وراثة الأحياء الدقيقة
Microbial Genetics

د. تركي محمد الداود
مكتب ٢ ب ٤٥

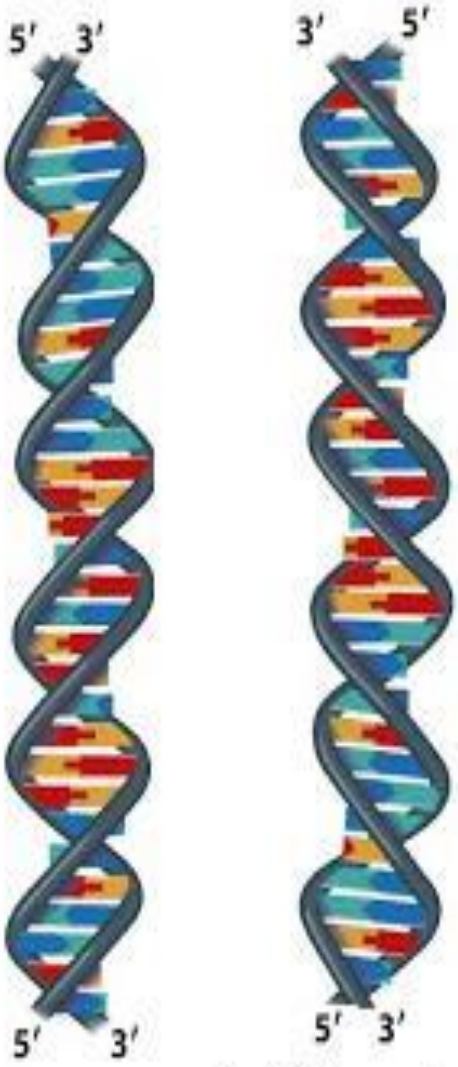
أساسيات في علم الوراثة
Fundamentals of Genetics
Lecture 4

Physical Chemistry of Nucleic Acids

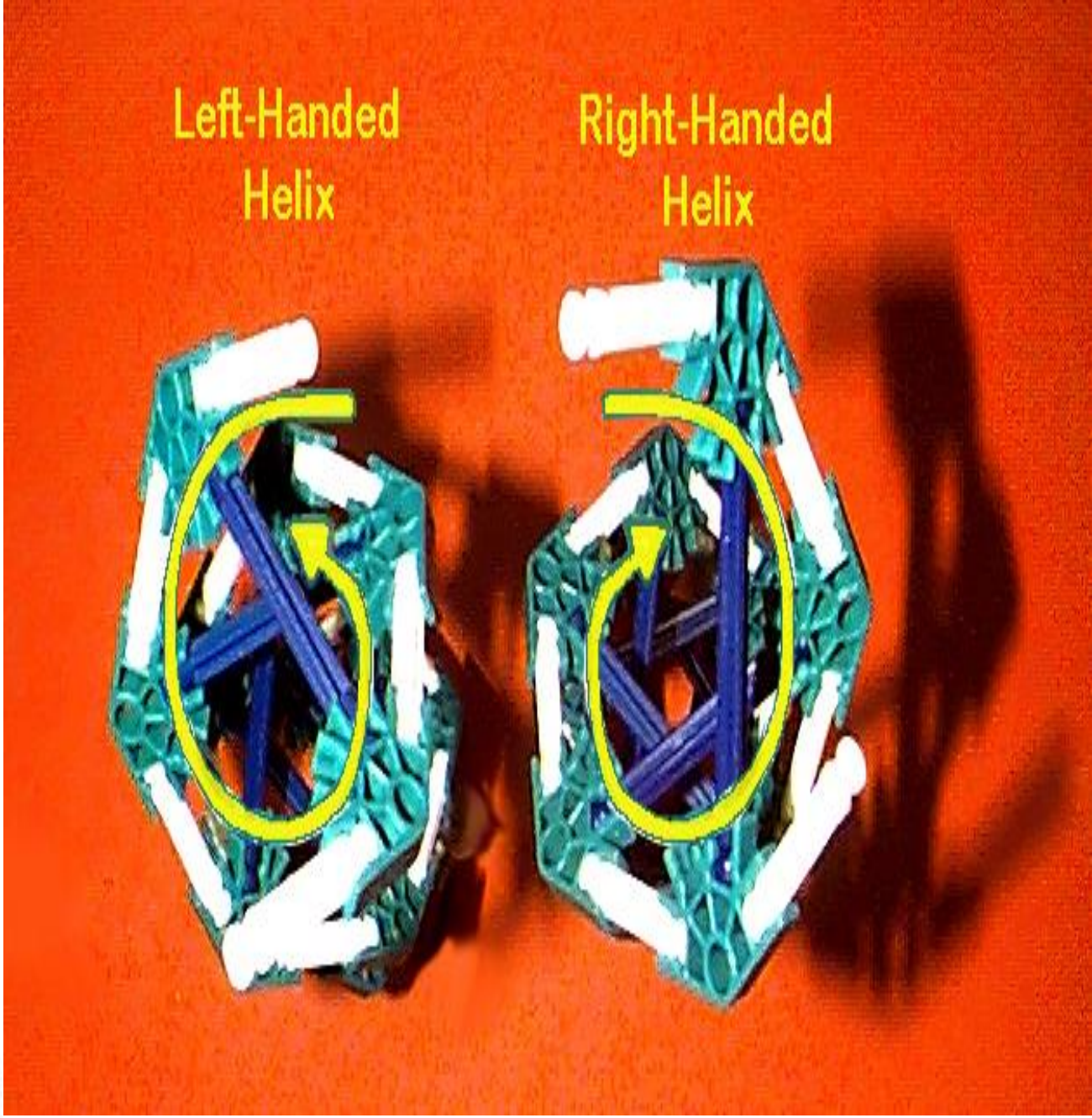
❖ DNA and RNA molecules can appear in several different structural variants

- Changes in relative humidity will cause variation in DNA molecular structure
- The twist of the DNA molecule is normally shown to be right-handed, but left-handed DNA was identified in 1979.

