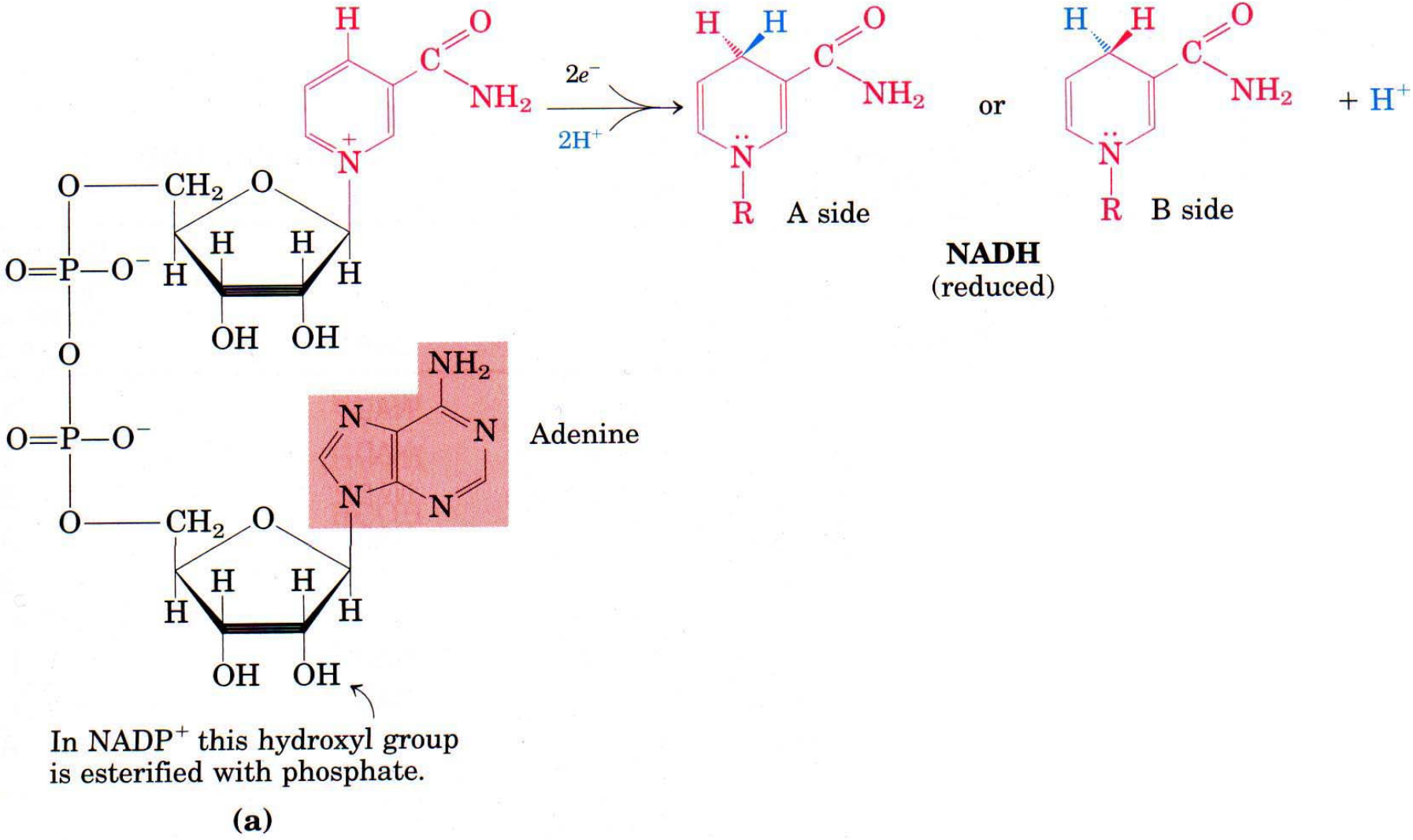
Adenine Nucleotides

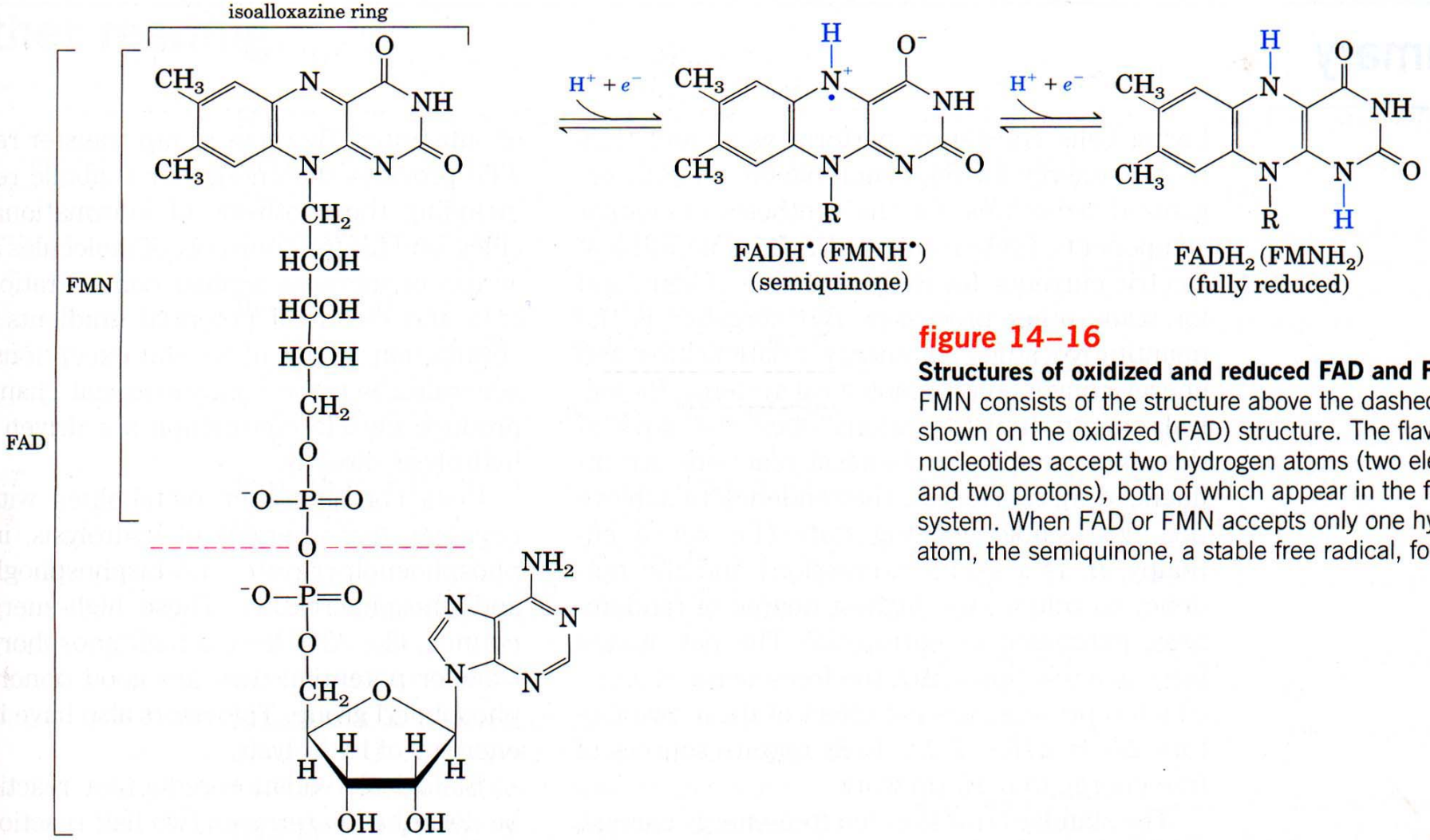
-components of many enzyme cofactors

-act as an electron acceptor in the biological oxidation reaction

Example:

