

Biomolecular structures: nucleic acids and proteins

Figures from

Matthews, van Holde: Biochemistry, Benjamin/Cummings.

Daune: Molecular Biophysics, Oxford Univ. Press.

Wikipedia.

Biomolecules

Biopolymers

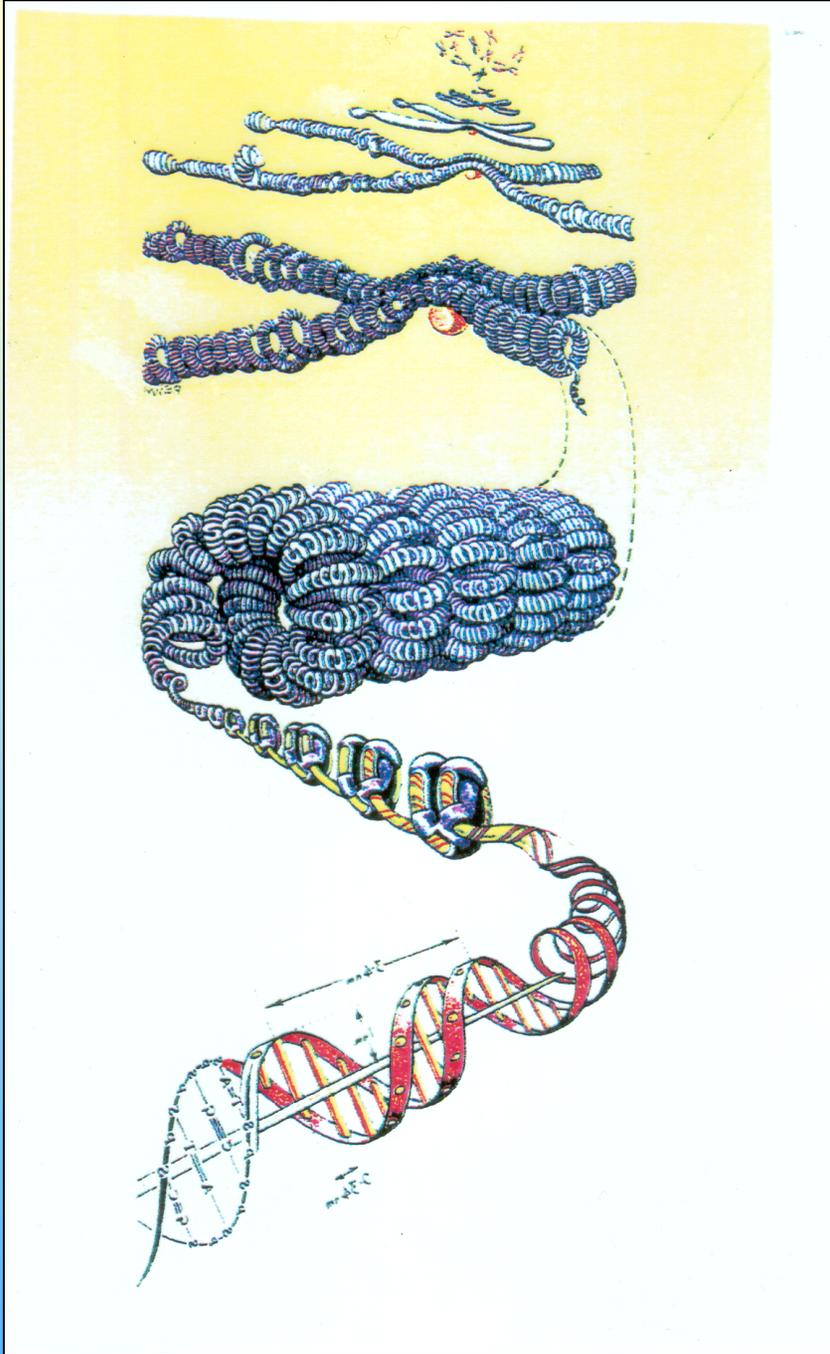
Nucleic acids: phosphate group, sugar, base

Proteins: amino acids

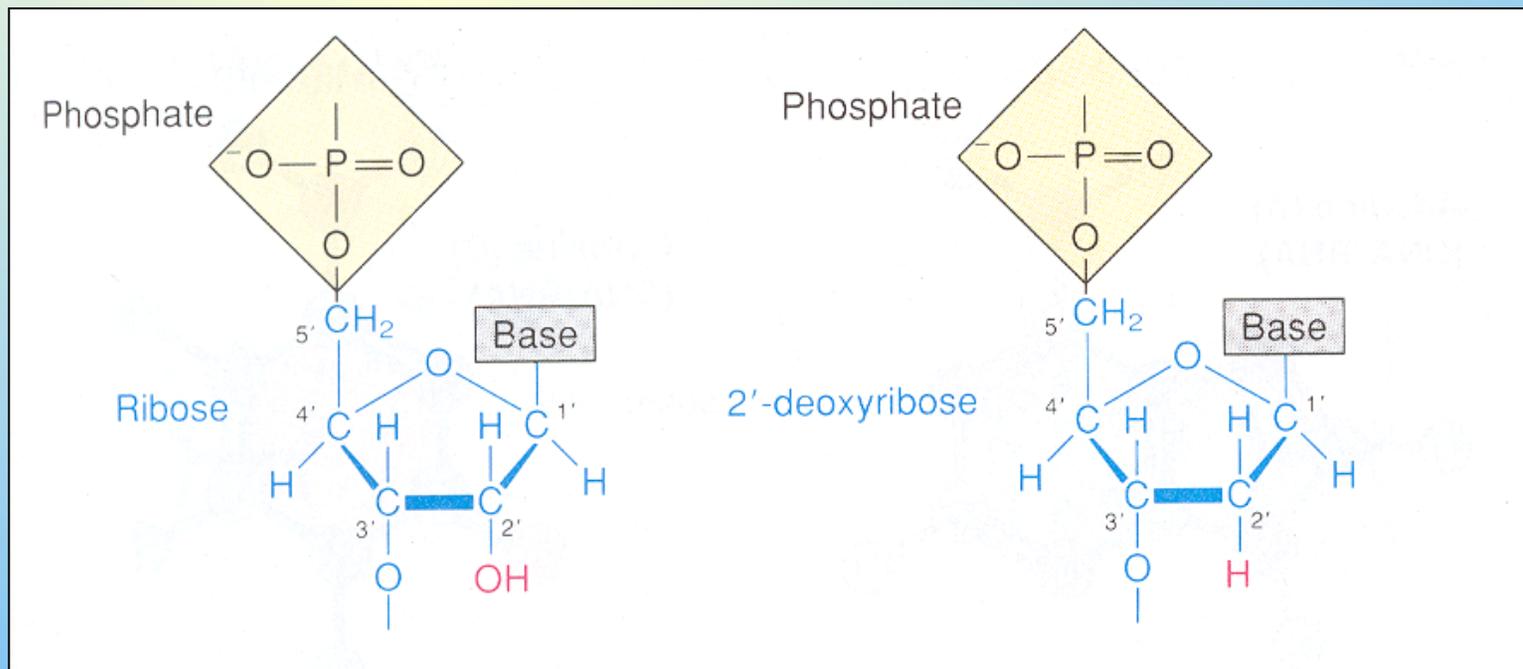
Carbohydrates: sugar units

Lipids: head group, alifatic chain

Nucleic acids



Monomer = nucleotide
phosphate group, sugar, base



RNA

nucleotides

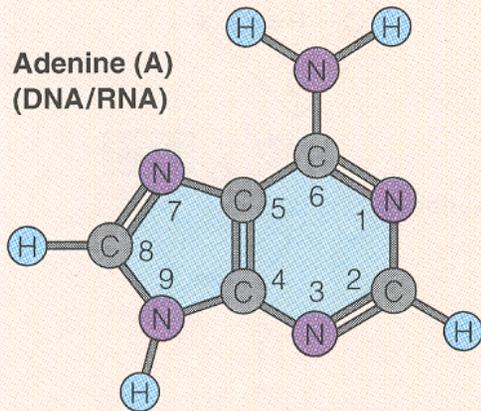
DNA

(phosphate group – dissociated at physiologic conditions)

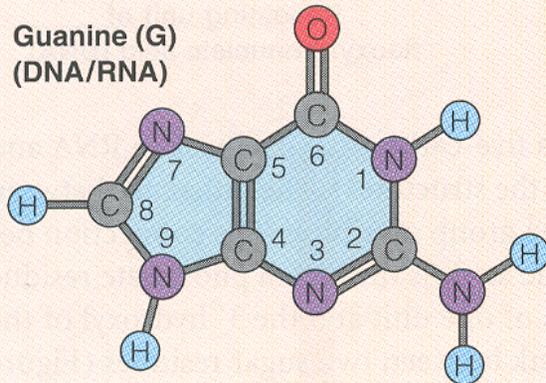
Nucleobases

PURINES

Adenine (A)
(DNA/RNA)

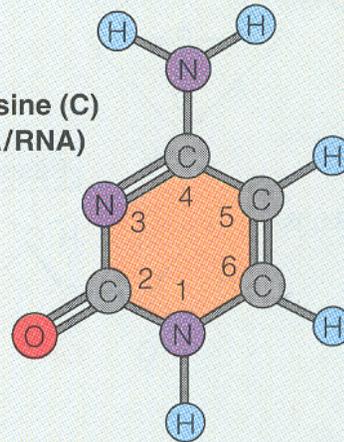


Guanine (G)
(DNA/RNA)

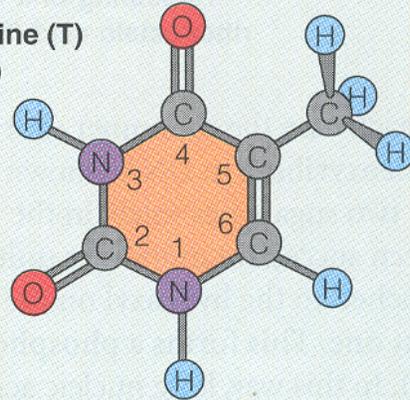


PYRIMIDINES

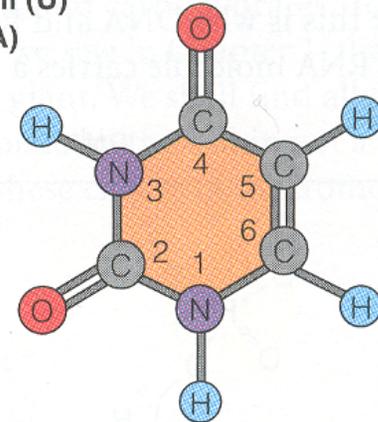
Cytosine (C)
(DNA/RNA)



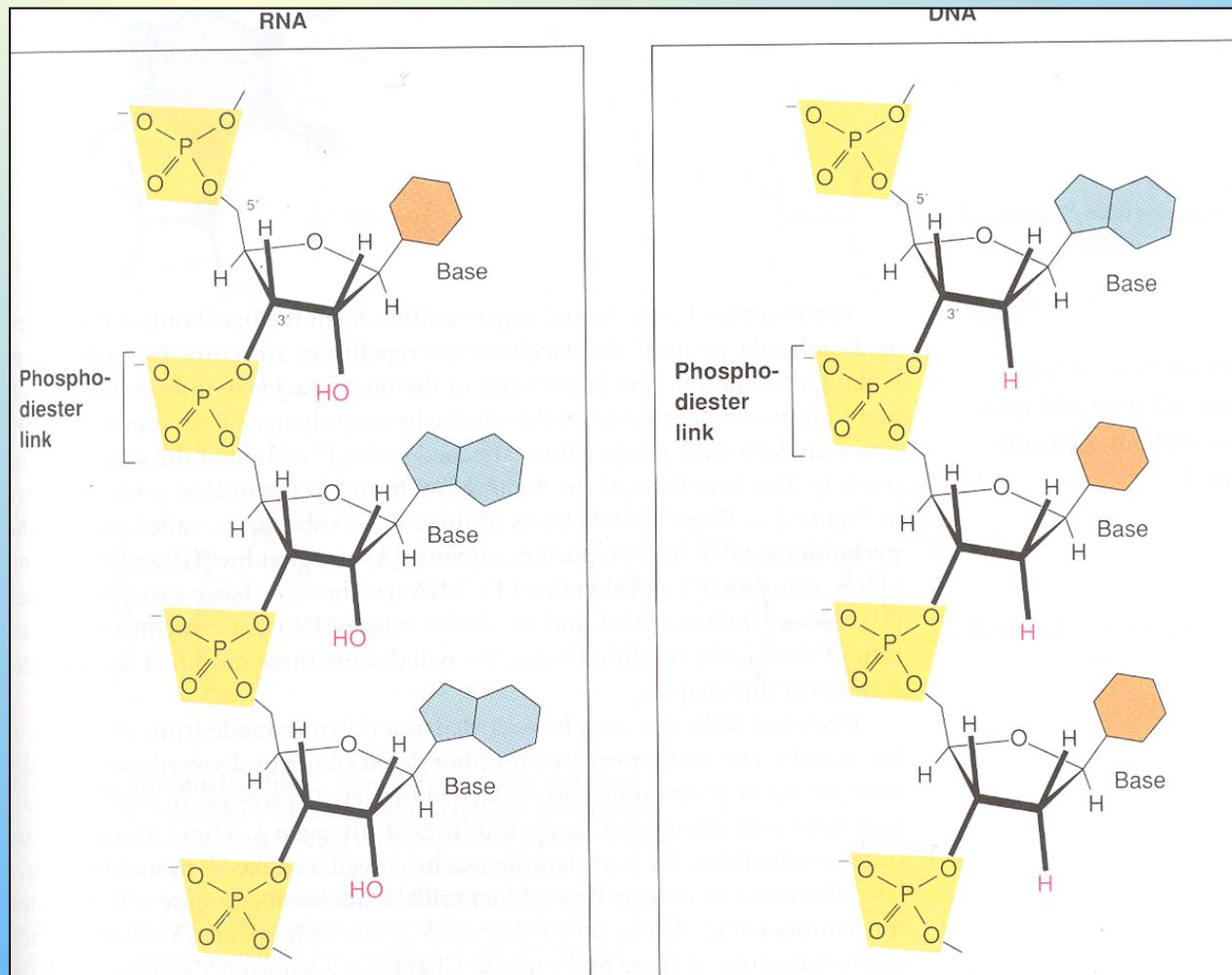
Thymine (T)
(DNA)