Right-handed helix: Correct



Left-handed helix: Incorrect



A Variety of DNA Structures

- High humidity DNA is called the B-form
- Lower humidity from cellular conditions to about 75% and DNA takes on the A-form
  - Plane of base pairs in A-form is no longer perpendicular to the helical axis
  - A-form seen when hybridize one DNA with one RNA strand in solution

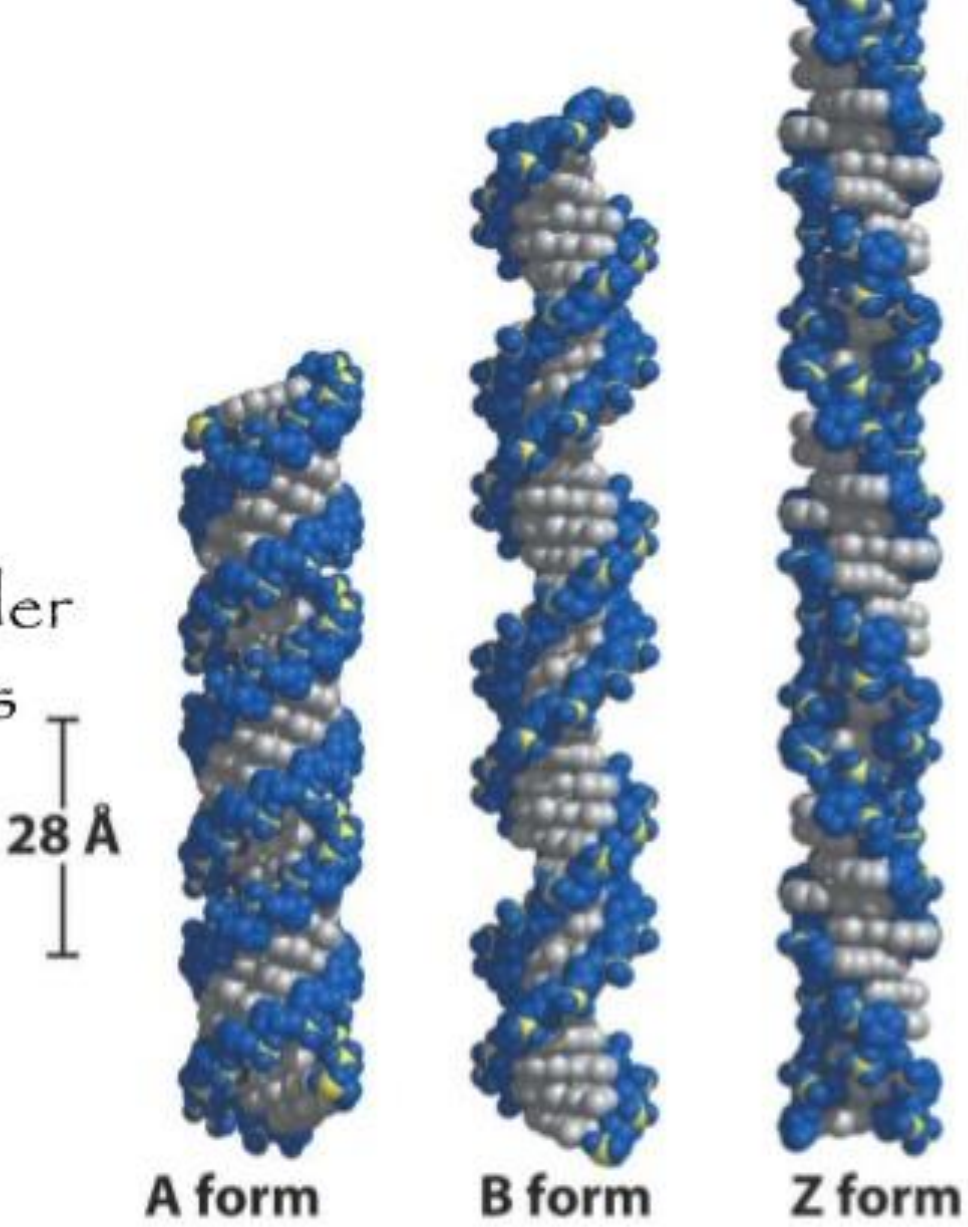
Table 2.2 Forms of DNA

Form	Pitch Å	Residues per Turn	Inclination of Base Pair from Horizontal (degrees)
A	24.6	10.7	+19
B	33.2	~10	−1.2
Z	45.6	12	−9

- When wound in a left-handed helix, DNA is termed Z-DNA
- One gene requires Z-DNA for activation

A, B and Z DNA

- A form – favored by RNA
- B form – Standard DNA double helix under physiological conditions
- Z form – laboratory anomaly,
  - Left Handed
  - Requires Alt. GC
  - High Salt/ Charge neutralization