- NAD^+
- NADH
- $NADP^+$
- NADPH
- FAD
- $FADH_2$
- Coenzyme A

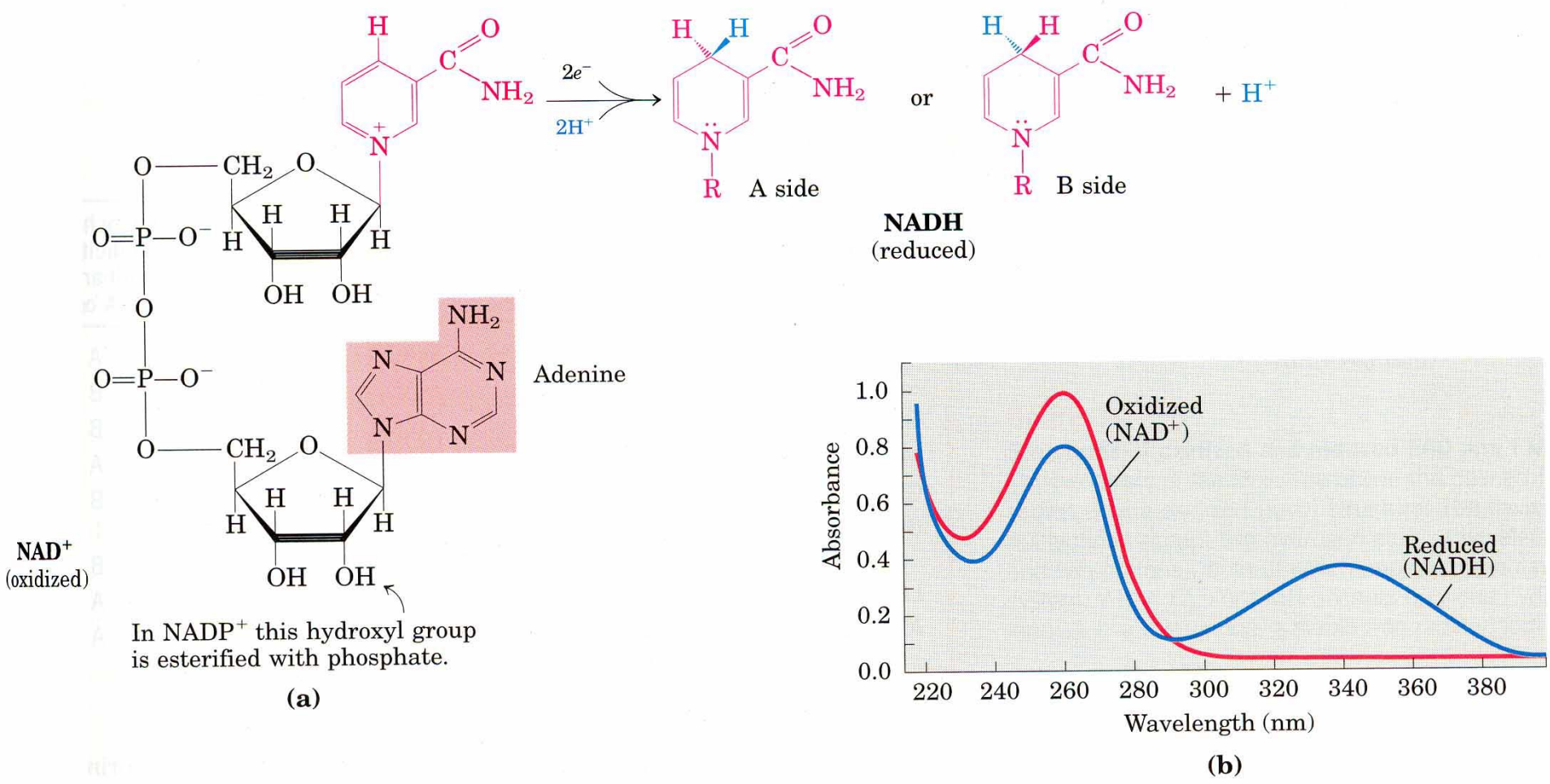

2e⁻
2H⁺
or
+ H⁺
A side
B side
NADH
(reduced)
Adenine
In NADP⁺ this hydroxyl group is esterified with phosphate.
(a)



Flavin adenine dinucleotide (FAD) and flavin mononucleotide (FMN)

figure 14–16

Structures of oxidized and reduced FAD and FMN. FMN consists of the structure above the dashed line shown on the oxidized (FAD) structure. The flavin nucleotides accept two hydrogen atoms (two electrons and two protons), both of which appear in the flavin ring system. When FAD or FMN accepts only one hydrogen atom, the semiquinone, a stable free radical, forms.


2e⁻
2H⁺
or
+ H⁺
A side
B side
NADH
(reduced)
Adenine
NAD⁺
(oxidized)
In NADP⁺ this hydroxyl group is esterified with phosphate.
(a)
Absorbance
Oxidized (NAD⁺)
Reduced (NADH)
Wavelength (nm)
(b)