NUCLEIC ACIDS

DR. ASMA

CONTENTS

Structure of Nucleic acids

- NA structure is often divided into four different levels:

  Primary structure

  Secondary structure

  Tertiary structure

  Quaternary structure

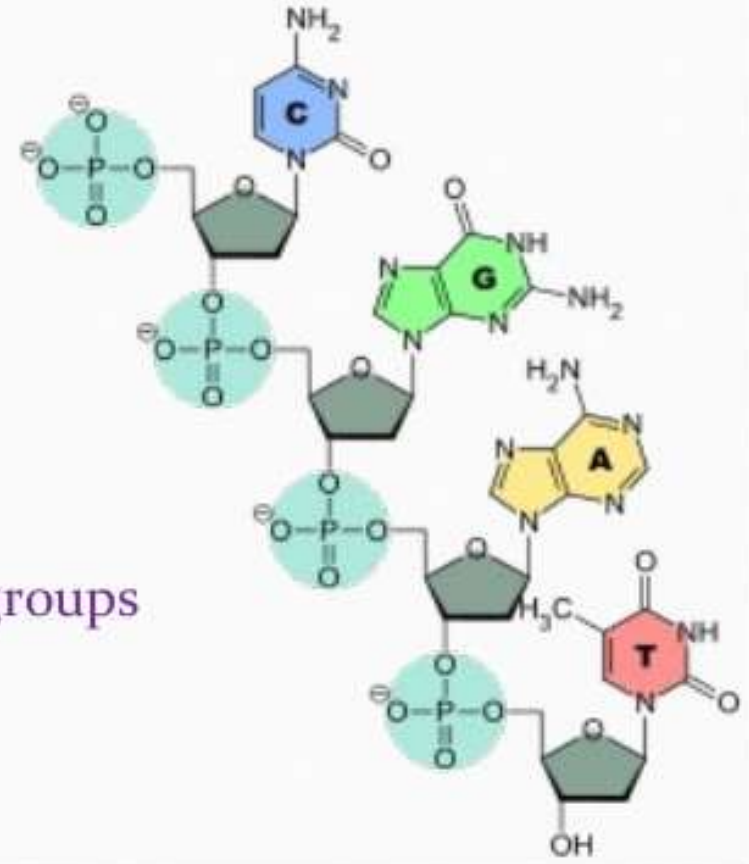
- Primary structure: consists of a linear sequence of nucleotides that are linked together by phosphodiester bond.

Nucleotides consists of 3 components:

Nitrogenous base

5-carbon sugar

One or more phosphate groups

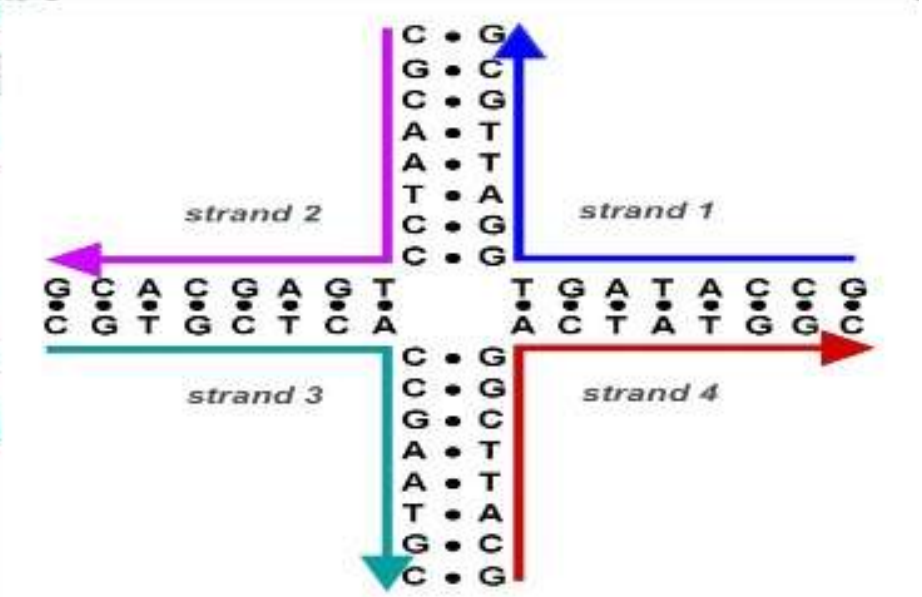


Secondary structure

This is the set of interactions between bases.

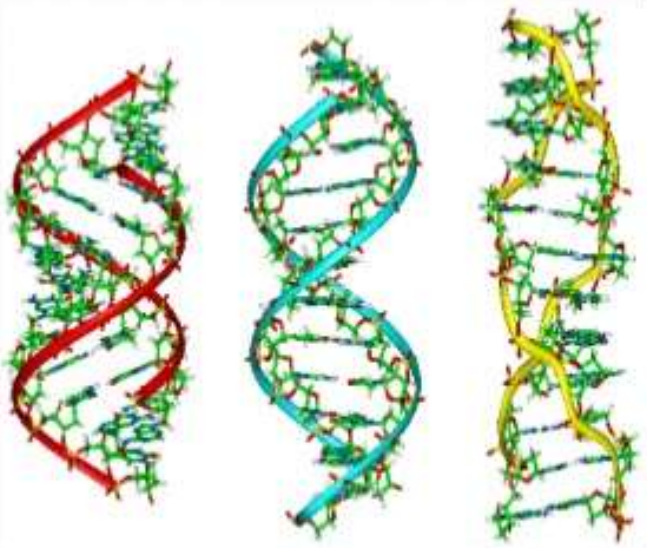
In DNA double helix, the two strands of DNA are held together by hydrogen bonds.

The nucleotides on o
strand base pairs wit
the nucleotide on the
other strand. The
secondary structure
is responsible for the
shape that the nuclei
acid assumes.



Tertiary structure

This is the locations of atoms in three-dimensional space, taking into consideration geometrical and steric constraits. A higher order than the secondary structure in which large scale folding in a linear polymer occurs and the entire chain is folded into a specific 3-dimensional shape.

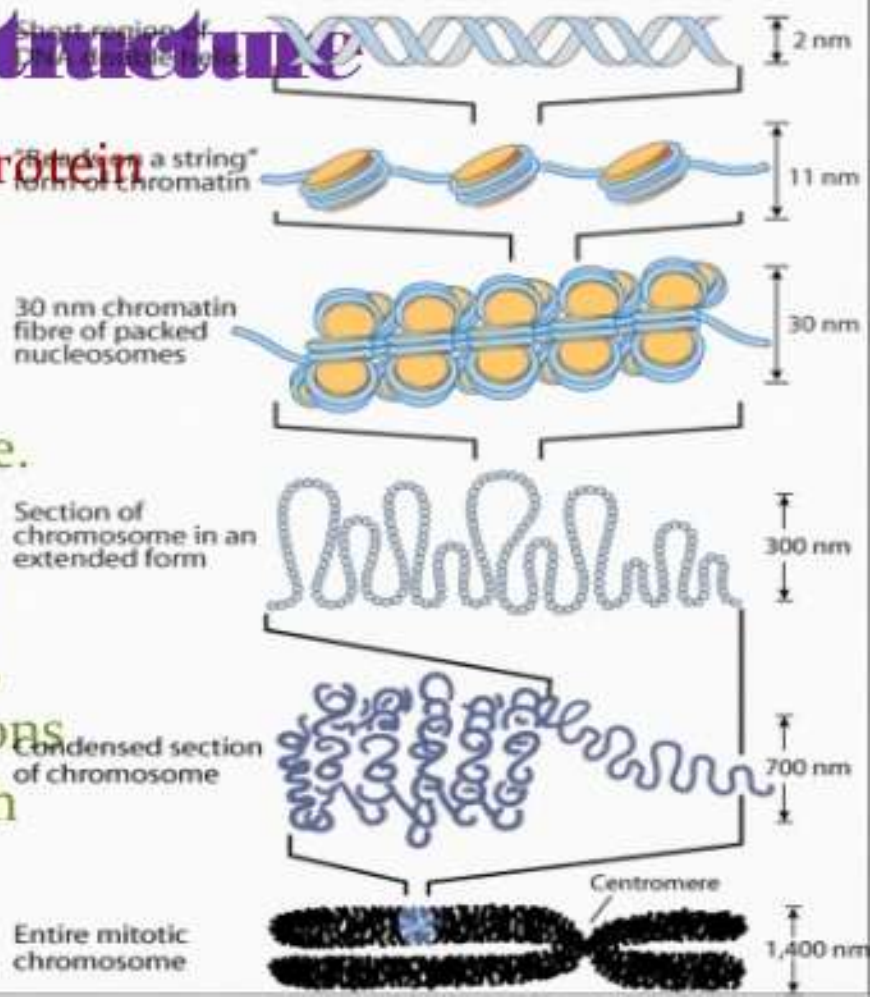


Quaternary structure

This is similar to that of protein quaternary structure.