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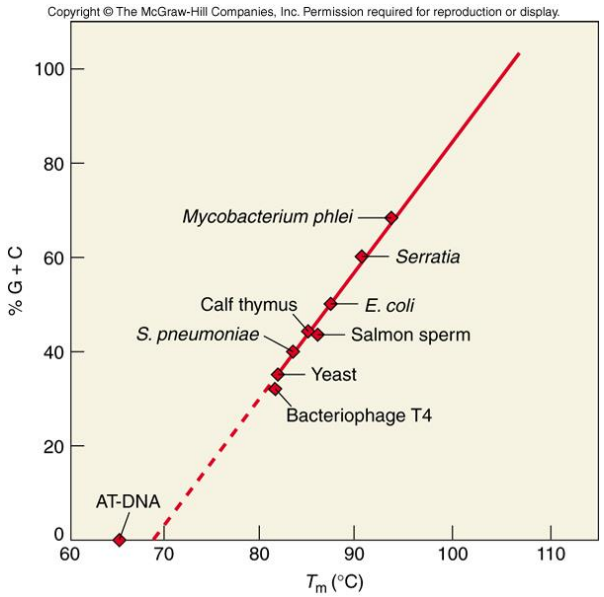
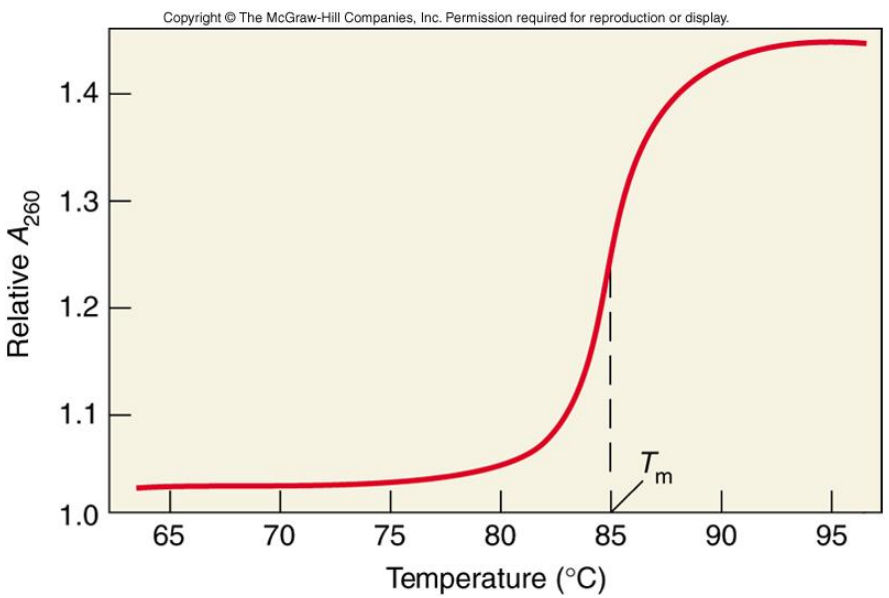
DNA Melting





- With heating, non-covalent forces holding DNA strands together weaken and break
- When the forces break, the two strands come apart in de-naturation or melting
- Temperature at which DNA strands are ½ denatured is the melting temperature or T_m
- GC content of DNA has a significant effect on T_m with higher GC content meaning higher T_m.

Deoxyribonucleic acid (DNA) Transcription

- If DNA is a book, then how is it read?
- In DNA transcription process, DNA is converted to RNA, a more portable set of instructions for the cell.
- Transcription is the synthesis of ssRNA from dsDNA.
- DNA-dependent RNA polymerase.
- DNA is double-stranded: one strand serves as a template for transcription.
- Template strand is called the non-coding strand, and the non-template strand is referred to as the coding strand.

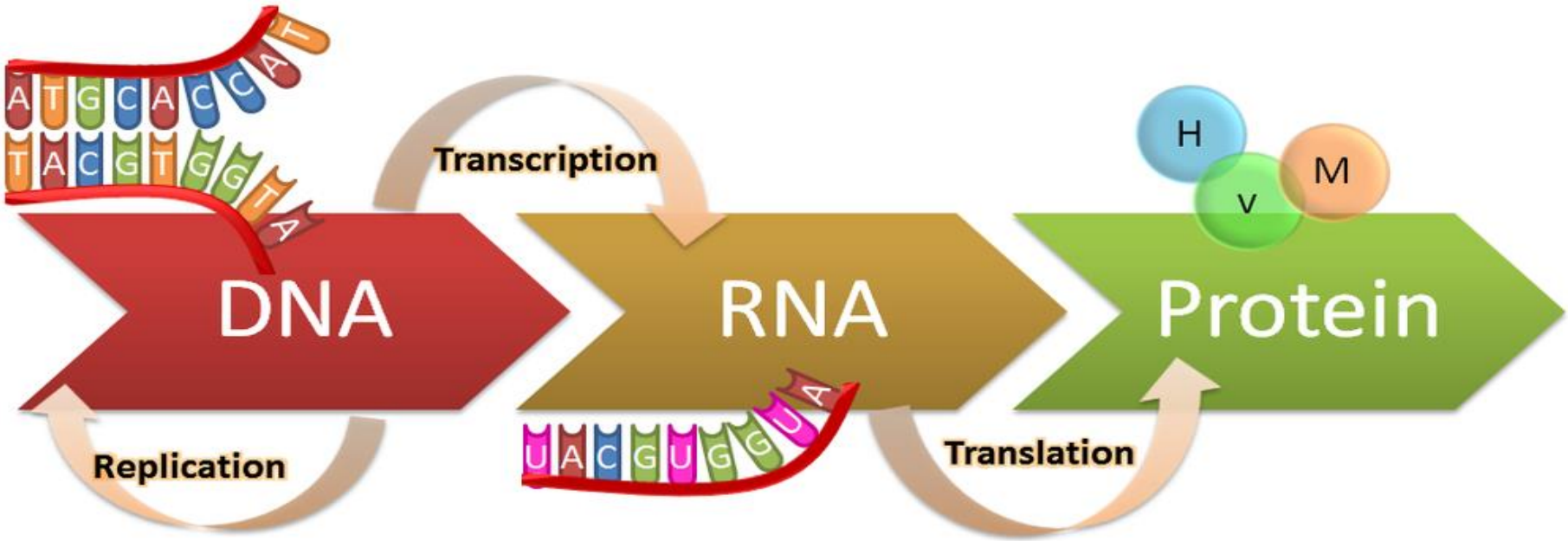
Deoxyribonucleic acid (DNA) Transcription