Uracil (U)
(RNA)



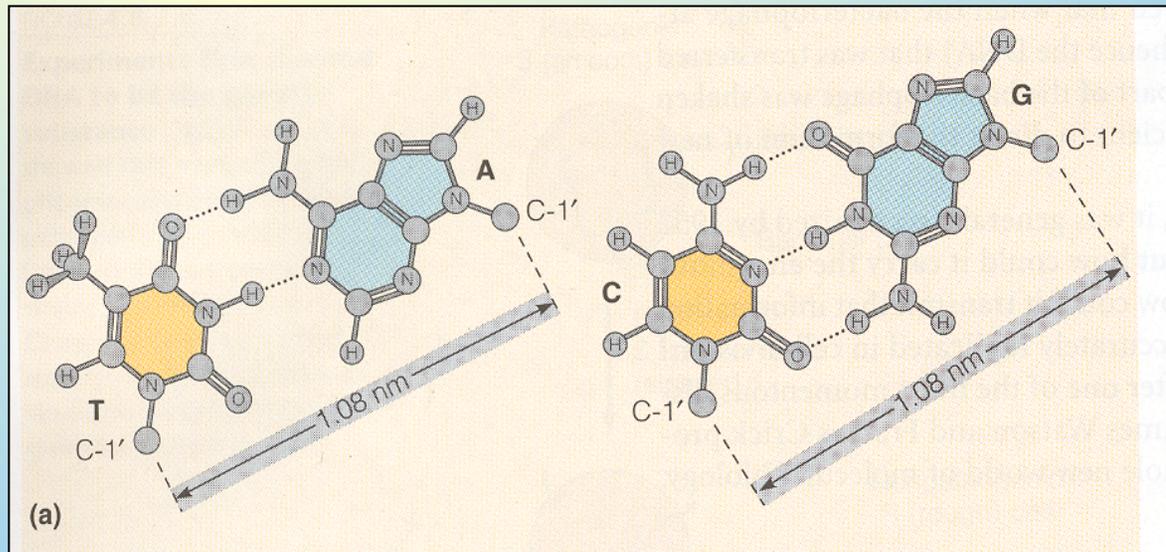
Polymers



Primary structure of nucleic acids

- Sequence of nucleotides/bases in the strand
- Written as ACGTT, d(ACGTT), d(ApCpGpTpT) etc.
TGCAA
- Complementarity due to base pairing
 - Usually only one strand written

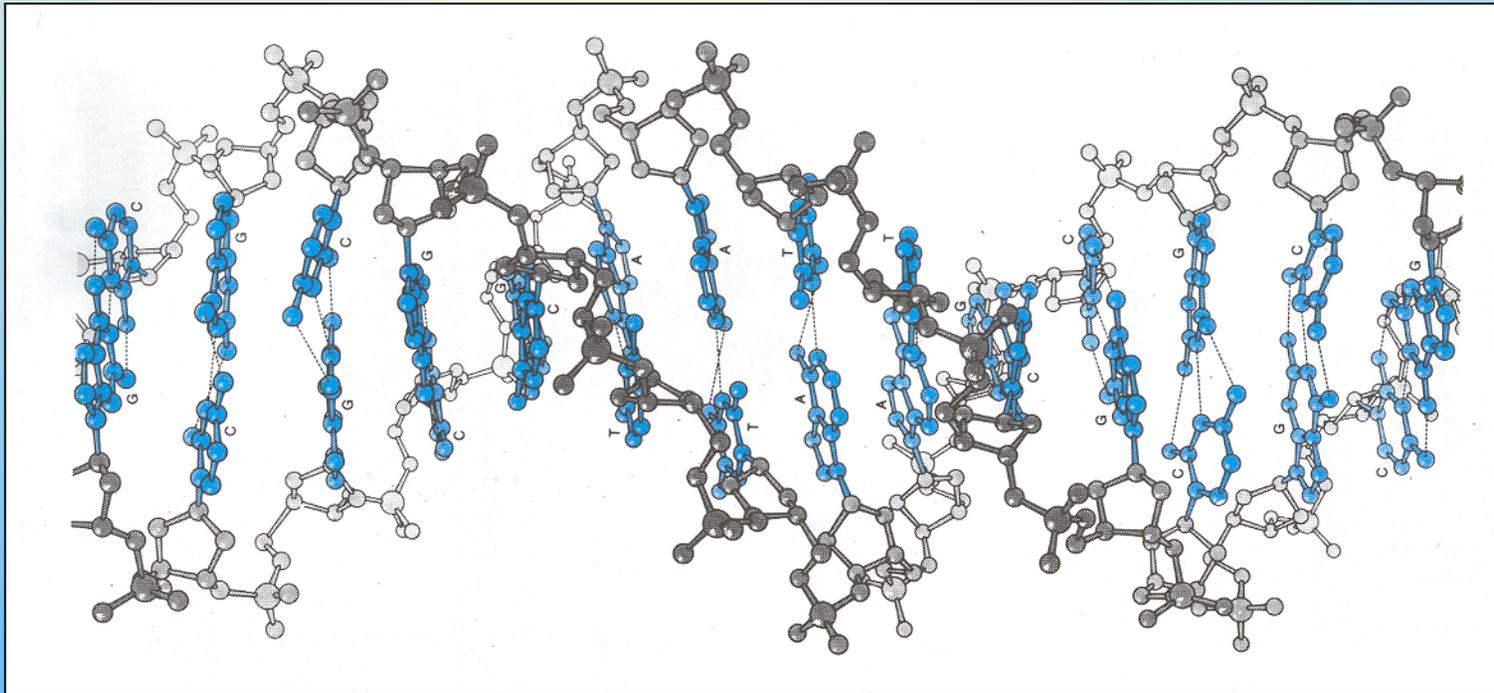
Watson-Crick base pairing



- exclusively A-T and G-C (a pyrimidine with a purine)
- strong hydrogen bonds ~ 100 kJ/mol
(chem. bond ~ 400 kJ/mol)

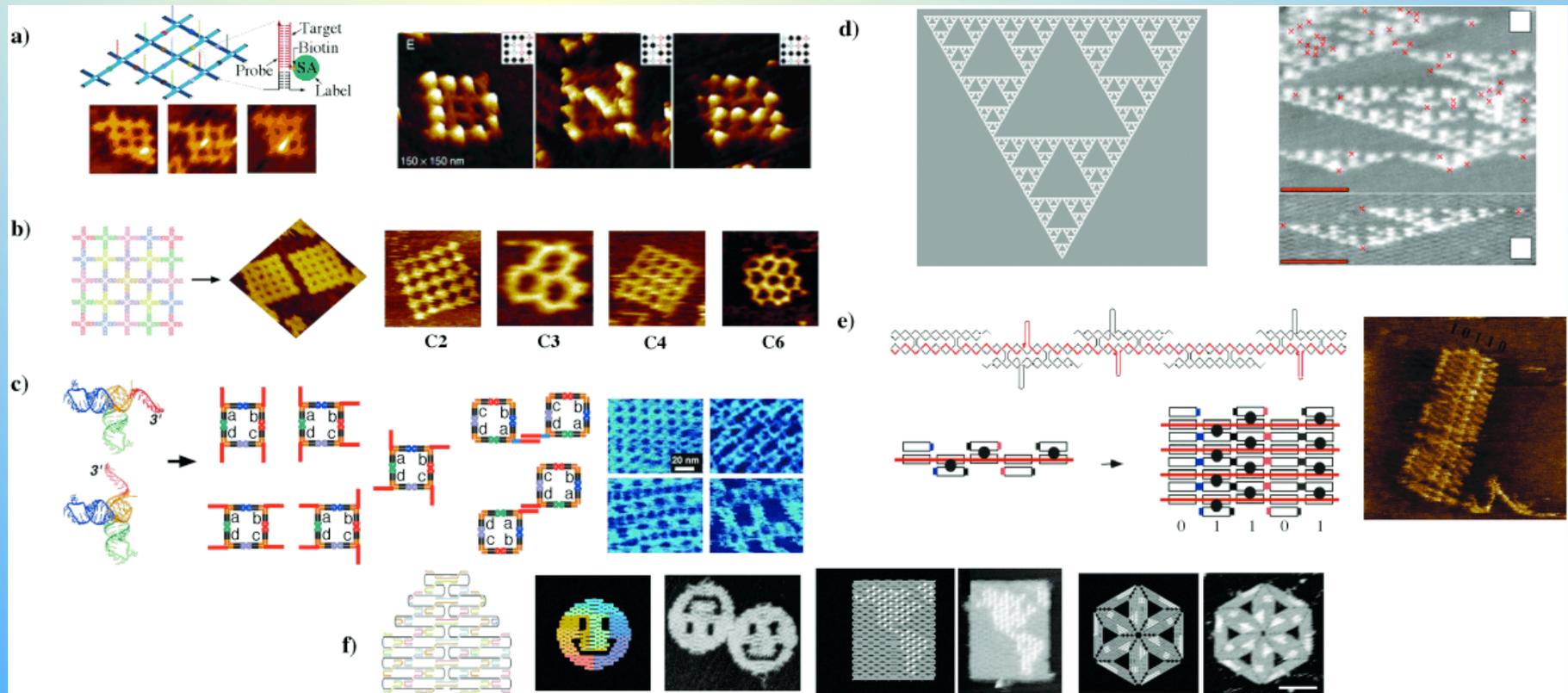
Secondary structure of DNA

- Double strand, base pairing (Watson-Crick)