Although some of the concepts are not exactly the same.

QS refers to a higher level of organization of nucleic acids moreover, it refers to the interactions of the nucleic acids with other molecules.



Nucleic Acids

- **Nucleic acids** are molecules that store information for cellular growth and reproduction

- There are two types of nucleic acids:
  - **deoxyribonucleic acid (DNA)** and **ribonucleic acid (RNA)**

- These are polymers consisting of long chains of monomers called nucleotides

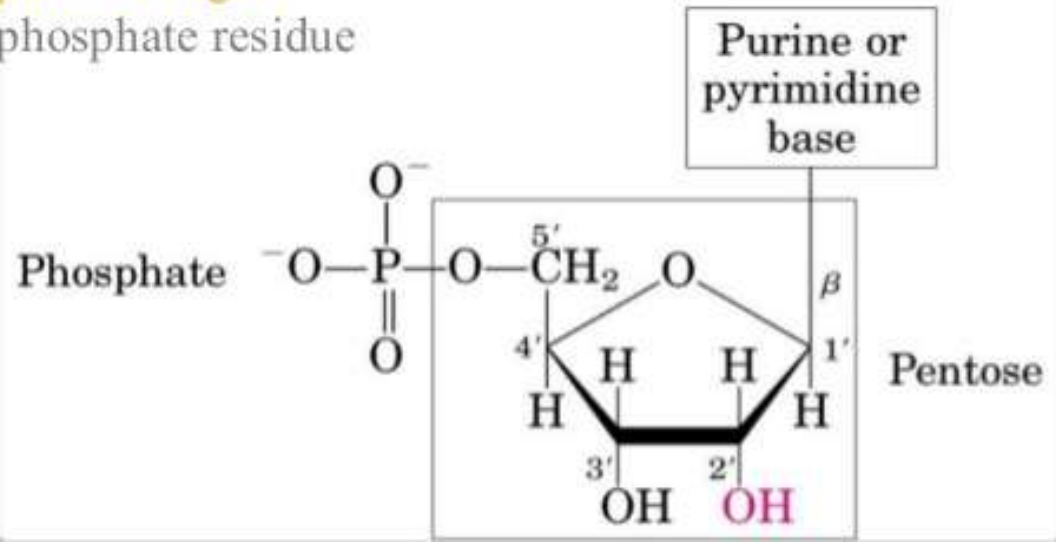
- A **nucleotide** consists of a nitrogenous base, pentose sugar and a phosphate group.

Nucleic Acids

DNA and RNA are nucleic acids, long, thread-like polymers made up of a linear array of monomers called nucleotides

All nucleotides contain three components:

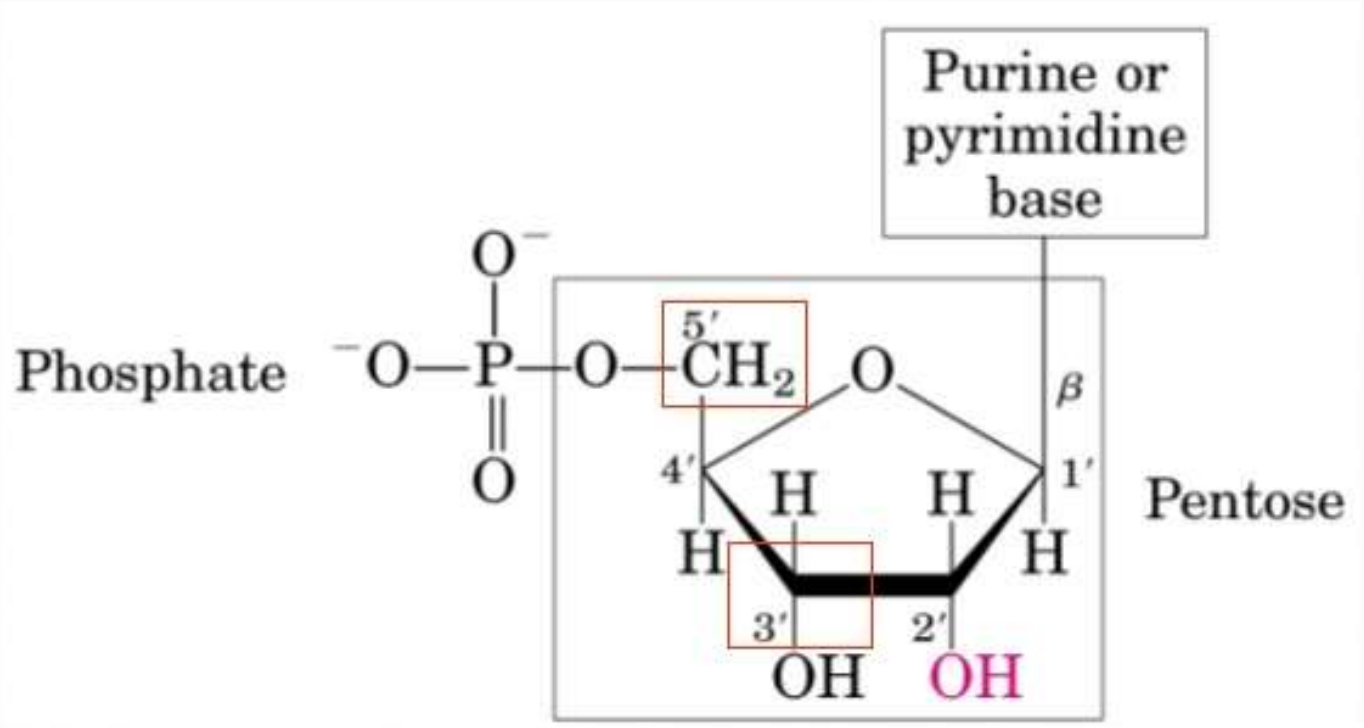
1. A nitrogen heterocyclic base
2. A pentose sugar
3. A phosphate residue