- Major RNA types-mRNA, rRNA and tRNA.
- All synthesized in a similar way-modified to their own specific forms “post-transcriptional processing”.
- Certain DNA regions with strong affinity for RNA polymerase- “**Promoters**”.
- Yeast promoters- TATA box.
- Bacterial- Pribnow–Schaller box.

Deoxyribonucleic acid (DNA) Transcription

- Eukaryotic cells- 3 RNA polymerase designated I, II, and III.
- RNA polymerase I resides in the nucleoli – synthesizes rRNA.
- RNA polymerase II synthesizes mRNA and some small RNA molecules.
- RNA polymerase III synthesizes tRNA and some small RNA molecules.
- In Bacteria there is only one RNA polymerase core.

Deoxyribonucleic acid (DNA)
Transcription



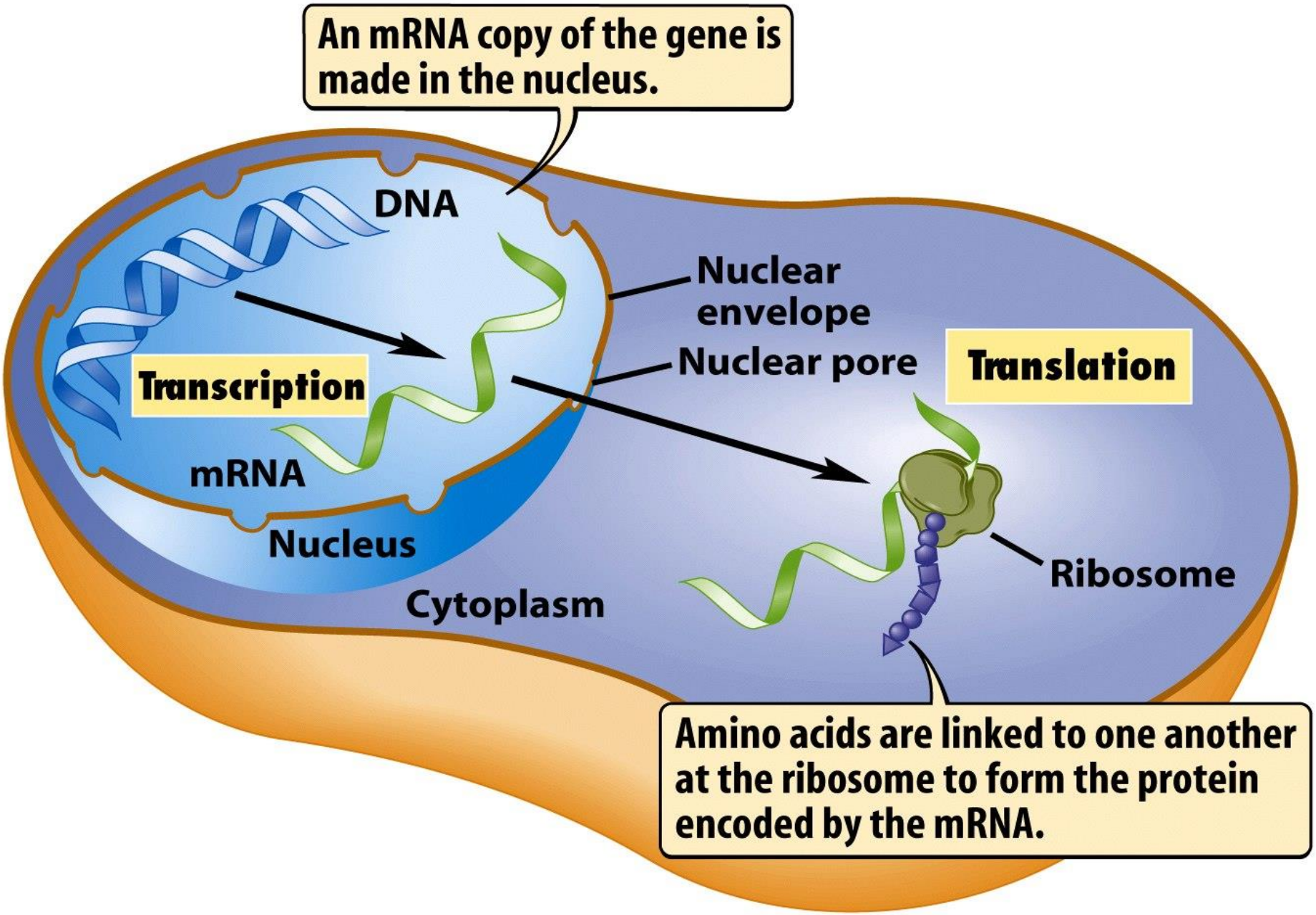
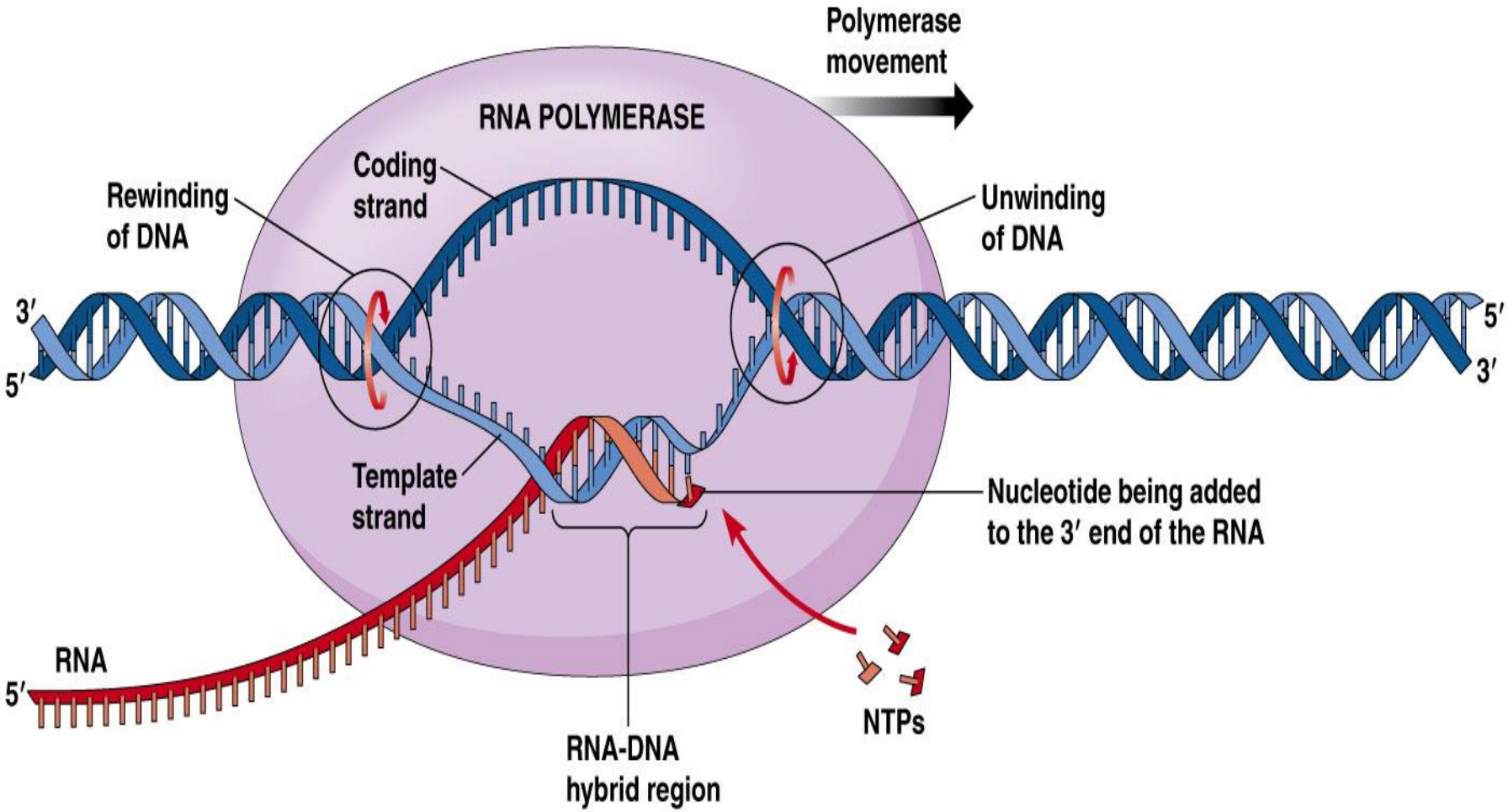
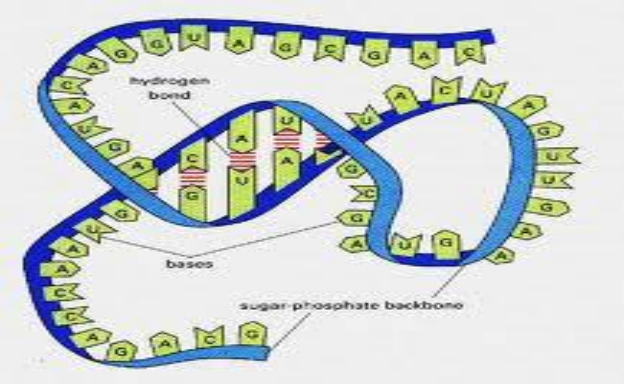


Figure 13-2 Discover Biology 3/e



Ribonucleic acid (RNA)