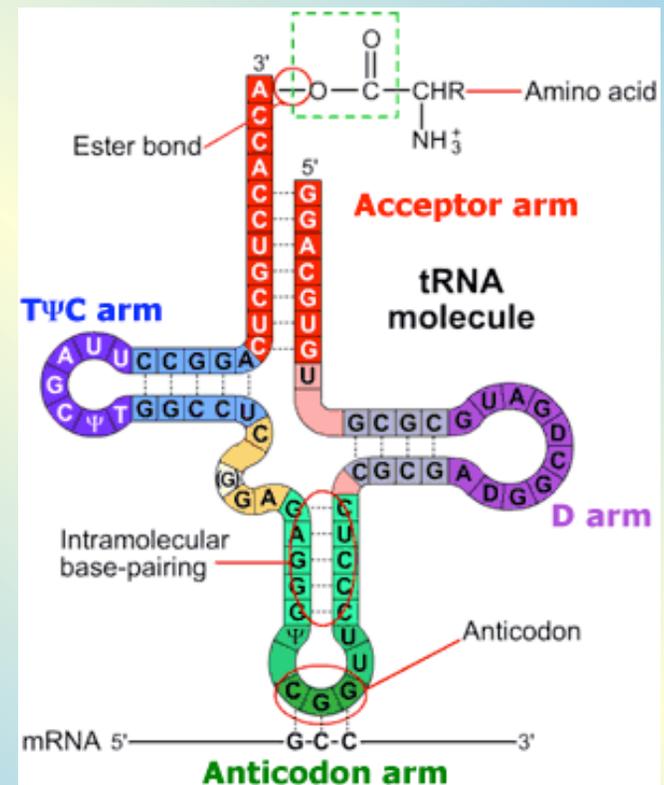
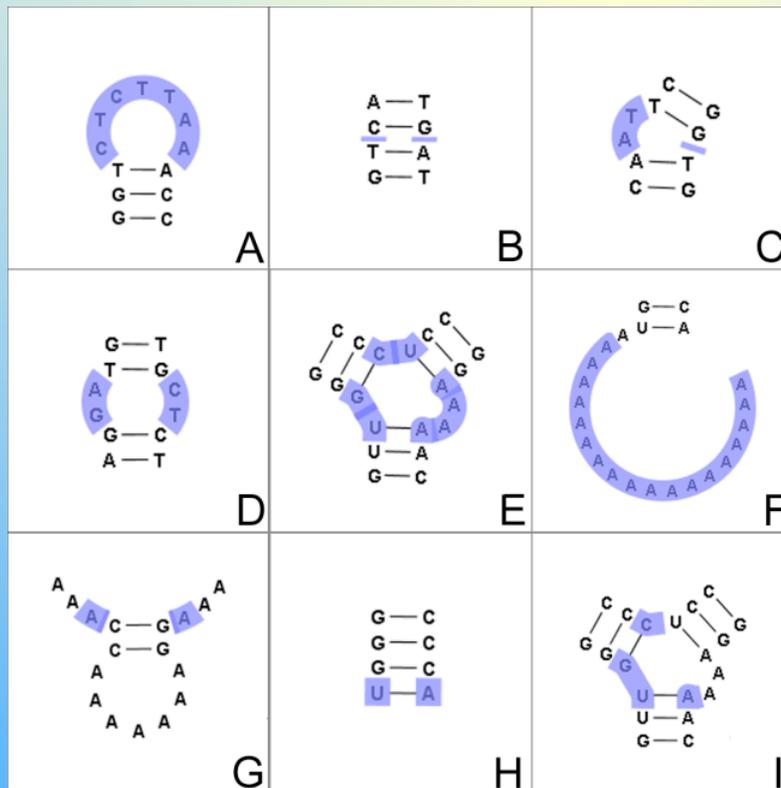
Secondary structure of DNA