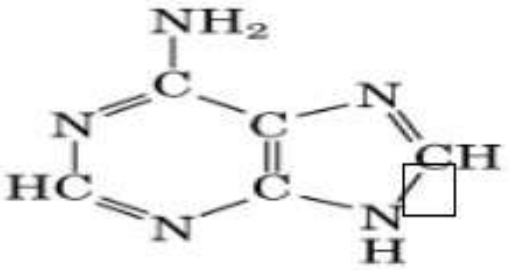
Chemical Structure of DNA vs RNA

Ribonucleotides have a 2'-OH

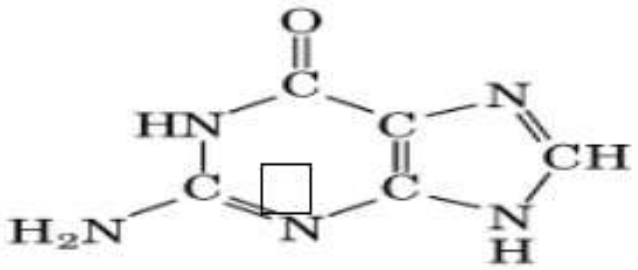
Deoxyribonucleotides have a 2'-H



Bases are classified as *Pyrimidines* or *Purines*

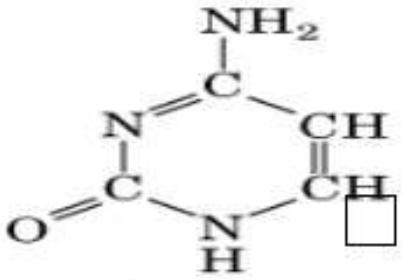


Adenine

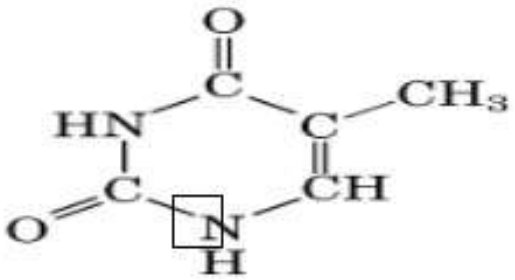


Guanine

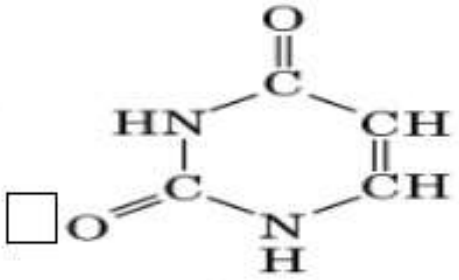
Purines



Cytosine



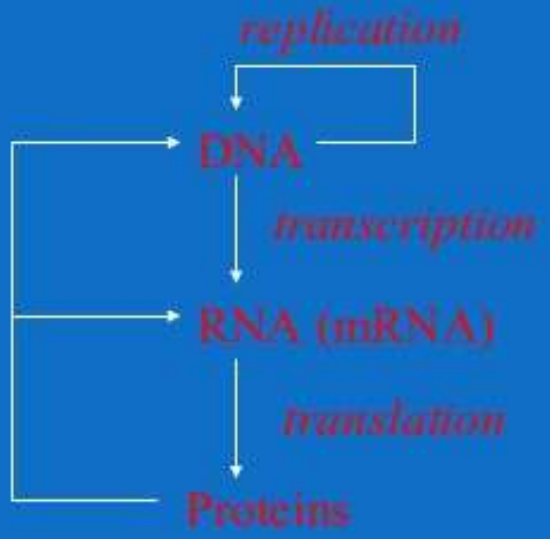
Thymine
(DNA)

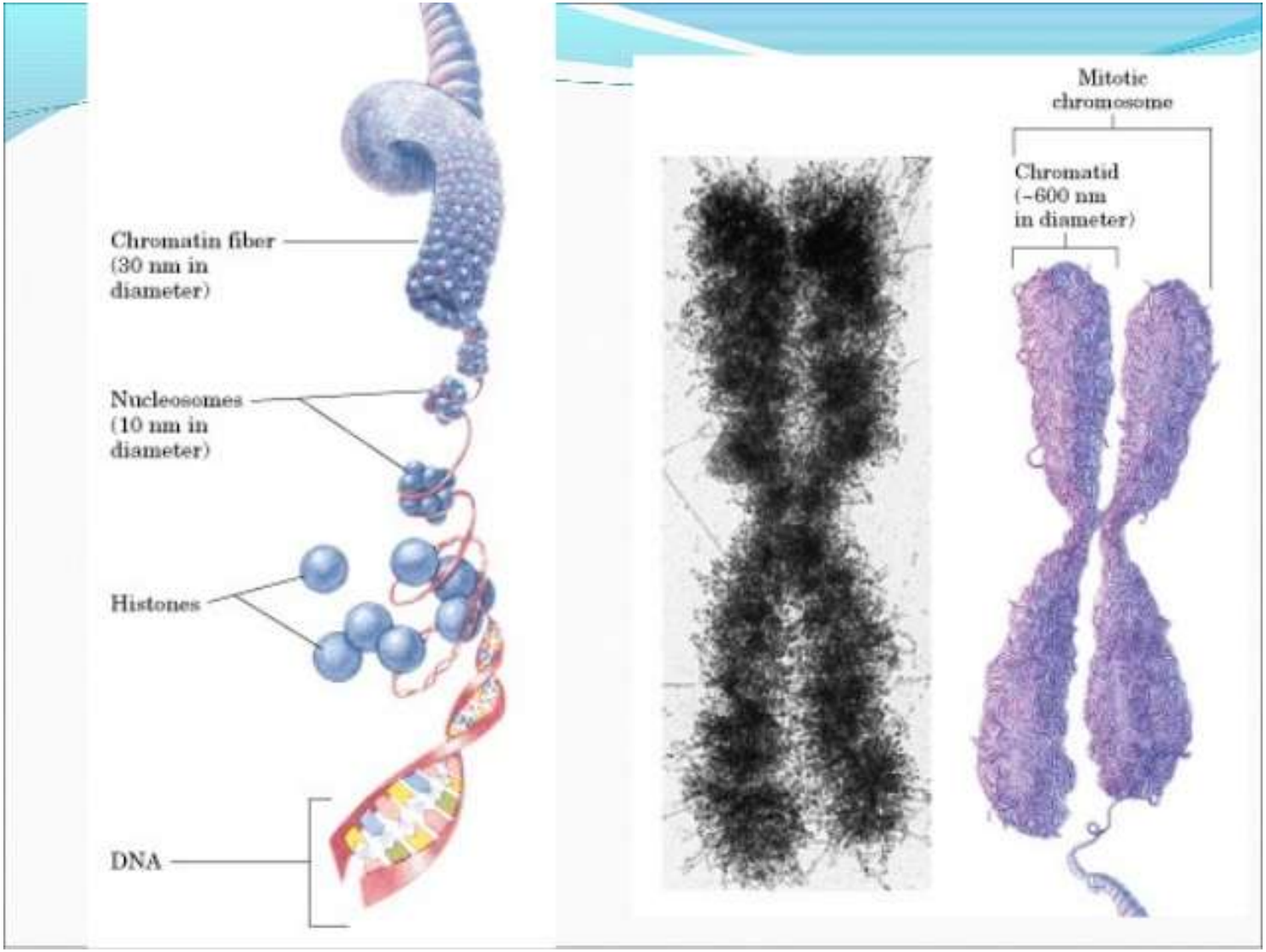


Uracil
(RNA)