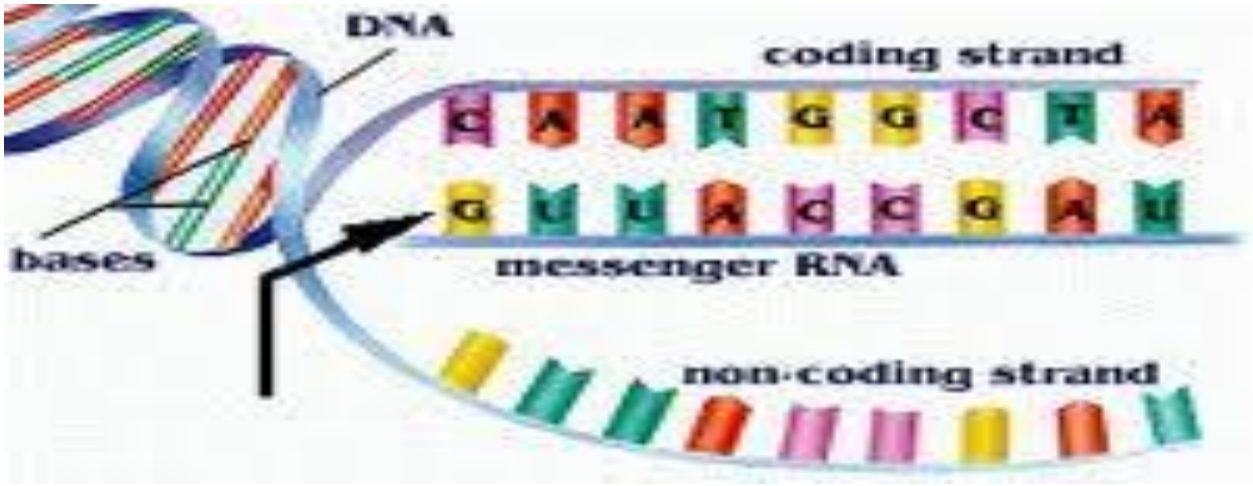
- **RNA** is a biologically important type of molecule that consists of a long chain of nucleotide units.
- Each nucleotide consists of a nitrogenous base, a ribose sugar, and a phosphate.
- RNA is a single stranded; the pyrimidine base **uracil** (U) replaces thymine and ribose sugar replaces deoxyribose**.**
- Three major classes of RNA: messenger (mRNA), transfer (tRNA) and ribosomal (rRNA). Minor classes of RNA include small nuclear RNA;……