- “Conservative” base pairing – use in nano-technology

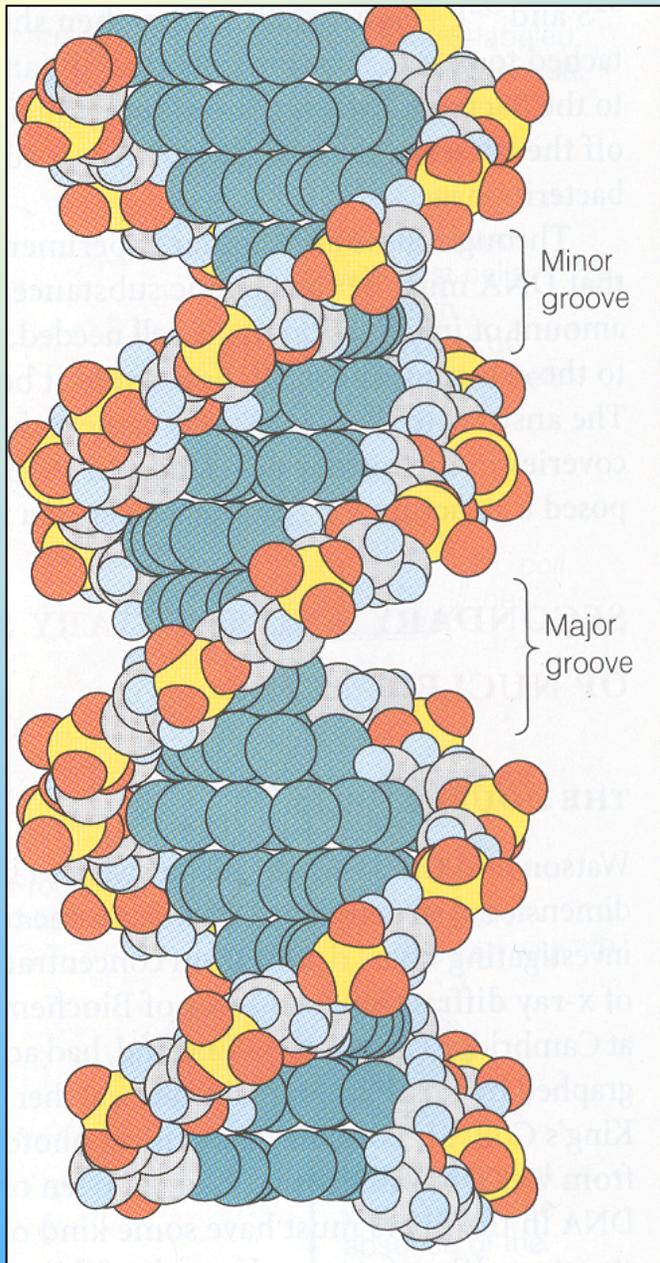


Secondary structure of RNA

- various structures
- an extra OH group – rich H-bonding possibilities



DNA double helix



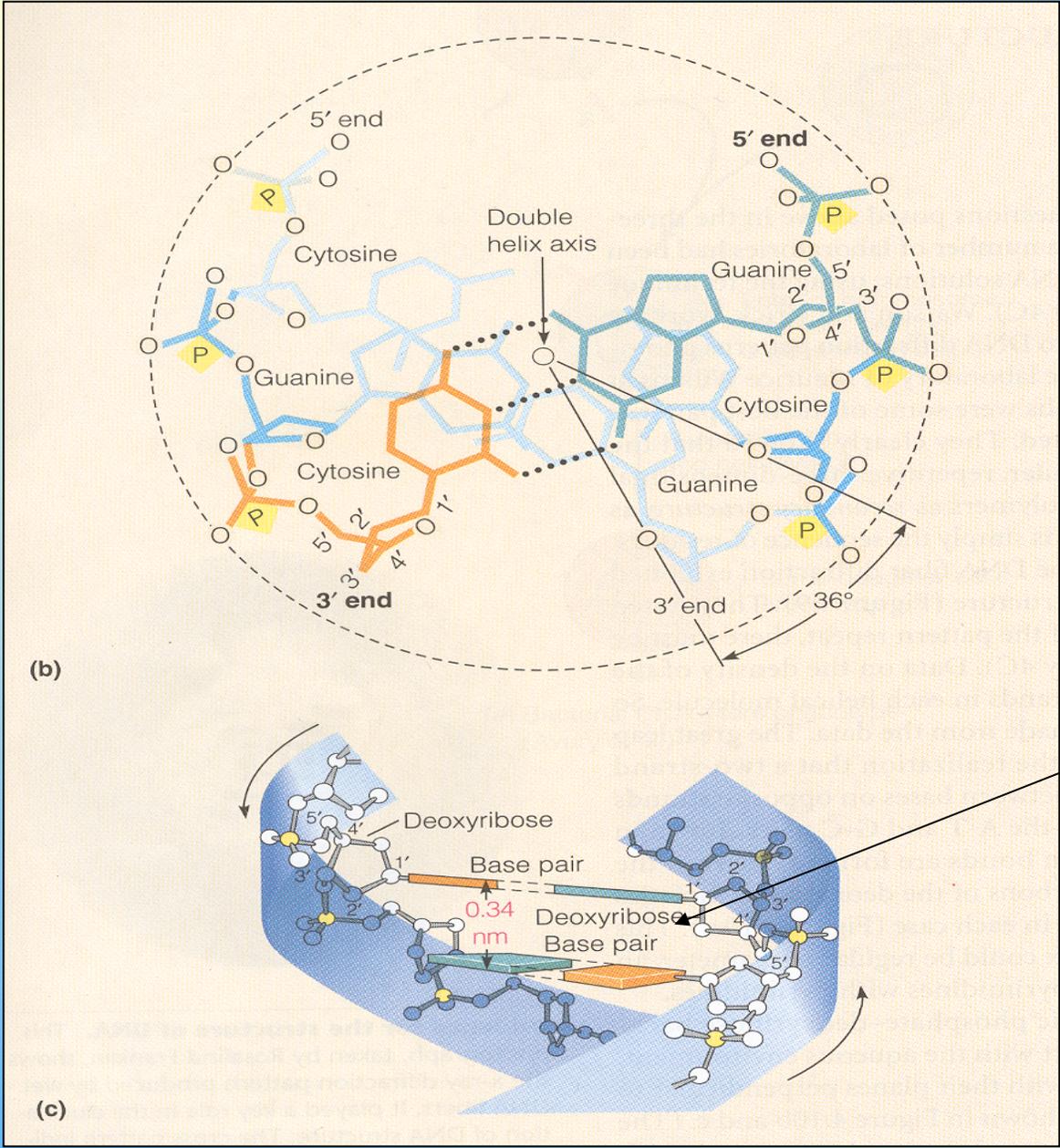
Two distinct grooves
minor x major

10 base pairs per turn

3.4 nm per turn

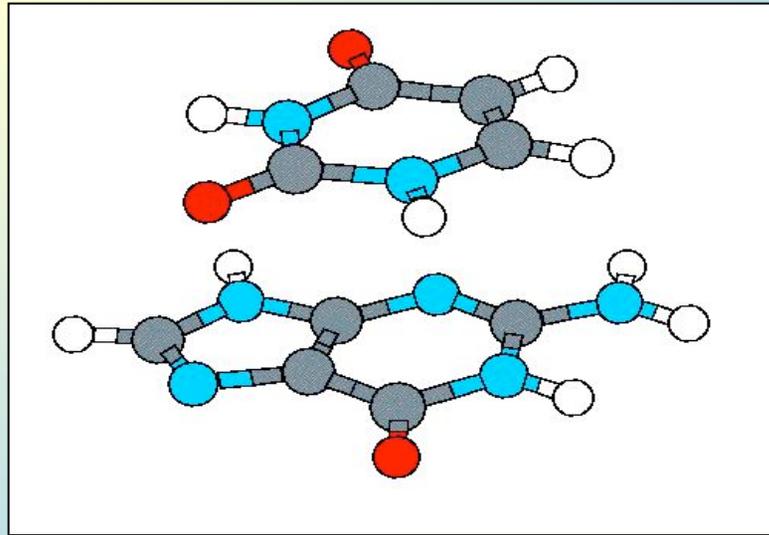
36° rotation between the pairs

→ 0.34 nm between pairs



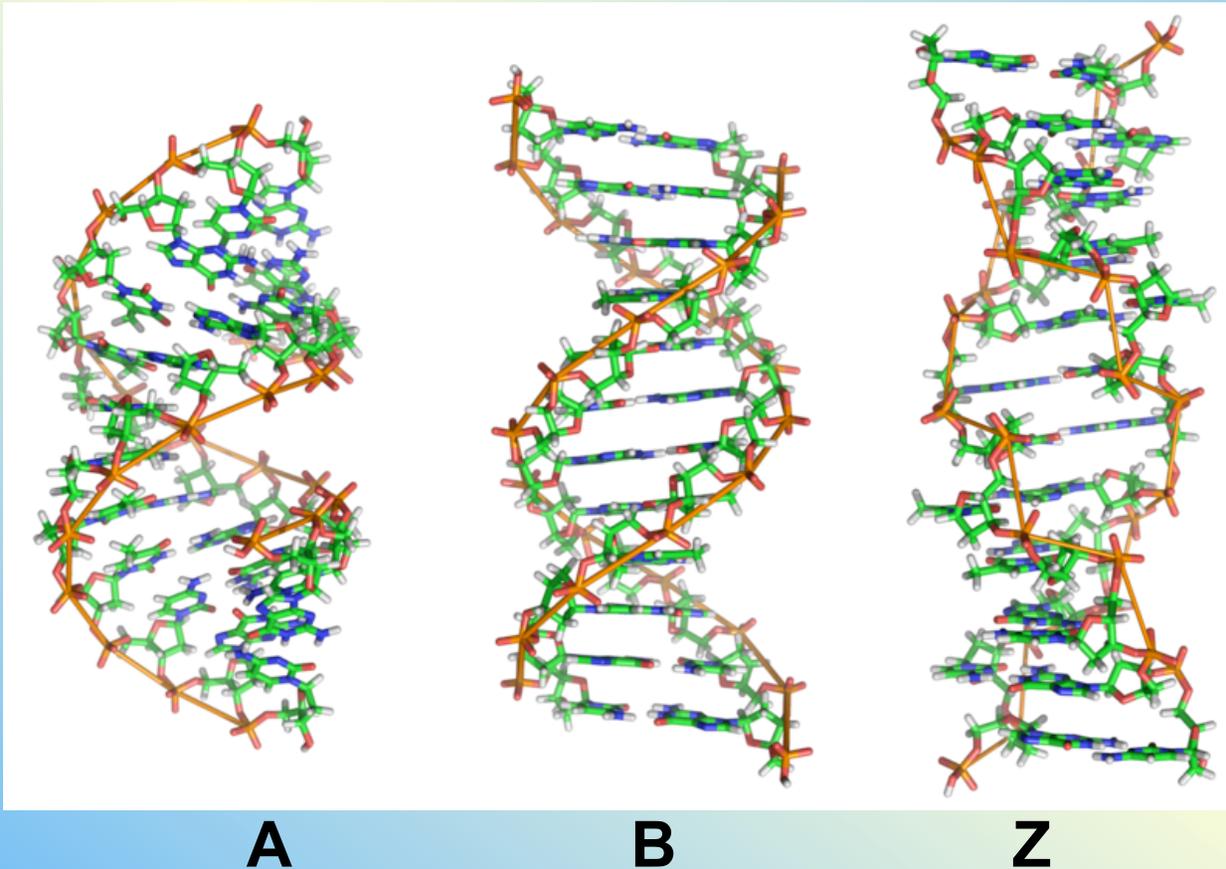
stacking interaction

Stacking interaction



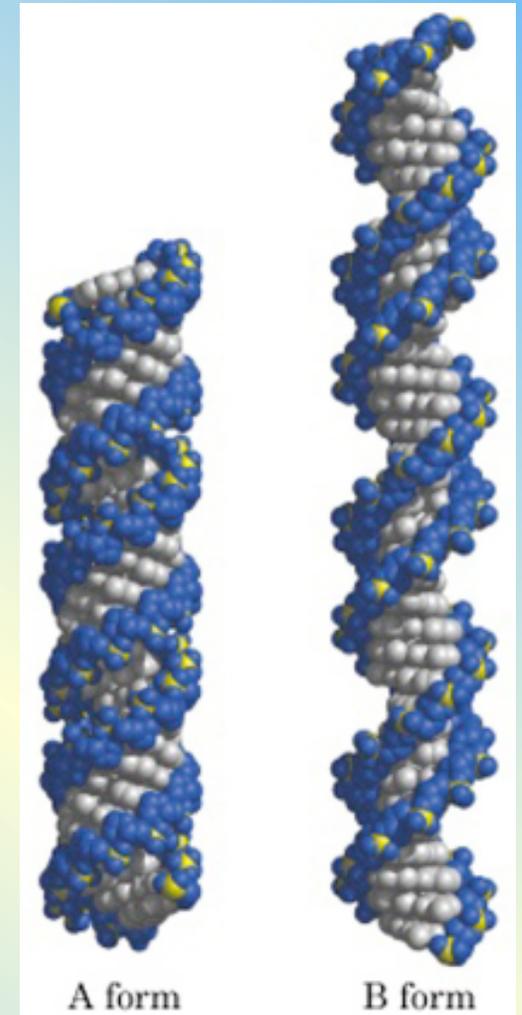
- per base pair: ~ 100 kJ/mol (chem. bond ~ 400 kJ/mol)
– as strong as hydrogen bonds
- van der Waals interaction
(dispersive forces – instantaneous dipole-induced dipole)
- key factor of the stabilization of DNA structure