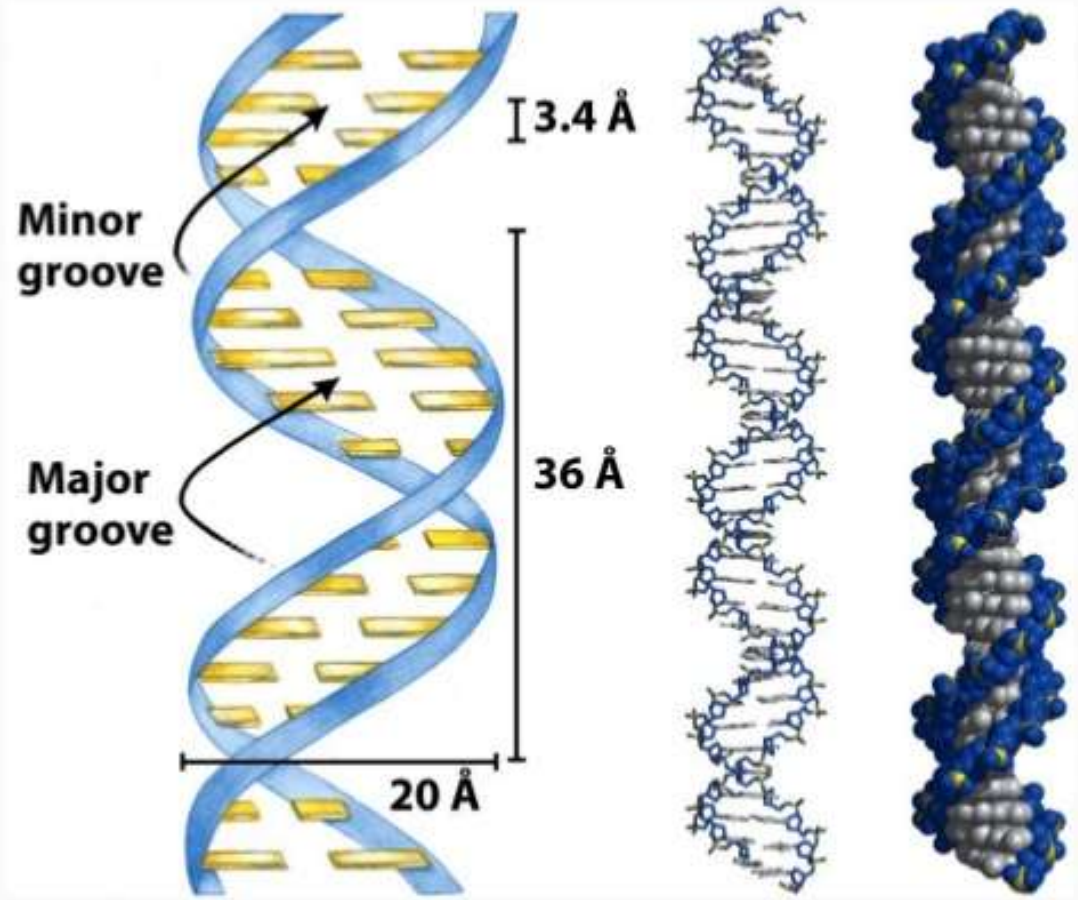
Pyrimidines

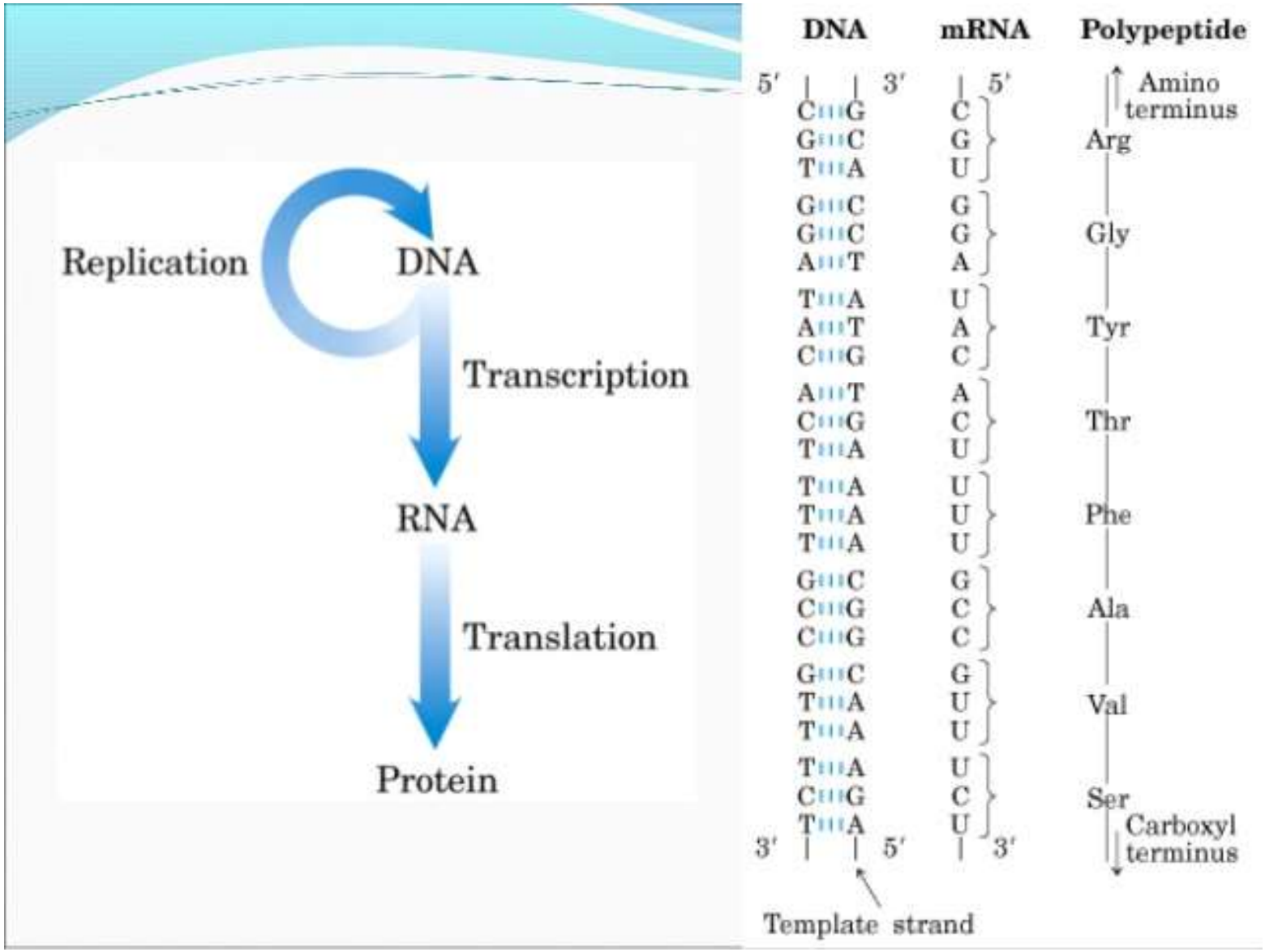
The nucleus contains the cell's DNA (genome)
RNA is synthesized in the nucleus and exported to the cytoplasm

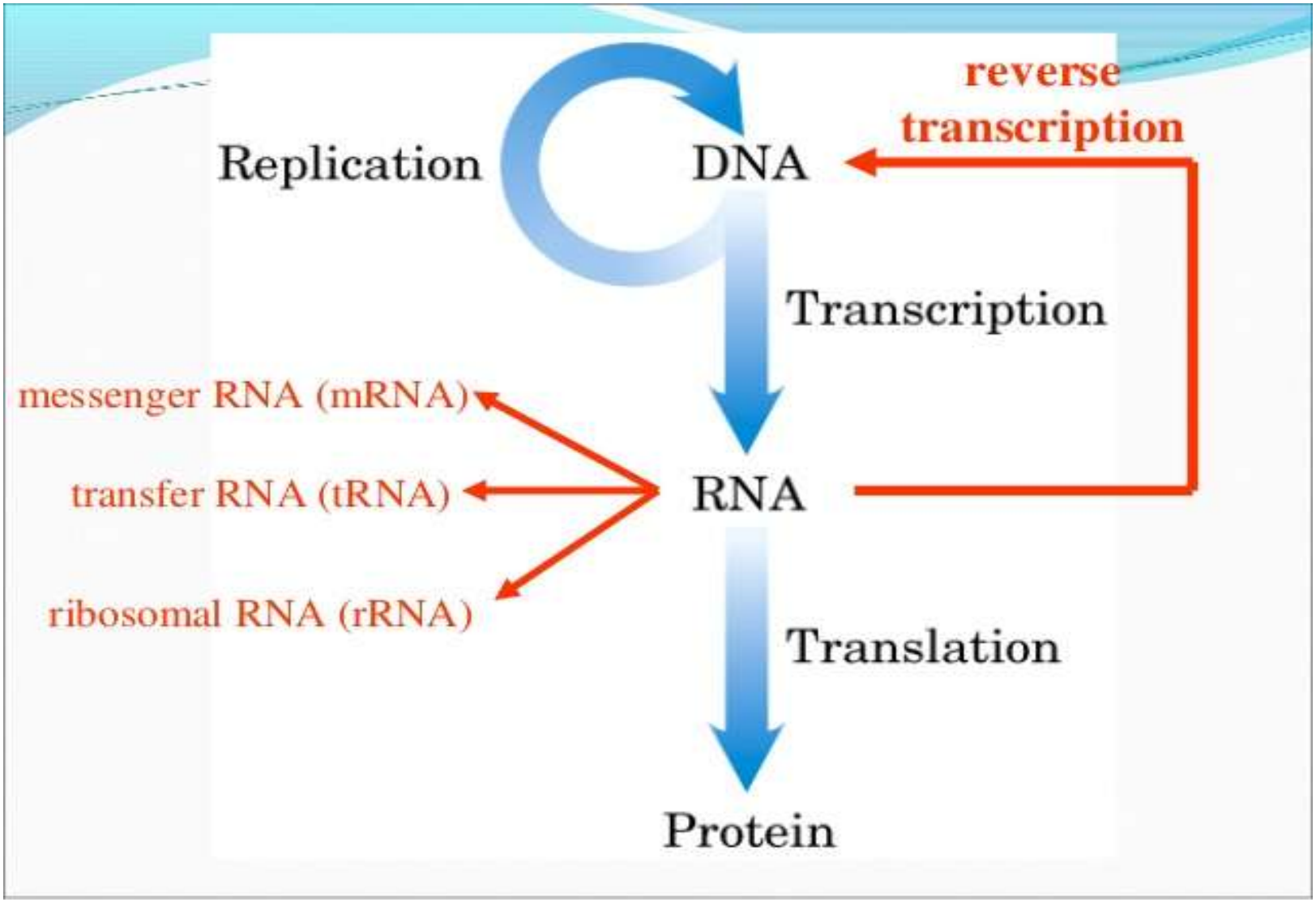



Chromatin fiber
(30 nm in
diameter)
Nucleosomes
(10 nm in
diameter)
Histones
DNA
Mitotic
chromosome
Chromatid
(~600 nm
in diameter)