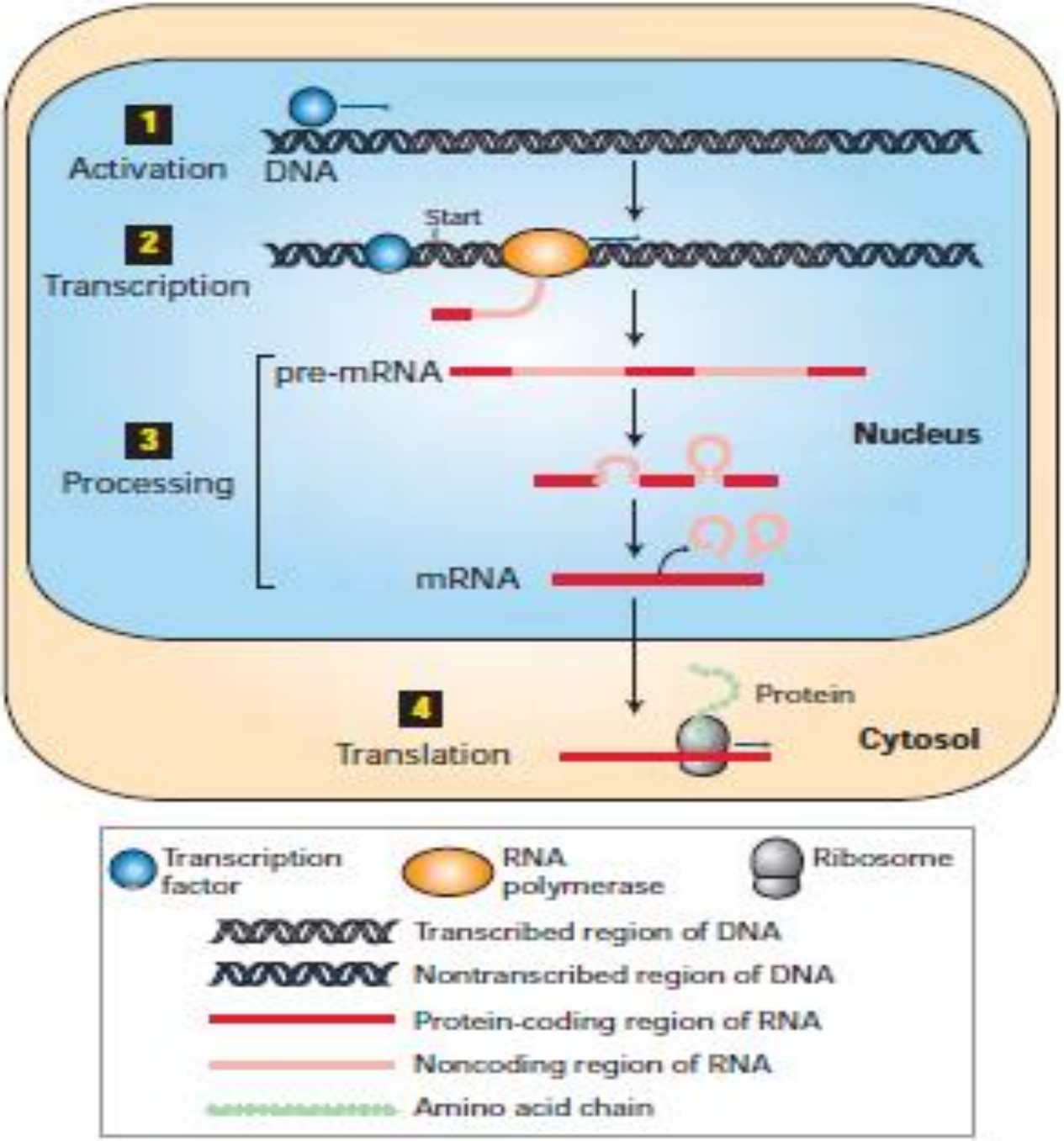
Types of RNA

Type	Abbr	Function	Distribution
Messenger RNA	**mRNA**	**Codes for protein**	**All organisms**
Ribosomal RNA	rRNA	Translation	All organisms
Transfer RNA	**tRNA**	**Translation**	**All organisms**
In post-transcriptional modification			
Small nuclear RNA	**snRNA**	**Splicing and other functions**	**Eukaryotes and Achaea**
Y RNA		RNA processing, DNA replication	Animals
Telomerase RNA		**Telomere synthesis**	**Most eukaryotes**
Regulatory RNAs			
Antisense RNA	**aRNA**	**Transcriptional attenuation / mRNA degradation / mRNA stabilization / Translation block**	**All organisms**

Messenger RNA

- mRNA carries information about a protein sequence to the ribosomes, the protein synthesis factories in the cell.
- It is coded so that every three nucleotides (a codon) correspond to one amino acid.
- In eukaryotic cells, once precursor mRNA (pre-mRNA) has been transcribed from DNA, it is processed to mature mRNA. This removes its introns—non-coding sections of the pre-mRNA.

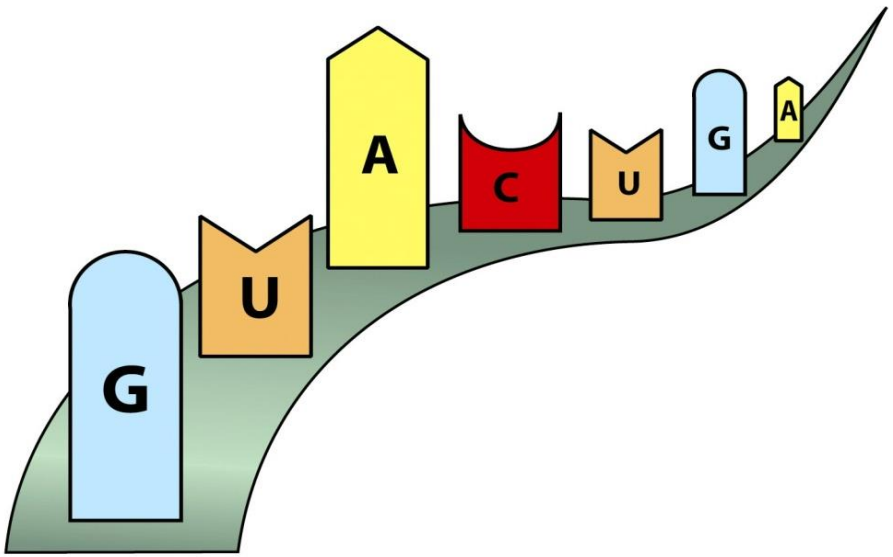



1
Activation
DNA
Start
2
Transcription
pre-mRNA
3
Processing
Nucleus
mRNA
4
Translation
Protein
Cytosol
Transcription factor
RNA polymerase
Ribosome
Transcribed region of DNA
Nontranscribed region of DNA
Protein-coding region of RNA
Noncoding region of RNA
Amino acid chain

Messenger RNA

- The mRNA is then exported from the nucleus to the cytoplasm, where it is bound to ribosomes and translated into its corresponding protein form with the help of tRNA.

- In prokaryotic cells, which do not have nucleus and cytoplasm compartments, mRNA can bind to ribosomes while it is being transcribed from DNA.