A- and B-DNA



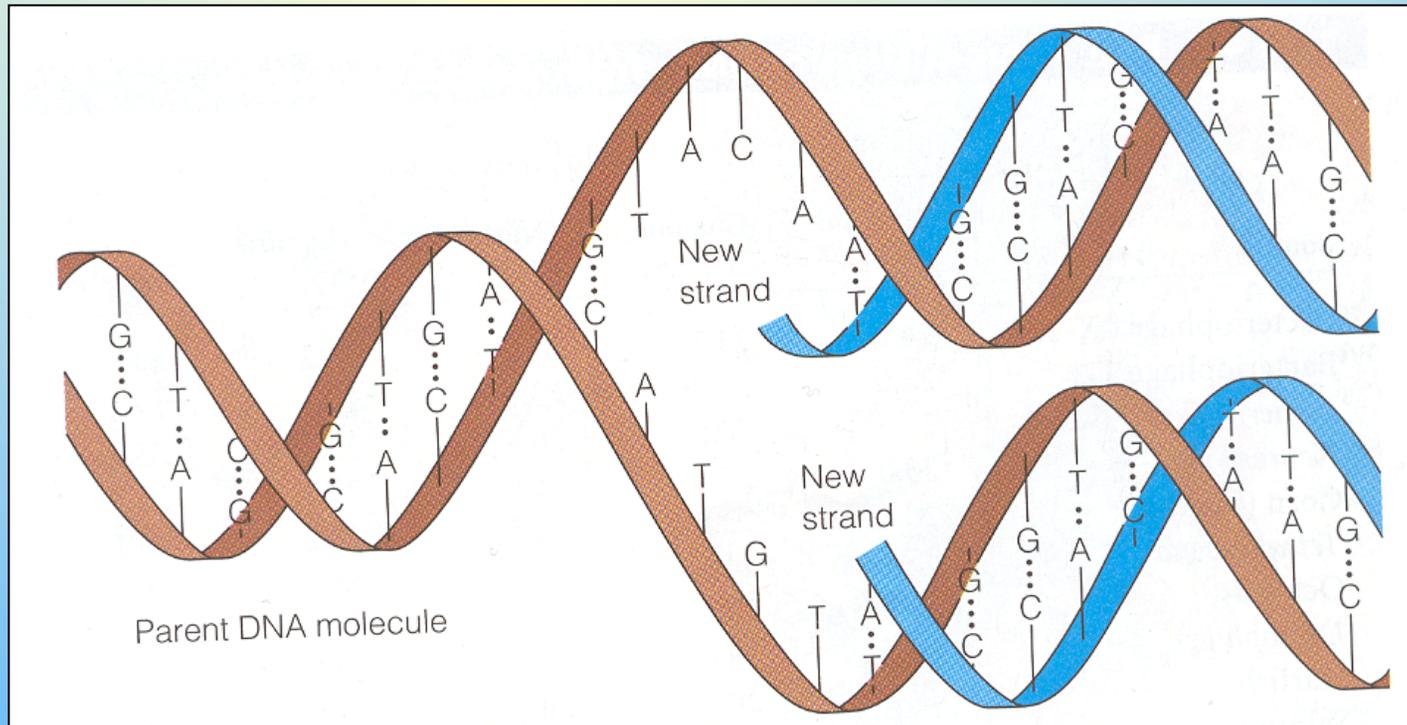
A-DNA: 11 bases per turn, 33° rotation

Z-DNA: left-handed, different steps



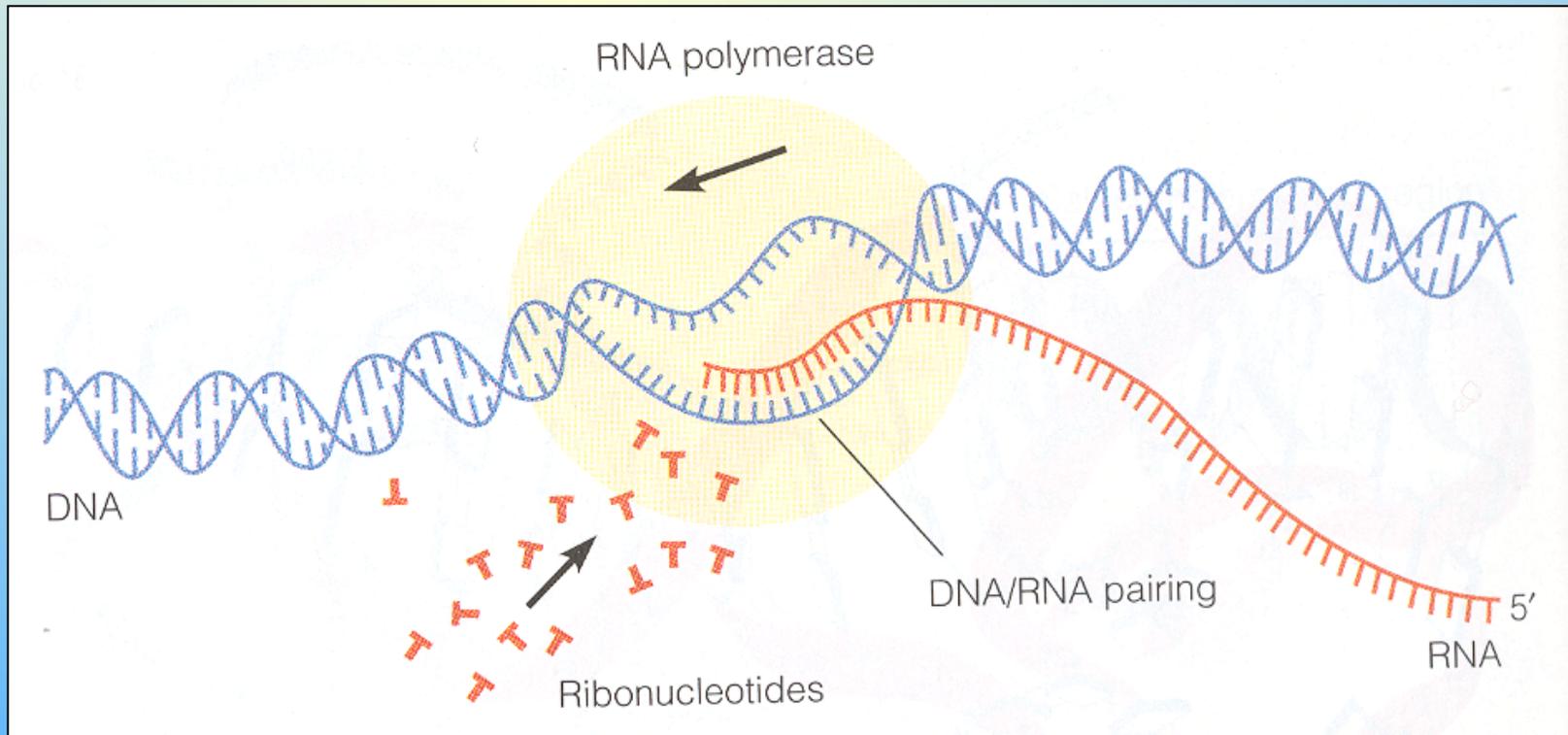
Replication

Duplication of a DNA molecule

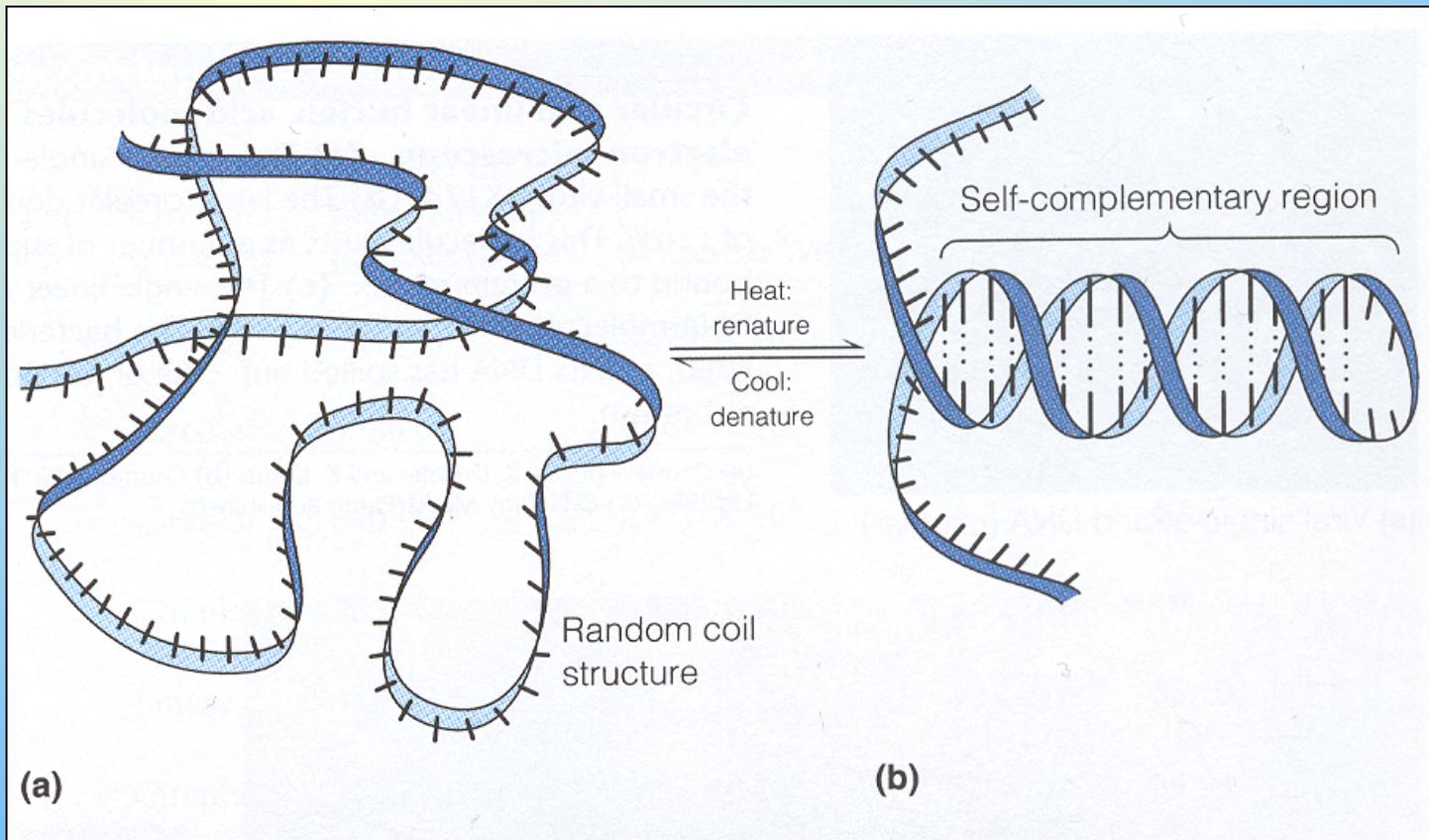


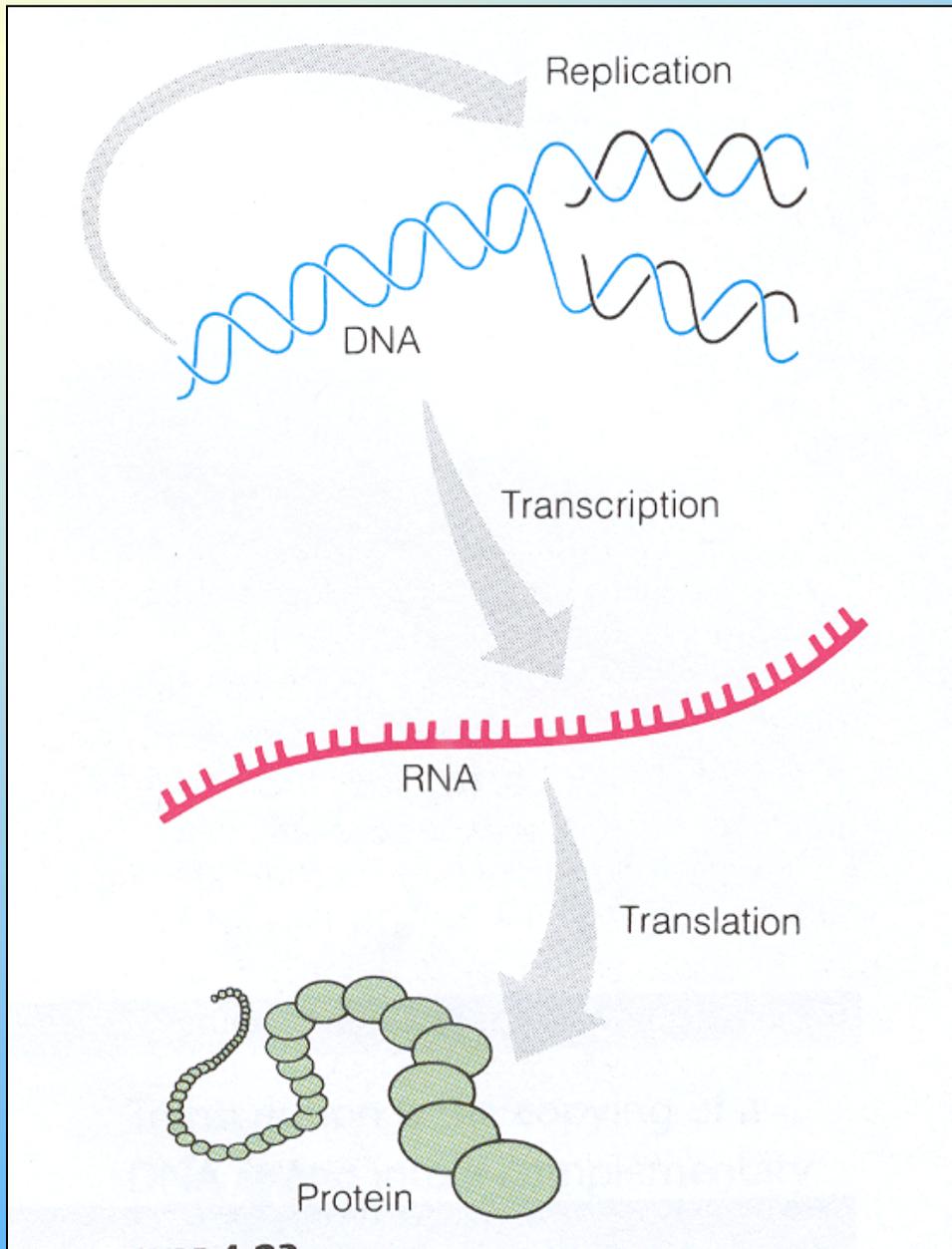
Transcription

of information from DNA to mRNA (messenger RNA)