DNA is a Double-Helix



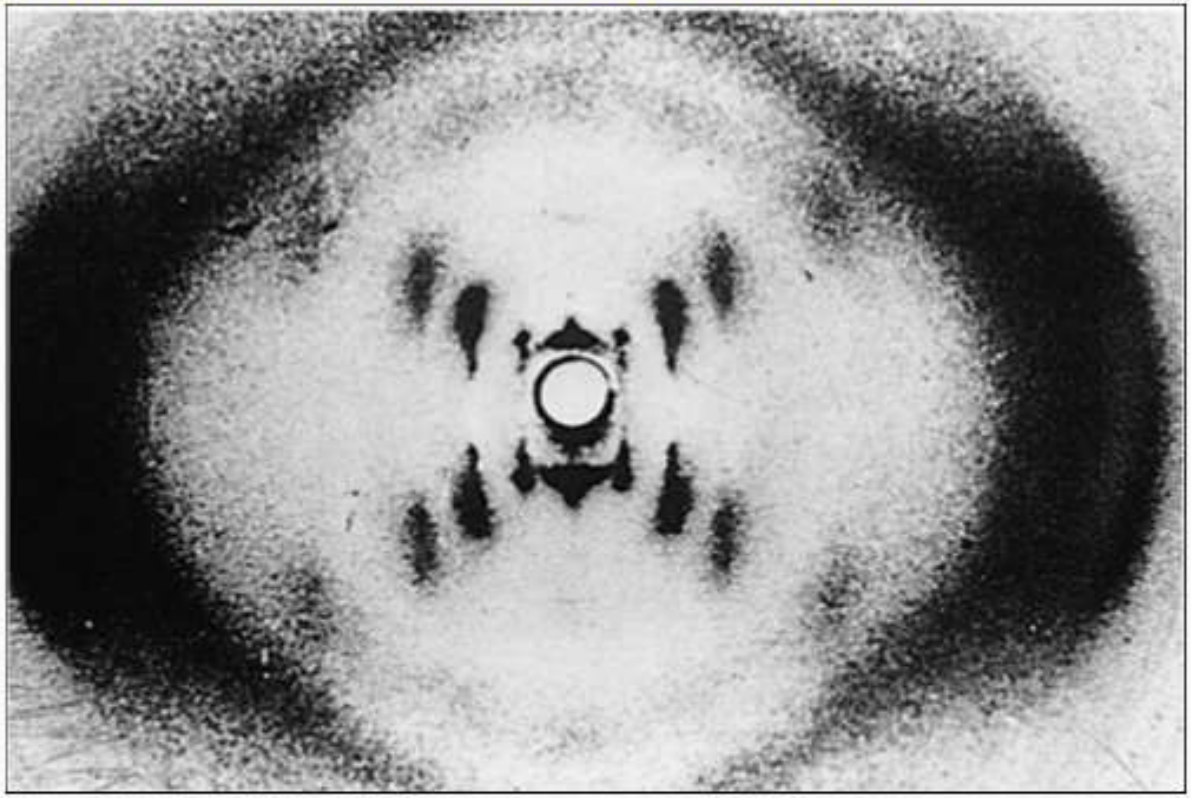

Replication
DNA
Transcription
RNA
Translation
Protein
DNA
mRNA
Polypeptide
5′
3′
5′
3′
5′
3′
Amino terminus
Carboxyl terminus
Arg
Gly
Tyr
Thr
Phe
Ala
Val
Ser
Template strand


reverse
transcription
Replication
DNA
Transcription
messenger RNA (mRNA)
transfer RNA (tRNA)
ribosomal RNA (rRNA)
RNA
Translation
Protein

Nucleotides

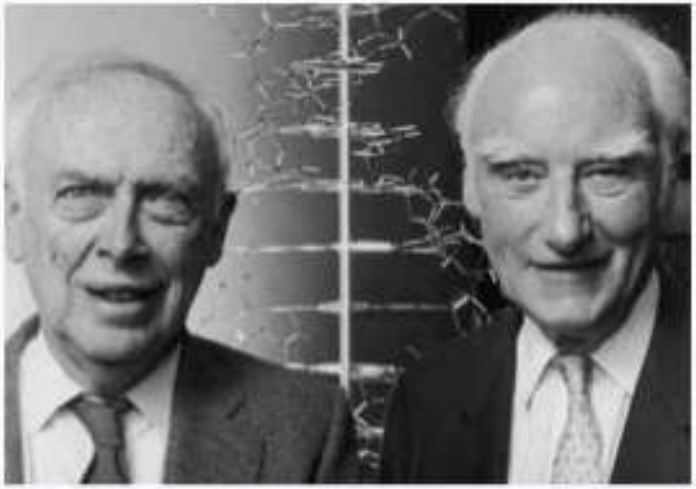
Base	Nucleosides	Nucleotides
RNA		
Adenine (A)	Adenosine (A)	Adenosine 5'-monophosphate (AMP)
Guanine (G)	Guanosine (G)	Guanosine 5'-monophosphate (GMP)
Cytosine (C)	Cytidine (C)	Cytidine 5'-monophosphate (CMP)
Uracil (U)	Uridine (U)	Uridine 5'-monophosphate (UMP)
DNA		
Adenine (A)	Deoxyadenosine (A)	Deoxyadenosine 5'-monophosphate (dAMP)
Guanine (G)	Deoxyguanosine (G)	Deoxyguanosine 5'-monophosphate (dGMP)
Cytosine (C)	Deoxycytidine (C)	Deoxycytidine 5'-monophosphate (dCMP)
Thymine (T)	Deoxythymidine (T)	Deoxythymidine 5'-monophosphate (dTMP)

X-ray diffraction patterns produced by DNA fibers Rosalind Franklin and Maurice Wilkins



1962 Nobel Prize in Physiology or Medicine

- *for their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in living material"*



James Watson Francis Crick

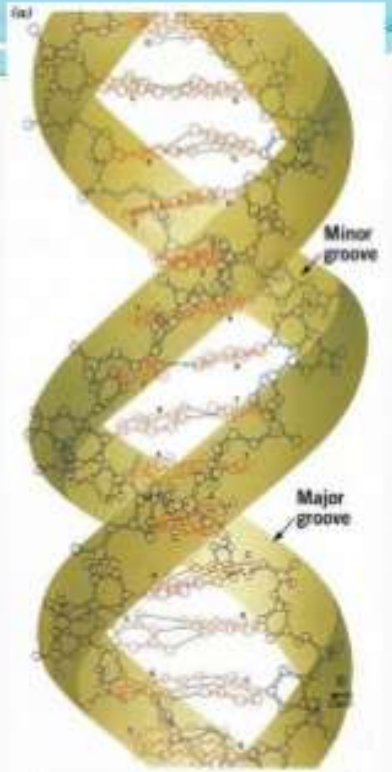
Maurice Wilkins

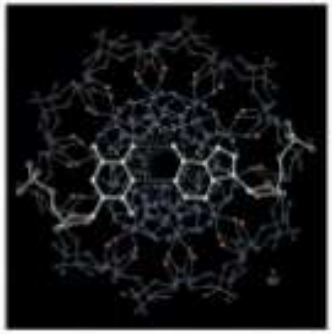
DNA conformations

	A- DNA	B-DNA	Z-DNA
Helix	Right-handed	Right-handed	Left-handed
Width	Widest	Intermediate	Narrowest
Planes of bases	planes of the base pairs inclined to the helix axis	planes of the base pairs nearly perpendicular to the helix axis	planes of the base pairs nearly perpendicular to the helix axis
Central axis	6A hole along helix axis	tiny central axis	no internal spaces
Major groove	Narrow and deep	Wide and deep	No major groove
Minor groove	Wide and shallow	Narrow and deep	Narrow and deep