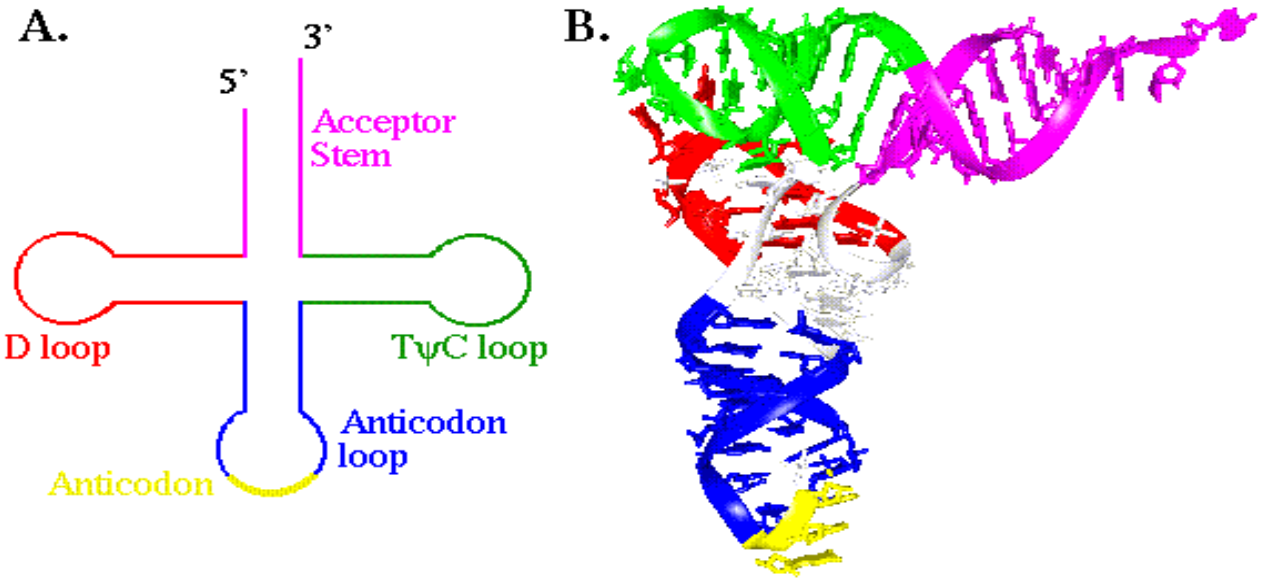


Transfer RNA

- Transfer RNA (tRNA) is a small RNA chain of about 80 nucleotides that transfers a specific amino acid to a growing polypeptide chain at the ribosomal site of protein synthesis during translation.
- It has sites for amino acid attachment and an anticodon region for codon recognition.
- the site binds to a specific sequence on the messenger RNA chain through hydrogen bonding.

Transfer RNA

- All the tRNAs share a common secondary structure resembles a cloverleaf: They have four base- paired stems defining three stem-loops (the D loop, anticodon loop, and T loop) and the acceptor stem.
- tRNA carry correct amino acids to their position along the mRNA template to be added to the growing polypeptide chain.



Ribosomal RNA

- Ribosomal RNA (rRNA) is the catalytic and central component of the ribosomes.
- Ribosome; factory for protein synthesis; composed of ribosomal RNA and ribosomal proteins (known as a Ribonucleoprotein or RNP).
- rRNA molecules are synthesized in the nucleolus.
- In the cytoplasm, ribosomal RNA and protein combine to form a nucleoprotein called a ribosome for decoding mRNA into amino acids.
- The ribosome binds mRNA and carries out protein synthesis. Several ribosomes may be attached to a single mRNA at any time.

Transcription in Prokaryotes

Three stages

- Initiation phase: RNA-polymerase recognizes the **promoter** and starts the transcription.
- Elongation phase: the RNA strand is continuously growing.
- Termination phase: the RNA-polymerase stops synthesis and the nascent RNA is separated from the DNA template.

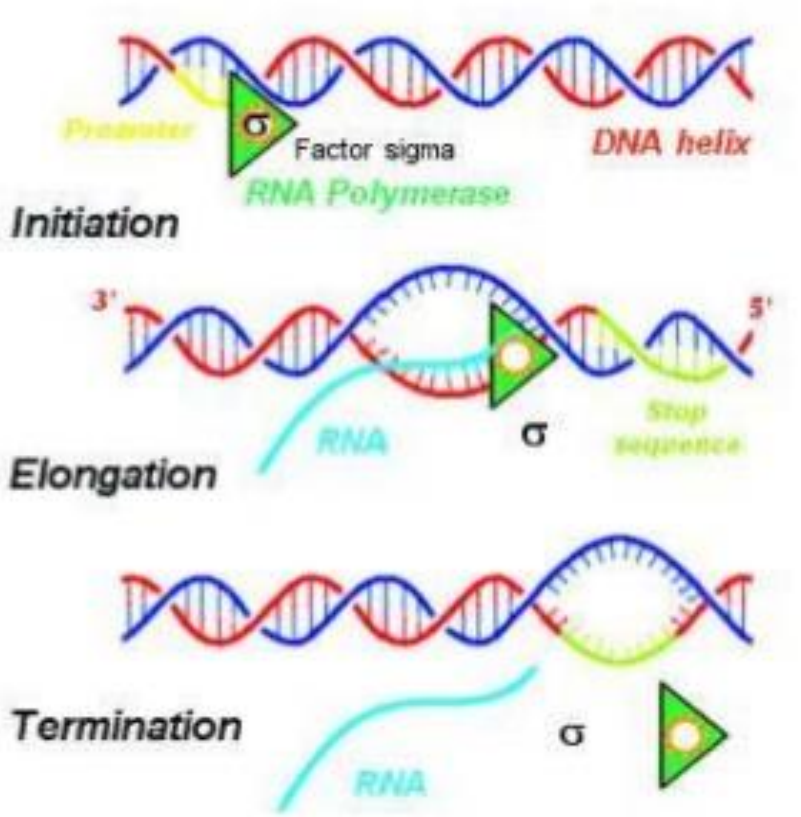
Similarities between Replication and Transcription

The processes of DNA and RNA synthesis are similar in that they involve-

(1) the general steps of initiation elongation, and termination with 5' to 3' polarity;

(2) large, multicomponent initiation complexes; and

(3) adherence to Watson-Crick base-pairing rules.



Differences between replication and transcription

	replication	transcription
template	double strands	single strand
substrate	dNTP	NTP
primer	yes	no
Enzyme	DNA polymerase	RNA polymerase
product	dsDNA	ssRNA
base pair	A-T, G-C	A-U, T-A, G-C

Differences between Replication and Transcription

(1) Ribonucleotides are used in RNA synthesis rather than deoxy ribonucleotides;

(2) U replaces T as the complementary base pair for A in RNA;

(3) A primer is not involved in RNA synthesis;

(4) Only a portion of the genome is transcribed or copied into RNA, whereas the entire genome must be copied during DNA replication; and

(5) There is no proofreading function during RNA transcription.

QUESTIONS??