Denaturation





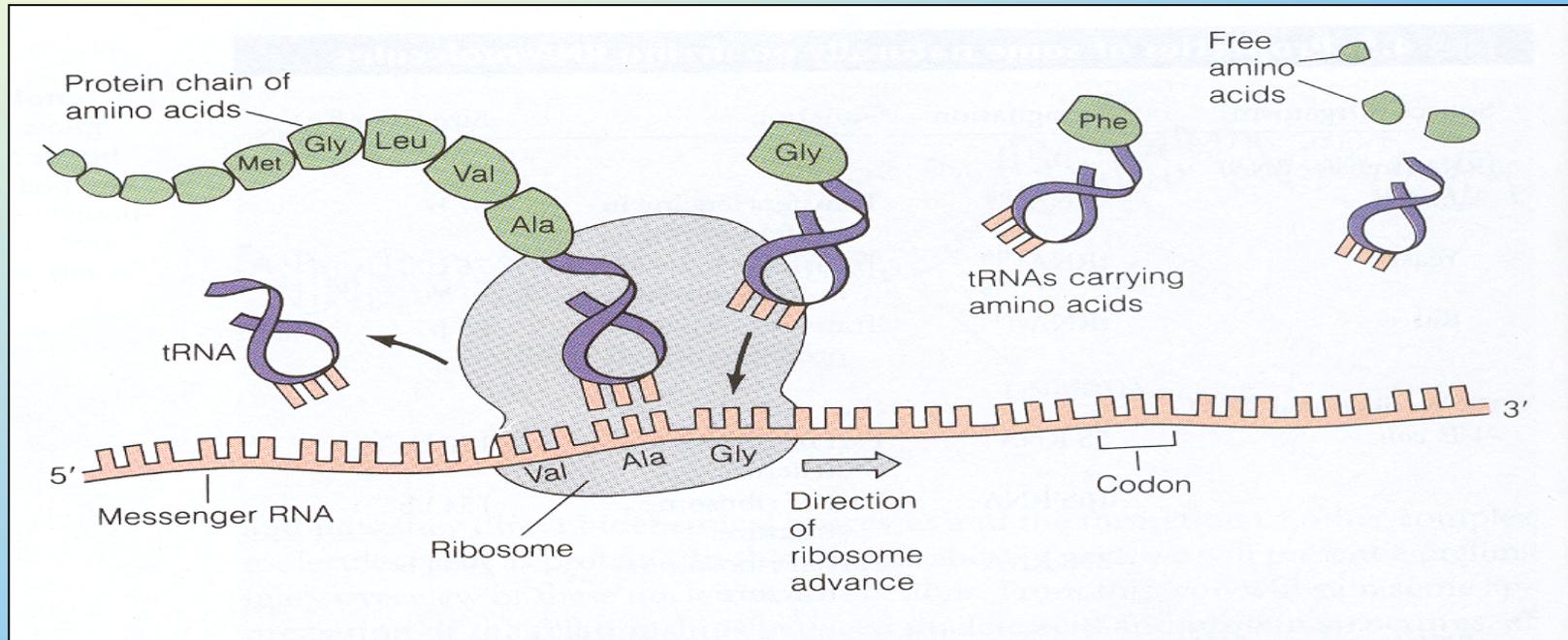
**From DNA
to a protein**

mRNA: messenger RNA
carrier of information
stored in DNA for protein
synthesis

tRNA: transfer RNA
transporter of an amino
acid in the translation

central dogma of molecular biology

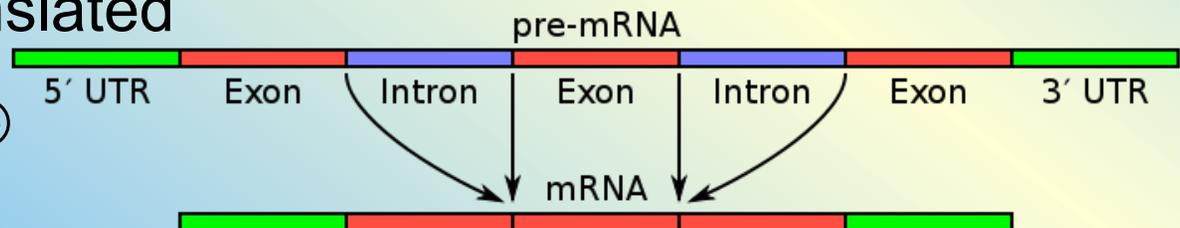
From DNA to a protein

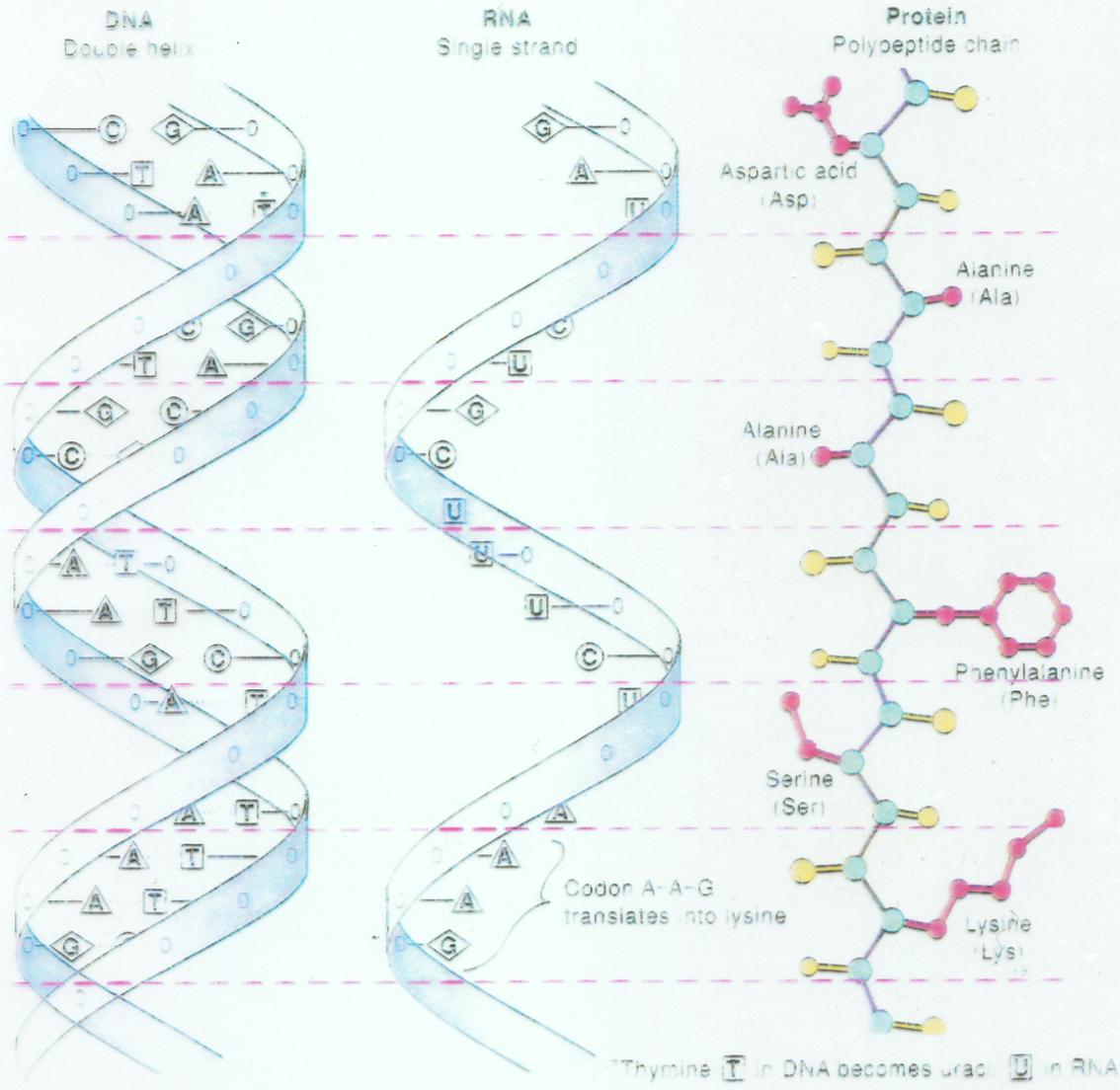


Gene: a locatable region of genomic sequence

Intron: region within a gene
which is not translated

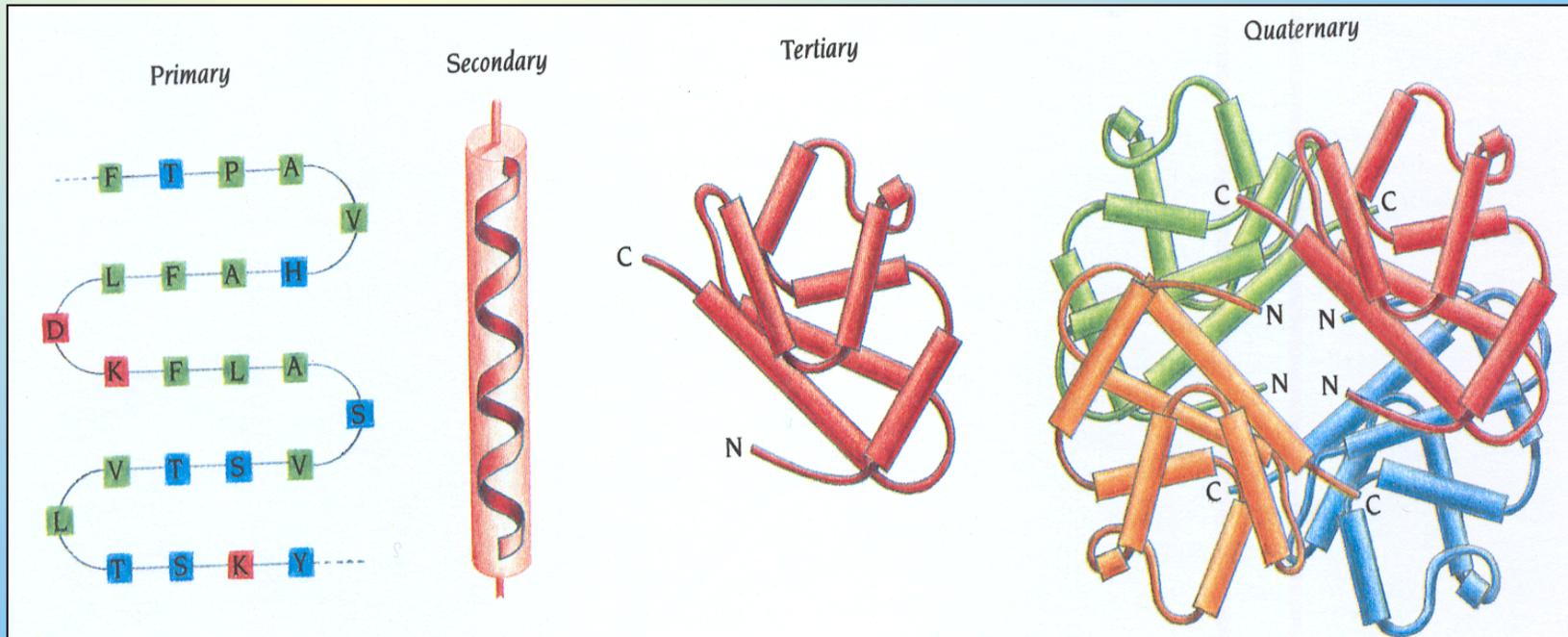
Exon: ... is translated 😊





*Thymine **T** in DNA becomes uracil **U** in RNA

Proteins

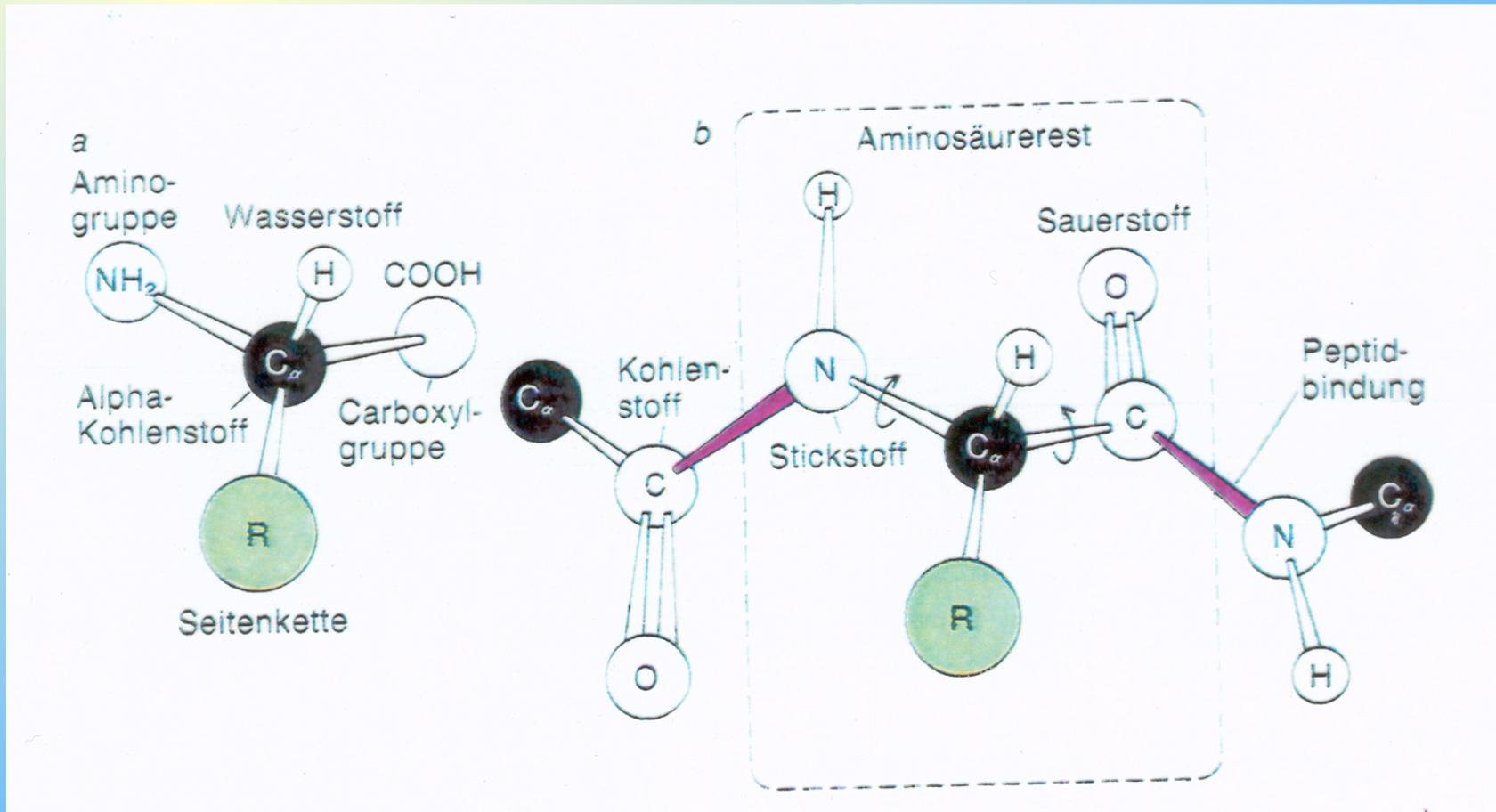


- Primary structure – sequence of amino acids
- Secondary structure – helix, sheet, turn
- Tertiary structure – 3D ordering of 2°-structure-elements