B-DNA

- Right-handed helix
- intermediate
- planes of the base pairs nearly perpendicular to the helix axis
- tiny central axis
- wide + deep major groove
- narrow + deep minor groove

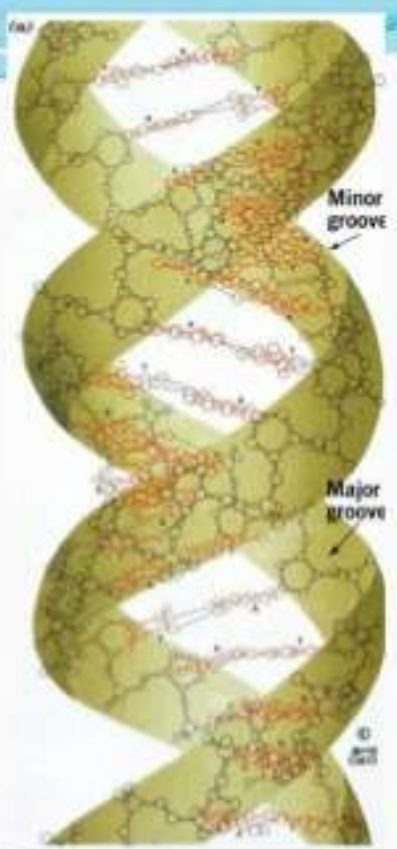


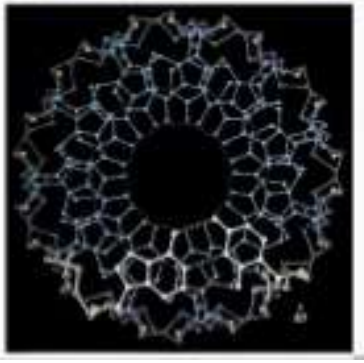


DNA conformations

A- DNA

- Right-handed helix
- Widest
- planes of the base pairs inclined to the helix axis
- 6A hole along helix axis
- narrow + deep major groove
- Wide + shallow minor groove

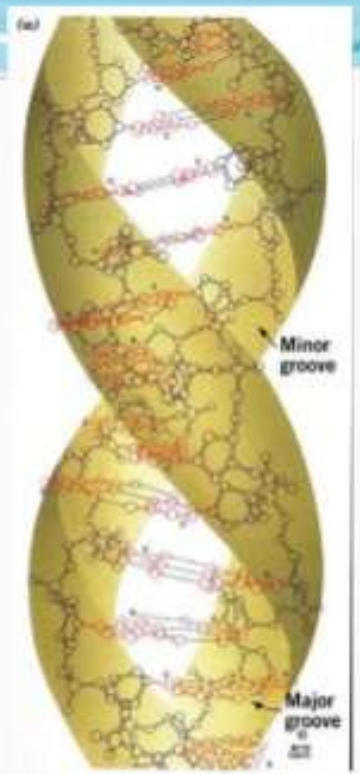


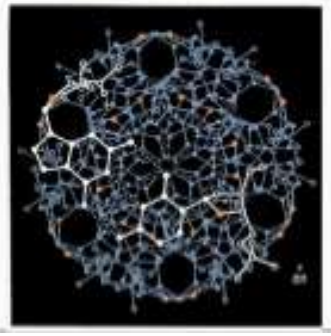


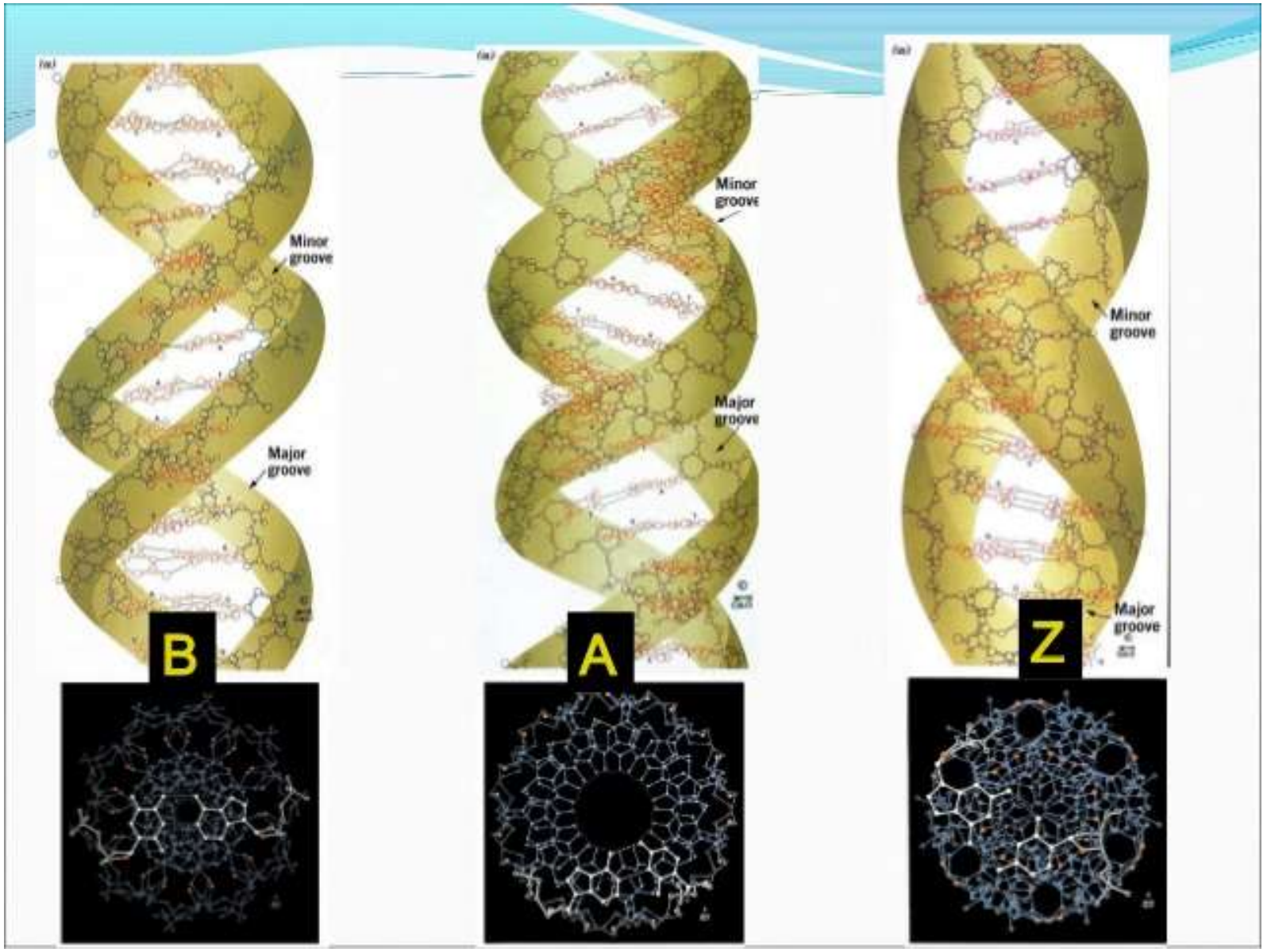
DNA conformations

Z-DNA

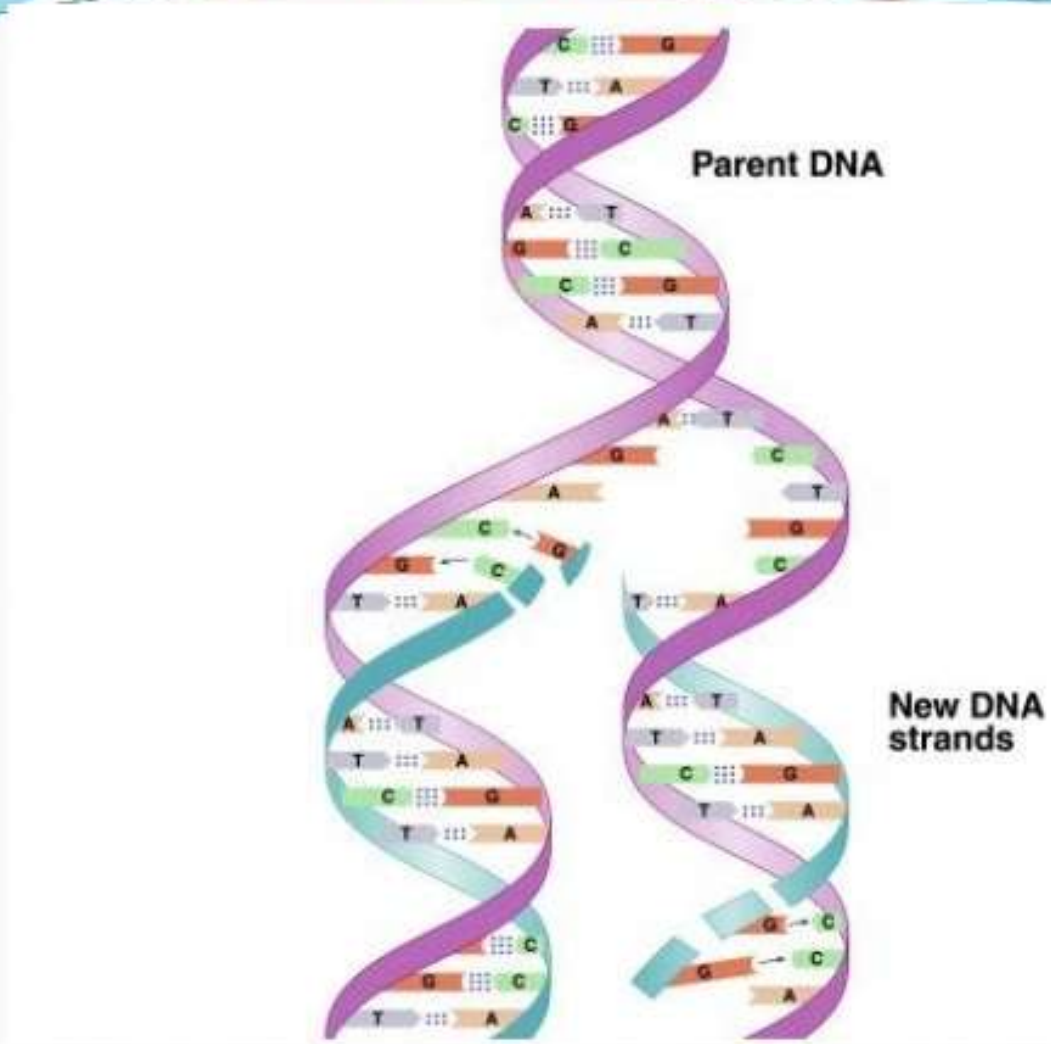
- Left-handed helix
- Narrowest
- planes of the base pairs nearly perpendicular to the helix axis
- no internal spaces
- no major groove
- narrow + deep minor groove





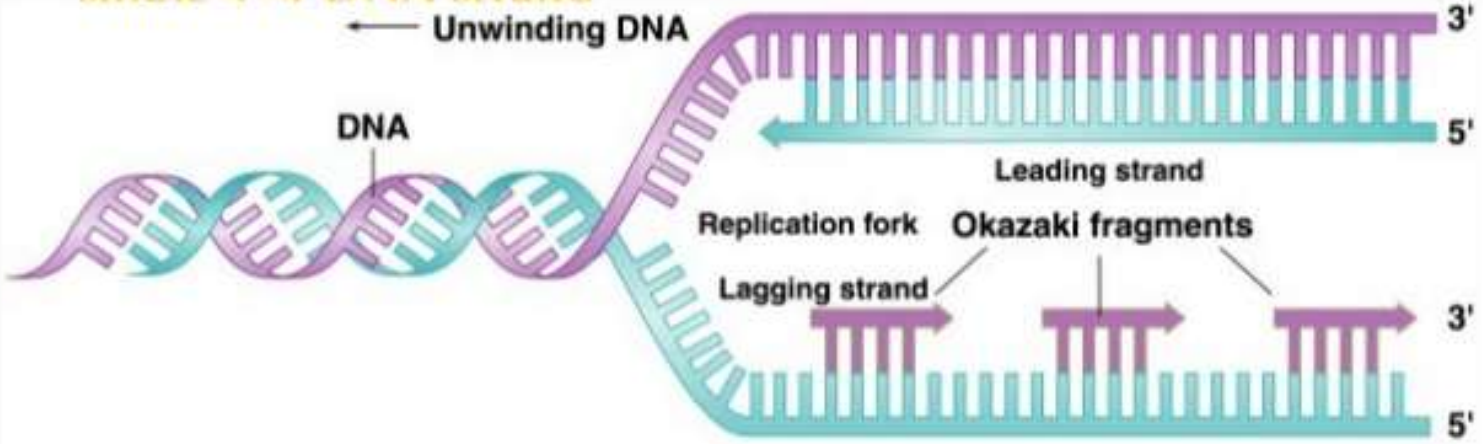

Minor groove
Major groove
B
Minor groove
Major groove
A
Minor groove
Major groove
Z

Semi-Conservative DNA Replication



Direction of Replication

- The enzyme *helicase* unwinds several sections of parent DNA
- At each open DNA section, called a **replication fork**, DNA *polymerase* catalyzes the formation of 5'-3'ester bonds of the **leading strand**
- The **lagging strand**, which grows in the 3'-5' direction, is synthesized in short sections called **Okazaki fragments**
- The Okazaki fragments are joined by DNA *ligase* to give a single 5'-3' DNA strand



Ribonucleic Acid (RNA)

- RNA is much more abundant than DNA
- There are several important differences between RNA and DNA:

  - the pentose sugar in RNA is ribose, in DNA it's deoxyribose
  - in RNA, uracil replaces the base thymine (U pairs with A)
  - RNA is single stranded while DNA is double stranded
  - RNA molecules are much smaller than DNA molecules
- There are three main types of RNA:

  - ribosomal (rRNA), messenger (mRNA) and transfer (tRNA)

Types of RNA

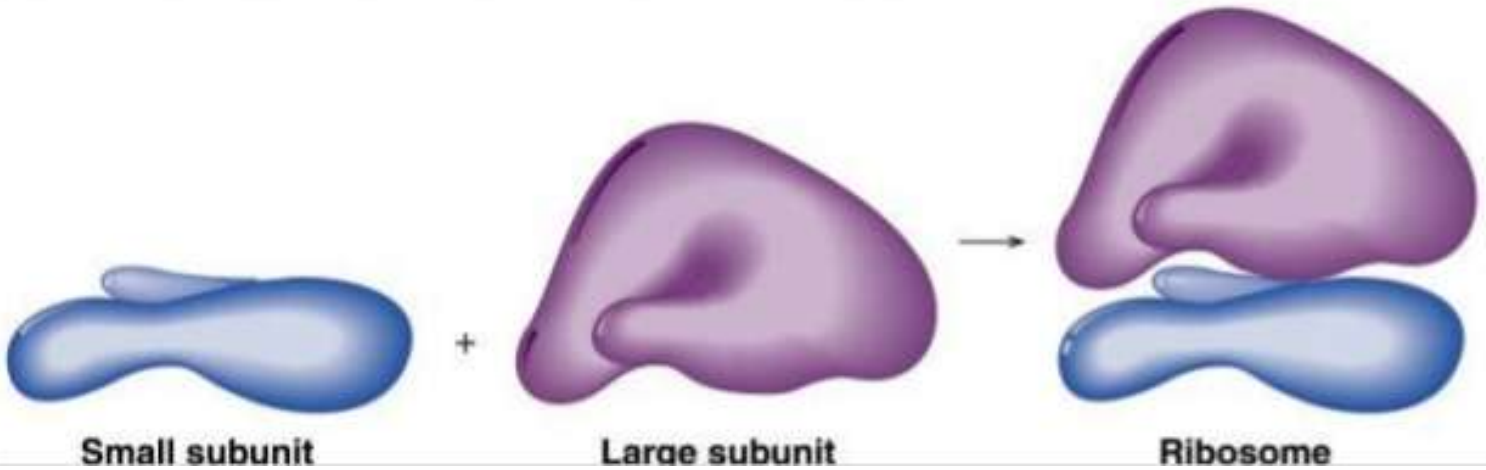
Table 22.3 Types of RNA Molecules

Type	Abbreviation	Percentage of Total RNA	Function in the Cell
Ribosomal RNA	rRNA	75	Major component of the ribosomes
Messenger RNA	mRNA	5–10	Carries information for protein synthesis from the DNA in the nucleus to the ribosomes
Transfer RNA	tRNA	10–15	Brings amino acids to the ribosomes for protein synthesis