20 amino acids

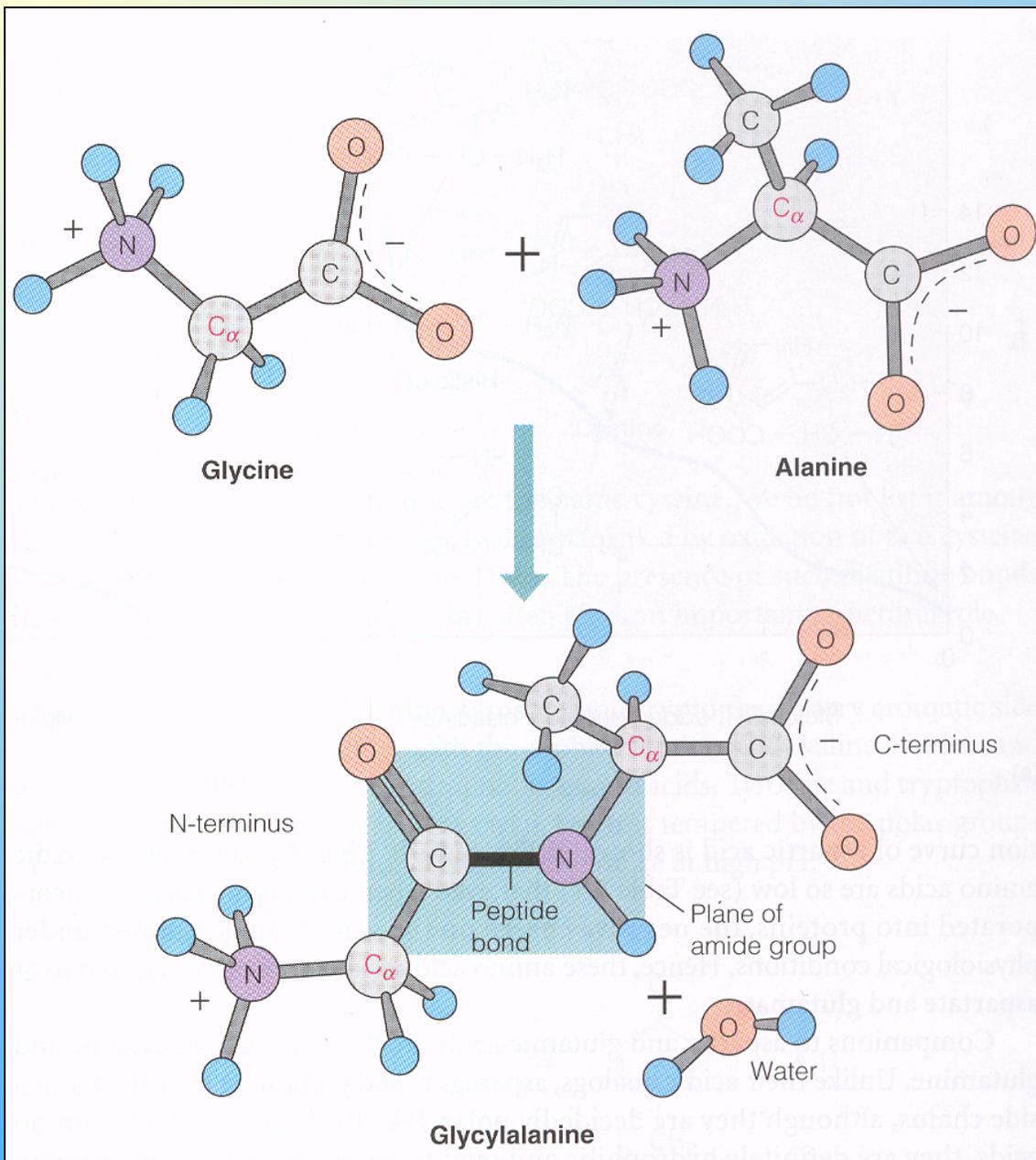


Amino acids as building stones

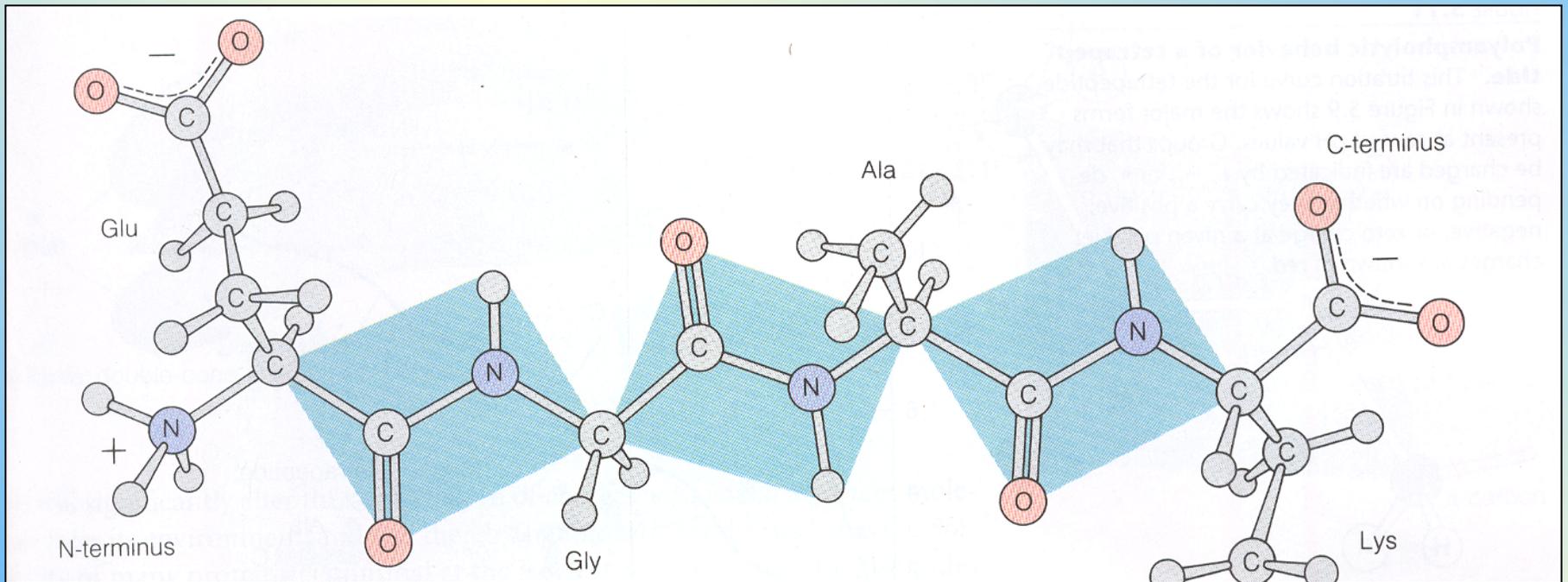


Condensation – peptide bond (actually amide bond)

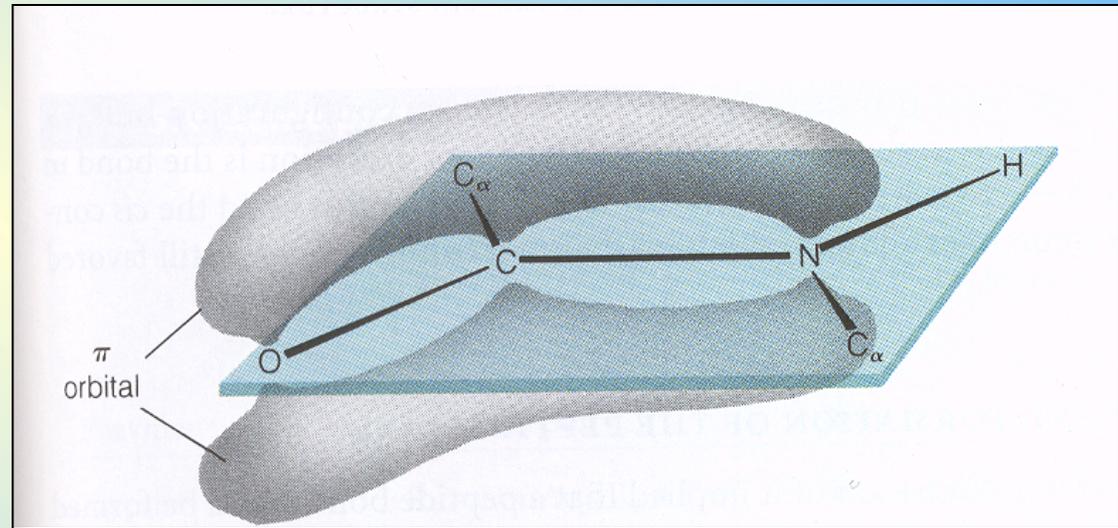
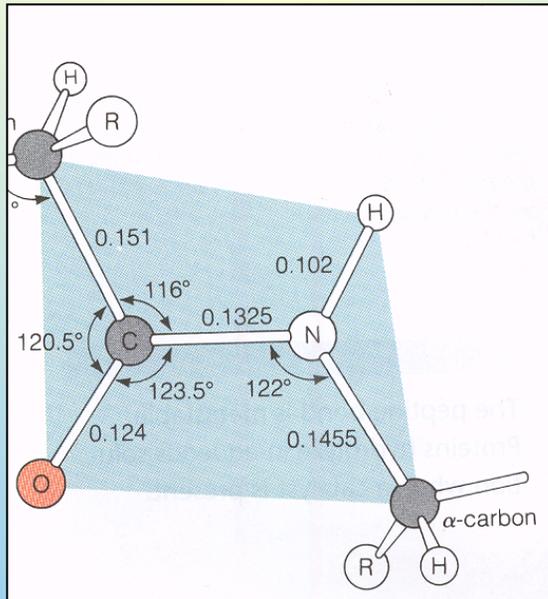
Condensation



Polymerization

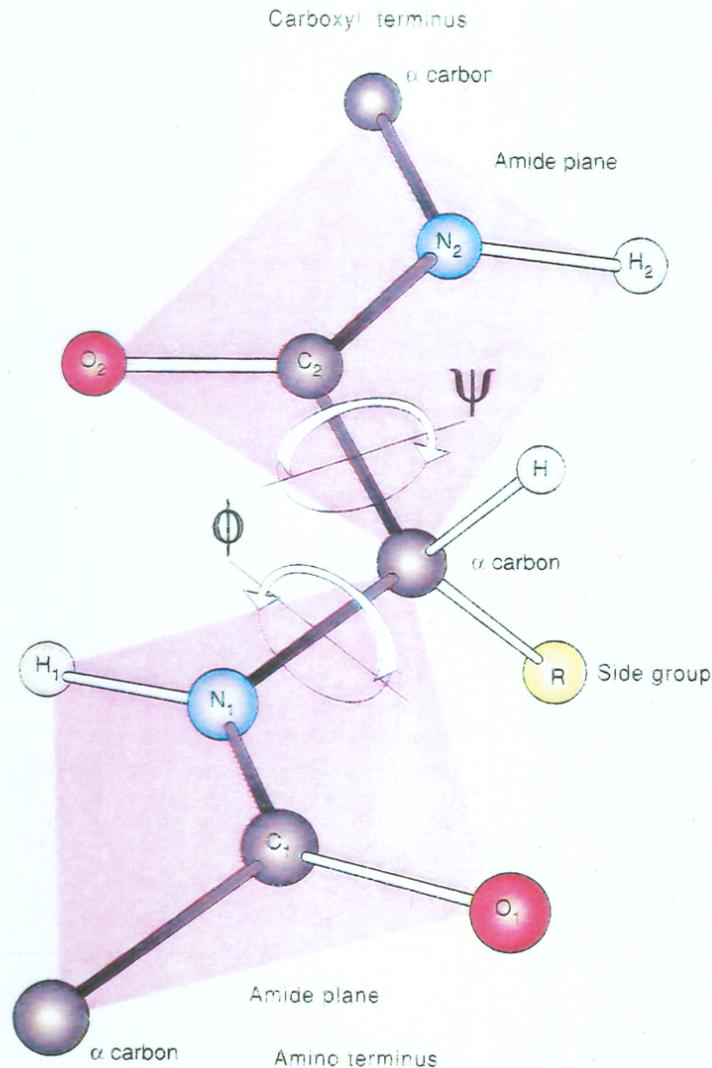


Peptide bond



- C=N – partial double-bond character
 - barrier opposing rotation (single bond ~ 10 kJ/mol, double bond ~ 200 kJ/mol)
- ~ 80 kJ/mol
- \rightarrow only rotation around the single bonds free (C–C α , N–C α)