Timberlake, *General, Organic, and Biological Chemistry*. Copyright © Pearson Education Inc., publishing as Benjamin Cummings

Ribosomal RNA and Messenger RNA

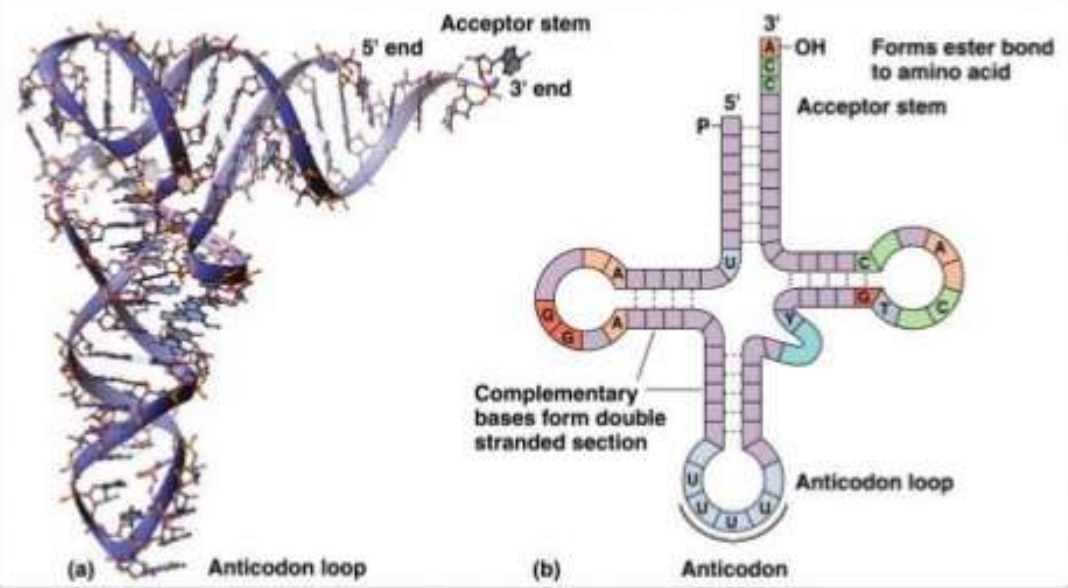
- **Ribosomes** are the sites of protein synthesis
  - they consist of **ribosomal DNA** (65%) and proteins (35%)
  - they have two subunits, a large one and a small one
- **Messenger RNA** carries the genetic code to the ribosomes
  - they are strands of RNA that are complementary to the DNA of the gene for the protein to be synthesized

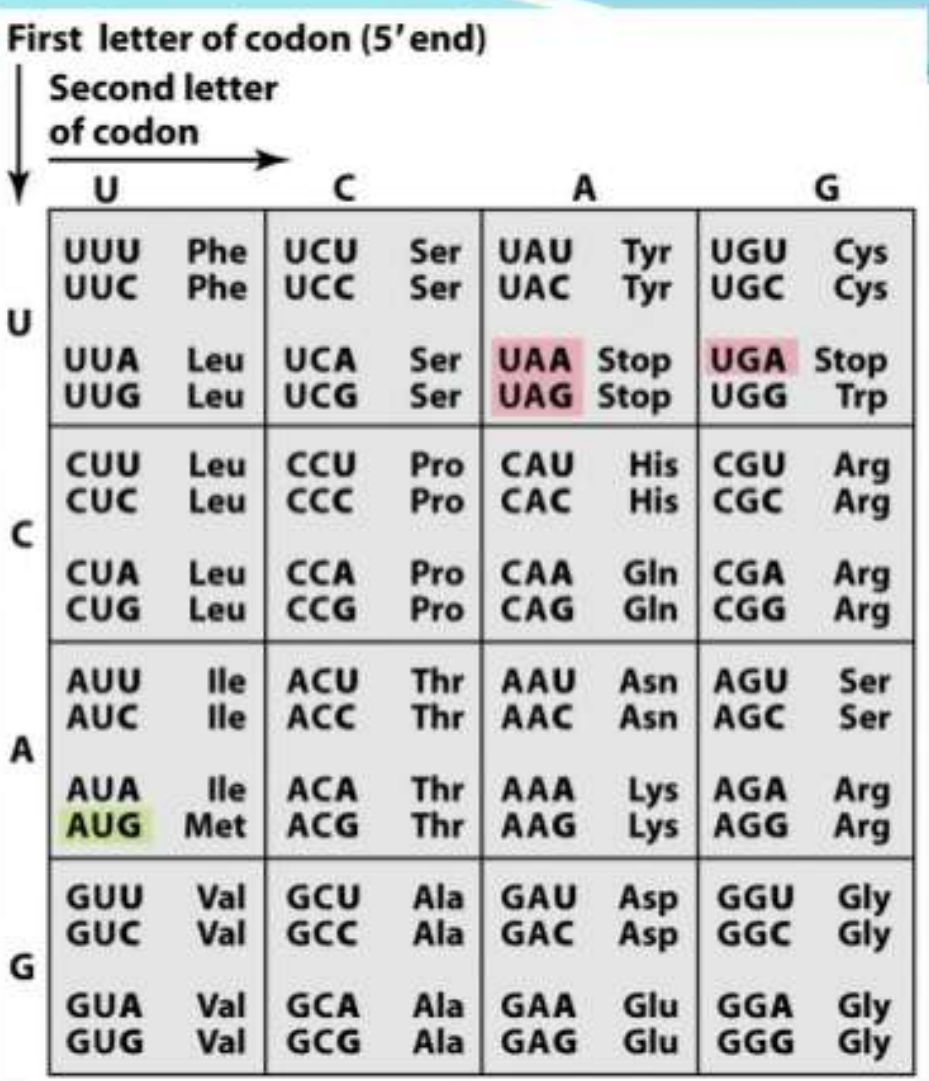


Transfer RNA

- **Transfer RNA** translates the genetic code from the messenger RNA and brings specific amino acids to the ribosome for protein synthesis
- Each amino acid is recognized by one or more specific tRNA
- tRNA has a tertiary structure that is L-shaped

  - one end attaches to the amino acid and the other binds to the mRNA by a 3-base complimentary sequence




First letter of codon (5′ end)
Second letter of codon
U
C
A
G
UUU Phe
UUC Phe
UUA Leu
UUG Leu
UCU Ser
UCC Ser
UCA Ser
UCG Ser
UAU Tyr
UAC Tyr
UAA Stop
UAG Stop
UGU Cys
UGC Cys
UGA Stop
UGG Trp
CUU Leu
CUC Leu
CUA Leu
CUG Leu
CCU Pro
CCC Pro
CCA Pro
CCG Pro
CAU His
CAC His
CAA Gln
CAG Gln
CGU Arg
CGC Arg
CGA Arg
CGG Arg
AUU Ile
AUC Ile
AUA Ile
AUG Met
ACU Thr
ACC Thr
ACA Thr
ACG Thr
AAU Asn
AAC Asn
AAA Lys
AAG Lys
AGU Ser
AGC Ser
AGA Arg
AGG Arg
GUU Val
GUC Val
GUA Val
GUG Val
GCU Ala
GCC Ala
GCA Ala
GCG Ala
GAU Asp
GAC Asp
GAA Glu
GAG Glu
GGU Gly
GGC Gly
GGA Gly
GGG Gly

Important conclusion

NUCLEIC ACIDS

NUCLEOTIDES

NUCLEOSIDES
NITROGENOUS BASES
purines and pyrimidines
A & G C,T & U

PHOSPHORIC ACID
SUGAR
ribose and deoxyribose

Thank you