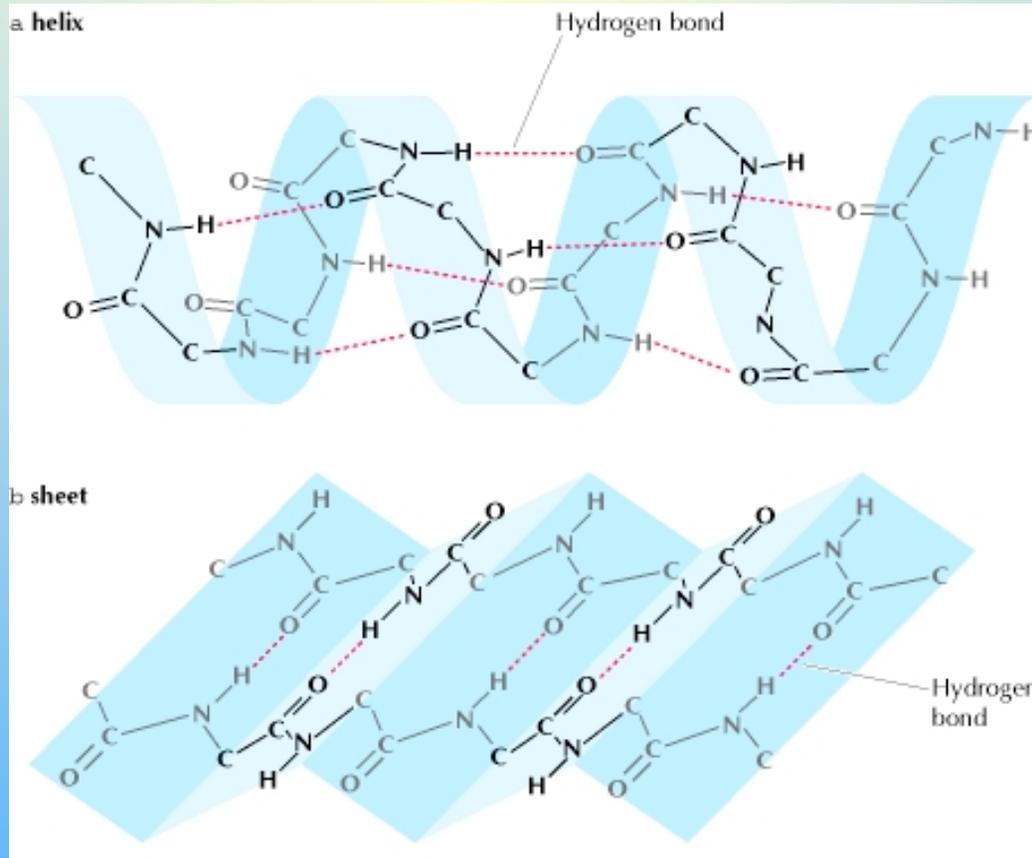
Conformation of peptides / proteins



single bonds $C-C^\alpha$ and $N-C^\alpha$

ψ und ϕ – torsional angles around these bonds

Elements of secondary structure

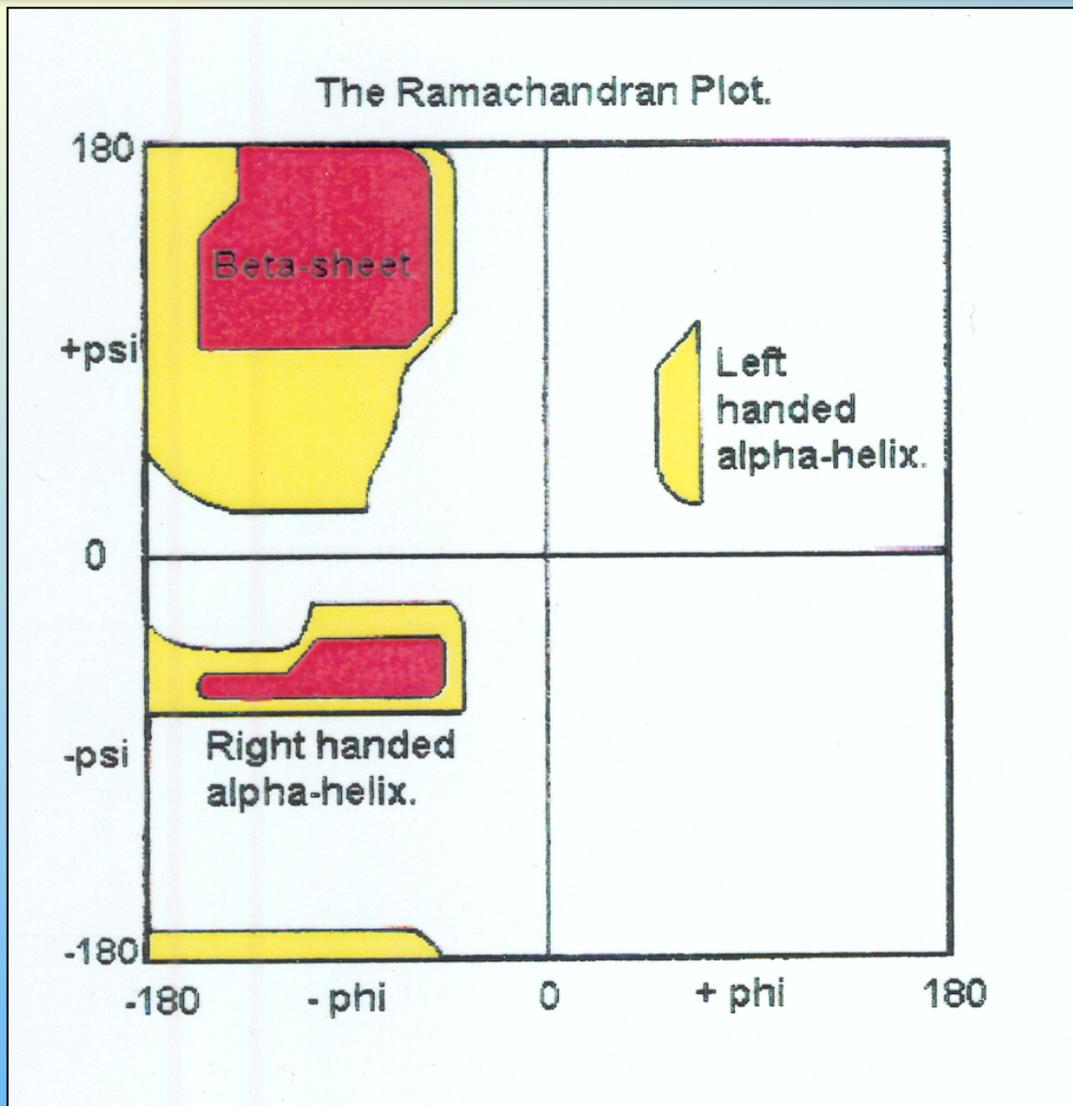


Helices (3_{10} , alpha, pi)

Beta-sheet (parallel,
anti-parallel)

Various turns etc.

Conformational space

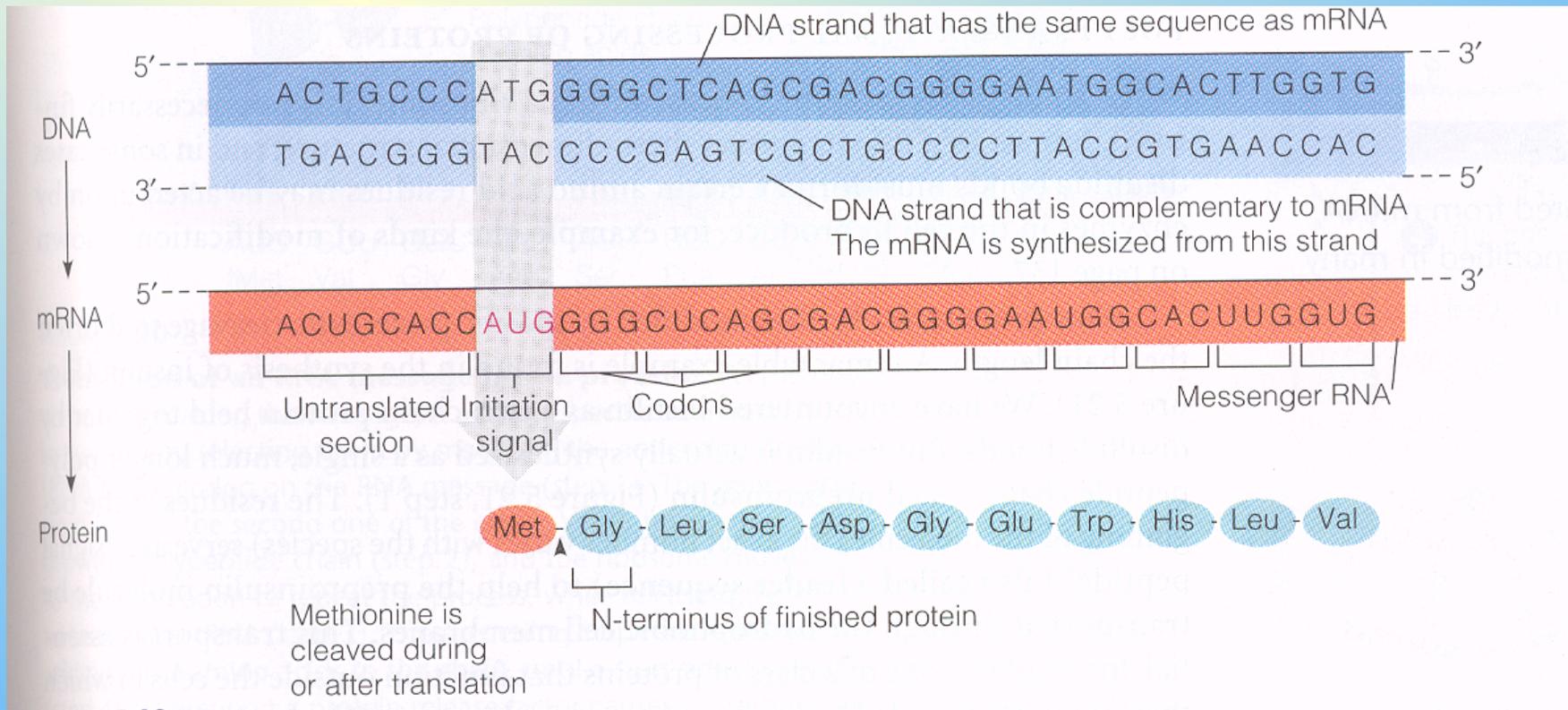


Transcription

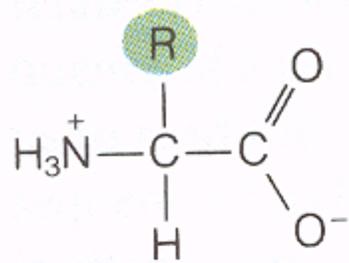
		Second position					
		U	C	A	G		
U	UUU	Phe	UCU	UAU	UGU	U	
	UUC					Ser	UAC
	UUA	Leu	UCA	UAA	Stop		
	UUG			UCG	UAG	Stop	UGG
C	CUU	Leu	CCU	CAU	CGU	U	
	CUC					Pro	CAC
	CUA	CCG	CAA	CGA	CAA		
	CUG				CAG	CGG	CGG
A	AUU	Ile	ACU	AAU	AGU	U	
	AUC					Thr	AAC
	AUA	ACA	AAA	AGA	AGA		
	AUG				ACG	AAG	AGG
G	GUU	Val	GCU	GAU	GGU	U	
	GUC					Ala	GAC
	GUA	GCA	GAA	GGA	GAA		
	GUG				GCG	GAG	GGG

Codons of 3 bases
Redundant code

Transcription



Transcription



Amino acid

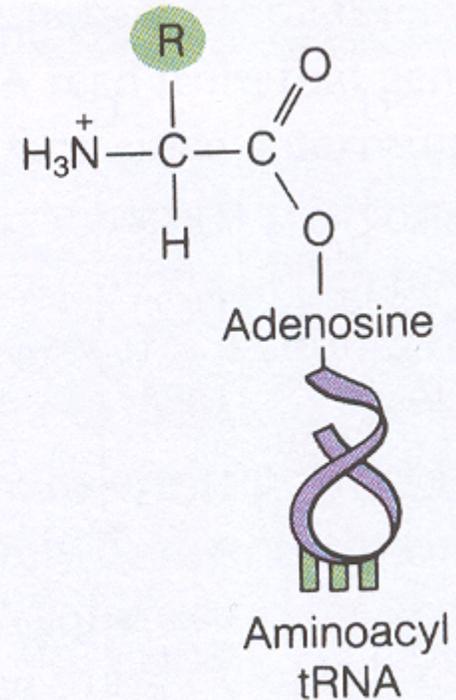
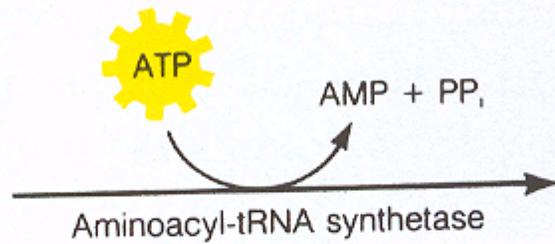
+

Adenosine 3'—OH



tRNA

Anticodon



Adenosine

Aminoacyl
tRNA

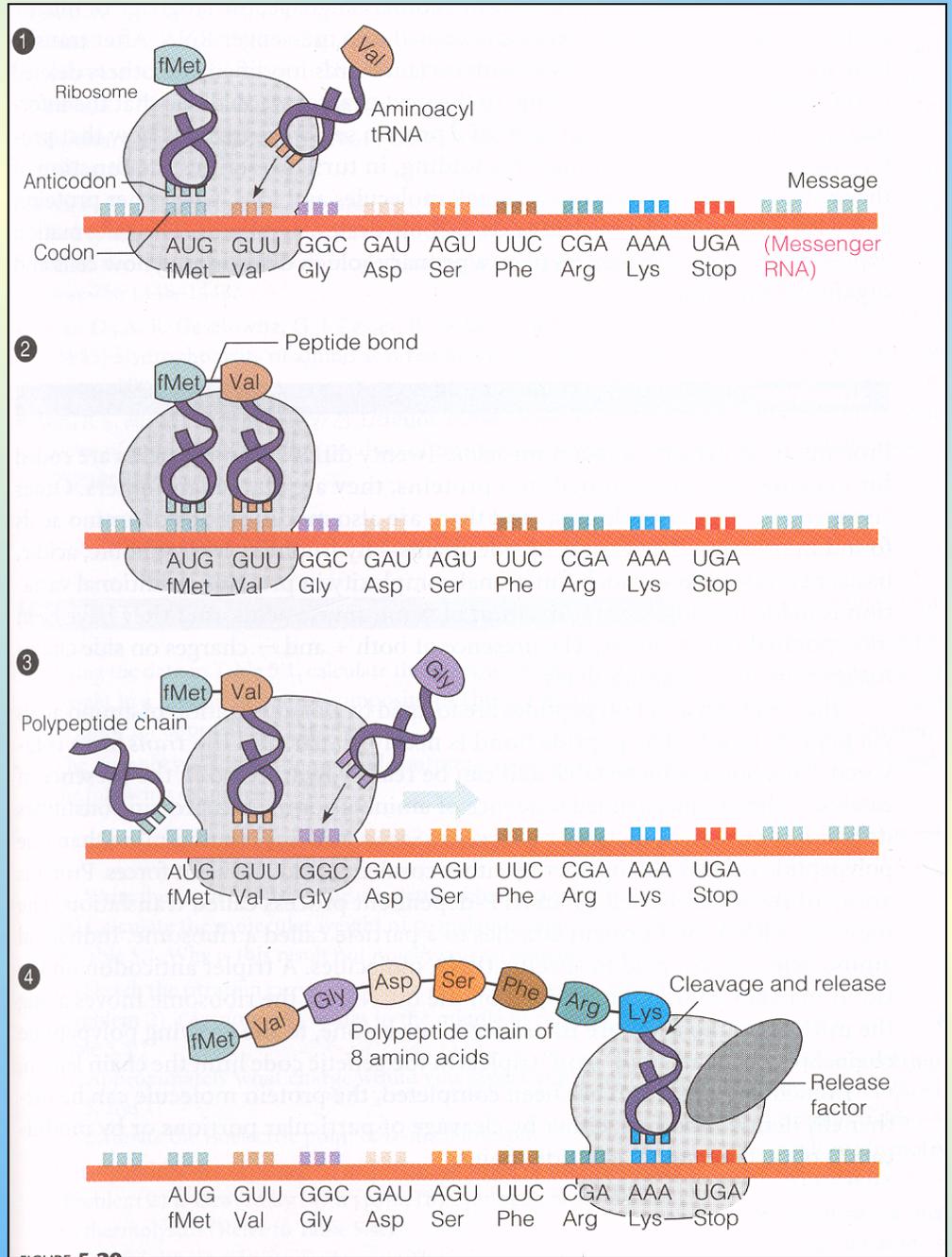


FIGURE 5-20